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Intermediate Ethanol Blends Catalyst Durability Program

February 2012

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UT-BATTELLE

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Fuels Technologies Program

INTERMEDIATE ETHANOL BLENDS CATALYST DURABILITY PROGRAM

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ACRONYMS

AFR	air : fuel ratio
BMI	Battelle Memorial Institute
CFR	Code of Federal Regulations
CMB	carbon mass balance
CO	carbon monoxide
CRC	Coordinating Research Council
DOE	U.S. Department of Energy
EERE	Office of Energy Efficiency and Renewable Energy (DOE)
EOT	end-of-test
EPA	U.S. Environmental Protection Agency
ETC	Environmental Testing Corporation
ETW	equivalent test weight
FFV	flexible-fuel vehicle
FTP	Federal Test Procedure
FUL	full useful life
LDT	light duty truck
LFT	long-term fuel trim (also known as learned fuel trim)
LVW	loaded vehicle weight
MAD	mileage accumulation dynamometer
MID	midlife aging
MIL	malfunction indicator lamp
NLEV	National Low Emission Vehicle (Program)
NMHC	nonmethane hydrocarbon
NMOG	nonmethane organic gas
NO_X	oxides of nitrogen
NREL	National Renewable Energy Laboratory
ORNL	Oak Ridge National Laboratory
RVP	Reid vapor pressure
SOT	start-of-test
SRC	standard road cycle
SwRI	Southwest Research Institute
TRC	Transportation Research Center Inc.
UEGO	universal exhaust gas oxygen sensor
WOT	wide-open throttle

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EXECUTIVE SUMMARY

E.1 INTRODUCTION

In the summer of 2007, the U.S. Department of Energy (DOE) initiated a test program to evaluate the potential impacts of intermediate ethanol blends (also known as mid-level blends) on legacy vehicles and other engines.[*] The purpose of the test program was to develop information important to assessing the viability of using intermediate blends as a contributor to meeting national goals for the use of renewable fuels. Through a wide range of experimental activities, DOE is evaluating the effects of E15 and E20—gasoline blended with 15% and 20% ethanol—on tailpipe and evaporative emissions, catalyst and engine durability, vehicle driveability, engine operability, and vehicle and engine materials.

This report provides the results of the catalyst durability study, a substantial part of the overall test program. Results from additional projects will be reported separately. The principal purpose of the catalyst durability study was to investigate the effects of adding up to 20% ethanol to gasoline on the durability of catalysts and other aspects of the emissions control systems of vehicles.

Section 1 provides further information about the purpose and context of the study. Section 2 describes the experimental approach for the test program, including vehicle selection, aging and emissions test cycle, fuel selection, and data handling and analysis. Section 3 summarizes the effects of the ethanol blends on emissions and fuel economy of the test vehicles. Section 4 summarizes notable unscheduled maintenance and testing issues experienced during the program. The appendixes provide additional detail about the statistical models used in the analysis, detailed statistical analyses, and detailed vehicle specifications.

E.2 BACKGROUND

The Energy Independence and Security Act of 2007 requires significant increases in the nation's use of renewable fuels to meet its transportation energy needs. The law expands the renewable fuel standard to require use of 36 billion gallons of renewable fuel by 2022. Given that ethanol is currently the most widely used renewable fuel in the U.S. market, it is reasonable to project that ethanol will likely make a significant contribution to meeting the 36-billion-gallon requirement.

The vast majority of ethanol currently used for transportation in the United States is blended with gasoline to create E10—gasoline with up to 10% ethanol. The remaining ethanol is sold in the form of E85—a gasoline blend with as much as 83% ethanol that can only be used in flexible-fuel vehicles (FFVs). Consumption of E85 is currently limited by the size of the FFV fleet, the number of E85 fueling stations, and occasional unfavorable pricing of E85 (on a dollars per unit energy basis).

The E10 market in the United States is reaching saturation; in 2010 13.2 billion gallons of ethanol were produced, and more than 90% of gasoline was sold as E10.[†] Although DOE remains committed to expanding the E85 infrastructure, the E85 market has represented less than 1% of the ethanol consumed each year, making it difficult for that market to absorb projected volumes of ethanol in the near term. As a result, since 2007 DOE and others have been assessing the viability of using mid-level ethanol blends as an additional way to accommodate growing volumes of ethanol.

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[*]The test program has been co-led and co-funded by the U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy (EERE) Biomass Program and the EERE Vehicle Technologies Program with technical support from the Oak Ridge National Laboratory and the National Renewable Energy Laboratory. DOE and the laboratory team have worked closely with representatives from the U.S. Environmental Protection Agency, U.S. auto manufacturers, engine companies, and other organizations to develop and conduct the test program.

[†]U.S. Energy Information Administration, *Monthly Energy Review,* DOE/EIA-0035(2011/07), July 27, 2011, available at http://www.eia.gov/FTPROOT/multifuel/mer/00351107.pdf.

E.3 DEVELOPMENT OF TEST PROGRAM

The Coordinating Research Council E-87 program[*] and DOE V1 program[†] identified several high-sales-volume vehicle models that did not apply long-term (or learned) fuel trim (LFT) at open loop conditions, and thus produced hotter exhaust and catalyst temperatures at full power operation when operated with ethanol blends compared to ethanol-free gasoline. Based on the literature, there was concern that increasing the ethanol fraction in gasoline for these vehicles could result in increased emissions over time.[‡,§] Because of this concern, DOE supported the development and execution of a catalyst durability study unprecedented in size and scope.

To assess the durability of emissions control systems, the U.S. Environmental Protection Agency's (EPA's) vehicle test procedures allow for whole vehicle "aging" using the standard road cycle (SRC).[**] In this program, vehicles at Southwest Research Institute and Environmental Testing Corporation were driven on mileage accumulation dynamometers (MADs), while vehicles at Transportation Research Center were driven on a closed test track. In all three cases, vehicles were operated recursively over the SRC. Vehicles were purchased in matched sets and aged on the MADs or on the track using a separate dedicated ethanol blend for each vehicle of a set. Emissions were measured using the Federal Test Procedure (FTP) at start-of-test (SOT), at one or two midlife points, and again at end-of-test (EOT). All test vehicles were driven at least 50,000 miles from SOT to EOT, while many vehicles were driven more than 100,000 miles. All vehicles were near or beyond their regulatory full useful life mileage at EOT. In total, 82 vehicles were driven more than 6 million miles in this project.

Vehicles from the six largest vehicle manufacturers were represented in the study, including cars and light trucks from General Motors, Ford, Chrysler, Toyota, Honda, and Nissan. Eighteen Tier 2 vehicle models (i.e., vehicle models built to meet EPA's Tier 2 emission standards) from model years 2005 through 2009 and eight pre-Tier-2 vehicle models from model years 2000–2003 were aged using the SRC protocol. Emissions were tested periodically throughout the program.

Vehicles were acquired to establish matched sets of two, three, or four vehicles of each model being tested. Each vehicle of a set was dedicated to a specific gasoline-ethanol blend for aging. Retail, top-tier ethanol-free gasoline[††] (RE0) was splash blended with ASTM D4806 ethanol to produce 10%, 15%, and 20% ethanol blends (RE10, RE15, and RE20) for vehicle aging. Four pairs of vehicles were aged with RE0 and RE15, five vehicle sets with four matched vehicles were aged with RE0, RE10, RE15, and RE20. The remaining 18 vehicle sets were aged with RE0, RE15, and RE20. Emissions tests were conducted with Federal Certification Gasoline (E0) similarly blended to make the appropriate emissions test fuels (E10, E15, and E20). All vehicles, including those dedicated to ethanol-blended fuels, were emissions tested with the E0 fuel at each test interval. Time and budget constraints necessitated the use of

[*]Transportation Research Center Inc., *Mid-Level Ethanol Blends Catalyst Durability Study Screening,* CRC Report E-87-1, Coordinating Research Council, Inc., Alpharetta, Georgia, June 2009.

[†]Keith Knoll et al., *Effects of Intermediate Ethanol Blends on Legacy Vehicles and Small Non-Road Engines,* Report 1—Updated, NREL/TP-540-43543/ORNL/TM-2008/117, February 2009, available at http://www.nrel.gov/docs/fy09osti/43543.pdf.

[‡]R. Bechtold et al., *Technical Issues Associated with the Use of Intermediate Ethanol Blends (>E10) in the U.S. Legacy Fleet: Assessment of Prior Studies,* ORNL/TM-2007/37, Oak Ridge National Laboratory, August 2007, available at http://info.ornl.gov/sites/publications/files/Pub7767.pdf.

[§]Orbital Engine Company, *Market Barriers to the Uptake of Biofuels Study; Testing Gasoline Containing 20% Ethanol (E20),* Phase 2B Final Report to the Department of the Environment and Heritage, Australia, May 2004.

[**]U.S. Environmental Protection Agency, "Emission Durability Procedures and Component Durability Procedures for New Light-Duty Vehicles, Light-Duty Trucks and Heavy-Duty Vehicles," Final Rule and Proposed Rule, 40 CFR Part 86, in *Federal Register,* Vol. 71(10), Tuesday, January 17, 2006.

[††]Top-tier gasoline contains more deposit-control additives than the minimum allowable by EPA (http://www.toptiergas.com/).

splash blends (as opposed to match blends) in this program. When using match blends, certain fuel properties such as volatility and octane can be tailored to match the desired ethanol blend level. When splash blends are used, it is understood that properties such as volatility and octane will vary with ethanol content,[*,†] but it was felt that these variations would not impact the change in emissions due to aging on the SRC.

E.4 SUMMARY OF FINDINGS

Statistical analysis of emissions test results determined the following.

- Aging vehicles on the SRC increased emissions over time, as expected.
- Aging with ethanol blends did not affect emissions changes over time differently than aging with ethanol-free gasoline.
- Whether vehicles applied LFT under open-loop conditions did not affect emissions and fuel economy results.
- Addition of 10% to 20% ethanol to certification gasoline caused the following general fleetwide changes in measured tailpipe emissions and fuel economy compared to gasoline. (These immediate effects are largely consistent with findings of the DOE V1 study.[‡§])
  - Median CO emissions decreased by 0.03 to 0.14 g/mile.
  - Median nonmethane hydrocarbon emissions decreased by 0.002 to 0.008 g/mile.
  - Median NO_X emissions increased by 0.001 to 0.004 g/mile.
  - Median ethanol emissions increased by 2.3 to 4.6 mg/mile.
  - Median acetaldehyde and formaldehyde emissions increased slightly (by less than 1 mg/mile).
  - Nonmethane organic gas and methane emissions were largely unchanged.
  - Fuel economy was decreased by about 3% to 7%, consistent with the energy density of the test fuel.

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[*] J. E. Anderson et al., "Octane Numbers of Ethanol- and Methanol-Gasoline Blends Estimated from Molar Concentrations," *Energy Fuels* 2010, 24, pp. 6576–6585.

[†] American Petroleum Institute, *Determination of the Potential Property Ranges of Mid-Level Ethanol Blends*, Final Report, April 2010.

[‡] Keith Knoll et al., *Effects of Intermediate Ethanol Blends on Legacy Vehicles and Small Non-Road Engines*, Report 1—Updated, NREL/TP-540-43543/ORNL/TM-2008/117, February 2009, available at http://www.nrel.gov/docs/fy09osti/43543.pdf.

[§] Keith Knoll et al., "Effects of Mid-Level Ethanol Blends on Conventional Vehicle Emissions," SAE paper 2009-01-2723, SAE International, Warrendale, Pennsylvania, November 2009.

1. BACKGROUND

The Energy Independence and Security Act of 2007 requires significant increases in the nation's use of renewable fuels to meet its transportation energy needs. The law establishes a new renewable fuel standard that requires the nation to use 36 billion gallons of renewable fuel in its vehicles by 2022. Given that ethanol is the most widely used renewable fuel in the United States and production is expected to continue to grow over the next several years, ethanol—both from corn[*] and from cellulosic feedstocks—will likely make up a significant portion of the renewable fuels required by the new standard. Most of the ethanol used in the United States is blended with gasoline to create E10—gasoline with up to 10% ethanol. The remaining ethanol is sold in the form of E85—a gasoline blend with as much as 83% ethanol that can only be used in flexible-fuel vehicles (FFVs). Consumption of E85 is currently limited by the size of the FFV fleet, the number of E85 fueling stations, and occasionally by unfavorable pricing of E85 (on a cost per unit energy basis).[†] While U.S. automakers have committed to significantly ramping up production of FFVs, only about 5% of the existing U.S. fleet is replaced each year. That means a significant number of the non-FFVs in use today will remain in the vehicle stock for many years to come.

The E10 market in the United States was largely saturated in 2010, with 13.2 billion gallons of ethanol produced domestically, 400 million gallons exported, and gasoline consumption just under 140 billion gallons.[‡] Although the U.S. Department of Energy (DOE) remains committed to expanding the E85 infrastructure, it will be difficult for that market to absorb projected volumes of ethanol in the near term. Given this reality, DOE and others have been assessing the viability of using mid-level ethanol blends as an additional way to potentially accommodate growing volumes of ethanol.

In early 2007, DOE tasked Oak Ridge National Laboratory (ORNL) to conduct a literature search on intermediate ethanol blends, which indicated that insufficient data existed to predict the impacts of these fuels on U.S. vehicles and engines.[§] Due to the lack of data, DOE then initiated a test program to assess the potential impacts of mid-level ethanol blends on conventional vehicles (non-FFVs) and other engines that rely on gasoline. The latter include small non-road engines such as those used in lawn and garden equipment and other non-automotive engines such as those used in marine applications, motorcycles, and snowmobiles.[**] The DOE team developed a number of vehicle and non-automotive testing projects to help understand the potential effects of intermediate blends on legacy equipment. Vehicle-related projects were denoted V1, V2, and so on.[††] This report provides the results of V4, the Catalyst Durability Study (DOE Catalyst Study[‡‡]).

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[*]The law puts a 15-billion-gallon limit on the amount of noncellulosic corn-based ethanol that can contribute to meeting the renewable fuel standard. Fifteen billion gallons is a little over 40% of the 36 billion gallon total.

[†]Less than 1% of the ethanol used in the United States today is sold in the form of E85. About 8–9 million flexible-fuel vehicles, or about 4% of the U.S. fleet, are in use today, with about 1% of U.S. fueling stations providing E85.

[‡]U.S. Energy Information Administration, *Monthly Energy Review,* DOE/EIA-0035(2011/07), July 27, 2011, available at http://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf.

[§]R. Bechtold et al., *Technical Issues Associated with the Use of Intermediate Ethanol Blends (>E10) in the U.S. Legacy Fleet,* ORNL/TM-2007/37, Oak Ridge National Laboratory, August 2007, available at http://info.ornl.gov/sites/publications/files/Pub7767.pdf.

[**]Keith Knoll et al., *Effects of Intermediate Ethanol Blends on Legacy Vehicles and Small Non-Road Engines,* Report 1—Updated, NREL/TP-540-43543/ORNL/TM-2008/117, February 2009, available at http://www.nrel.gov/docs/fy09osti/43543.pdf.

[††]Brian West, et al., "Mid-Level Ethanol Blends Test Program," presented at the 2010 U.S. DOE Hydrogen Program and Vehicle Technologies Program Annual Merit Review and Peer Evaluation Meeting, June 9, 2010, available at http://www1.eere.energy.gov/vehiclesandfuels/pdfs/merit_review_2010/fuel_technologies/ft005_west_2010_o.pdf.

[‡‡]*Federal Register*, Vol. 76(17), Wednesday, January 26, 2011, Notices.

In 2009, Growth Energy and a number of ethanol producers submitted a waiver request to the U.S. Environmental Protection Agency (EPA) to allow 15% ethanol in gasoline. EPA granted partial approval to the waiver in October 2010[*] and January 2011,[†] citing the DOE research program in the rulings.

The DOE program has been co-led and co-funded by the DOE Office of Energy Efficiency and Renewable Energy (EERE) Vehicle Technologies Program and EERE Biomass Program with technical support from ORNL and the National Renewable Energy Laboratory (NREL). DOE requested that the program be conducted as rapidly as possible. Multiple sites and parallel resources were combined to expedite the program.

[*] *Federal Register*, Vol. 75(213), Thursday, November 4, 2010, Notices.

[†] *Federal Register*, Vol. 76(17), Wednesday, January 26, 2011, Notices.

2. APPROACH

EPA regulations allow the following two standard options for evaluating emissions durability.

A. Standard whole vehicle exhaust durability procedure using the standard road cycle (SRC).

B. Standard bench aging exhaust durability procedure using the standard bench aging exhaust durability schedule.[*]

Project leadership felt that option A was more robust and offered more convincing proof of the effects of mid-level ethanol blends; therefore, option A was used in this project. In this vehicle aging program, entire vehicles were aged, using a separate vehicle for each fuel blend. In most cases, vehicles were aged to their regulatory full useful life (FUL) mileage or beyond. Because manufacturers frequently use different control algorithms, catalyst formulations, etc., even among their own models, the aging program included vehicles from a number of manufacturers and car lines. Emissions tests were conducted throughout the aging program to assess the emissions compliance and emissions control deterioration as the vehicles accumulated mileage. This approach is described in Sect. 2.3.

2.1 SUBCONTRACT LABORATORIES

Southwest Research Institute (SwRI) in San Antonio, Texas, was initially selected as the laboratory to execute the planned testing program. However, after initiation of the program Transportation Research Center Inc. (TRC) in East Liberty, Ohio, and Environmental Testing Corporation (ETC) in Denver, Colorado, were added to expand and accelerate the anticipated testing efforts. It is worth noting that ETC is located at an elevation of roughly 5,000 feet; the impacts of testing at altitude may have been relevant for a fraction of the test fleet.

The SwRI and TRC contracts and testing programs were managed by ORNL, while NREL managed the contract and testing at ETC. Minor differences in the test plans at each laboratory owing to differences in the facilities, timing and management of the subcontracts, and specific vehicles assigned to each laboratory will be discussed in greater detail in later sections of this report. The SwRI contract was initiated by ORNL as a Coordinating Research Council (CRC[†]) project (E-87-2). Members of the CRC Emissions Committee and the ORNL project manager participated in on-site meetings at SwRI and quarterly CRC Emissions Committee meetings to discuss progress and to help resolve technical issues with the test program.

The emissions test data from all three sites were forwarded to Battelle Memorial Institute (BMI) throughout the program. BMI was subcontracted by ORNL to serve as a clearinghouse for the data and to conduct statistical analyses to determine the impact of the ethanol fuels, if any, on the emissions test results. BMI created a database incorporating the data from the test sites for use in statistical analyses and additionally hosted a website where stakeholders could access the latest data during the program.

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[*]U.S. Environmental Protection Agency, "Emission Durability Procedures and Component Durability Procedures for New Light-Duty Vehicles, Light-Duty Trucks and Heavy-Duty Vehicles," Final Rule and Proposed Rule. 40 CFR Part 86, in *Federal Register*, Vol. 71(10), Tuesday, January 17, 2006.

[†]Coordinating Research Council (CRC) is a nonprofit organization that directs engineering and environmental studies on the interaction between automotive/other mobility equipment and petroleum products. Sustaining Members of CRC are the American Petroleum Institute and a group of automobile manufacturer members (Chrysler, Ford, General Motors, Honda, Mitsubishi, Nissan, Toyota, and Volkswagen). For more information see: http://crcao.org/.

2.2 VEHICLE SELECTION

2.2.1 Vehicle Model Identification

A number of relevant criteria were used to select the Tier 2 vehicle models used in the program. These criteria included manufacturer, model year, sales/registration volumes, and whether a vehicle model did or did not apply long-term (or learned) fuel trim (LFT or non-LFT, respectively) at wide-open throttle (WOT). Several previous and ongoing studies provided information that impacted vehicle selection: EPA and DOE's EPAct/V2 vehicle study at SwRI,[*] CRC's E-87-1 study,[†] and DOE's previous 16-vehicle screening study (DOE V1).[‡] Guidance from DOE and EPA on vehicle selection stipulated that all Tier 2 vehicles should include the 19 models from the EPAct study but allowed for a range of model years for these vehicles. One exception to the EPAct vehicle list was that the 2006 Nissan Quest (a high-priority CRC E-87-1 vehicle) replaced the Toyota Sienna.

In selecting the non-Tier-2 vehicles, similar factors were considered. The results of the CRC E-87-1 screening study, the DOE V1 study, relevant sales volumes, and matching with a similar late-model Tier 2 vehicle were all considered.

A database consisting of numbers of registered vehicles (as of July 1, 2008) by model year, manufacturer, model type, number of cylinders, fuel type, and engine size was purchased from R. L. Polk. Criteria for selecting additional models (beyond the 18 EPAct vehicle models) included the number of registered vehicles for each manufacturer and engine size. Selection was limited to vehicles from the six vehicle manufacturers with the highest vehicle registration volume: General Motors, Ford, Chrysler, Toyota, Honda, and Nissan. The CRC E-87-2 committee also provided input to the selection process. The study included vehicles certified to both Tier 1/NLEV (National Low Emission Vehicle Program) (model years 2000–2003) and Tier 2 (model years 2004 to 2009) standards. The non-Tier-2 fleet was limited to eight models by budget constraints. Extra care was required during acquisition of matched older vehicles due to the challenge of procuring matched older vehicles that had not exceeded their regulatory FUL and did not have repair or maintenance problems. Most of the Tier1/NLEV vehicles matched the model type (or replacement model type) and engine size for a subset of the Tier 2 models tested. A total of 19 Tier 2 and 8 Tier 1/NLEV vehicle models were chosen and are shown in Tables 2.1 and 2.2.

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[*] Brian West, et al., "Mid-Level Ethanol Blends Test Program," presented at the 2010 U.S. DOE Hydrogen Program and Vehicle Technologies Program Annual Merit Review and Peer Evaluation Meeting, June 9, 2010, available at http://www1.eere.energy.gov/vehiclesandfuels/pdfs/merit_review_2010/fuel_technologies/ft005_west_2010_o.pdf.

[†] Transportation Research Center Inc., *Mid-Level Ethanol Blends Catalyst Durability Study Screening*, CRC Report E-87-1, Coordinating Research Council, Inc., Alpharetta, Georgia, June 2009.

[‡] Keith Knoll et al., *Effects of Intermediate Ethanol Blends on Legacy Vehicles and Small Non-Road Engines*, Report 1—Updated, NREL/TP-540-43543/ORNL/TM-2008/117, February 2009, available at http://www.nrel.gov/docs/fy09osti/43543.pdf.

Table 2.1. Tier 2 vehicle models in the study

Test site	Model year	Vehicle model	Engine family number[a]	Engine displacement (liters)	Engine configuration	Tier 2 emissions standard[b]
Southwest Research Institute	2007	Honda Accord	7HNXV02.4KKC	2.4	I4	Bin 5
	2006	Chevrolet Silverado	6GMXT05.3379	5.3	V8	Bin 8
	2008	Nissan Altima	8NSXV02.5G5A	2.5	I4	Bin 5
	2008	Ford Taurus	8FMXV03.5VEP	3.5	V6	Bin 5
	2007	Dodge Caravan	7CRXT03.8NEO	3.8	V6	Bin 5
	2006	Chevrolet Cobalt	6GMXV02.4029	2.4	I4	Bin 5
	2007	Dodge Caliber	7CRXB02.4MES	2.4	I4	Bin 5
Transportation Research Center	2009	Jeep Liberty	9CRXT03.74PO	3.7	V6	Bin 5
	2009	Ford Explorer	9FMXT04.03DC	4.0	V6	Bin 4
	2009	Honda Civic	9HNXV01.8XB9	1.8	I4	Bin 5
	2009	Toyota Corolla	9TYXV01.8BEA	1.8	I4	Bin 5
	2005	Toyota Tundra	5TYXT04.0NEM	4.0	V6	Bin 5
	2006	Chevrolet Impala	6GMXV03.9048	3.9	V6	Bin 5
	2005	Ford F150	5FMXT05.4R17	5.4	V8	Bin 8
	2006	Nissan Quest	6NSXT03.5G7B	3.5	V6	Bin 5
Environmental Testing Corporation	2009	Saturn Outlook	9GMXT03.6151	3.6	V6	Bin 5
	2009	Toyota Camry	9TYXV02.4BEA	2.4	I4	Bin 5
	2009	Ford Focus	9FMXV02.0VDX	2.0	I4	Bin 4
	2009	Honda Odyssey	9HNXT03.5J29	3.5	V6	Bin 5

[a]"Engine family" and "test group" are often used interchangeably.
[b]Emissions standards are provided in Appendix A.

Table 2.2. Non-Tier-2 vehicle models in the study

Test site[a]	Model year	Vehicle model	Engine family number	Engine displacement (liters)	Engine configuration	Emissions standard[b]
SwRI	2000	Chevrolet Silverado	YMXT05.3181	5.3	V8	Tier 1/LDT3[c]
	2002	Nissan Frontier	2NSXT02.4C4B[d]	2.4	I4	NLEV/LDT1[c]
	2002	Dodge Durango	2CRXT04.75B0	4.7	V8	Tier 1/LDT3[c]
TRC	2003	Toyota Camry	3TYXV02.4HHA	2.4	I4	ULEV
	2003	Ford Taurus	3FMXV03.0VF3	3.0	V6	NLEV
	2003	Chevrolet Cavalier	3GMXV02.2025	2.2	I4	NLEV
ETC	2000	Honda Accord	YHNXV02.3PF3	2.3	I4	NLEV
	2000	Ford Focus	YFMXV02.0VF3	2.0	I4	NLEV

[a]SwRI = Southwest Research Institute, TRC = Transportation Research Center Inc., ETC = Environmental Testing Corporation.
[b]Emissions standards provided in Appendix A. LDT = light duty truck, ULEV = ultralow emission vehicle, NLEV = National Low Emission Vehicle (Program).
[c]LDT1–LDT3 are light truck emissions categories based on vehicle weight. (See Appendix A.)
[d]"Engine family" on Frontier vehicles did not exactly match the EPA database for the 2002 Frontier (see Appendix C).

2.2.2 Vehicle Acceptance

Matched sets of vehicles were needed to provide a direct comparison of fuel effects on essentially identical vehicles. The subcontract laboratories procured the necessary vehicles under the direction of the program leadership. The vehicle sets were matched to prevent confounding of the data by undesirable vehicle attribute changes. The engine family, engine displacement, evaporative emissions control family, model year, powertrain control unit calibration, axle ratios, wheel size, and tire size were constrained to be identical within a vehicle set. Physical inspections of the vehicles to eliminate obvious problematic vehicles (such as those with gross fluid leaks or obvious and excessive body damage) were also a part of the selection process. Odometer mileage was used to identify candidate pre-titled vehicles with the goal of restricting the range of odometer readings within a vehicle set to a maximum of 10,000 miles (this goal was met in 24 of 27 cases). The number of vehicles in a matched set varied during the test program according to the number of fuels being targeted for test. In some cases four ethanol blend levels were tested (E0, E10, E15, and E20), and in other cases a subset of these fuels was tested. In all cases, one vehicle from each set was dedicated to a given ethanol blend level.

Upon purchase of suitably matched vehicle sets, the vehicles were inspected to ensure that any necessary maintenance (e.g., tires, brakes, fluid changes, overlooked scheduled maintenance) was performed before beginning the program. Vehicles were then subjected to a single emissions test to ensure that they were emissions compliant before instrumentation was installed. A few vehicles were rejected during this process, either because they exhibited maintenance issues that were deemed unacceptable or because they were found not to correctly match the other vehicles of their sets. Upon acceptance, instrumentation was installed and testing initiated, as detailed in other sections of this report.

2.3 VEHICLE AGING

2.3.1 Driving Schedule

EPA specifies the SRC as a driving schedule to be used for aging vehicle emissions control systems. Details on the SRC can be found in the Code of Federal Regulations (CFR).* The SRC contains driving elements typical of both city and highway driving, including, for example, cruise conditions, mild acceleration and deceleration events, idle conditions, and hard acceleration events. The SRC is shown graphically in Fig. 2.1.

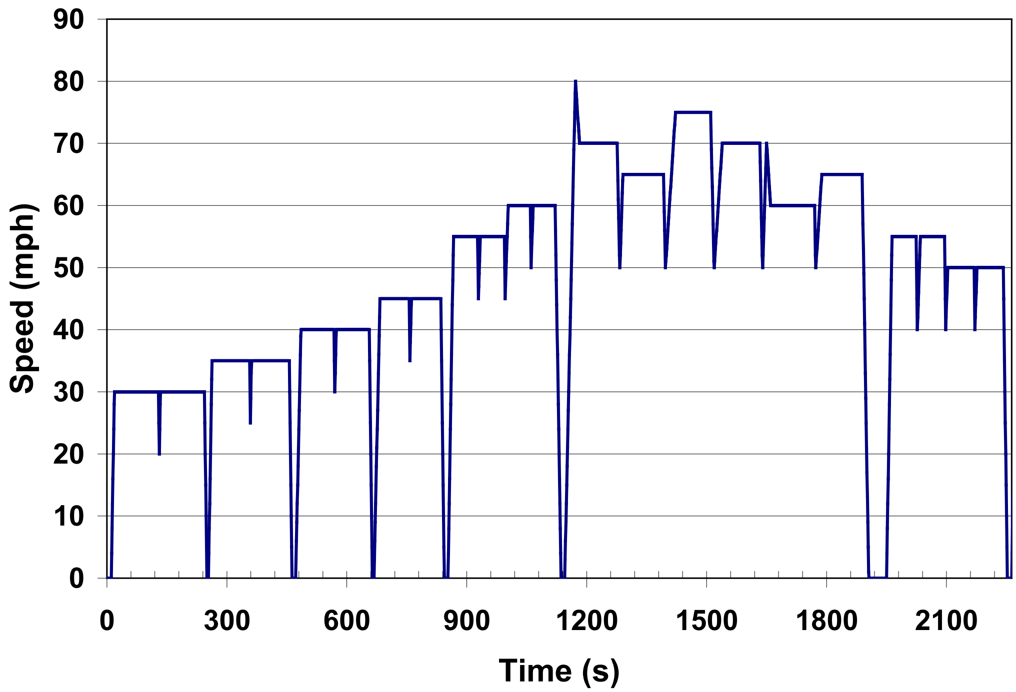

Fig. 2.1. The standard road cycle for vehicle emissions control system aging.

Both SwRI and ETC implemented the SRC using mileage accumulation dynamometers (MADs). Use of MADs offers the advantage of not requiring a driver during mileage accumulation; however, the number of vehicles that can be aged simultaneously is limited by the number of dynamometers available. Figure 2.2 shows several vehicles under test on the MADs at ETC. TRC implemented the SRC on a 7.5-mile closed track. This method of aging offers the ability to age a larger number of vehicles simultaneously; however, it requires a driver for each vehicle and scheduling delays can occur in the event of adverse weather conditions such as heavy snowfall. Figure 2.3 shows a view of the TRC high-speed track.

In this testing program vehicles were aged in around-the-clock operation to bring the program to a successful conclusion as rapidly as possible. Vehicles on MADs stopped several times per day for refueling but otherwise only stopped for maintenance or emissions tests, thus accumulating on the order of 1,000 miles per vehicle per test day. Vehicles tested on the track at TRC were stopped for driver breaks in addition to refueling, maintenance, and emissions tests and the occasional track safety shutdown due to

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*U.S. Environmental Protection Agency, "Emission Durability Procedures and Component Durability Procedures for New Light-Duty Vehicles, Light-Duty Trucks and Heavy-Duty Vehicles," Final Rule and Proposed Rule. 40 CFR Part 86, in *Federal Register*, Vol. 71(10), Tuesday, January 17, 2006.

inclement weather, accumulating on average 600–800 miles per vehicle per test day. Thus the vehicles did not experience many extended soak periods (extended periods with engine off) during the mileage accumulation portions of the program regardless of whether they were aged using MADs or the TRC track. Around-the-clock operation accelerates mileage accumulation and allows for more rapid assessment of catalyst durability. Limiting the soak periods would not be expected to affect tailpipe emissions changes associated with mileage accumulation.

Fig. 2.2. Mileage accumulation dynamometers at the Environmental Testing Corporation.

Fig. 2.3. Test track at the Transportation Research Center.

2.3.2 Aging Fuels

Aging was conducted by assigning one vehicle of each set to a fuel with a given ethanol concentration (including E0). Because the vehicles would be accruing considerable mileage and because of the relatively large number of vehicles involved in the program, it was necessary to use splash blended fuels for the aging program to reduce the fuel cost to a manageable level. For this purpose, top-tier retail gasoline[*] that did not contain ethanol was purchased locally and splash blended to produce the necessary ethanol-containing blends. SwRI acquired top-tier gasoline and splash blended it with retail ethanol (E95) on-site to produce the 10%, 15%, and 20% ethanol blends required. TRC and ETC procured the ethanol blends from the terminal, pre-blended to the desired levels. The aging fuels were termed RE0, RE10, RE15, and RE20 to convey that they were blended using retail gasoline (also frequently referred to as “road fuel”) and to denote the nominal ethanol content of each fuel. In all cases the ethanol content was tested before use of the fuel batch to ensure it fell within the desired range (ethanol content ±1%). Additional fuel analyses were also conducted; these analyses varied from site to site. SwRI and ETC analyzed each lot of fuel while TRC retained samples of each lot and subsequently analyzed some of the samples.

Time and budget constraints necessitated the use of splash blends as opposed to match blends in this program. When using match blends, certain fuel properties such as volatility and octane can be tailored to match the desired ethanol blend level. When splash blends are used, it is understood that properties such as volatility and octane will vary with ethanol content[†,‡], but it was felt that these variations would not impact the change in emissions due to aging on the SRC. Because the aging fuels were splash blended, the octane number, Reid vapor pressure (RVP), and other fuel properties varied depending upon the ethanol content and whether the gasoline was a summer or winter blend.

The test laboratories implemented procedures to prevent misfueling during the aging program. At TRC, for example, the fuel filler doors were retrofitted with a keyed lock; the key needed to open the lock was located at the appropriate fuel pump.

2.3.3 Vehicle Maintenance

Because all of the vehicles were each driven at least 50,000 miles, maintenance was a required part of the aging program. As previously mentioned, all pre-titled vehicles were checked initially to ensure that any routine or scheduled maintenance was performed before the beginning of the program. During the aging program, the owner’s manual for each vehicle model was consulted to determine the maintenance schedule. Scheduled maintenance (including lubricating oil changes; brake service; spark plug, tire, and belt replacements) was performed by the test laboratories on-site to minimize downtime in the program. Oil changes were scheduled such that they never occurred less than 500 miles before an emissions test sequence. Oil samples were collected at each oil change and retained for potential future analysis. A selection of these samples was analyzed at the end of the program as a part of the engine component inspection activity at SwRI.[§]

Occasionally there was a need for unscheduled maintenance on the vehicles. Unscheduled maintenance was frequently performed on-site, but occasionally local dealership service departments were used.

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[*]Top-tier gasoline contains more deposit-control additives than the minimum allowable by EPA (http://www.toptiergas.com/).

[†]J. E. Anderson et al., “Octane Numbers of Ethanol- and Methanol-Gasoline Blends Estimated from Molar Concentrations,” *Energy Fuels*, 2010, 24, pp. 6576–6585.

[‡]American Petroleum Institute, *Determination of the Potential Property Ranges of Mid-Level Ethanol Blends*, Final Report, April 2010.

[§]Brent A. Shoffner et al., *Powertrain Component Inspection from Mid-Level Blends Vehicle Aging Study*, ORNL/TM-2011/65, Prepared by Southwest Research Institute for Oak Ridge National Laboratory, November 2010, available at http://info.ornl.gov/sites/publications/files/Pub28733.pdf.

Unscheduled maintenance included events such as transmission replacement or repair, wheel bearing replacement, and body damage repair from animal strikes on the test track. The test laboratories were instructed to stop mileage accumulation and investigate any occurrence of a malfunction indicator lamp (MIL). Upon gathering information about the possible causes of the MILs, the test laboratories contacted the program leadership to discuss the most appropriate actions to address the MILs. In cases where component parts were replaced that could conceivably be related to the fuel being used, the original parts were labeled and retained for possible analysis later in the program. Vehicle maintenance issues are summarized in Sect. 4.

2.4 EMISSIONS TEST INTERVALS

The primary purpose of this program was to investigate the potential impacts of the use of mid-level ethanol blends on the emissions control systems of vehicles; hence, emissions tests were an essential part of the program. Vehicles dedicated to RE0 aging fuel were only emissions tested using ethanol-free emissions fuel. Vehicles dedicated to an ethanol-containing retail fuel blend (RE10, RE15, or RE20) were subjected to emissions tests using both an emissions test fuel with matching ethanol level and ethanol-free fuel. The Federal Test Procedure (FTP) driving schedule was used for all emissions tests in the program. WOT tests were incorporated at each test interval both to examine the vehicles' use of LFT at WOT conditions and to desulfurize the catalysts before emissions tests. All emissions and WOT tests were conducted using the certification fuel blends.

2.4.1 Vehicle Instrumentation and Configuration

Because FTP test results can be influenced by differences in tire condition and tire pressure, a duplicate set of wheels and tires for the driven wheels was acquired for each vehicle so that the vehicle would use the same set of wheels and tires for each FTP test throughout the program. This approach reduced concerns about the impacts of replacement tires that would be needed for the vehicles as they completed the lengthy aging program. The tires used for emissions tests were retained at the emissions laboratory and were reinstalled when vehicles arrived for emissions tests and subsequently removed and replaced as the vehicles returned to mileage accumulation.

Additionally, instrumentation was installed in each vehicle to support the LFT evaluations during WOT tests. Thermocouples were installed in the vehicle exhausts to monitor catalyst inlet and outlet gas temperatures. In some cases thermocouples were also installed in the catalyst monolith for more direct assessment of the catalyst temperature. A universal exhaust gas oxygen sensor (UEGO) was also installed upstream of the first catalyst to characterize the engine air : fuel ratio (AFR) during WOT tests. The UEGOs were removed from the vehicles before mileage accumulation to avoid damage and reinstalled during each emissions test sequence. The thermocouples and UEGOs were used primarily in the WOT tests to assess the use of LFT at WOT and its impact on catalyst temperature.

2.4.2 Chassis Dynamometer Laboratories

All three test sites used modern 48 in. single roll motoring dynamometers for emissions testing. TRC used their four-wheel-drive-capable AVL dynamometer; tests at SwRI used a Horiba two-wheel-drive unit, and ETC used their Burke Porter two-wheel-drive dynamometers. All laboratories used full flow dilution tunnels with bag benches for determining emissions of carbon monoxide (CO), carbon dioxide, total hydrocarbons, and oxides of nitrogen (NO_X). Methane (CH_4) was measured by gas chromatographic flame ionization analyzer at all sites. Ethanol measurements at SwRI were conducted using the impinger method throughout the program. TRC initially used an Innova 1312 photoacoustic spectrometer to measure ethanol but switched to an impinger method, as will be discussed later in the report. ETC used an Innova 1312 photoacoustic spectrometer for ethanol measurements throughout the program. All three laboratories used di-nitrophenylhydrazine cartridges to trap carbonyls for later analysis by high-performance liquid chromatography.

2.4.3 Emissions Test Intervals

Emissions tests were conducted at several points during the program to assess both the emissions compliance of the vehicles and to track changes in emissions due to aging with different fuels. Emissions tests were conducted at the start-of-test (SOT), midlife aging (MID1 and MID2), and end-of-test (EOT). Vehicles purchased new were aged 4,000 miles using RE0 fuel before the initial emissions tests to de-green (or break in) the catalysts and powertrain. Thus for the new vehicles, the SOT tests occurred at 4,000 odometer miles. Vehicles purchased from the in-use fleet (pre-titled or used vehicles) had accumulated mileage before their acquisition for this program. These mileages varied but were generally consistent with the age of the vehicle and typically ranged less than 10,000 odometer miles from highest to lowest in each vehicle set. Thus, the pre-titled cars underwent SOT tests at various mileages, but the mileage accumulation for each vehicle of a set was always the same.

Midpoint emissions tests were scheduled according to the mileage accumulated on the vehicles before the start of the program. For vehicles purchased new, the midlife emissions tests were conducted at 60,000 odometer miles (or 56,000 test miles given the 4,000-mile break-in period before the SOT emissions tests). New vehicles that were tested at ETC received a second midpoint test at 90,000 odometer miles (MID2). Midpoint tests were scheduled for pre-titled cars in accordance with the previously accrued mileage on the vehicles. Determination of the midlife schedule in terms of odometer miles was made according to a sliding scale, shown in Fig. 2.4.

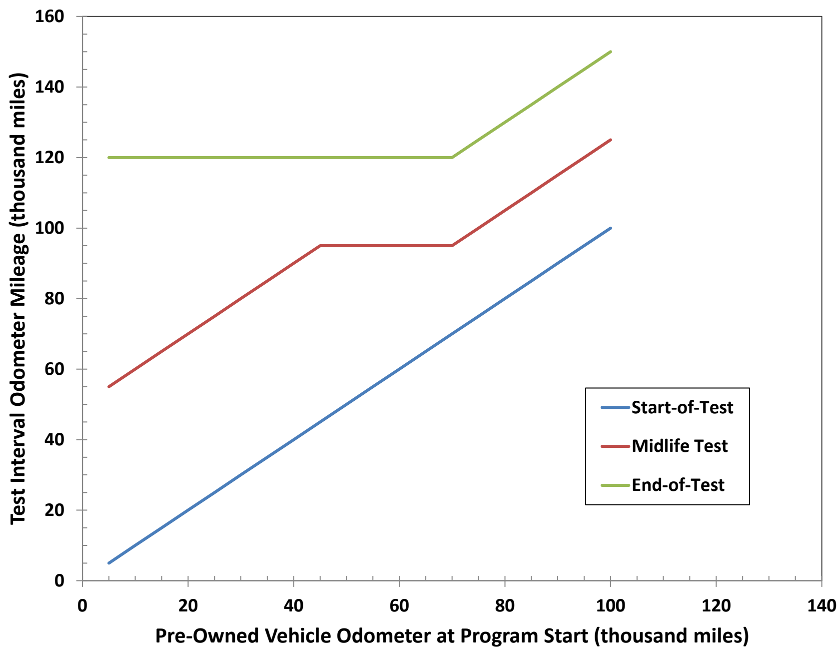

Fig. 2.4. Sliding scale for emissions test scheduling.

Vehicles with less than 45,000 miles at the start of the program were driven 50,000 miles before the midpoint emissions test. Vehicles with mileages between 45,000 and 70,000 miles were driven to 90,000 miles before the midpoint emissions test. Finally, vehicles with more than 75,000 miles were driven 25,000 miles before the midpoint emissions test.

The EOT emissions tests were also scheduled according to the sliding scale shown in Fig. 2.4. If the highest mileage vehicle of a set had previously accrued mileage less than 70,000 miles, then the EOT test was performed at 120,000 odometer miles. If the vehicle had in excess of 70,000 miles at SOT, the EOT test was scheduled to occur after an additional 50,000 miles of aging (or 25,000 miles beyond the midpoint test).

In all cases, the mileage used in determining the midpoint and EOT scheduling was the highest odometer mileage vehicle of each vehicle set. Thus, the highest mileage vehicle of a set determined the total aging mileages and all vehicles of a given set were aged an equal number of miles. This strategy also resulted in a minimum of 25,000 miles of aging between any two emissions test intervals.

2.4.4 Emissions Test Fuels

The emissions test fuels were splash blends using emissions certification gasoline and denatured ethanol. TRC sourced the emissions fuel components (UTG-96 Federal Certification Gasoline and denatured ethanol) from Chevron-Phillips Specialty Chemical Company. SwRI obtained Haltermann EEE certification gasoline, and ETC used both Chevron-Phillips and Haltermann fuels. The ethanol blends were splash blended on-site at each test laboratory and subsequently analyzed to provide the fuel properties needed to support data analysis. Additional fuel analyses beyond those required for emissions tests were also performed on selected samples. These emissions test fuels were termed E0, E10, E15, and E20 to denote that they were different from the retail fuels used for vehicle aging (RE0, for example). As with the aging fuels, the octane number, RVP, and other properties of the emissions fuels varied with the ethanol content as a consequence of the splash blended nature of the fuels. Because all emissions tests were conducted at a nominal 25°C and because tracking emissions changes over time was the primary program objective, the use of splash blends in lieu of match blends was not expected to impact the results. In addition, acquisition of match blends would have presented unreasonable cost and time delay burdens to the program. Table 2.3 shows selected fuel properties for typical batches of emissions test fuels at each laboratory.

2.4.5 Fuel Change and Adaptation Procedures

Fuel change and adaptation procedures were required both to transition vehicles from the retail fuels used for aging to the certification fuel blends used for emissions testing, as well as to transition between ethanol-blended and ethanol-free certification fuels during emissions tests. The procedure for fuel change and vehicle adaptation was as follows.

1. Drain vehicle fuel tank.
2. Fill the fuel tank to about 40% of capacity with the desired fuel.
3. Start the engine and allow it to idle for 2 min; then stop the engine.
4. Drain vehicle fuel tank.
5. Key-on for 30 s to allow the engine control unit to observe the empty fuel tank; then return to key-off.
6. Fill the fuel tank to about 40% of capacity with the desired fuel.
7. Perform three LA4[*] driving cycles, and allow the vehicle to idle in park for 2 min before engine shutdown.
8. Move vehicle to soak area without starting or driving.
9. Soak 12 to 36 h for cold start FTP test.

ETC additionally conducted a single drain-and-fill to 40% fuel tank capacity and an evaporative canister butane loading procedure before each individual FTP test per the CFR protocol.

[*]LA4, also known as the Urban Dynamometer Driving Schedule (UDDS), refers to the first two phases (or "bags") of the Federal Test Procedure.

Table 2.3. Emissions test fuel properties

Fuel Characteristic	Test Site	SouthWest Research Institute[a]				Transportation Research Center[a]			Environmental Testing Corp[a]		
	Fuel	E0	E10	E15	E20	E0[b]	E15	E20	E0	E15	E20
	Batch / ASTM Method	GA-6889	GB-6968	GB-7467	GB-7198	ORNLE0	ORNLE15	ORNLE20	949727	949728	949729
Carbon (wt%)	D5291	86.31	82.99	81	79.58	87.2	81.32	79.2	87.61	81.33	78.64
Hydrogen (wt%)	D5291	12.98	13.22	13.19	13.36	12.8	13.36	13.33	13.58	13.27	13.16
Oxygen (wt%)	D5599/D5622[c]	0	3.77	5.64	7.38	0	6	7.65	0	5.46	7.44
Specific Gravity	D4052	0.7437	0.7484	0.7516	0.7525	0.7439	0.7532	0.7563	0.7385	0.7492	0.7525
Net Heating Value (BTU/lbm)	D240	18611	17853	17345	17093	18581	17298	16809	18614	17449	17030
Ethanol Content (vol %)	D5599/D4815[d]	0	10.04	15.21	20.16	0	14.53	20.49	0	14.8	20.3
Distillation	D86										
IBP (°F)		88	89	89	90	86	89	90	89	97	96
5% (°F)		113	115	117	119	110	111	110	115	118	121
10% (°F)		127	124	126	128	120	121	122	127	126	128
20% (°F)		149	137	139	141	138	134	136	144	136	139
30% (°F)		175	149	150	152	162	147	149	165	148	150
40% (°F)		203	157	159	160	194	158	160	190	157	158
50% (°F)		222	202	164	164	220	166	165	213	164	164
60% (°F)		233	228	214	169	233	218	169	226	212	167
70% (°F)		244	239	235	236	246	241	237	237	236	227
80% (°F)		265	258	255	256	267	261	258	255	255	250
90% (°F)		319	312	307	308	313	306	301	299	296	294
95% (°F)		337	334	333	331	345	339	341	345	345	347
FBP (°F)		396	376	383	372	388	390	388	390	402	399
DVPE (psi)	D5191	8.74	9.61	9.36	8.74	N/A	10.09	9.87	7.91	8.55	8.33

[a] All test sites used multiple batches of each fuel; this table includes examples of emissions test fuel properties for each ethanol blend level.
[b] TRC E0 properties were provided by Chevron-Phillips specialty chemical company as a certificate of analysis for UTG96 batch 09EPU9601.
[c] SwRI and ETC fuels analyzed by D5599; TRC fuels analyzed by D5622.
[d] SwRI and ETC fuels analyzed by D5599; TRC fuels analyzed by D4815.

2.4.6 Emissions Test Procedure

Emissions tests at SwRI and TRC were generally conducted in duplicate for each vehicle and fuel combination, although additional tests were conducted occasionally when test-to-test variability was unusually high or if there was a known problem with any of the measurements. ETC conducted a minimum of three tests for each vehicle and fuel combination throughout the program. Vehicles were typically tested first at the ethanol level corresponding to their respective aging fuels, then using E0 (for the vehicles being aged using ethanol-blended fuels), although there were a few exceptions. Vehicles aged with RE0 were only emissions tested using E0. The typical procedure for tests at each test interval was as follows.

1. Reinstall emissions test tires and wide-range oxygen sensors.
2. Conduct fuel drain and adaptation procedure to emissions fuel at the same ethanol level as the vehicle aging fuel.
3. Conduct WOT test procedure.
4. Conduct duplicate (or triplicate) cold-start FTP tests.
5. Conduct fuel drain and adaptation procedure to E0 emissions fuel (for vehicles aged using ethanol-blended fuels).
6. Conduct WOT test procedure.
7. Conduct duplicate (or triplicate) cold-start FTP tests.
8. Uninstall emissions test tires and wide-range oxygen sensors.
9. Conduct compression and leak-down tests.

The data from the FTP tests were examined after each test sequence to determine whether any tests were obviously flawed before the vehicles were released to return to mileage accumulation; however, the nonmethane organic gas (NMOG) speciation was not typically available until after the vehicles returned to mileage accumulation. In the event that any test was determined to be flawed, a repeat test was conducted before the car resumed mileage accumulation.

2.4.7 Wide-Open Throttle Tests

As mentioned previously, WOT tests were included in the program both to assess whether the vehicles applied LFT at WOT and to desulfurize the catalysts before emissions testing. The procedure for the WOT tests was similar to the CRC E-60 Program but with slight modifications as in the DOE V1 program.[*] The WOT tests were performed on the emissions dynamometer as follows.

1. Drive from idle to 55 mph and hold at 55 mph for 5 min.
2. Reduce speed to 30 mph and hold at 30 mph for 1 min.
3. Reduce speed to idle and hold for 1 min.
4. Accelerate at WOT for a minimum of 10 s to achieve speed in excess of 70 mph. Continue WOT above 70 mph if necessary to achieve minimum 10 s WOT. Hold peak speed for 15 s then decelerate to 30 mph.
5. Repeat steps 2–4 to achieve five WOT excursions.
6. Repeat steps 1–5 for a total of 10 WOT accelerations.

Thermocouple and UEGO readings were recorded to monitor the catalyst temperature and engine AFR at a sample rate of at least 10 Hz during the WOT tests. These data were used to determine whether or not a vehicle applied LFT at WOT and to examine the catalyst temperatures for both types.

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[*] Keith Knoll et al., *Effects of Intermediate Ethanol Blends on Legacy Vehicles and Small Non-Road Engines*, Report 1—Updated, NREL/TP-540-43543/ORNL/TM-2008/117, February 2009, available at http://www.nrel.gov/docs/fy09osti/43543.pdf.

The WOT test was conducted at each emissions test interval using E0 and the emissions fuel with the same ethanol level as the retail fuel (road fuel) used in the vehicle during mileage accumulation. Additionally, at the beginning of the program, all vehicles at SwRI and TRC were WOT-tested using both E0 and E20 to examine whether all cars of a given model responded in the same way to the difference in ethanol content.

2.4.8 Compression and Leak-Down Tests

After the completion of emissions and WOT tests at each test interval, compression and leak-down tests were conducted. These tests were added to the test program in an effort to monitor the vehicles for abnormal degradation of the engines as a consequence of using fuels containing more than 10% ethanol. SwRI conducted one compression and leak-down test on each vehicle at each mileage interval. A need to establish the variability of the compression and leak-down tests was later identified, and TRC and ETC were asked to conduct three compression and leak-down tests on each vehicle at each test interval as a means of providing additional data. SwRI was also asked to perform additional compression and leak-down tests on several vehicles at the end of the program. The procedures in use at each site varied slightly in accordance with the instructions provided by the manufacturers of the leak-down tools that each site used. In general, however, a procedure for these tests was as follows.

1. Start and warm the vehicle until the cooling fan cycles on two times.
2. Conduct compression and leak-down tests. Use a battery charger during all compression tests to reduce the impact of battery condition on the test result.
3. Repeat steps 1 and 2 until three compression and leak-down tests have been performed.

While there were a few unusually high leak-down rates or low compression test results, there was no correlation between the two measurements, and none of the atypical results correlated to any out-of-compliance emissions results or fuel-ethanol concentrations. The application of compression and leak-down measurements to vehicle aging are summarized in a separate technical paper.[*]

2.5 STATISTICAL ANALYSIS

Statistical analyses were conducted for the immediate and long-term effects of the fuel ethanol content on vehicle emissions for each vehicle model. Some immediate impacts of blending ethanol into gasoline are known. For example, it is well-accepted that the fuel economy (but not necessarily the engine's fuel efficiency) measured during an emissions test will decrease consistent with the change in the energy density of the fuel. This effect is immediate and does not require extended aging to become observable. However, the long-term aging effects posed by mid-level ethanol blends are not known and are the subject of this testing program. These effects, if present, require aging the vehicle before they become observable. One hypothetical example of a long-term effect might be more rapid decrease in the catalyst performance when aged using E15 relative to a vehicle that is aged using E0. The statistical model constructed for this program was designed to separate immediate and long-term effects. Details of the statistical model are presented in Appendix B.

Following the individual vehicle model analyses, a second set of statistical analyses was conducted to evaluate the overall effect of ethanol across the fleet of vehicle types tested. Specifically, the average (or median) test fuel and aging fuel effects were investigated to determine whether they were statistically

[*]C. S. Sluder and B. H. West, "Limitations and Recommended Practice in the Use of Compression and Leak-Down Tests to Monitor Gradual Engine Degradation," *SAE International Journal of Engines*, December 2011, 4(3), pp. 2767–2777.

significantly different[*] from zero. A t-test (for Gaussian distributed data) and a sign test (a nonparametric statistical test which does not require the assumption of a particular data distribution) were used in this determination. Additionally, a Wilcoxon two-sample test was applied to determine whether there was a difference between the LFT and non-LFT vehicles.

[*]Statistical significance corresponds to 95% confidence. Specifically, under the assumptions of the analysis, there was no more than a 1 in 20 chance that the observed outcomes (or an outcome more extreme) could have occurred by chance alone.

3. RESULTS

3.1 APPLICATION OF LONG-TERM FUEL TRIM AT WIDE-OPEN THROTTLE

Manufacturers use LFT to continuously adjust the vehicle fueling system to adapt to minor changes in fuel delivery. Such changes may occur as a result of variations in fuel formulations, variations in manufacturing tolerances in the fuel system components, and fuel system aging or clogging. LFT ensures that the vehicle continues to operate at stoichiometric conditions during most types of driving. Stoichiometric operation is important because it results in the lowest overall emissions profile and allows the catalyst to operate most efficiently for removing pollutants from the exhaust gases. Vehicle manufacturers often use fuel-rich combustion during high-power events such as WOT to prevent the catalyst and engine components from overheating and becoming damaged as a result of high exhaust gas temperatures and flow rates. While rich operation results in increased hydrocarbon and CO emissions during WOT events, overall it reduces vehicle emissions because it protects the catalyst from premature damage and allows it to be more efficient over the lifetime of the vehicle. While some engine calibrations apply stored values of LFT during WOT conditions to adjust the enrichment, others do not. Because ethanol blending adds an oxygen-bearing species to the fuel, additional fuel must be added at any given condition to maintain consistent stoichiometry. Vehicles that do not apply LFT at WOT are thus less enriched under these open-loop conditions, which can result in higher catalyst temperatures and may degrade the catalyst more rapidly than if there were no ethanol in the fuel.[*,†,‡] The data collected during the WOT tests at the SOT interval were used to determine whether a vehicle model applied LFT at WOT. Characterizing the vehicles in this way allowed the emissions results from subgroups of LFT and non-LFT at WOT vehicles to be analyzed to address the concern noted above. Figure 3.1 shows a typical time-speed profile for the WOT test, with the 10 WOT events noted.

The LFT or non-LFT determination was accomplished by examining the AFR data for a given vehicle tested with both E0 and E20 to determine whether the lambda ratio[§] at WOT conditions was nominally the same with both fuels or whether lambda was considerably leaner with E20. (Lambda is typically 6%–8% leaner with E20 when LFT is not applied.) During the entire WOT test procedure, the vehicles experience stoichiometric cruise and idle conditions, decelerations that frequently cause fuel shutoff, and hard accelerations that result in fuel enrichment. Example data sets are shown in the histograms of Figs. 3.2 and 3.3. The periods of operation near stoichiometry result in the large amount of data around a lambda value of 1.0. As the vehicles are intended to operate at or near stoichiometry under most driving conditions, these data are the most prevalent. The data at lower lambda values are indicative of enriched operation during WOT acceleration events. A third grouping of data, not shown, is caused by fuel shutoff during deceleration events, which results in lambda values greater than 1.1. The fuel shutoff data are not shown as they are not important in making the LFT at WOT determination. Examination of the data at a lambda of about 0.85 in Fig. 3.2, for example, shows that the data collected using E0 and the data collected using E20 agree very closely in terms of the average lambda during enrichment. The agreement between these two conditions indicates that the 2009 Ford Explorer does apply LFT at WOT.

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[*] R. Bechtold et al., *Technical Issues Associated with the Use of Intermediate Ethanol Blends (>E10) in the U.S. Legacy Fleet: Assessment of Prior Studies,* ORNL/TM-2007/37, Oak Ridge National Laboratory, August 2007, available at http://info.ornl.gov/sites/publications/files/Pub7767.pdf.

[†] Keith Knoll et al., *Effects of Intermediate Ethanol Blends on Legacy Vehicles and Small Non-Road Engines,* Report 1—Updated, NREL/TP-540-43543/ORNL/TM-2008/117, February 2009, available at http://www.nrel.gov/docs/fy09osti/43543.pdf.

[‡] Transportation Research Center Inc., *Mid-Level Ethanol Blends Catalyst Durability Study Screening,* CRC Report E-87-1, Coordinating Research Council, Inc., Alpharetta, Georgia, June 2009.

[§] Lambda is the normalized air : fuel ratio, or excess air factor. Lambda < 1 indicates rich combustion (excess fuel), lambda $= 1$ indicates stoichiometric combustion, and lambda > 1 indicates lean combustion (excess air).

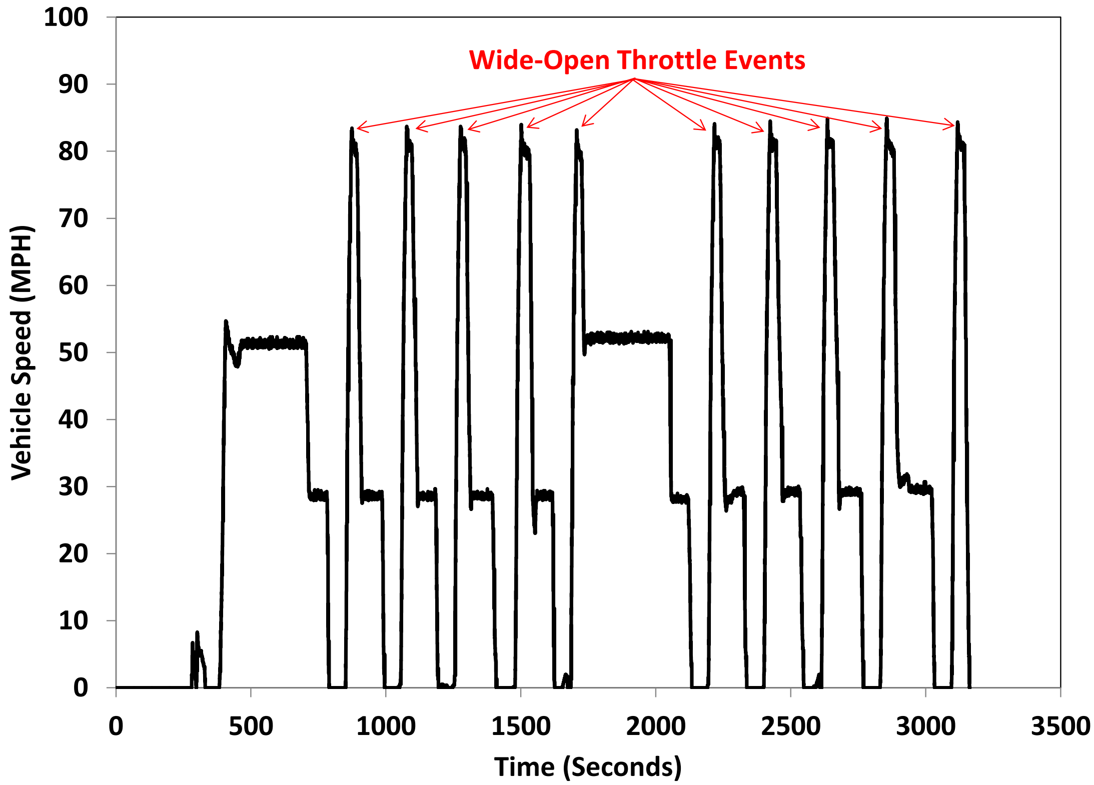

Fig. 3.1. Typical time-speed driving profile for the wide-open throttle tests.

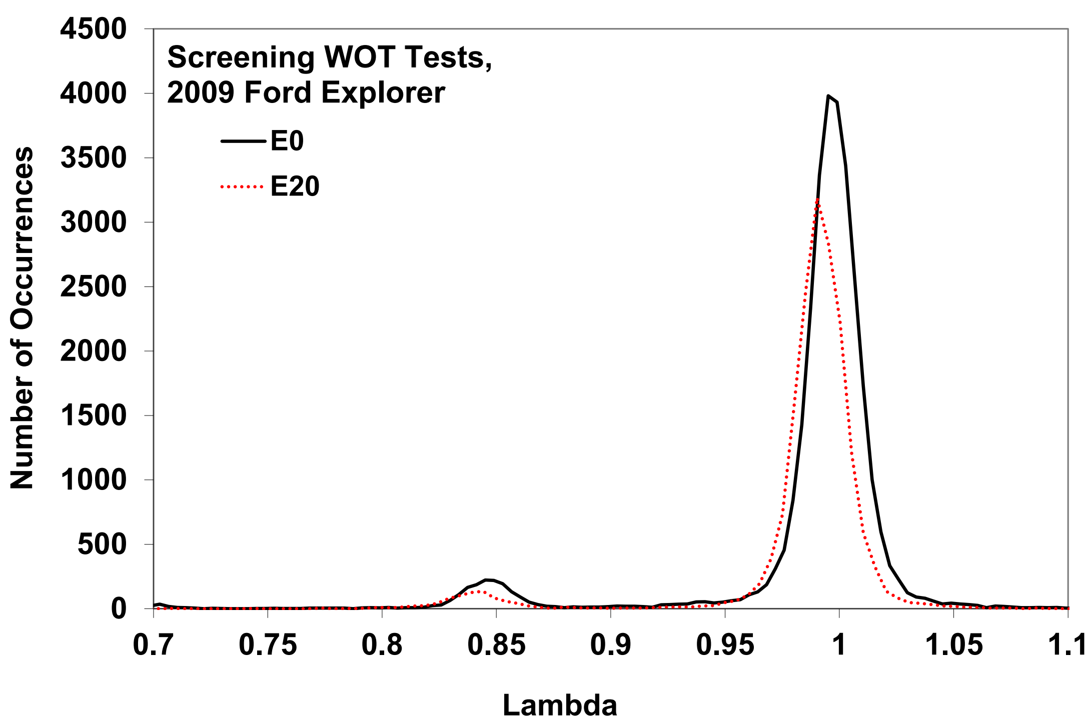

Fig. 3.2. Wide-open throttle (WOT) test lambda data for a 2009 Ford Explorer.

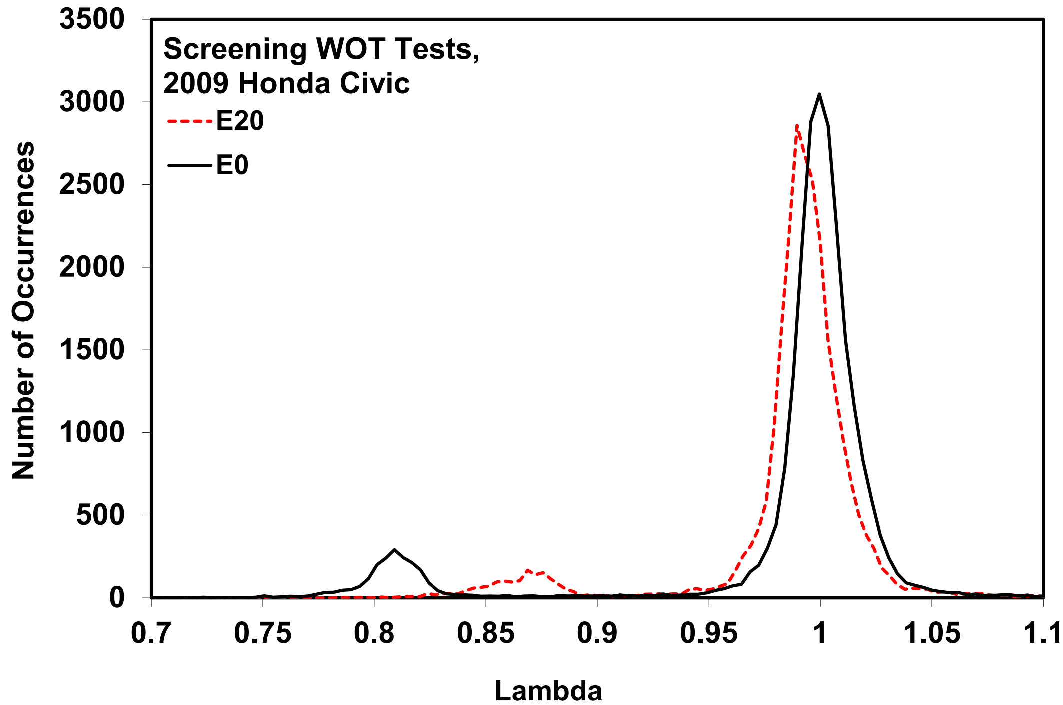

Fig. 3.3. Wide-open throttle (WOT) test lambda data for a 2009 Honda Civic.

The data shown in Fig. 3.3 indicate that stoichiometric operation is the most prevalent, and the data from enriched operation are present at a lower incidence. However in this case, the data indicate that the lambda during enrichment averaged about 0.82 when using E0 but averaged about 0.87 when using E20, which shows that conditions at WOT are less rich when E20 is used. The separation between the average enrichment values for these two conditions indicates that the 2009 Honda Civic does *not* apply LFT at WOT. It is worth clarifying that the use of E20 at WOT for non-LFT cars causes less enrichment and not fuel-lean operation, as this would be a very different condition with lambda results higher than the stoichiometric condition. Furthermore, while these two cases give a clear indication of the LFT at WOT status, there were some cars for which this status was more difficult to determine with confidence. Vehicles characterized as not applying LFT at WOT may do so by design or may have had inadequate time or operating range for complete adaption. Table 3.1 shows the LFT at WOT status as determined for the vehicles in this testing program.

Previous experience in CRC E-87-1 and DOE V1 showed that about half the tested vehicles did not apply LFT at WOT. Vehicles that do not apply LFT at WOT tend to exhibit higher exhaust and catalyst temperatures during WOT events. Previous work indicated that the catalyst temperature difference during WOT conditions for non-LFT cars using E20 was 29°C–35°C hotter than with E0.[*] Concern over premature catalyst degradation as a result of this increase in temperature was a prime motivator for this study. Based on WOT measurements during this program, seventy percent (19/27) of the vehicle models tested were found to not apply LFT at WOT. Early in the program, before all vehicles had been acquired or WOT tested, LFT status closer to 50% was generally assumed based on a “best guess at this time,” which was developed from the prior CRC and DOE studies of similar vehicles.[†]

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[*]Keith Knoll et al., *Effects of Intermediate Ethanol Blends on Legacy Vehicles and Small Non-Road Engines*, Report 1—Updated, NREL/TP-540-43543/ORNL/TM-2008/117, February 2009, available at http://www.nrel.gov/docs/fy09osti/43543.pdf.

[†] Catalyst Durability, V4/E-87-2 Project Status, Mid-Level Ethanol Blends Coordination Group Meeting, May 5, 2010, available at http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2009-0211-13993.

Table 3.1. Long-term fuel trim (LFT) at wide-open throttle (WOT) status for the program vehicles

Vehicle	LFT at WOT?	Vehicle	LFT at WOT?	Vehicle	LFT at WOT?
2007 Accord	No	2009 Civic	No	2009 Odyssey	No
2006 Silverado	Yes	2009 Corolla	No	2000 Silverado	Yes
2008 Altima	No	2005 Tundra	No	2002 Frontier	No
2008 Taurus	Yes	2006 Impala	No[a]	2002 Durango	No
2007 Caravan	No	2005 F150	Yes	2003 Camry	No
2006 Cobalt	No	2006 Quest	No	2003 Taurus	No
2007 Caliber	No	2009 Outlook	Yes	2003 Cavalier	No
2009 Liberty	No	2009 Camry	Yes	2000 Accord	No
2009 Explorer	Yes	2009 Focus	Yes	2000 Focus	No

[a]Vehicle classified as "No" based on some WOT results; however, some results did indicate application of LFT at WOT.

3.2 EMISSIONS AND FUEL ECONOMY

3.2.1 Fuel Economy Calculation

To date, EPA has only required emissions and fuel economy testing of gasoline-fuelled vehicles with a certification gasoline that does not contain ethanol. Hence, the testing requirements and calculations used in this testing program are those required for certification gasoline. The fuel economy equation that is specified in CFR for gasoline-fuelled vehicles is based on a carbon mass balance (CMB) approach to determine the amount of fuel used by measuring the carbon-bearing emissions that are produced; however, it also incorporates scaling factors based on the net heating value of the fuel and the "sensitivity" of fuel economy to changes in the heating value.[*,†] The impact of the scaling factors is a fixed offset in the resultant fuel economy that is dependent upon fuel properties other than those required for a typical CMB calculation. This algorithm was put in place in 1988 to correct for differences between certification fuels. The algorithm adjusts the calculated fuel economy to be equivalent, on a British thermal unit per mile basis, to tests conducted with certification fuel as it was formulated in 1975 to address corporate average fuel economy credit issues associated with fuel property variations. An R factor was defined as the sensitivity of the fuel economy result to changes in fuel energy content. The R factor was defined to be 0.6 based on tests using 1980s vehicles. Since that time, the Auto/Oil test program has established that the R factor for 1990s vehicles is higher (about 0.93).[‡] The CFR fuel economy equation, if rearranged, is a CMB calculation with a multiplier based on fuel properties and the R factor. The choice of R factor can reduce the observed impact of fuel properties on fuel economy quite significantly. For example, Fig. 3.4 shows the fuel economy multiplier with both an R factor of 0.6 per CFR and an R factor of 0.93 as determined by the Auto/Oil study. These factors were calculated using the actual net heating value and specific gravity of emissions test fuels at SwRI.

[*]*Federal Register* Vol. 51(206), Friday, October 24, 1986, pp. 37844–37852.

[†]40 CFR Pt. 600.

[‡]Albert Hochhauser et al., "Fuel Composition Effects on Automotive Fuel Economy—Auto/Oil Air Quality Improvement Research Program," SAE paper 930138, SAE International, Warrendale, Pennsylvania, March 1993.

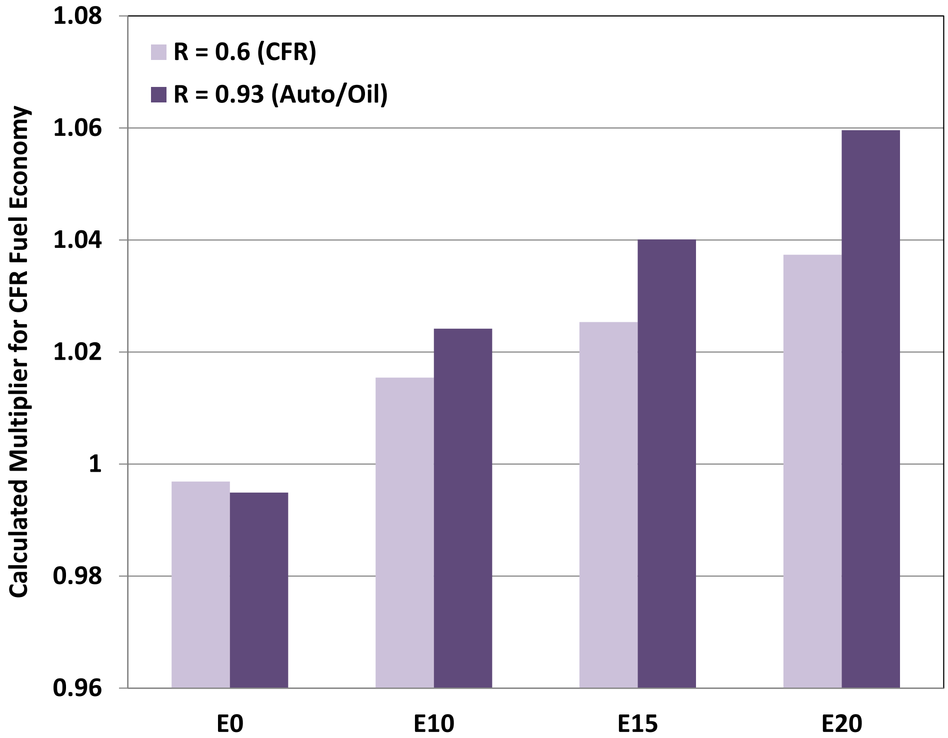


Fig. 3.4. Code of Federal Regulations (CFR) fuel economy equation scaling, using different R factors, for emissions test fuels used at Southwest Research Institute.

The differences caused by the CFR equation and choice of R factor are large compared with the range of variation of fuel energy content for the fuels in this study. Given these facts, the present study was conducted with fuel economy calculated based on a CMB approach without the scaling factors that are included in the CFR equation. This approach allows a straightforward evaluation of the impact of ethanol content on fuel economy.

3.2.2 Vehicle Dynamometer Coefficients

Dynamometer coefficients and equivalent test weights (ETWs) for modern motoring chassis dynamometers are available for all U.S.-legal vehicles from a database maintained by EPA.* Four parameters are needed by the dynamometer controller to match the vehicle load-speed profile, including three coefficients (A, B, and C) and the ETW. For most of the vehicles tested in this program, the EPA database was consulted for vehicles with matching engine families to determine target coefficients, and the test laboratories conducted dynamometer coast downs to determine the appropriate set coefficients for their respective dynamometers. In some cases the vehicle manufacturers were consulted to assist in selecting the appropriate coefficients and ETW. Dynamometer coast downs were conducted on each vehicle of a set; then the A, B, and C set coefficients were averaged so that each vehicle of a set used the same dynamometer coefficients for all testing.

*U.S. Environmental Protection Agency, "Cars and Light Trucks; Annual Certification Test Results and Data," http://www.epa.gov/otaq/crttst.htm.

A number of the pre-Tier-2 vehicles that were included in this program were originally certified for emissions compliance using an older style chassis dynamometer in which only the ETW and a target horsepower at 50 mph were needed to set the dynamometer to model the vehicle load-speed profile. Because the parameters needed for an older vehicle to operate on a newer style dynamometer do not generally exist, they were determined using methods established in the literature.[*,†] The coefficients and ETW settings used for each vehicle are provided in Appendix C.

3.2.3 Nonmethane Organic Gas Estimations

During the program the method in use for calculating NMOG at two of the test sites came into question. Specifically, TRC found the use of the Innova photoacoustic multigas analyzer for determining ethanol concentration in the vehicle exhaust to be inadequate. This approach had previously been approved by the California Air Resources Board for fuels containing at least 10% ethanol.[‡] TRC switched to the older impinger and gas chromatography approach for the remainder of the program. ETC continued to use the Innova instrument, but the data produced were later deemed to be unreliable, presumably due to the exceedingly long length of the sample line. EPA subsequently expressed a lack of confidence in the ethanol measurements made by the photoacoustic instrument in this program and requested an estimation technique be developed based on correlation of the data obtained using the gas chromatography method. SwRI had used the chromatography method throughout the program, and considerable data using this method were also available from TRC. An NMOG estimation procedure was developed using the complete data sets and used to estimate NMOG results for all tests at all sites.

Development of the estimation technique was as follows. The data collected using chromatography for ethanol quantification in the exhaust gases were used to develop a correlation between NMHC and NMOG as a function of the ethanol content of the test fuel being used. The data were first binned according to the nominal fuel ethanol content (0, 10%, 15%, and 20%). A regression between NMOG and NMHC data was determined for each fuel ethanol level and each of the two test sites (TRC and SwRI) that were the sources of the data. Lines of best fit were determined, with the slopes of the lines providing an NMOG/NMHC ratio for each fuel ethanol level at each test site. The NMOG/NMHC ratios from both SwRI and TRC were plotted versus the nominal fuel ethanol content and a best-fit line determined. This line provided a means of assessing the appropriate NMOG/NMHC ratio as a function of the fuel ethanol content. Figure 3.5 shows the ratios from each site and the lines of best fit.

The two dashed lines in Fig. 3.5 show the site-specific correlations, while the solid line in the center shows the correlation based on data from both sites. The site-specific correlations provided the best representation of the data from each site. The need to estimate NMOG for results from ETC and early TRC results (where no reliable ethanol data were available) and the need to evaluate the NMOG results statistically on a common basis without confounding effects from the test location necessitated that one common correlation be used for all three sites. With this need in mind, and no defensible reason to

[*]Charles Brownell et al., "Simulation of 8.65 inch Uncoupled Twin-Roll Hydrokinetic Dynamometer Operation on a 48 inch Single-Roll Electric Dynamometer," SAE paper 940486, SAE International, Warrendale, Pennsylvania, March 1994.

[†]SAE International, *Chassis Dynamometer Simulation of Road Load Using Coastdown Techniques,* Surface Vehicle Recommended Practice, SAE Standard J2264, Warrendale, Pennsylvania, April 1995.

[‡]California Air Resources Board, *Use of Innova Photoacoustic Multi-Gas Monitor to Measure Ethanol Exhaust and Evaporative Vehicle Emissions,* Mail-Out MSO 2000-08, June 29, 2000.

eliminate either the TRC or SwRI data, the correlation using data from both sites was used to estimate NMOG emissions for all of the tests conducted in this program. This correlation was updated several times as additional data that could be included were generated. The error introduced by this technique was most typically on the order of 2–4 mg/mile compared with actual test data. An example of the error introduced for data from TRC is shown in Fig. 3.6. The slight positive bias in the error is a result of the influence of the relatively higher NMOG/NMHC ratios determined at SwRI on the overall correlation. Given that the NMOG certification levels for the vehicles in the program were Tier 2 Bin 4 (70 mg/mile) or higher, this level of error was not anticipated to cause undue difficulty in assessing the degradation of the emissions control systems under test. Additional detail about the NMOG estimation approach can be found in a separate publication.*

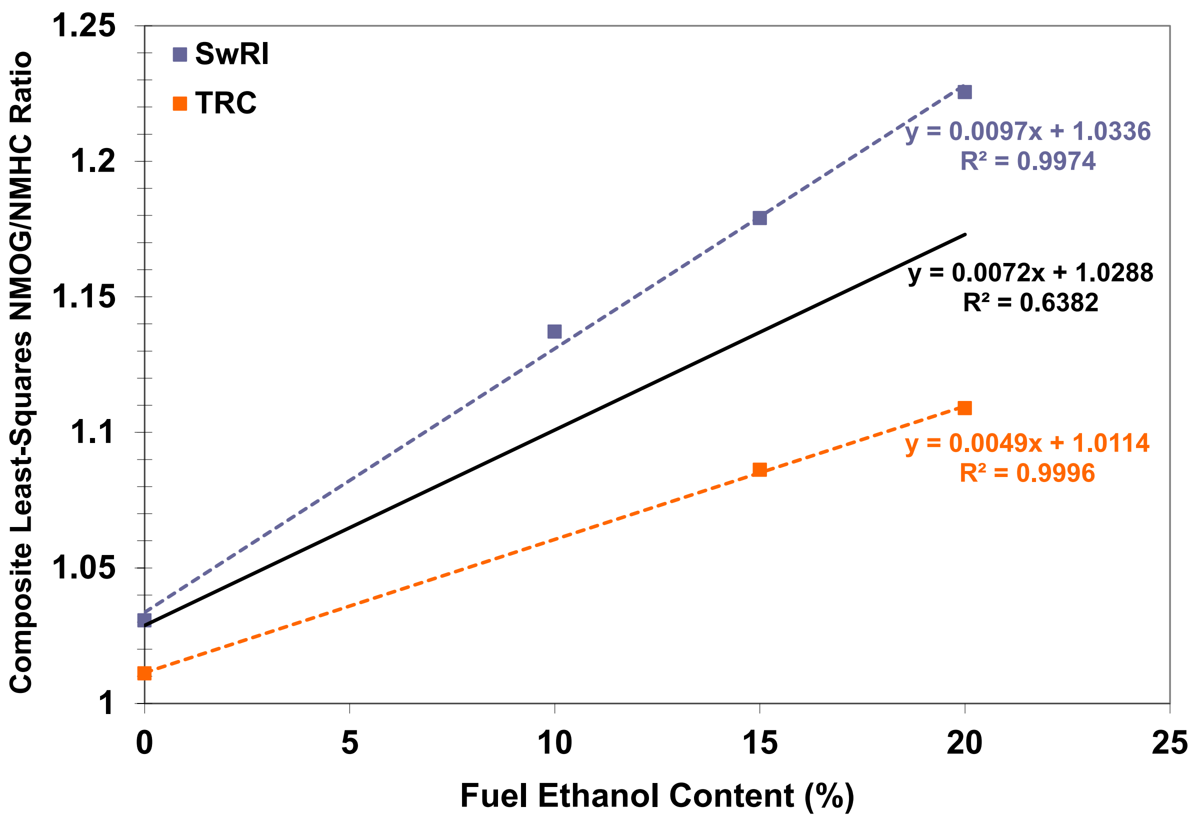


Fig. 3.5. Regression of nonmethane organic gas/nonmethane hydrocarbon (NMOG/NMHC) ratios to fuel ethanol content.

*C. Scott Sluder and Brian H. West, *NMOG Emissions Characterizations and Estimation for Vehicles Using Ethanol-Blended Fuels*, ORNL/TM-2011/461, Oak Ridge National Laboratory, October 15, 2011, available at http://info.ornl.gov/sites/publications/Files/Pub33272.pdf.

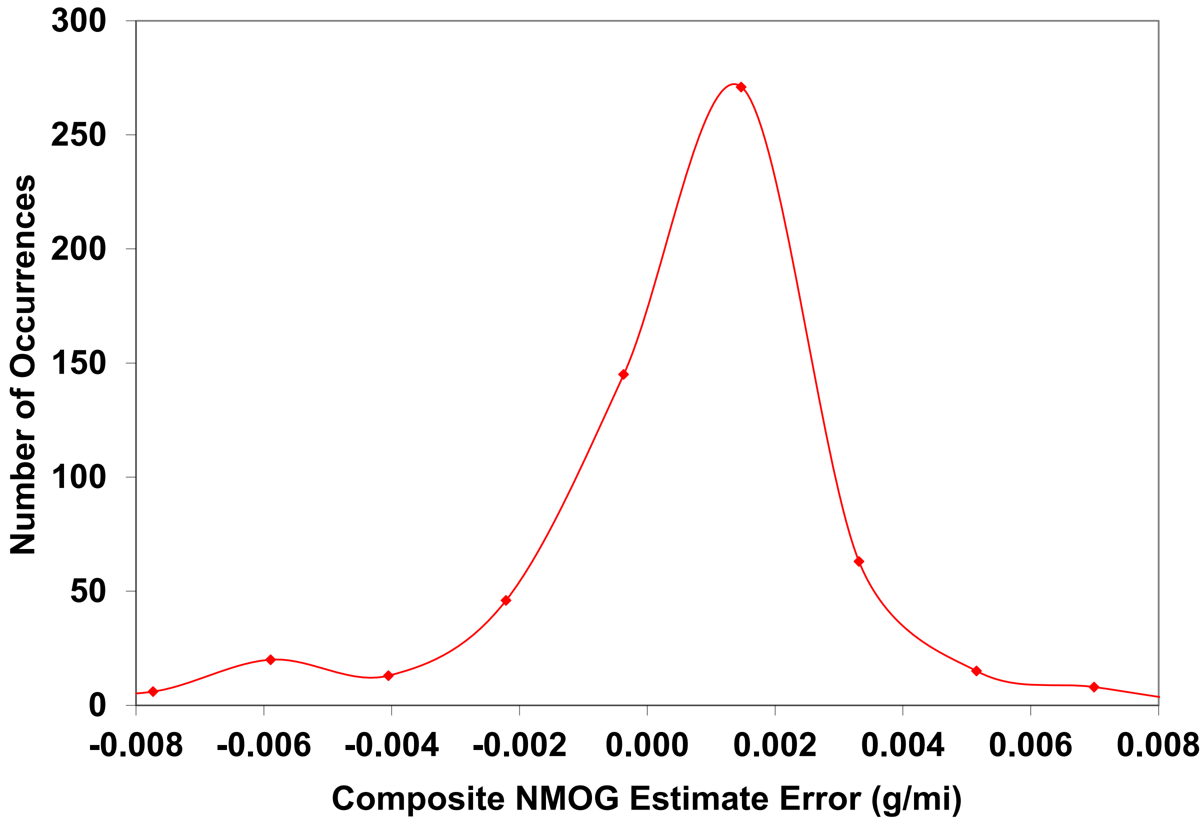


Fig. 3.6. Nonmethane organic gas (NMOG) estimate error for test results from the Transportation Research Center.

3.2.4 End-of-Test Emissions Results

Data in Tables 3.2–3.5 show the minimum, average, and maximum emissions test results for CO, NO_X, and NMOG for all vehicles at EOT. Data values are presented with one additional decimal place beyond the applicable standards. Tier 2 standards for CO are generally to one decimal place (e.g., 4.2 g/mile), NO_X standards are generally to two decimal places (e.g., 0.07 g/mile), and NMOG standards are generally to three decimal places (e.g., 0.090 g/mile).

Table 3.2 summarizes the EOT emissions test results with the E0 emissions certification gasoline for the Tier 2 vehicles. The minimum, maximum, and average of all tests for each vehicle are shown. Similarly, Table 3.3 summarizes the emissions test results with E0 fuel for the pre-Tier-2 vehicles.

Tables 3.4 and 3.5 summarize the EOT emissions test results with the relevant ethanol blend (E10, E15, or E20) for the Tier 2 and pre-Tier-2 vehicles, respectively.

It is important to note that all of the pre-Tier-2 vehicles were thousands of miles beyond their regulatory FUL at EOT.

Emissions standards for light duty vehicles are provided in Appendix A.

Table 3.2. Summary of minimum, average, and maximum emissions test (Federal Test Procedure with E0 fuel) results for Tier 2 vehicles
(all results in g/mile)

Vehicle (Tier 2 Emissions Category)	Aging Fuel	CO			NOx			NMOG		
		Min	Avg	Max	Min	Avg	Max	Min	Avg	Max
2007 Accord (Bin 5)	RE0	0.21	**0.23**	0.24	0.019	**0.026**	0.032	0.0360	**0.0479**	0.0597
	RE10	0.28	**0.29**	0.30	0.025	**0.026**	0.027	0.0309	**0.0329**	0.0350
	RE15	0.18	**0.24**	0.31	0.013	**0.016**	0.019	0.0103	**0.0211**	0.0319
	RE20	0.26	**0.27**	0.27	0.022	**0.022**	0.022	0.0309	**0.0314**	0.0319
2006 Silverado (Bin 8)	RE0	0.52	**0.54**	0.56	0.023	**0.032**	0.040	0.0453	**0.0484**	0.0515
	RE10	0.72	**0.81**	0.90	0.043	**0.046**	0.049	0.0525	**0.0556**	0.0587
	RE15	0.89	**0.99**	1.09	0.035	**0.036**	0.038	0.0587	**0.0638**	0.0690
	RE20	0.81	**0.84**	0.86	0.045	**0.050**	0.054	0.0669	**0.0674**	0.0679
2008 Altima (Bin 5)	RE0	2.84	**3.18**	3.59	0.061	**0.067**	0.071	0.1215	**0.1348**	0.1482
	RE10	0.58	**0.63**	0.68	0.046	**0.048**	0.051	0.0587	**0.0623**	0.0659
	RE15	0.61	**0.62**	0.62	0.042	**0.051**	0.061	0.0556	**0.0582**	0.0607
	RE20	0.55	**0.56**	0.57	0.042	**0.044**	0.046	0.0607	**0.0628**	0.0648
2008 Taurus (Bin 5)	RE0	0.47	**0.53**	0.59	0.010	**0.010**	0.011	0.0288	**0.0293**	0.0298
	RE10	0.25	**0.34**	0.44	0.010	**0.012**	0.015	0.0185	**0.0223**	0.0268
	RE15	0.39	**0.42**	0.44	0.008	**0.009**	0.009	0.0226	**0.0232**	0.0237
	RE20	0.28	**0.37**	0.53	0.006	**0.008**	0.012	0.0196	**0.0229**	0.0268
2007 Caravan (Bin 5)	RE0	1.54	**1.67**	1.79	0.050	**0.051**	0.052	0.0484	**0.0484**	0.0484
	RE10	1.13	**1.22**	1.30	0.048	**0.053**	0.057	0.0412	**0.0437**	0.0463
	RE15	1.49	**1.56**	1.61	0.033	**0.036**	0.038	0.0443	**0.0508**	0.0607
	RE20	2.36	**2.37**	2.39	0.072	**0.086**	0.100	0.0473	**0.0479**	0.0484
2006 Cobalt (Bin 5)	RE0	0.76	**0.87**	1.07	0.041	**0.042**	0.045	0.0371	**0.0389**	0.0422
	RE15	0.38	**0.45**	0.53	0.025	**0.026**	0.028	0.0350	**0.0391**	0.0432
	RE20	0.79	**0.82**	0.86	0.064	**0.075**	0.085	0.0422	**0.0458**	0.0494
2007 Caliber (Bin 5)	RE0	2.53	**2.60**	2.68	0.078	**0.078**	0.079	0.0803	**0.0829**	0.0854
	RE15	3.31	**4.30**	5.69	0.051	**0.059**	0.074	0.0576	**0.0755**	0.0865
	RE20	3.01	**3.54**	4.28	0.057	**0.059**	0.061	0.0618	**0.0703**	0.0772
2009 Liberty (Bin 5)	RE0	0.84	**0.99**	1.07	0.045	**0.052**	0.061	0.0360	**0.0453**	0.0525
	RE15	1.56	**1.77**	1.94	0.050	**0.056**	0.059	0.0556	**0.0624**	0.0669
	RE20	1.54	**1.66**	1.77	0.054	**0.057**	0.060	0.0607	**0.0849**	0.1091
2009 Explorer (Bin 4)	RE0	1.17	**1.23**	1.28	0.032	**0.033**	0.033	0.0576	**0.0597**	0.0618
	RE15	1.16	**1.18**	1.19	0.029	**0.031**	0.033	0.0556	**0.0566**	0.0576
	RE20	1.21	**1.26**	1.31	0.028	**0.029**	0.030	0.0648	**0.0654**	0.0659
2009 Civic (Bin 5)	RE0	0.55	**0.57**	0.59	0.025	**0.027**	0.029	0.0350	**0.0396**	0.0443
	RE15	0.45	**0.46**	0.46	0.029	**0.030**	0.030	0.0391	**0.0401**	0.0412
	RE20	0.49	**0.51**	0.53	0.025	**0.025**	0.025	0.0432	**0.0443**	0.0453
2009 Corolla (Bin 5)	RE0	0.54	**0.55**	0.56	0.048	**0.061**	0.073	0.0473	**0.0484**	0.0494
	RE15	0.58	**0.60**	0.61	0.051	**0.056**	0.061	0.0453	**0.0484**	0.0515
	RE20	0.61	**0.61**	0.61	0.040	**0.043**	0.046	0.0515	**0.0535**	0.0556
2005 Tundra (Bin 5)	RE0	0.78	**0.80**	0.81	0.040	**0.042**	0.043	0.0515	**0.0520**	0.0525
	RE15	1.13	**1.17**	1.20	0.038	**0.039**	0.039	0.0638	**0.0654**	0.0669
	RE20	0.83	**0.88**	0.93	0.031	**0.038**	0.044	0.0494	**0.0571**	0.0648
2006 Impala (Bin 5)	RE0	1.04	**1.13**	1.22	0.036	**0.038**	0.040	0.0401	**0.0401**	0.0401
	RE15	1.28	**1.40**	1.51	0.034	**0.038**	0.041	0.0432	**0.0448**	0.0463
	RE20	1.49	**1.69**	1.88	0.040	**0.041**	0.041	0.0494	**0.0504**	0.0515
2005 F150 (Bin 8)	RE0	2.78	**3.25**	3.71	0.077	**0.078**	0.078	0.0628	**0.0767**	0.0906
	RE15	2.20	**2.56**	2.92	0.078	**0.089**	0.099	0.0906	**0.0988**	0.1070
	RE20	1.74	**2.32**	2.90	0.053	**0.059**	0.065	0.0504	**0.0582**	0.0659
2006 Quest[a] (Bin 5)	RE15	1.04	**1.08**	1.12	0.035	**0.036**	0.036	0.0731	**0.0793**	0.0854
2009 Outlook[b] (Bin 5)	RE0	1.21	**1.34**	1.41	0.035	**0.047**	0.060	0.0453	**0.0491**	0.0587
	RE15	0.47	**0.62**	0.71	0.016	**0.022**	0.026	0.0288	**0.0326**	0.0350
2009 Camry[b] (Bin 5)	RE0	0.26	**0.29**	0.32	0.050	**0.053**	0.057	0.0298	**0.0323**	0.0350
	RE15	0.20	**0.23**	0.26	0.041	**0.046**	0.052	0.0309	**0.0326**	0.0360
2009 Focus[b] (Bin 4)	RE0	1.07	**1.10**	1.14	0.101	**0.113**	0.130	0.0257	**0.0316**	0.0401
	RE15	0.70	**0.77**	0.84	0.037	**0.058**	0.077	0.0268	**0.0292**	0.0329
2009 Odyssey[b] (Bin 5)	RE0	0.50	**0.60**	0.73	0.068	**0.074**	0.083	0.0422	**0.0508**	0.0597
	RE15	0.15	**0.22**	0.32	0.022	**0.044**	0.057	0.0226	**0.0250**	0.0268

Acronymns: CO= Carbon Monoxide, NOx =Oxides of Nitrogen, NMOG=Non-Methane Organic Gases

[a] Nissan Quest vehicles did not run standard road cycle throughout the aging program. RE0 and RE20 Quests did not complete the aging program. See Section 4.2.1.

[b] RE20 vehicles at ETC currently under test.

Table 3.3. Summary of minimum, average, and maximum emissions test (Federal Test Procedure with E0 fuel) results for pre-Tier-2 vehicles
(all results in g/mile)

Vehicle (Emissions Category)	Aging Fuel	CO			NOx			NMOG		
		Min	Avg	Max	Min	Avg	Max	Min	Avg	Max
2000 Silverado (Tier 1/LDT3)	RE0	2.91	**3.08**	3.24	0.439	**0.448**	0.456	0.2717	**0.2717**	0.2717
	RE15	1.97	**2.12**	2.21	0.351	**0.364**	0.384	0.1740	**0.1830**	0.1997
	RE20	1.42	**1.79**	2.00	0.361	**0.389**	0.411	0.1626	**0.1909**	0.2151
2002 Frontier (NLEV/LDT1)	RE0	3.05	**3.26**	3.48	0.125	**0.131**	0.137	0.0700	**0.0731**	0.0762
	RE15	1.94	**3.92**	6.04	0.093	**0.216**	0.421	0.0854	**0.0990**	0.1163
	RE20	3.97	**4.17**	4.38	0.120	**0.131**	0.140	0.0937	**0.1026**	0.1112
2002 Durango (Tier1/LDT3)	RE0	1.45	**2.03**	2.76	0.387	**0.441**	0.484	0.0607	**0.1043**	0.1606
	RE15	2.31	**2.55**	2.80	0.376	**0.391**	0.407	0.1492	**0.1580**	0.1667
	RE20	2.52	**2.54**	2.55	0.604	**0.605**	0.606	0.1513	**0.1554**	0.1595
2003 Camry (ULEV)	RE0	1.24	**1.29**	1.34	0.136	**0.144**	0.152	0.0638	**0.0674**	0.0710
	RE15	0.57	**0.64**	0.70	0.108	**0.118**	0.127	0.0319	**0.0340**	0.0360
	RE20	2.46	**2.60**	2.73	0.261	**0.286**	0.310	0.1482	**0.1709**	0.1935
2003 Taurus (NLEV)	RE0	0.31	**0.33**	0.35	0.077	**0.080**	0.083	0.0576	**0.0623**	0.0669
	RE15	0.55	**0.59**	0.62	0.134	**0.137**	0.140	0.0772	**0.0813**	0.0854
	RE20	0.63	**0.64**	0.64	0.059	**0.064**	0.068	0.0638	**0.0762**	0.0885
2003 Cavalier (NLEV)	RE0	1.45	**1.57**	1.69	0.264	**0.280**	0.296	0.1143	**0.1189**	0.1235
	RE15	0.69	**0.71**	0.72	0.090	**0.092**	0.093	0.0607	**0.0618**	0.0628
	RE20	1.01	**1.06**	1.11	0.090	**0.091**	0.092	0.0926	**0.0983**	0.1040
2000 Accord (NLEV)	RE0	4.79	**5.48**	5.74	0.100	**0.130**	0.152	0.1070	**0.1338**	0.1462
	RE15	3.02	**3.17**	3.26	0.174	**0.192**	0.205	0.0865	**0.0878**	0.0895
	RE20	1.00	**1.05**	1.08	0.108	**0.113**	0.117	0.0576	**0.0611**	0.0669
2000 Focus (NLEV)	RE0	1.11	**1.29**	1.50	0.072	**0.097**	0.152	0.0638	**0.0948**	0.1091
	RE15	0.47	**0.50**	0.53	0.106	**0.117**	0.124	0.0340	**0.0391**	0.0494
	RE20	1.72	**1.89**	1.99	0.233	**0.239**	0.245	0.0690	**0.0710**	0.0731

Acronymns: CO= Carbon Monoxide, NOx =Oxides of Nitrogen, NMOG=Non-Methane Organic Gases, LDT=light duty truck (number following indicates category), NLEV=National Low Emission Vehicle (Program), ULEV=ultralow emissions vehicle.

Table 3.4. Summary of minimum, average, and maximum emissions test (Federal Test Procedure with E10, E15, or E20 fuel) results for Tier 2 vehicles
(all results in g/mile)

Vehicle (Tier 2 Emissions Category)	Emissions Test Fuel	CO			NOx			NMOG			Aging Fuel
		Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	
2007 Accord (Bin 5)	E10	0.18	**0.18**	0.18	0.026	**0.026**	0.027	0.0255	**0.0260**	0.0266	RE10
	E15	0.10	**0.13**	0.15	0.022	**0.024**	0.026	0.0184	**0.0184**	0.0184	RE15
	E20	0.10	**0.14**	0.18	0.014	**0.019**	0.024	0.0119	**0.0190**	0.0261	RE20
2006 Silverado (Bin 8)	E10	0.75	**0.77**	0.80	0.040	**0.043**	0.045	0.0598	**0.0604**	0.0610	RE10
	E15	0.75	**0.76**	0.76	0.033	**0.035**	0.037	0.0574	**0.0574**	0.0574	RE15
	E20	0.64	**0.64**	0.64	0.038	**0.038**	0.039	0.0499	**0.0516**	0.0534	RE20
2008 Altima (Bin 5)	E10	0.55	**0.56**	0.57	0.054	**0.058**	0.063	0.0698	**0.0709**	0.0720	RE10
	E15	0.60	**0.62**	0.65	0.053	**0.053**	0.053	0.0528	**0.0545**	0.0562	RE15
	E20	0.46	**0.47**	0.47	0.041	**0.042**	0.043	0.0499	**0.0516**	0.0534	RE20
2008 Taurus (Bin 5)	E10	0.21	**0.21**	0.21	0.012	**0.016**	0.019	0.0177	**0.0188**	0.0199	RE10
	E15	0.42	**0.45**	0.48	0.010	**0.013**	0.016	0.0253	**0.0275**	0.0298	RE15
	E20	0.24	**0.27**	0.30	0.013	**0.014**	0.015	0.0214	**0.0237**	0.0261	RE20
2007 Caravan (Bin 5)	E10	1.13	**1.31**	1.41	0.040	**0.044**	0.049	0.0399	**0.0432**	0.0477	RE10
	E15	1.06	**1.12**	1.18	0.046	**0.047**	0.048	0.0367	**0.0385**	0.0402	RE15
	E20	1.58	**1.63**	1.68	0.042	**0.046**	0.049	0.0499	**0.0617**	0.0736	RE20
2006 Cobalt (Bin 5)	E15	0.43	**0.47**	0.53	0.024	**0.027**	0.030	0.0402	**0.0409**	0.0425	RE15
	E20	0.40	**0.43**	0.47	0.118	**0.119**	0.120	0.0309	**0.0356**	0.0404	RE20
2007 Caliber (Bin 5)	E15	3.50	**3.61**	3.72	0.055	**0.059**	0.063	0.0758	**0.0769**	0.0781	RE15
	E20	1.78	**2.23**	2.48	0.060	**0.064**	0.068	0.0594	**0.0689**	0.0867	RE20
2009 Liberty (Bin 5)	E15	1.15	**1.16**	1.17	0.035	**0.045**	0.054	0.0448	**0.0448**	0.0448	RE15
	E20	0.83	**0.89**	0.94	0.034	**0.044**	0.054	0.0427	**0.0427**	0.0427	RE20
2009 Explorer (Bin 4)	E15	0.99	**1.04**	1.08	0.027	**0.028**	0.028	0.0574	**0.0585**	0.0597	RE15
	E20	1.04	**1.09**	1.14	0.027	**0.028**	0.029	0.0617	**0.0760**	0.0902	RE20
2009 Civic (Bin 5)	E15	0.30	**0.33**	0.36	0.038	**0.043**	0.048	0.0287	**0.0333**	0.0379	RE15
	E20	0.46	**0.48**	0.50	0.033	**0.035**	0.037	0.0249	**0.0255**	0.0261	RE20
2009 Corolla (Bin 5)	E15	0.56	**0.57**	0.58	0.044	**0.047**	0.049	0.0505	**0.0528**	0.0551	RE15
	E20	0.44	**0.48**	0.51	0.042	**0.046**	0.049	0.0463	**0.0487**	0.0511	RE20
2005 Tundra (Bin 5)	E15	0.85	**0.94**	1.02	0.032	**0.035**	0.038	0.0528	**0.0545**	0.0562	RE15
	E20	0.85	**0.88**	0.91	0.038	**0.039**	0.040	0.0522	**0.0730**	0.0938	RE20
2006 Impala (Bin 5)	E15	1.28	**1.44**	1.59	0.035	**0.039**	0.043	0.0413	**0.0471**	0.0528	RE15
	E20	1.40	**1.46**	1.51	0.010	**0.019**	0.028	0.0416	**0.0487**	0.0558	RE20
2005 F150 (Bin 8)	E15	2.01	**2.23**	2.44	0.050	**0.060**	0.069	0.0895	**0.0901**	0.0907	RE15
	E20	1.59	**1.95**	2.31	0.058	**0.061**	0.064	0.0475	**0.0564**	0.0653	RE20
2006 Quest[a] (Bin 5)	E15	1.02	**1.02**	1.02	0.036	**0.040**	0.044	0.0677	**0.0694**	0.0712	RE15
2009 Outlook[b] (Bin 5)	E15	0.37	**0.43**	0.49	0.012	**0.016**	0.020	0.0310	**0.0341**	0.0356	RE15
2009 Camry[b] (Bin 5)	E15	0.22	**0.25**	0.27	0.051	**0.052**	0.053	0.0321	**0.0348**	0.0390	RE15
2009 Focus[b] (Bin 4)	E15	0.57	**0.67**	0.75	0.055	**0.062**	0.072	0.0241	**0.0275**	0.0321	RE15
2009 Odyssey[b] (Bin 5)	E15	0.16	**0.20**	0.22	0.031	**0.039**	0.046	0.0253	**0.0278**	0.0321	RE15

Acronymns: CO= Carbon Monoxide, NOx =Oxides of Nitrogen, NMOG=Non-Methane Organic Gases

[a] Nissan Quest vehicles did not run standard road cycle throughout the aging program. RE0 and RE20 Quests did not complete the aging program. See Section 4.2.1.

[b] RE20 vehicles at ETC currently under test.

Table 3.5. Summary of minimum, average, and maximum emissions test results for pre-Tier-2 vehicles tested with ethanol-blended emissions test fuels (Federal Test Procedure with E15 or E20 fuel) (all results in g/mile)

Vehicle (Emissions Category)	Emissions Test Fuel	CO			NOx			NMOG			Aging Fuel
		Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	
2000 Silverado (Tier 1/LDT3)	E15	1.55	**1.72**	1.97	0.352	**0.370**	0.382	0.1676	**0.1763**	0.1859	RE15
	E20	1.51	**1.57**	1.63	0.433	**0.436**	0.438	0.1923	**0.1941**	0.1959	RE20
2002 Frontier (NLEV/LDT1)	E15	1.86	**4.02**	5.63	0.058	**0.102**	0.190	0.0792	**0.0933**	0.1044	RE15
	E20	3.95	**4.57**	5.11	0.086	**0.117**	0.138	0.1152	**0.1203**	0.1259	RE20
2002 Durango (Tier1/LDT3)	E15	2.00	**2.34**	2.66	0.452	**0.462**	0.471	0.1389	**0.1523**	0.1607	RE15
	E20	2.14	**2.23**	2.31	0.691	**0.701**	0.712	0.1449	**0.1454**	0.1460	RE20
2003 Camry (ULEV)	E15	0.69	**0.72**	0.74	0.070	**0.084**	0.098	0.0344	**0.0436**	0.0528	RE15
	E20	2.40	**2.65**	2.89	0.267	**0.267**	0.267	0.1627	**0.1716**	0.1805	RE20
2003 Taurus (NLEV)	E15	0.34	**0.35**	0.36	0.153	**0.155**	0.157	0.0585	**0.0620**	0.0654	RE15
	E20	0.35	**0.38**	0.40	0.107	**0.122**	0.136	0.0522	**0.0528**	0.0534	RE20
2003 Cavalier (NLEV)	E15	0.52	**0.56**	0.59	0.084	**0.085**	0.086	0.0539	**0.0608**	0.0677	RE15
	E20	0.65	**0.68**	0.70	0.088	**0.092**	0.095	0.0985	**0.1027**	0.1069	RE20
2000 Accord (NLEV)	E15	1.97	**2.25**	2.71	0.168	**0.189**	0.213	0.0872	**0.1119**	0.1251	RE15
	E20	0.97	**1.12**	1.23	0.130	**0.135**	0.143	0.0617	**0.0657**	0.0701	RE20
2000 Focus (NLEV)	E15	0.30	**0.37**	0.48	0.096	**0.120**	0.141	0.0310	**0.0421**	0.0505	RE15
	E20	0.81	**1.01**	1.16	0.173	**0.190**	0.207	0.0546	**0.0594**	0.0665	RE20

Acronymns: CO= Carbon Monoxide, NOx =Oxides of Nitrogen, NMOG=Non-Methane Organic Gases, LDT=light duty truck (number following indicates category), NLEV=National Low Emission Vehicle (Program), ULEV=ultralow emissions vehicle.

3.2.5 Statistical Analysis of Emissions Results

Within each parameter (emissions or fuel economy), statistical models have been separately fit to data for the 26 different vehicle models. Each of these statistical models aggregates test data for multiple individual vehicles, road test fuels (RE0, RE10, RE15, and RE20), mileage points (SOT, MID, and EOT), and emissions test fuels (E0, E10, E15, and E20). The Nissan Quest was omitted from these analyses because it did not run the SRC for the duration of the program and because the RE0 vehicle did not reach EOT.

Table 3.6 summarizes the emissions results at the fleet level. In this table, the immediate impacts of ethanol at SOT are shown in the second column. FUL aging effects both with and without ethanol added to the fuels are shown in the third and fourth columns. The road fuel aging effect (third column) is defined as the effect of vehicle aging on each parameter absent ethanol in the road fuel. The differential road aging effect of ethanol (fourth column) is defined as the additional deterioration (or potentially amelioration of deterioration) associated with ethanol over and above that associated with vehicle aging alone. A result of “Increase” or “Decrease” in the table corresponds to statistical significance with 95% confidence. A “marginal” result corresponds to statistical significance with 90% confidence.

As shown, CO, NMHC, and fuel economy were lower in vehicles tested with ethanol fuels before any aging, while NO_X, ethanol, acetaldehyde, and formaldehyde emissions were higher. There was no statistically significant change to NMOG or CH_4 emissions for vehicles tested with ethanol fuels before any aging. As expected, mileage accumulation with RE0 road fuel corresponded to fleetwide increases in emissions (with the exception of ethanol emissions) and an increase in fuel economy. This is the road fuel aging effect. Where it could be determined, there was no statistically significant fleetwide differential effect of emission/performance parameter results for aging the vehicles with ethanol-containing blends (RE10, RE15, RE20) versus retail gasoline (RE0). The road aging effect was neither systematically enhanced nor suppressed under road aging with ethanol blends.

Table 3.6. Summary of results by emission/performance parameter

Parameter	Immediate ethanol effect	Road fuel aging effect	Differential road aging effect of ethanol
CO	Decrease	Increase	No
NO_X	Increase	Increase	No
NMHC[a]	Decrease	Increase	No
NMOG[b]	None	Increase	No
Fuel economy	Decrease	Increase	No
Ethanol	Increase	Inconclusive—not linear with mileage	Inconclusive
Acetaldehyde	Increase	Increase (marginal)	No
Formaldehyde	Increase	Increase	No
CH_4	None	Increase	No

[a]nonmethane hydrocarbons
[b]nonmethane organic gases

Table 3.7 summarizes the median change in emissions and fuel economy for each ethanol blend relative to E0 for the fleet at the start of testing, thus reflecting the short-term, or immediate ethanol emissions effect. Data in Table 3.7 expand on column 2 (immediate ethanol effect) of Table 3.6 by showing statistical results for each ethanol blend. The median change is shown in bold type in the shaded center column for each ethanol blend, and the minor columns to the left and right represent the 25th and 75th percentile of the changes across the fleet for each ethanol blend. Note that E10 results are for only 5 vehicle models, E15 results are for 26 vehicle models, and E20 results are for 22 vehicle models.

Results from Table 3.7 are shown graphically in Figs. 3.7 and 3.8. Figure 3.7 shows the median change in fuel economy and CO, NO_X, NMHC, NMOG, and CH_4 emissions, and the range bars show the interquartile range (25th percentile to 75th percentile) across all vehicles in the test fleet at SOT. The results in Fig. 3.7 are shown as a percent change relative to the E0 tests for the same vehicle. For example, fuel economy at SOT for E15 test fuel across the vehicle fleet ranges from 4.5% to 5.5% lower (median of 5.1% lower) than for E0 test fuels. These results are as expected and are consistent with previous studies. Similar results for ethanol, acetaldehyde, and formaldehyde are shown in Fig. 3.8, except units are change in milligrams per mile compared to E0. Here again the colored bars represent the median change and the range bars show the interquartile range. While the statistical models find a statistically significant increase in formaldehyde with increasing ethanol (Table 3.6), note in Table 3.7 and Fig. 3.8 that the levels are extremely low, increasing by less than 0.2 mg/mile (less than 1% of the Tier 2/Bin 5 formaldehyde standard of 18 mg/mile).

Appendix B provides details regarding the statistical models used in these analyses. A more detailed discussion of the statistical results is provided in Appendixes D and E. In Appendix D the results are presented and discussed by emission parameter, analyzed at the vehicle and fleet level. Appendix E provides the results by vehicle type with a summary table and nine figures shown for each of the 26 vehicles analyzed. Note that the Nissan Quest was omitted from this analysis due to the lack of an RE0 comparison vehicle. Similarly, ethanol results are based on only the vehicles at SwRI, and aldehydes analysis is based on SwRI and TRC vehicles.

Table 3.7. Median change in fuel economy and emissions relative to E0 with interquartile range (Federal Test Procedure results at start-of-test)

Parameter (unit of change)	E10			E15			E20		
	25th percentile	median	75th percentile	25th percentile	median	75th percentile	25th percentile	median	75th percentile
Fuel Economy (%)	-4.02%	**-3.67%**	-3.25%	-5.49%	**-5.12%**	-4.54%	-6.98%	**-6.46%**	-6.19%
CO (%)	-7.57%	**-2.36%**	3.54%	-22.86%	**-11.18%**	-4.29%	-38.60%	**-20.43%**	-8.71%
NOx (%)	12.08%	**34.26%**	34.34%	-4.64%	**5.94%**	30.21%	6.04%	**12.32%**	20.99%
NMHC (%)	-11.82%	**-7.02%**	14.62%	-21.23%	**-9.85%**	-4.09%	-27.07%	**-17.05%**	-8.26%
NMOG (%)	-3.53%	**-1.36%**	22.38%	-10.66%	**-0.07%**	6.91%	-14.99%	**-0.90%**	6.91%
Ethanol (mg/mi)	1.185	**2.335**	2.349	3.204	**3.551**	5.237	4.307	**4.642**	6.422
Acetaldehyde (mg/mi)	0.296	**0.409**	0.468	0.472	**0.626**	0.733	0.607	**0.915**	1.113
Formaldehyde (mg/mi)	0.007	**0.025**	0.025	-0.068	**0.066**	0.113	0.042	**0.135**	0.192
CH_4 (%)	-4.70%	**3.17%**	11.02%	-4.00%	**4.47%**	10.17%	-4.59%	**1.62%**	20.00%

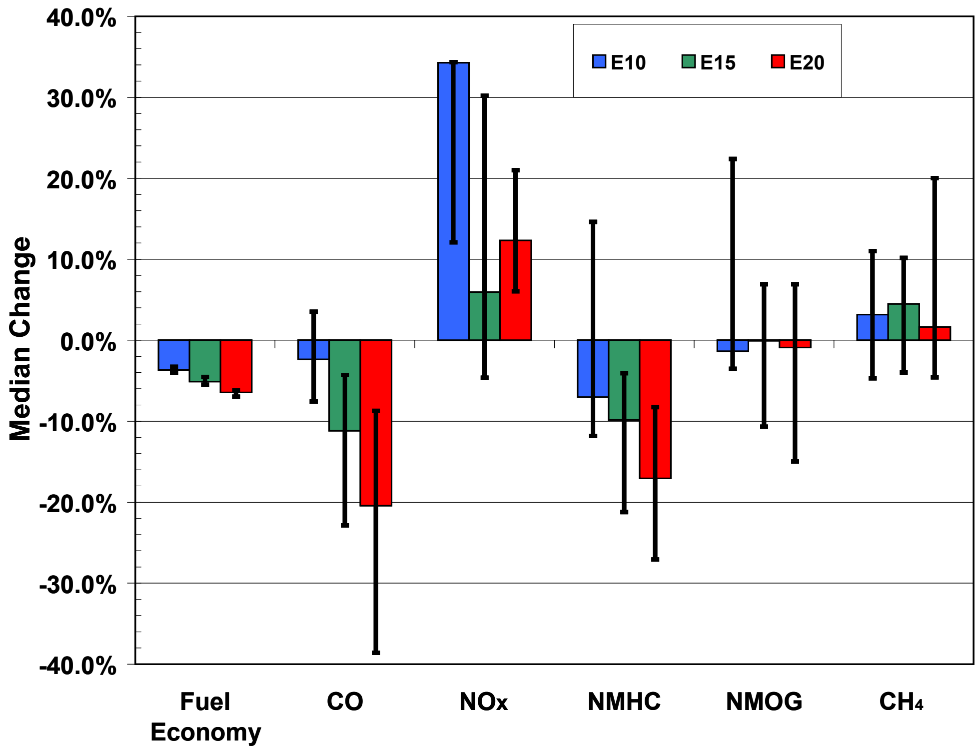


Fig. 3.7. Median change in fuel economy and CO, NO_X, nonmethane hydrocarbon (NMHC), nonmethane organic gas (NMOG), and CH_4 emissions relative to E0. Range bars show interquartile range (25th to 75th percentile). Results for Federal Test Procedure at start-of-test.

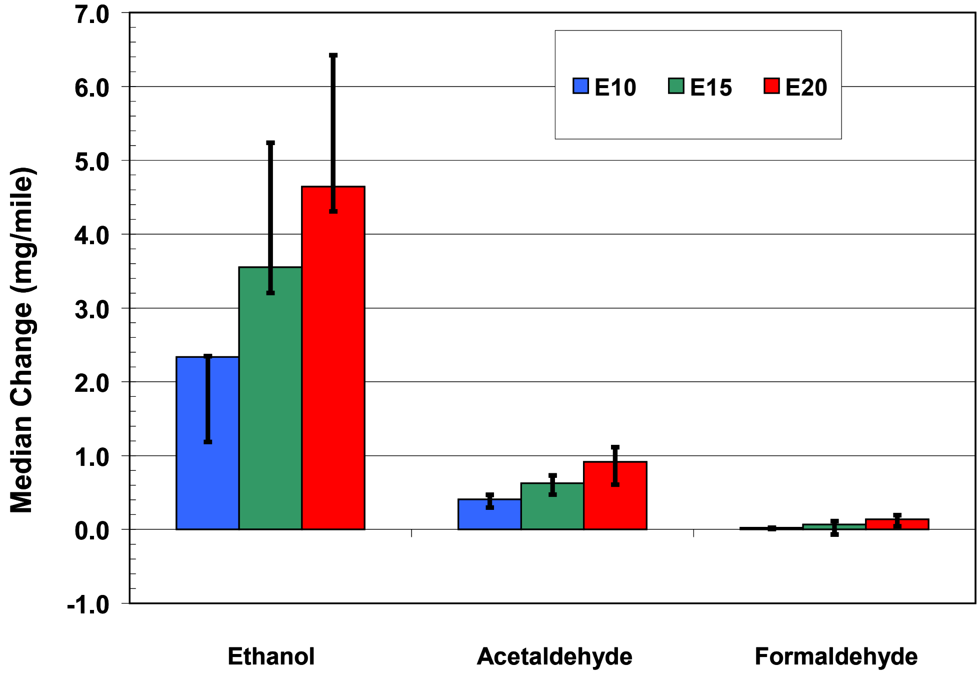


Fig. 3.8. Median change in ethanol, acetaldehyde, and formaldehyde emissions relative to E0. Range bars show interquartile range (25th to 75th percentile). Results for Federal Test Procedure at start-of-test.

4. SUMMARY OF UNSCHEDULED MAINTENANCE AND VEHICLE TESTING ISSUES

4.1 UNSCHEDULED MAINTENANCE

Table 4.1 summarizes some of the more notable unscheduled maintenance occurrences during the program. Routine scheduled and unscheduled maintenance (such as oil changes, transmission service, wheel bearing replacement, and body work) are not shown. Incidents that resulted in excessive downtime, rigorous investigations, potential fuel-related issues, or complete vehicle replacement are described.

Table 4.1. Notable unscheduled maintenance issues

Vehicle model	Maintenance issues
2007 Honda Accord	RE10 Accord rejected early in program due to relatively high oil consumption. Noted at first oil change, RE10 vehicle consumed roughly 3 times the oil of companion vehicles over the same distance. Due to concern that oil consumption could impact catalyst efficiency over time, vehicle replaced after ~7k miles of aging.
2006 Chevrolet Silverado	RE20 fuel pump failed at 32,400 test miles (49,500 odometer miles). Pump was replaced and vehicle resumed testing. Failed pump was returned to the manufacturer for root cause analysis. Manufacturer disassembled the pump and determined that failure was due to mechanical failure of internal electrical connector; not deemed a fuel-related failure.
2007 Dodge Caravan	First vehicle assigned to RE20 rejected due to marginal emissions performance during screening tests. Vehicle replaced before start-of-test (SOT).
2006 Chevrolet Cobalt	At end-of-test (EOT) (72,000 test miles, 120,000 odometer miles), RE15 vehicle fuel pump found to be leaking due to a cracked fuel feed nipple. The pump was replaced and the vehicle completed emissions tests. The broken fuel nipple was analyzed with Fourier transform infrared (FTIR) spectrometer to determine whether the inner surface had changed relative to the outer surface. No molecular change between the inner and outer surfaces was noted. Failure was attributed to vehicle age.
2007 Dodge Caliber	RE20 Caliber tripped a catalyst temperature limit during mileage accumulation at 2,500 test miles (43,000 odometer miles). The catalyst had experienced severe thermal damage, indicative of a misfire event. Review of data logs and inspection of the vehicle found no clear cause of misfire. The original RE20 vehicle was shipped to the manufacturer for additional root cause analysis. The manufacturer replaced the catalyst and conducted extensive tests. The anomaly could not be replicated on the original test vehicle and did not recur in the program. A replacement vehicle was acquired and aged to EOT.
2009 Jeep Liberty	Apparent adaptation issues noted at SOT. (See Sect. 4.2.2).
2006 Chevrolet Impala	All three Impalas (RE0, RE15, RE20) experienced malfunction indicator lamp (MIL) illumination associated with manifold absolute pressure sensor performance and evaporative emissions system leaks between SOT and midlife tests. After repeated trips to the shop, replacement of canister vent solenoids eventually resolved the issue. This problem was not deemed fuel related.
2006 Nissan Quest	1. Problems with traction control on 2WD dynamometer prompted move from Southwest Research Institute to Transportation Research Center Inc. to allow emissions tests on 4WD dynamometer and aging on track (in lieu of 2WD mileage accumulation dynamometer). After SOT and initial standard road cycle (SRC) aging on track, DOE directed protocol changes to accelerate completion of this vehicle set. Changes included modification of aging protocol from SRC to series of steady high speed laps on track and omission of midlife emissions tests.

Table 4.1. Notable unscheduled maintenance issues (continued)

Vehicle model	Maintenance issues
2006 Nissan Quest (continued)	2. Exhaust catalyst on RE0 and RE20 vehicles failed during aging (appeared to be failure of mounting mat, catalyst monoliths moved downstream inside their can). Catalysts were returned to the manufacturer for root cause analysis. While no specific cause was given, failures did not appear to be related to test fuel or aging protocol. Vehicles not replaced; only RE15 vehicle reached full useful life. (See Sect. 4.2.1).
2009 Ford Focus	RE15 vehicle experienced a transmission failure at 70,300 miles. Failure was related to excessive wear of band for planetary gear set. Transmission was replaced and mileage accumulation resumed. RE20 vehicle experienced a similar transmission failure at 90,285 miles. Transmission was replaced and mileage accumulation was resumed.
2009 Honda Odyssey	RE0 vehicle began setting P0420 fault code (catalyst system efficiency below threshold—bank 1) at about 80,000 miles. MIL illuminated four times leading up to 90,000 mile emissions test interval, including during prep cycle for emissions. MIL was not cleared before emissions testing due to possible impact on adaptive controls. Following 90,000 mile emissions test, Bank1/Sensor 2 oxygen sensor signal was seen to exhibit excessive noise. Sensor was replaced and issue was resolved. Exhaust mass emissions were comparable before and after sensor replacement at 90,000 miles.
2000 Chevrolet Silverado	1. Shortly after SOT (at 112,000 odometer miles), the RE15 vehicle fuel gauge registered “empty” after a fuel fill. The fuel level sender was replaced. After 131 miles of aging on the SRC, the vehicle stopped and would not start. Fuel pump was replaced and testing resumed. Manufacturer was contacted and fuel pump and sender set aside to afford the opportunity for root cause analysis. 2. Exhaust leak on RE15 vehicle discovered after EOT. Because of concern over potential effect on emissions measurements, the vehicle was repaired and retested. Repair consisted of removal and replacement of exhaust manifold, broken fastener, and gasket. Because of an unrelated transmission leak, the transmission was also swapped at the same time (swapped with RE0 vehicle). Results of repeat tests after repair were consistent with the original EOT tests, indicating the leak was very minor.
2002 Dodge Durango	Evaporative emissions hose on RE20 vehicle split at throttle body connection after 25,000 miles of aging (89,000 odometer miles). Hose replaced and vehicle resumed mileage accumulation. Hose section analyzed with FTIR spectrometer. Analysis suggests that material is nitrile rubber. There were no signs of any chemical differences between the inside and outside of the hose. Failure attributed to vehicle age.
2003 Chevrolet Cavalier	High oil consumption on RE20 vehicle noted at 14,700 test miles (102,000 odometer miles). Vehicle replaced.
2000 Honda Accord	1. RE0 vehicle illuminated MIL (P0420) at about 25,000 miles (~130,000 total odometer miles). Emission test showed elevated levels of CO and NO_X. Following emissions test and wide-open throttle (WOT), vehicle was returned to mileage accumulation. After 1,000 additional miles, high catalyst outlet temperature (> 840°C) triggered test shutdown. Catalyst monolith found to be fractured and front face partially melted. Vehicle removed from test. Spare RE0 Honda Accord used as replacement. 2. Second RE0 vehicle experienced a transmission failure within first 1,000 miles of mileage accumulation. Transmission was replaced and mileage accumulation was resumed. Following 25,000-mile-emissions test and WOT, vehicle was returned to mileage accumulation. Catalyst monolith found to be fractured and front face partially melted shortly after aging resumed, with catalyst failure mode nearly identical to first RE0 failure. Vehicle removed from test. Third Honda Accord used as RE0 replacement; vehicle completed 50,000 miles of aging without further incident.

Table 4.1. Notable unscheduled maintenance issues (continued)

Vehicle model	Maintenance issues
2000 Honda Accord (continued)	3. RE15 vehicle experienced two MIL illuminations at 40,000 accumulated miles (135,000 odometer miles): a P0420 (catalyst efficiency) and a P1381 (cylinder position sensor interruption). There was no evidence of a catalyst temperature excursion. Ignition coil, position sensor, and ignition module were replaced, and mileage accumulation was resumed. No further issues were observed. 4. RE20 vehicle experienced a coolant boilover within first 1,000 miles of mileage accumulation. High coolant temperature alarm shut down test sequence. Inspection showed excessive engine oil in coolant; head gasket failure suspected but not verified. Spare vehicle was used as replacement.
2000 Ford Focus	RE0 vehicle experienced a misfire on cylinders 2 and 3 (MIL P0302 and P0303) at about 8,000 accumulated miles (~95,000 odometer miles). Cause of failure diagnosed as failed plug wire which caused subsequent failure of ignition coil. Misfire resulted in high temperature catalyst exposure and deactivation of the catalyst coating. Spare vehicle was used as replacement.

4.2 VEHICLE TESTING ISSUES

4.2.1 Nissan Quest Testing Issues

The Nissan Quests were reassigned from SwRI to TRC during the program due to problems with the traction control feature on these vehicles when tested on the two-wheel-drive dynamometer. Moving the vehicles to TRC allowed emissions tests on these vehicles using a four-wheel-drive dynamometer. SOT tests were successfully conducted on all three Quests at TRC using the four-wheel-drive dynamometer. Aging these vehicles on the track averted the two-wheel-drive issues that occurred on the MADs. Initial attempts to resolve the traction control problems on the two-wheel drive dynamometer and the change in test laboratories resulted in undesired program delays. Consequently, DOE directed that these vehicles begin using a nonstandard driving schedule for aging in an effort to accelerate completion of the program for these vehicles. After less than 20,000 miles of aging on the track using the SRC, the drive schedule was changed to a series of high-speed laps, at 65, 70, and 75 mph, and the midpoint emissions tests on these vehicles were cancelled to further accelerate completion of the vehicle set.

Additionally, two of the three Quests (the RE0 and RE20 vehicles) experienced catalyst failures during the aging process. The RE0 failure occurred just before the change in mileage accumulation protocol (at about 17,000 test miles), and the RE20 failure occurred at just over 30,000 test miles. Both failures were identified through a MIL illumination associated with catalyst performance. Upon inspection, the catalyst monoliths on both vehicles were found to have moved toward the rear of the catalyst housing by about 1 in., perhaps indicating a problem with the matting surrounding the monoliths. Both failed catalysts were returned to Nissan for analysis. The failures were not considered fuel related. At the direction of DOE, the RE0 and RE20 vehicles were dropped from the program.

Because no RE0 baseline data were available after SOT and because the results from the RE15 vehicle at EOT could not be assumed to be typical of aging on the SRC, the emissions results from the Quests were not used in the statistical analysis of emissions results. However, the EOT RE15 results that were obtained are included in the tabulated EOT results in Sect. 3.2.4.

4.2.2 Jeep Liberty Start-of-Test Emissions Tests

During the initial emissions tests conducted at 4,000 odometer miles on the Jeep Liberty vehicles, a nonmethane hydrocarbon (NMHC) noncompliance issue and high-CO state were noted when the vehicles were tested using E0. The SOT emissions results did not closely agree with the results previously obtained in the single screening FTP test on each vehicle. No significant mileage was accrued between these emissions tests, and hence, there was no reason to expect a large difference in the results. Moreover, all three vehicles were only exposed briefly to E20 during the screening WOT test, and none of the vehicles had yet been aged using an ethanol-containing fuel. An incomplete or incorrect adaptation from E15 and E20 to E0 during the course of testing was suspected as the cause of the higher E0 emissions. The problem was determined to occur in bag 1 and bag 3, probably during the first few seconds of open-loop operation after start-up. Bag 2 exhibited typically low emissions levels. The first step in responding to this situation was to check that complete emissions test data had been collected in the abnormal state. Next, the vehicles were re-prepped by performing the fuel adaptation procedure twice; then a repeat FTP test was performed. Even after the additional prep and adaptation, abnormally high NMHC and CO emissions were noted. Finally, the vehicles were forced into readjustment by disconnecting the batteries (to force an LFT reset) followed by once again performing the fuel adaptation procedure. After this step the results of FTPs were found to be in close agreement with the original screening FTP, allowing the full course of emissions tests to be run again with the vehicles at this lower CO condition. Comparisons of the NMHC and CO results from before and after the battery disconnection are shown in Figs. 4.1 and 4.2. Results are shown for the single screening test, the two SOT tests, and the two SOT retests. (Note that NMHC emissions are compared against the relevant NMOG standard. NMOG emissions were not measured for the screening tests but are always higher than NMHC.)

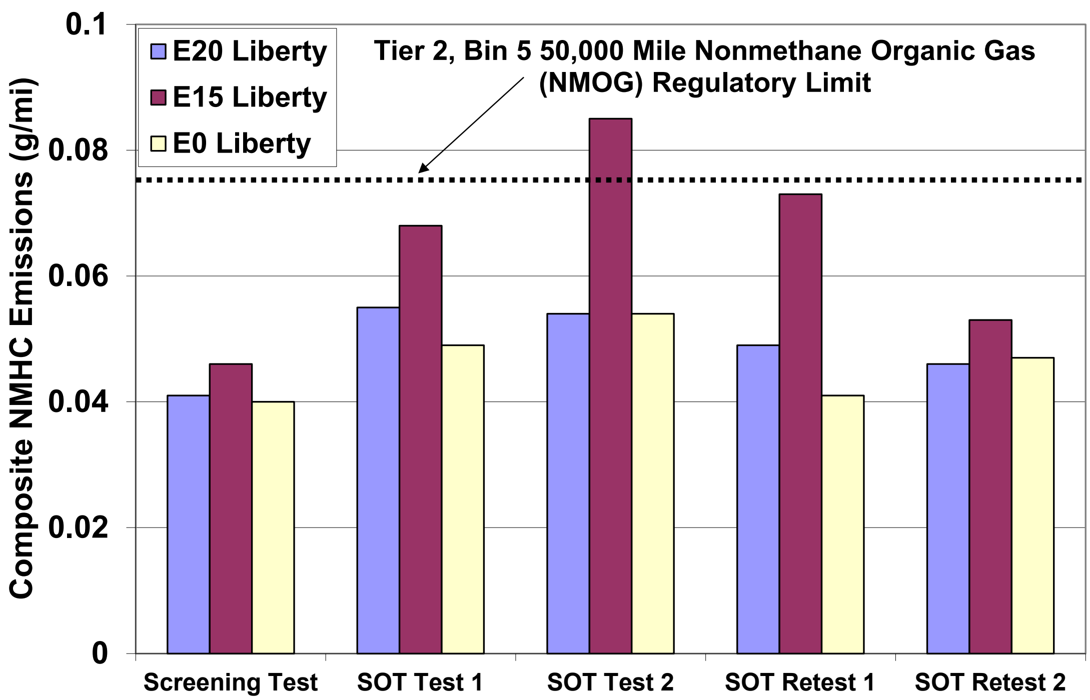


Fig. 4.1. Jeep Liberty start-of-test (SOT) nonmethane hydrocarbon (NMHC) emissions using E0 before and after battery disconnection.

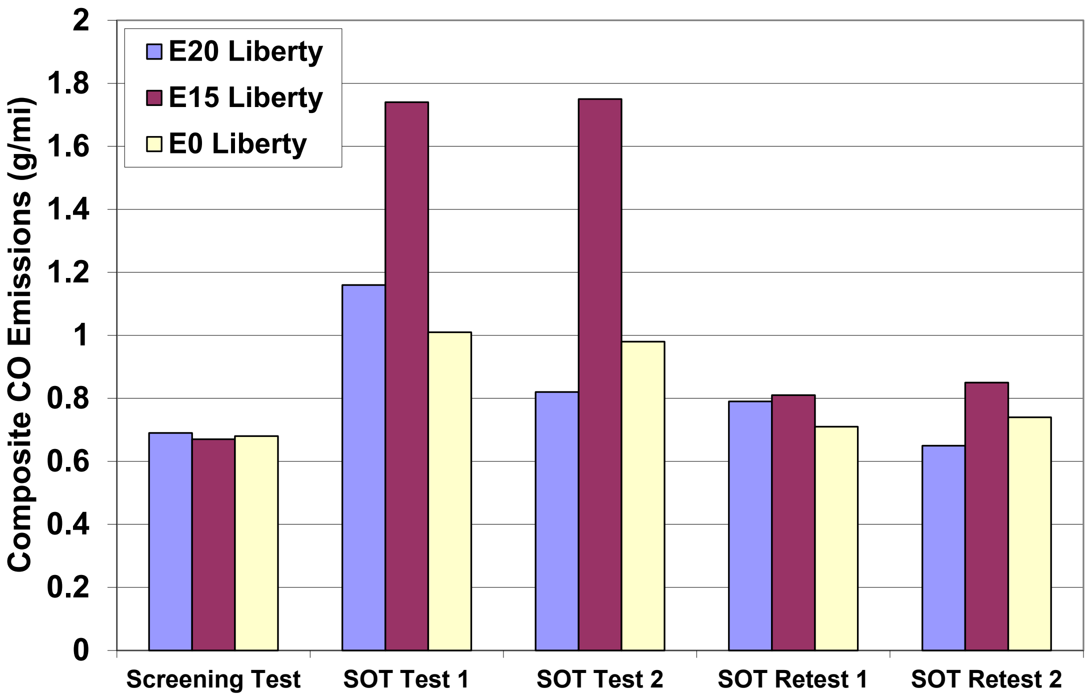


Fig. 4.2. Jeep Liberty start-of-test (SOT) CO emissions using E0 before and after battery disconnection.

The exact cause of the high-emissions condition for the Liberty vehicles may never be known with certainty; however, it appears very likely that the situation was caused by inadequate adaptation after exposure to E15 and E20 during screening and SOT. It is worth noting that this problem did not reoccur during subsequent emissions test intervals, leading to the conclusion that the original problem was likely a result of the imposed test sequence. This finding raises an issue that could be further investigated. As there was no E10 test vehicle in this group, no data exist to determine whether this situation may also have arisen if E10 were used. The retest results collected after battery disconnection were used as the baseline for the statistical analyses for this program. The results from the high-emissions state were retained in the program database for completeness.

4.2.3 Ethanol and Aldehyde Emissions Issues

As described briefly in Sect. 3.2.3, NMOG emissions were estimated for all tests based on a correlation between NMOG and NMHC. Some problems with ethanol and aldehyde measurements precluded calculation of NMOG emissions for some tests, but results for NMHC were available for virtually all tests.

The application of the photoacoustic analyzer used for tests early in the TRC program and used at ETC throughout the program was deemed unreliable. Impingers were used at TRC for some of the later tests. The photoacoustic analyzer is an approved method for ethanol measurement, but results are dependent on laboratory setup. Sample lines need to be short and/or heated to minimize retention of ethanol in the sampling system.

All sites used di-nitrophenylhydrazine cartridges to trap carbonyls (aldehydes and ketones) for later analysis by high performance liquid chromatography. Aldehyde results from ETC were notably much lower than expected, and the problem was traced to a sample leak for all phase 1 (bag 1) samples. The bulk of the aldehydes and other organics are emitted in phase 1, so without reliable phase 1 results, the weighted FTP results are unusable.

APPENDIX A.
VEHICLE EMISSIONS STANDARDS

APPENDIX A. VEHICLE EMISSIONS STANDARDS

Emissions from vehicles have been regulated by the U.S. Environmental Protection Agency and the California Air Resources Board since the early 1970s. Tier 0 refers to standards that were phased in during the 1970s as a result of the 1970 Clean Air Act. These standards were amended in the late 1970s and first met in 1981. Tier 0 standards were in force until 1994. Tier 1 standards were phased in from 1994 through 1996. Table A.1 shows the Tier 0, Tier 1, and National Low Emission Vehicle (NLEV) Program emissions standards. Table A.2 gives the footnotes (i.e., superscript numbers in brackets [x]) for Table A.1, and Table A.3 defines the acronyms used in Tables A.1, A.4, and A.5.

Phase-in of Tier 2 standards began in 2004, although some manufacturers had the option of early compliance under the NLEV Program. Full useful life (FUL) for Tier 2 vehicles is 100,000 miles, 120,000 miles, or 150,000 miles, depending on a number of factors. The rule is described in detail in the *Federal Register*, Vol. 65(28). Tier 2 FUL standards are shown in Table A.4, and Tier 2 50,000-mile standards are shown in Table A.5.

Table A.1. Federal certification exhaust emission standards for light duty vehicles and light duty trucks

[All emissions in grams/mile on Federal Test Procedure (*Source:* www.epa.gov/otaq/standards.htm)]

	Vehicle Type	Emission Category	Vehicle Useful Life													
			5 Years / 50,000 Miles							10 Years / 100,000 Miles						
			THC[2,5,39]	NMHC[3]	NMOG	CO[35,39]	NOx	PM[29]	HCHO	THC[2,5]	NMHC[3]	NMOG	CO[38]	NOx	PM[29]	HCHO
Federal	LDV [37,40,43]	Tier 0	0.41	[6] 0.34	-	3.4	1.0	[4] 0.20	-							
		Tier 1	[28] 0.41	0.25	-	3.4	[7] 0.4	0.08	-	-	0.31	-	4.2	[9] 0.6	0.10	-
	LDT1 [37,40,43]	Tier 0[26]								0.80	[6] 0.67	-	10	1.2	[4] 0.26	-
		Tier 1	-	0.25	-	3.4	[7] 0.4	0.08	-	[26,28] 0.80	0.31	-	4.2	[9] 0.6	0.10	-
	LDT2 [37,40,43]	Tier 0[26]								0.80	[6] 0.67	-	10	1.7	[4] 0.13	-
		Tier 1	-	0.32	-	4.4	[8] 0.7	0.08	-	[26,28] 0.80	0.40	-	5.5	0.97	0.10	-
Federal National Low Emission Vehicle (NLEV) Program	LDV [36,40,41]	TLEV	[28] 0.41	-	[1,31] 0.125	3.4	[34] 0.4	0.08	0.015	-	-	[1,31] 0.156	4.2	[34] 0.6	[32] 0.08	0.018
		LEV[42]	[28] 0.41	-	[1,31] 0.075	3.4	[34] 0.2	0.08	0.015	-	-	[1,31] 0.090	4.2	[34] 0.3	[32] 0.08	0.018
		ULEV[42]	[28] 0.41	-	[1,31] 0.040	1.7	[34] 0.2	0.08	0.008	-	-	[1,31] 0.055	2.1	[34] 0.3	[32] 0.04	0.011
		ZEV	0.00	0.00	0.000	0.0	[34] 0.0	0.00	0.000	0.00	0.000	0.000	0.0	[34] 0.0	0.00	0.000
	LDT1 [36,40,41]	TLEV	-	-	[1,31] 0.125	3.4	[34] 0.4	0.08	0.015	[26,28] 0.80	-	[1,31] 0.156	4.2	[34] 0.6	[32] 0.08	0.018
		LEV[42]	-	-	[1,31] 0.075	3.4	[34] 0.2	0.08	0.015	[26,28] 0.80	-	[1,31] 0.090	4.2	[34] 0.3	[32] 0.08	0.018
		ULEV[42]	-	-	[1,31] 0.040	1.7	[34] 0.2	0.08	0.008	[26,28] 0.80	-	[1,31] 0.055	2.1	[34] 0.3	[32] 0.04	0.011
		ZEV	0.00	0.00	0.000	0.0	[34] 0.0	0.00	0.000	0.00	0.000	0.000	0.0	[34] 0.0	0.00	0.000
	LDT2 [36,40,41]	TLEV	-	-	[1,31] 0.160	4.4	[34] 0.7	0.08	0.018	[26,28] 0.80	-	[1,31] 0.200	5.5	[34] 0.9	[32] 0.10	0.023
		LEV[42]	-	-	[1,31] 0.100	4.4	[34] 0.4	0.08	0.018	[26,28] 0.80	-	[1,31] 0.130	5.5	[34] 0.5	[32] 0.10	0.023
		ULEV[42]	-	-	[1,31] 0.050	2.2	[34] 0.4	0.08	0.009	[26,28] 0.80	-	[1,31] 0.070	2.8	[34] 0.5	[32] 0.05	0.013
		ZEV	0.00	0.00	0.000	0.0	[34] 0.0	0.00	0.000	0.00	0.000	0.000	0.0	[34] 0.0	0.00	0.000
Federal Clean Fueled Vehicle (CFV) Program	LDV [37,40,41]	LEV	[28] 0.41	-	[30] 0.075	3.4	[34] 0.2	-	0.015	-	-	[30] 0.090	4.2	[34] 0.3	[10] 0.08	0.018
		ILEV [33]	[28] 0.41	-	0.075	3.4	[34] 0.2	-	0.015	-	-	0.090	4.2	[34] 0.3	[10] 0.08	0.018
		ULEV	[28] 0.41	-	[30] 0.040	1.7	[34] 0.2	-	0.008	-	-	[30] 0.055	2.1	[34] 0.3	[10] 0.04	0.011
		ZEV	0.00	0.00	0.000	0.0	[34] 0.0	0.00	0.000	0.00	0.000	0.000	0.0	[34] 0.0	0.00	0.000
	LDT1 [37,40,41]	LEV	-	-	[30] 0.075	3.4	[34] 0.2	-	0.015	[26,28] 0.80	-	[30] 0.090	4.2	[34] 0.3	[10] 0.08	0.018
		ILEV [33]	-	-	0.075	3.4	[34] 0.2	-	0.015	[26,28] 0.80	-	0.090	4.2	[34] 0.3	[10] 0.08	0.018
		ULEV	-	-	[30] 0.040	1.7	[34] 0.2	-	0.008	[26,28] 0.80	-	[30] 0.055	2.1	[34] 0.3	[10] 0.04	0.011
		ZEV	0.00	0.00	0.000	0.0	[34] 0.0	0.00	0.000	0.00	0.000	0.000	0.0	[34] 0.0	0.00	0.000
	LDT2 [37,40,41]	LEV	-	-	[30] 0.100	4.4	[34] 0.4	-	0.018	[26,28] 0.80	-	[30] 0.130	5.5	[34] 0.5	[10] 0.08	0.023
		ILEV [33]	-	-	0.100	4.4	[34] 0.4	-	0.018	[26,28] 0.80	-	0.130	5.5	[34] 0.5	[10] 0.08	0.023
		ULEV	-	-	[30] 0.050	2.2	[34] 0.4	-	0.009	[26,28] 0.80	-	[30] 0.070	2.8	[34] 0.5	[10] 0.04	0.013
		ZEV	0.00	0.00	0.000	0.0	[34] 0.0	0.00	0.000	0.00	0.000	0.000	0.0	[34] 0.0	0.00	0.000

Table A.2. Footnotes used in Table A.1
(*Source:* www.epa.gov/otaq/standards.htm)

Footnotes to the tables of emission standards

1. NMHC FOR DIESEL CYCLE VEHICLES
2. THCE FOR METHANOL VEHICLES
3. THCE FOR TIER 0 METHANOL VEHICLES, NMHCE FOR OTHER ALCOHOL VEHICLES
4. APPLIES TO DIESEL VEHICLES ONLY
5. DOES NOT APPLY TO CNG VEHICLES
6. CNG VEHICLES ONLY
7. 1.0 FOR DIESEL-FUELED VEHICLES THROUGH 2003 MODEL YEAR
8. DOES NOT APPLY TO DIESEL-FUELED VEHICLES
9. 1.25 FOR DIESEL-FUELED VEHICLES THROUGH 2003 MODEL YEAR
10. DIESEL-FUELED VEHICLES ONLY
11. METHANOL AND ETHANOL VEHICLES ONLY
12. GASOLINE VEHICLES ONLY
13. 0.7 THROUGH MODEL YEAR 1997
14. 1.0 THROUGH MODEL YEAR 1997
15. 1.1 THROUGH MODEL YEAR 1997
16. 1.5 THROUGH MODEL YEAR 1997
17. 1.3 THROUGH MODEL YEAR 1997
18. 1.8 THROUGH MODEL YEAR 1997
19. 2.0 THROUGH MODEL YEAR 1997
20. 2.8 THROUGH MODEL YEAR 1997
21. 1.48 FOR DIESEL-FUELED VEHICLES
22. 2.07 FOR DIESEL-FUELED VEHICLES
23. OTHER EQUIVALENT SCHEDULES ALLOWED.
24. PC/LDV MAY BE COMBINED WITH LDT1 & LDT2 FOR TIER 1 PHASE-IN
25. PC/LDV & LDT1 COMBINED WITH LDT2 FOR SFTP PHASE-IN
26. STANDARDS APPLY AT A USEFUL LIFE OF 11 YEARS / 120,000 MILES
27. GASOLINE AND DIESEL VEHICLES ONLY
28. TOTAL HC COMPLIANCE STATEMENT ALLOWED (IN LIEU OF TEST DATA)
29. PARTICULATES COMPLIANCE STATEMENT ALLOWED FOR NON-DIESEL CYCLE VEHICLES (IN LIEU OF SUPPLYING ACTUAL TEST DATA)
30. SPECIAL NMOG STANDARDS APPLY TO DUAL & FLEXIBLE FUEL VEHICLES, SEE 40 CFR 88.104-94(h) & (i)
31. DUAL & FLEXIBLE FUEL VEHICLES MAY MEET NEXT HIGHER (LESS STRINGENT) NMOG STANDARD WHEN OPERATING ON GASOLINE.
32. 0.10 GM/MILE PARTICULATE STANDARD APPLIES TO NON-DIESEL VEHICLES
33. SPECIAL EVAPORATIVE REQUIREMENTS APPLY (5.0 GRAMS MAX WITH THE EVAPORATIVE SYSTEM DISCONNECTED)
34. HIGHWAY NOx EMISSIONS SHALL NOT EXCEED 1.33 TIMES THE APPLICABLE FTP (CITY) NOx STANDARDS
35. COLD CO EMISSIONS FOR GASOLINE FUELED VEHICLES SHALL NOT EXCEED 10.0 GR/MI (LDV, LDT1, LDT2) OR 12.5 GM/MI (LDT3 & LDT4) AT 50K MILES
36. CALIFORNIA OBD-II SYSTEM REQUIRED, REF 40 CFR 86.1717-99
37. FEDERAL OBD SYSTEM REQUIRED BEGINNING WITH 1994 MODEL YEAR VEHICLES, REF 40 CFR 86.1806-01
38. IDLE CO EMISSIONS FROM GASOLINE, METHANOL, CNG & LPG TRUCKS SHALL NOT EXCEED 0.50 PERCENT EXHAUST GAS AT 120K MILES/11 YEARS COMPLIANCE STATEMENT ALLOWED (IN LIEU OF ACTUAL TEST DATA)
39. CERTIFICATION SHORT TEST (CST) EMISSIONS FROM GASOLINE VEHICLES SHALL NOT EXCEED 100 PPM HC OR 0.50 PERCENT EXHAUST GAS CO AT IDLE AND 2500 RPM AT 4K MILES; COMPLIANCE STATEMENT ALLOWED (IN LIEU OF DATA)
40. TIER 1, NLEV & CFV VEHICLES MUST MEET TIER 1 EMISSION STANDARDS AT HIGH ALTITUDE; TIER 0 VEHICLES MUST MEET SPECIAL HIGH ALTITUDE STANDARDS; COMPLIANCE STATEMENT ALLOWED (IN LIEU OF ACTUAL TEST DATA)
41. NLEV AND CFV (LDV, LDT1, LDT2) VEHICLES MUST MEET SPECIAL 50 DEG F EMISSION STANDARDS AT 4K MILES (NOT APPLICABLE TO DIESEL, CNG, OR HYBRID ELECTRIC VEHICLES); REF. 40 CFR 86.1708 & 1709-99 (b)(1)(iv)
42. SPECIAL INTERIM IN-USE EMISSION STANDARDS APPLY TO 1999 LEV AND 1999 TO 2002 ULEV VEHICLES; REF. 40 CFR 86.1808 & 1809-99(C) AS CORRECTED IN EPA GUIDANCE LETTER VPCD-98-03, APRIL 8, 1998.
43. TIER 0 AND TIER 1 EMISSION STANDARDS DO NOT APPLY TO ETHANOL VEHICLES

Table A.3. Acronyms used in Tables A.1, A.4, and A.5

Acronym	Definition
ALVW	adjusted loaded vehicle weight ([VCW+GWVR]/2)
CFV	Clean Fueled Vehicle (Program)
CO	carbon monoxide
GVWR	gross vehicle weight rating
HCHO	formaldehyde
HLDT	heavy light duty truck
ILEV	inherently low emission vehicle
LDT1	light duty truck, category 1 (GVWR ≤ 6,000 lb, LVW < 3,750 lb)
LDT2	light duty truck, category 2 (GVWR ≤ 6,000 lb, 3,751 ≤ LVW ≤ 5,750 lb)
LDT3	light duty truck, category 3 (6,000 < GVWR ≤ 8,500 lb, ALVW ≤ 5,750 lb)
LDT4	light duty truck, category 4 (6,000 < GVWR ≤ 8,500 lb, 5,750 < ALVW ≤ 3,450 lb)
LDV	light duty vehicle (passenger car)
LEV	low emission vehicle
LVW	loaded vehicle weight (VCW + 300 lb)
MDPV	medium duty passenger vehicle
NLEV	National Low Emission Vehicle (Program)
NMHC	nonmethane hydrocarbons
NMOG	nonmethane organic gases
NO_X	oxides of nitrogen
PM	particulate matter
THC	total hydrocarbons
TLEV	transitional low emission vehicle
ULEV	ultralow emission vehicle
VCW	vehicle curb weight [weight of vehicle with full tanks and components included but without passengers or luggage (load)]
ZEV	zero emission vehicle

Table A.4. Tier 2 and interim non-Tier-2 full useful life exhaust emissions standards

[All emissions in grams/mile (*Source*: www.epa.gov/otaq/standards.htm)]

Bin No.	NO_X	NMOG	CO	HCHO	PM	Notes
11	0.9	0.280	7.3	0.032	0.12	a, c
10	0.6	0.156/0.230	4.2/6.4	0.018/0.027	0.08	a, b, d
9	0.3	0.090/0.180	4.2	0.018	0.06	a, b, e
8	0.20	0.125/0.156	4.2	0.018	0.02	b, f
7	0.15	0.090	4.2	0.018	0.02	
6	0.10	0.090	4.2	0.018	0.01	
5	0.07	0.090	4.2	0.018	0.01	
4	0.04	0.070	2.1	0.011	0.01	
3	0.03	0.055	2.1	0.011	0.01	
2	0.02	0.010	2.1	0.004	0.01	
1	0.00	0.000	0.0	0.000	0.00	

Notes:

[a] This bin and its corresponding intermediate life bin are deleted at end of 2006 model year (end of 2008 model year for HLDTs and MDPVs).
[b] Higher NMOG, CO and HCHO values apply for HLDTs and MDPVs only.
[c] This bin is only for MDPVs.
[d] Optional NMOG standard of 0.280 g/mi applies for qualifying LDT4s and qualifying MDPVs only.
[e] Optional NMOG standard of 0.130 g/mi applies for qualifying LDT2s only.
[f] Higher NMOG standard deleted at end of 2008 model year.

Table A.5. Tier 2 and interim non-Tier-2 intermediate full useful life (50,000 mile) exhaust emissions standards

[All emissions in grams/mile (*Source:* www.epa.gov/otaq/standards.htm)]

Bin No.	NO_X	NMOG	CO	HCHO	PM	Notes
11	0.6	0.195	5.0	0.022		a c f h
10	0.4	0.125/0.160	3.4/4.4	0.015/0.018	....	a b d f g h
9	0.2	0.075/0.140	3.4	0.015	....	a b c f h
8	0.14	0.100/0.125	3.4	0.015	....	b f h i
7	0.11	0.075	3.4	0.015	....	f h
6	0.08	0.075	3.4	0.015	....	f h
5	0.05	0.075	3.4	0.015	....	f h

Notes:

[a] This bin deleted at end of 2006 model year (end of 2008 model year for HLDTs and MDPVs).
[b] Higher NMOG, CO and HCHO values apply for HLDTs and MDPVs only.
[c] This bin is only for MDPVs.
[d] Optional NMOG standard of 0.195 g/mi applies for qualifying LDT4s and qualifying MDPVs only.
[e] Optional NMOG standard of 0.100 g/mi applies for qualifying LDT2s only.
[f] The full useful life PM standards from Table S04–1 also apply at intermediate useful life.
[g] Intermediate life standards of this bin are optional for diesels.
[h] Intermediate life standards are optional for vehicles certified to a useful life of 150,000 miles.
[i] Higher NMOG standard deleted at end of 2008 model year.

APPENDIX B.
STATISTICAL ANALYSIS MODEL AND HYPOTHESES FOR ANALYZING VEHICLE DURABILITY TEST DATA

APPENDIX B. STATISTICAL ANALYSIS MODEL AND HYPOTHESES FOR ANALYZING VEHICLE DURABILITY TEST DATA

Assuming Linear Effect of Test Miles

Y_{jklm} = Emissions measure (or natural log of emissions measure) from m^{th} test on vehicle l (operated on road fuel REk) under emission test fuel Ek at j^{th} set of emissions tests following X_j miles,

where

j = 1, 2, 3 corresponding to X_j test miles (X_1 = 0 miles and X_2 and X_3 are as follows:
X_2 = 50,000 miles, if starting odometer (SO) is less than 45,000 miles;
95,000 - SO, if SO is between 45,000 and 70,000 miles;
25,000 miles, if SO is greater than 70,000 miles.
X_3 = 120,000 − X2, if SO is less than 70,000 miles;
25,000 miles, if SO is greater than 70,000 miles.
Here we assume that the full useful life (FUL) of every vehicle model is 120,000 miles.

k = 0, 10, 15, 20 corresponding to Ek, the emissions test fuel containing k% ethanol, k = 0, 10, 15, 20;
l = 1, 2, 3, 4 vehicles, each associated with one unique REk, the road fuel containing k% ethanol, k = 0, 10, 15, 20;
m = 1, 2 replicate tests;

The statistical model for evaluating the immediate and durability effects of ethanol on emissions and fuel economy for each vehicle model was as follows.

$$Y_{jklm} = \mu + \beta_0 X_j + \gamma_{1,Ek} T_{Ek} + \beta_{1,Rk} X_j R_{REk} + \beta_{2,Rk} X_j T_{Ek} R_{REk} + \delta_l + \eta_{jkl} + \varepsilon_{m(jkl)} ,$$

where

μ is a constant that represents the Vehicle 1 (RE0 tested vehicle) baseline (0 miles) average emissions with the E0 test fuel;
β_0 is the effect (per mile) of aging with road fuel RE0 on emissions using E0 test fuel;
$\gamma_{1,Ek}$ is the “ethanol effect” on emissions using test fuel Ek (k=10, 15, and 20);
$\beta_{1,Rk}$ is the “road fuel durability” effect (per mile) of operating with road fuel REk on E0 emissions;
$\beta_{2,Rk}$ is the effect (per mile) of the interaction of the “ethanol” and “durability” (i.e., change in emissions/mile increase with Ek test fuel and REk road fuel over and above the additive effects of $\gamma_{1,Ek}$ and $\beta_{1,REk}$ for k=10, 15, and 20, noting that $\beta_{2,RE0}$=0);
δ_l is the vehicle effect ($\delta_1 = 0$);
η_{jkl} is the random effect of differences among test setups (between pairs of replicates);
$\varepsilon_{m(jkl)}$ is the random effect of differences among replicate tests (within the same test setup);
T and R are indicator variables (i.e., $T_{Ek} = 1$ if Ek is the test fuel; 0, otherwise).

To address the study questions, the following statistical hypotheses were tested.

H_{1k}: $\gamma_{1,Ek}$=0; k=10, 15, 20	No immediate effect of k% ethanol in the test fuel
H_{2k}: $\beta_{1,Rk}$; k=10, 15, 20	No effect of k% road fuel on E0 emissions

H_{3k}: $\beta_{2,Rk}$; k=10, 15, 20 — No interaction between the immediate effect of the test fuel and the road fuel (i.e., effects are additive)

Figure B.1 illustrates how the model parameters are related to changes in measured emissions. Figure B.2 is an example of modeled results from a full data set for a single vehicle model. The error bars can represent confidence bounds on the predicted emissions.

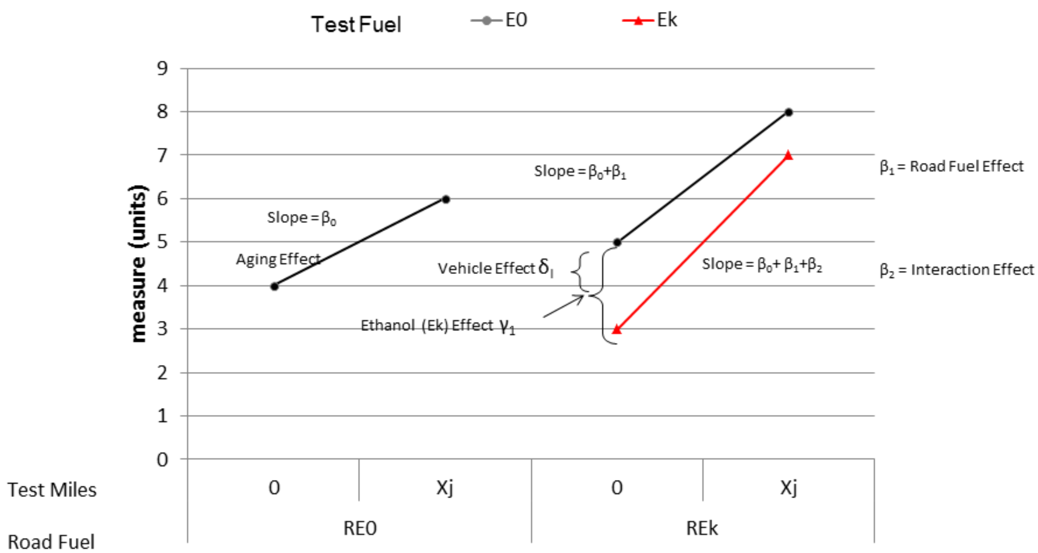


Fig. B.1. Illustration of model parameters.

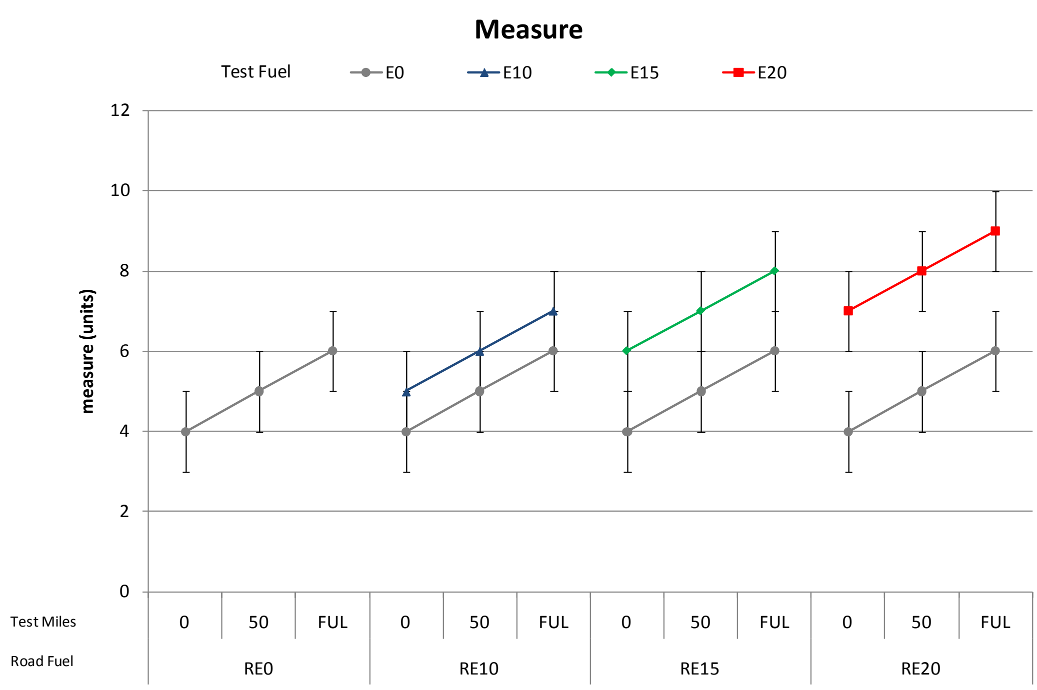


Fig. B.2. Example of a statistical model data set for a single vehicle type (error bars can represent 95% confidence bounds on the predicted emissions).

The statistical analyses for this project were done in Stata, v. 11.2. Before fitting the models, an outlier detection program was executed to identify any outliers. If any observation was outside the range (mean-3*standard deviation, mean+3*standard deviation), it was identified as a potential outlier. After comparing the results by fitting the model both with and without the potential outlier, if the results were significantly different (for example, a slope changed from insignificant to significant), the outlier was excluded from the analysis and noted in the summary table. Otherwise the potential outlier was not considered as an outlier, and it was included in the analysis.

The statistical models fit for each emission parameter and vehicle model were linear mixed effects models using the xtmixed procedure in Stata. The models included terms for mileage; interaction between mileage and road fuel; and interaction among mileage, test fuel, and road fuel, as covariates; road fuel and test fuel as fixed effects; and test-to-test setup as a random effect. The remaining error left unexplained by the model was assumed to represent the random differences between replicate tests within a test setup. If the interaction among mileage, test fuel, and road fuel was not significant, which indicated there was no significant slope difference between test fuel for the same road fuel, this term was dropped from the model. For the ethanol and aldehydes parameters, the emission data were log-transformed before fitting the model. To avoid the complexity of reporting the comparison results in the original units as ratios, approximating adjustments were made. The estimates and their confidence intervals were produced using the delta method and exponentiation of the log transformed model parameters.

By default, the xtmixed procedure in Stata uses the residual method to calculate degrees of freedom. With the relatively small sample sizes for this evaluation, it was more appropriate to calculate the degrees of freedom using the Satterthwaite estimation method. The xtmixed procedure in Stata does not have this calculation as an option. Therefore, it had to be calculated directly from the estimated variance components. The procedure used was as follows.

For any fixed effect or any linear combination of fixed effects, Stata provided the estimate $\widehat{\beta}$ and the variance of $\widehat{\beta}$,. $\widehat{Var(\beta)}$. It also output the two model variance components (η_{jkl} and $\varepsilon_{m(jkl)}$). Because the two variance components are independent, we know that the estimated variance can be written as a linear combination of the two variance components:

$$\widehat{Var(\beta)} = c_1\, \eta_{jkl} + c_2\, \varepsilon_{m(jkl)} \quad ,$$

where c_1, c_2 depend only on the study design and not on the values of the data. A similar equation can be generated by taking the original data, making minor random perturbations to it, and calculating a perturbated estimated variance $\widehat{Var(\beta)}'$ and corresponding model variance components, $(\eta_{jkl})'$ and $(\varepsilon_{m(jkl)})'$:

$$\widehat{Var(\beta)}' = c_1\, (\eta_{jkl})' + c_2\, (\varepsilon_{m(jkl)})' \quad .$$

The study design is identical for the new data, so the c_1, c_2 will be identical. Solving these two equations simultaneously provides the c_1, c_2.

The degrees of freedom for the original $\widehat{Var(\beta)}$ can then be calculated using Satterthwaite approximation as

$$DOF = \frac{[c_1\eta_{jkl} + c_2\varepsilon_{m(jkl)}]^2}{[\frac{c_1^2\eta_{jkl}^2}{\nu(\eta_{jkl})} + \frac{c_2^2\varepsilon_{m(jkl)}^2}{\nu(\varepsilon_{m(jkl)})}]} \quad ,$$

where $\nu(\eta_{jkl})$ and $\nu(\varepsilon_{m(jkl)})$ are the corresponding degrees of freedom for each variance component.

For some models, the assumption of a linear relationship between emission and mileage did not prove reasonable. In these cases, a mixed effects model, which included road fuel, test fuel, the interaction between test stage and road fuel as fixed effects and test-to-test setup as random effect, was used instead.

APPENDIX C.
DETAILED VEHICLE INFORMATION

APPENDIX C. DETAILED VEHICLE INFORMATION

This appendix contains detailed vehicle specifications such as powertrain configuration, engine family (test group), equivalent test weight, dynamometer coefficients, and individual vehicle identification numbers (VINs) for the vehicles tested at the three sites [Southwest Research Institute (SwRI), Transportation Research Center (TRC), and Environmental Testing Corporation (ETC)]. There is one table per vehicle model. Table C.1 shows the contents of this appendix.

Table C.1. List of Appendix C tables

2007 Honda Accord (SwRI)						
Powertrain Config	**Displ. (L)**	**Layout**	**Evap Family**	**Engine Family**	**Transmission**	**Certification Level**
	2.4	I-4	7HNXR0140BBA	7HNXV02.4KKC	A5	Tier 2 Bin 5

Dyno Coefficients		A	B	C	ETW
	Target	24.87	0.444	0.01465	3,500
	Set	11.43	0.066	0.01801	3,500

Aging Fuel	VIN	Starting Odometer
RE0	1HGCM56367A137174	31,686
RE10	1HGCM56727A141399	32,182
RE15	1HGCM56737A016217	31,308
RE20	1HGCM56347A138128	34,383

2006 Chevrolet Silverado (SwRI)						
Powertrain Config	**Displ. (L)**	**Layout**	**Evap Family**	**Engine Family**	**Transmission**	**Certification Level**
	5.3	V-8	6GMXR0176820	6GMXT05.3379	A4	Tier 2 Bin 8

Dyno Coefficients		A	B	C	ETW
	Target	28.96	1.6815	0.02177	5,250
	Set	11.77	1.097	0.02665	5,250

Aging Fuel	VIN	Starting Odometer
RE0	1GCEK19B16Z267999	27,606
RE10	1GCEK19B66Z154114	14,319
RE15	1GCEK19B96Z19468	17,121
RE20	1GCEK19B56EZ20201	17,103

2008 Nissan Altima (SwRI)						
Powertrain Config	**Displ. (L)**	**Layout**	**Evap Family**	**Engine Family**	**Transmission**	**Certification Level**
	2.5	I-4	8NSR0120PBA	8NSXV02.5G5A	CVT	Tier 2 Bin 5

Dyno Coefficients		A	B	C	ETW
	Target	46.47	-0.4531	0.02414	3,500
	Set	19.71	-0.3066	0.021358	3,500

Aging Fuel	VIN	Starting Odometer
RE0	1N4AL21E28C198677	19,263
RE10	1N4AL21E08C198208	19,517
RE15	1N4AL21E08C231286	9,935
RE20	1N4A121E08C218263	10,295

2008 Ford Taurus (SwRI)						
Powertrain Config	**Displ. (L)**	**Layout**	**Evap Family**	**Engine Family**	**Transmission**	**Certification Level**
	3.5	V-6	8FMXR0145KBK	8FMXV03.5VEP	A6	Tier 2 Bin 5
Dyno Coefficients			**A**	**B**	**C**	**ETW**
	Target		37.32	0.4299	0.02115	4,250
	Set		20.71	-0.3787	0.028959	4,250

Aging Fuel	VIN	Starting Odometer
RE0	1FAHP24W28G175013	17,230
RE10	1FAHP24W58G174230	15,662
RE15	1FAHP24W58G175717	17,098
RE20	1FAHP24W38G177188	13,081

2007 Dodge Caravan (SwRI)						
Powertrain Config	**Displ. (L)**	**Layout**	**Evap Family**	**Engine Family**	**Transmission**	**Certification Level**
	3.8	V-6	7CRXR0177GHA	7CRXT03.8NEO	A4	Tier 2 Bin 5
Dyno Coefficients			**A**	**B**	**C**	**ETW**
	Target		34.46	0.3867	0.0231	4,500
	Set		11.96	0.1832	0.02351	4,500

Aging Fuel	VIN	Starting Odometer
RE0	1D4GP24R67B186773	46,467
RE10	1D4GP24RX7B138127	44,721
RE15	1D4GP24R07B137987	40,024
RE20	1D4GP24R27B104022	50,797

2006 Chevrolet Cobalt (SwRI)						
Powertrain Config	**Displ. (L)**	**Layout**	**Evap Family**	**Engine Family**	**Transmission**	**Certification Level**
	2.4	I-4	6GMXR0105817	6GMSV02.4029	A4	Tier 2 Bin 5
Dyno Coefficients			**A**	**B**	**C**	**ETW**
	Target		26.11	0.4655	0.01565	3,125
	Set		9.54	0.2268	0.01598	3,125

Aging Fuel	VIN	Starting Odometer
RE0	1G1AK55F367813690	38,862
RE10	N/A	N/A
RE15	1G1AK55F367666822	47,672
RE20	1G1AK55F367638180	38,454

2007 Dodge Caliber (SwRI)						
Powertrain Config	**Displ. (L)**	**Layout**	**Evap Family**	**Engine Family**	**Transmission**	**Certification Level**
	2.4	I-4	7CRXR0112GHA	7CRXB02.4ME5	CVT	Tier 2 Bin 5

Dyno Coefficients		**A**	**B**	**C**	**ETW**
	Target	43.86	0.2502	0.02394	3,375
	Set	-7.72	1.187	0.0125	3,375

Aging Fuel	**VIN**	**Starting Odometer**
RE0	1B3HB48B47D225987	41,126
RE10	N/A	N/A
RE15	1B3HB48B67D563987	48,037
RE20	1B3HB48B47D147730	46,853

2009 Jeep Liberty (TRC)						
Powertrain Config	**Displ. (L)**	**Layout**	**Evap Family**	**Engine Family**	**Transmission**	**Certification Level**
	3.7	V-6	9CRXR0150PK0	9CRXT03.74PO	A4	Tier 2 Bin 5

Dyno Coefficients		**A**	**B**	**C**	**ETW**
	Target	54.27	0.5165	0.02833	4,500
	Set	23.180	0.245	0.029	4,500

Aging Fuel	**VIN**	**Starting Odometer**
RE0	1J8GP28K09W523520	New
RE10	N/A	N/A
RE15	1J8GP28K49W520670	New
RE20	1J8GP28K69W517351	New

2009 Ford Explorer (TRC)						
Powertrain Config	**Displ. (L)**	**Layout**	**Evap Family**	**Engine Family**	**Transmission**	**Certification Level**
	4.0	V-6	9FMXR0195GBR	9FMXT04.03DC	A5	Tier 2 Bin 4

Dyno Coefficients		**A**	**B**	**C**	**ETW**
	Target				
	Set	13.168	0.425	0.027	5,000

Aging Fuel	**VIN**	**Starting Odometer**
RE0	1FMEU63E79UA03855	New
RE10	N/A	N/A
RE15	1FMEU63E19UA02233	New
RE20	1FMEU63E89UA03279	New

2009 Honda Civic (TRC)						
Powertrain Config	**Displ. (L)**	**Layout**	**Evap Family**	**Engine Family**	**Transmission**	**Certification Level**
	1.8	I-4	9HNXR0106VEA	9HNXV01.8XB9	A5	Tier 2 Bin 5

Dyno Coefficients		**A**	**B**	**C**	**ETW**
	Target	25.71	0.2759	0.01645	3,125
	Set	10.270	0.151	0.016	3,125

Aging Fuel	**VIN**	**Starting Odometer**
RE0	2HGFA16359H330824	New
RE10	N/A	N/A
RE15	2HGFA163X9H337767	New
RE20	2HGFA16309H334618	New

2009 Toyota Corolla (TRC)						
Powertrain Config	**Displ. (L)**	**Layout**	**Evap Family**	**Engine Family**	**Transmission**	**Certification Level**
	1.8	I-4	9TYXR0115P12	9TYXV01.8BEA	A4	Tier 2 Bin 5

Dyno Coefficients		**A**	**B**	**C**	**ETW**
	Target	33.029	-0.03433	0.023937	3,250
	Set	12.773	-0.009	0.023	3,250

Aging Fuel	**VIN**	**Starting Odometer**
RE0	2T1BU40E89C145385	New
RE10	N/A	N/A
RE15	2T1BU40E09C179787	New
RE20	2T1BU40E79C113978	New

2005 Toyota Tundra (TRC)						
Powertrain Config	**Displ. (L)**	**Layout**	**Evap Family**	**Engine Family**	**Transmission**	**Certification Level**
	4.0	V-6	5TYXR0190P20	TYXT04.0NEM	A5	Tier 2 Bin 5

Dyno Coefficients		**A**	**B**	**C**	**ETW**
	Target				
	Set	21.826	0.229	0.034	4,500

Aging Fuel	**VIN**	**Starting Odometer**
RE0	5TBJU32135S454661	54,169
RE10	N/A	N/A
RE15	5TBJU32105S444430	44,171
RE20	5TBJU32175S450600	42,398

2006 Chevrolet Impala (TRC)						
Powertrain Config	Displ. (L)	Layout	Evap Family	Engine Family	Transmission	Certification Level
	3.9	V-6	6GMXR0133810	6GMXV03.9048	A4	Tier 2 Bin 5

Dyno Coefficients		A	B	C	ETW
	Target				
	Set	11.510	0.093	0.018	4,000

Aging Fuel	VIN	Starting Odometer
RE0	2G1WC581969116199	30,997
RE10	N/A	N/A
RE15	2G1WC581X69183846	36,323
RE20	2G1WC581469113906	37,772

2005 Ford F150 (TRC)						
Powertrain Config	Displ. (L)	Layout	Evap Family	Engine Family	Transmission	Certification Level
	5.4	V-8	5FMXR0240NBM	5FMXT05.4R17	A	Tier 2 Bin 8

Dyno Coefficients		A	B	C	ETW
	Target				
	Set	13.132	0.581	0.032	6,000

Aging Fuel	VIN	Starting Odometer
RE0	1FTPX14555FA81636	42,314
RE10	N/A	N/A
RE15	1FTPX14595NA31506	44,685
RE20	1FTPX14585NA46126	51,388

2006 Nissan Quest (TRC)						
Powertrain Config	Displ. (L)	Layout	Evap Family	Engine Family	Transmission	Certification Level
	3.5	V-6	6NSXR0120PBB	6NSXT03.5G7B	A5	Tier 2 Bin 5

Dyno Coefficients		A	B	C	ETW
	Target				
	Set	14.660	-0.231	0.034	4,750

Aging Fuel	VIN	Starting Odometer
RE0	5N1BV28U16N124511	49,998
RE10	N/A	N/A
RE15	5N1BV28U96N124840	55,076
RE20	5N1BV28U16N124511	49,848

2009 Saturn Outlook (ETC)						
Powertrain Config	Displ. (L)	Layout	Evap Family	Engine Family	Transmission	Certification Level
	3.6	V-6	9GMXR0197972	9GMXT03.6151	A6	Tier 2 Bin 5

Dyno Coefficients		A	B	C	ETW
	Target	48.31	0.5976	0.02597	5,250
	Set	30.44	0.1266	0.0287	5,250

Aging Fuel	VIN	Starting Odometer
RE0	5GZER13D59J180937	New
RE10	N/A	N/A
RE15	5GZER13D49J181741	New
RE20	5GZER13D39J197980	11,638

2009 Toyota Camry (ETC)						
Powertrain Config	Displ. (L)	Layout	Evap Family	Engine Family	Transmission	Certification Level
	2.4	I-4	9TYXR0130A12	9TYXV02.4BEA	A5	Tier 2 Bin 5

Dyno Coefficients		A	B	C	ETW
	Target	29.35	0.1659	0.01845	3,750
	Set	11.64	-0.1228	0.02084	3,750

Aging Fuel	VIN	Starting Odometer
RE0	4T1BE46K89U375470	New
RE10	N/A	N/A
RE15	4T1BE46K79U892484	New
RE20	4T1BE46K79U288823	12,226

2009 Ford Focus (ETC)						
Powertrain Config	Displ. (L)	Layout	Evap Family	Engine Family	Transmission	Certification Level
	2.0	I-4	9FMXR0125NAA	9FMXV02.0VDX	A4	Tier 2 Bin 4

Dyno Coefficients		A	B	C	ETW
	Target	24.40	0.7652	0.01193	3,000
	Set	8.26	0.6083	0.01289	3,000

Aging Fuel	VIN	Starting Odometer
RE0	1FAHP35N29W172017	New
RE10	N/A	N/A
RE15	1FAHP35NX9W178664	New
RE20	1FAHP36N89W168617	16,133

2009 Honda Odyssey (ETC)						
Powertrain Config	Displ. (L)	Layout	Evap Family	Engine Family	Transmission	Certification Level
	3.5	V-6	9HNXR01562EA	9HNXT03.5J29	A5	Tier 2 Bin 5

Dyno Coefficients		A	B	C	ETW
	Target	36.13	0.5849	0.02162	5,000
	Set	21.32	0.1407	0.02412	5,000

Aging Fuel	VIN	Starting Odometer
RE0	5FNRL38229B024871	New
RE10	N/A	N/A
RE15	5FNRL38219B024876	New
RE20	5FNRL38289B033459	19,540

2000 Chevrolet Silverado (SwRI)						
Powertrain Config	Displ. (L)	Layout	Evap Family	Engine Family	Transmission	Certification Level
	5.3	V-8		YMXT05.3181	A4	Tier 1 LDT3

Dyno Coefficients		A	B	C	ETW
	Target	69.36	0	0.04641	5,500
	Set	62.32	-1.2855	0.05486	5,500

Aging Fuel	VIN	Starting Odometer
RE0	2GCEK19T7Y1270491	110,730
RE10	N/A	N/A
RE15	1GECEK19T1YE135912	110,990
RE20	1GCEK19TXYE191296	114,277

2002 Nissan Frontier (SwRI)						
Powertrain Config	**Displ. (L)**	**Layout**	**Evap Family**	**Engine Family**	**Transmission**	**Certification Level**
	2.4	I-4	2NSXR0110RCC	2NSXT02.4C4B*	A4	NLEV LDT1

		A	B	C	ETW
Dyno Coefficients	**Target**	45.22	0	0.03021	3,625
	Set	15.63	0.0328	0.02745	3,625

Aging Fuel	VIN	Starting Odometer
RE0	1N6DD26S02C389876	94,498
RE10	N/A	N/A
RE15	1N6DD26S42C344018	90,650
RE20	1N6DD26S02C346445	96,408

*The EPA online emissions database (U.S. Environmental Protection Agency, "Cars and Light Trucks; Annual Certification Test Results and Data," http://www.epa.gov/otaq/crttst.htm) contains only two entries for 2002 Nissan light trucks using a 2.4 L four-cylinder engine. The Frontier entry shows a four-speed automatic transmission, ETW of 3,625 lb, and LDT1 emissions standards. The XTerra entry shows a five-speed manual transmission, ETW of 4,000 lb, and LDT2 emissions standards. Confusion arose during vehicle acquisition as the engine family number listed in the EPA database for the Frontier (2NSXT02.4C4A) could only be found in XTerra vehicles, and the EPA-listed XTerra engine family (2NSXT02.4C4B) was only found in Frontier vehicles. Three matching Frontiers were acquired, with matching engine family, as shown. Frontiers were weighed and found to have curb weights of about 3,200 pounds. The manufacturer was consulted and confirmed that the Frontiers should be tested at 3,625 pounds.

2002 Dodge Durango (SwRI)						
Powertrain Config	**Displ. (L)**	**Layout**	**Evap Family**	**Engine Family**	**Transmission**	**Certification Level**
	4.7	V-8	2CRXE0101GDH	2CRXT04.75B0	A4	Tier 1 LDT3

		A	B	C	ETW
Dyno Coefficients	**Target**	32.61	0.1049	0.03253	4,750
	Set	17.03	0.4993	0.02793	4,750

Aging Fuel	VIN	Starting Odometer
RE0	1B4HR38N42F134968	70,556
RE10	N/A	N/A
RE15	1B4HR38NX129581	59,764
RE20	1B4HR48N02F148582	63,713

2003 Toyota Camry (TRC)						
Powertrain Config	Displ. (L)	Layout	Evap Family	Engine Family	Transmission	Certification Level
	2.4	I-4	3TYXR0135AK1	3TYXV02.4HHA	A4	ULEV

Dyno Coefficients		A	B	C	ETW
	Target				
	Set	8.153	0.057	0.019	3,500

Aging Fuel	VIN	Starting Odometer
RE0	4T1BE32K93V710212	76,695
RE10	N/A	N/A
RE15	JTDBE32K330193579	76,550
RE20	JTDBE32K730174467	80,729

2003 Ford Taurus (TRC)						
Powertrain Config	Displ. (L)	Layout	Evap Family	Engine Family	Transmission	Certification Level
	3.0	V-6	3FMXR0115BAE	3FMXV03.0VF3	A4	NLEV

Dyno Coefficients		A	B	C	ETW
	Target				
	Set	10.396	0.428	0.014	3,625

Aging Fuel	VIN	Starting Odometer
RE0	1FAHP56S93A163402	92,710
RE10	N/A	N/A
RE15	1FAFP55S53G275037	88,130
RE20	1FAFP55S13A216277	83,671

2003 Chevrolet Cavalier (TRC)						
Powertrain Config	Displ. (L)	Layout	Evap Family	Engine Family	Transmission	Certification Level
	2.2	I-4	3GMXR0124919	3GMXV02.2025	A4	NLEV

Dyno Coefficients		A	B	C	ETW
	Target				
	Set	20.500	0.657	0.013	3,375

Aging Fuel	VIN	Starting Odometer
RE0	1G1JC52F337344890	88,752
RE10	N/A	N/A
RE15	1G1JC52F437299216	80,702
RE20	1G1JC52FX37325494	87,472

2000 Honda Accord (ETC)						
Powertrain Config	**Displ. (L)**	**Layout**	**Evap Family**	**Engine Family**	**Transmission**	**Certification Level**
	2.3	I-4	YHNXR0130AAA	YHNXV02.3PF3	A4	NLEV
Dyno Coefficients		**A**	**B**	**C**	**ETW**	
	Target	26.01	0.4918	0.01591	3,375	
	Set	7.68	0.0291	0.0197	3,375	

Aging Fuel	VIN	Starting Odometer
RE0	1HGCG5649YA027642	91,475
RE10	N/A	N/A
RE15	1HGCG5647YA153420	95,285
RE20	1HGCG5649YA049592	89,499

2000 Ford Focus (ETC)						
Powertrain Config	**Displ. (L)**	**Layout**	**Evap Family**	**Engine Family**	**Transmission**	**Certification Level**
	2.0	I-4	YFMXR0080BBE	YFMXV02.0VF3	A4	NLEV
Dyno Coefficients		**A**	**B**	**C**	**ETW**	
	Target	30.85	0.5080	0.01649	3,125	
	Set	16.03	0.1742	0.0183	3,125	

Aging Fuel	VIN	Starting Odometer
RE0	1FAFP34P3YW412653	102,994
RE10	N/A	N/A
RE15	1FAFP34P9YW400216	85,425
RE20	1FAFP34P4YW422950	69,919

APPENDIX D.
DETAILED STATISTICAL RESULTS BY PARAMETER

APPENDIX D. DETAILED STATISTICAL RESULTS BY PARAMETER

D.1 Introduction

For each parameter (emissions or fuel economy) statistical models have been separately fit to data for 26 different vehicle models from the Federal Test Procedure (FTP). [The Nissan Quest was omitted from these analyses because it did not run the standard road cycle (SRC) for the duration of the program and because the RE0 vehicle did not reach end-of-test (EOT).] Each of these statistical models aggregates test data for multiple individual vehicles, road test fuels (RE0, RE10, RE15, and RE20), mileage points [start-of-test (SOT), midlife aging (MID), and EOT], and emissions test fuels (E0, E10, E15, and E20). The discussion below provides references to these individual parameter models but, more importantly, summarizes the observed results at the fleet level. For each parameter, the results of immediate ethanol effects are provided first. The immediate ethanol effect is the change in the emission/performance parameter as estimated by the statistical model for a vehicle at acquisition (i.e., before beginning its road fuel aging) that is operated with an ethanol blend test fuel (E10, E15, or E20) as compared to a vehicle of the same design that is operated on E0. Results for the immediate ethanol effect are presented for each of the three separate ethanol blend test fuels and overall for all of them.

Following the immediate ethanol effects, the results of aging are discussed. Aging is presented as the change in emission/performance parameter as estimated by the statistical model over a normalized 100,000-mile test period. Aging was evaluated for each vehicle model and for all road fuels (RE0, RE10, RE15, and RE20). The model estimates of data from vehicles run with RE0 and tested at three intervals with E0 provide a base evaluation of aging effects. Estimates were also developed for vehicles run with an “RExx” ethanol blend road fuel and tested at three intervals with the “Exx” blend of the same ethanol content as well as E0. Note that it was possible for the Exx and E0 test results for an RExx ethanol blend to provide different aging estimates. If this happened, the E0 test results for the RExx vehicle are reported as the aging effect, and the incremental Exx impact on aging is separately reported. This situation occurred in only a few instances, and the results are shown in the tables but are not discussed further hereafter. In addition to separately estimating the aging effect for each vehicle model under each road fuel, the RE10, RE15, and RE20 statistical model aging results were jointly tested to determine whether there was evidence of a differential ethanol road fuel effect on aging.

In Tables D.1 through D.9, results are presented by parameter in the following order: CO, oxides of nitrogen (NO_X), nonmethane hydrocarbon (NMHC), nonmethane organic gas (NMOG), fuel economy, ethanol, acetaldehyde, formaldehyde, and CH_4. Each table shows separate statistical model results for each vehicle model and one emission parameter or fuel economy. The components of these tables are as follows.

- Emissions (units)—The emission/performance parameter being modeled and its corresponding test units.
- V1 results (immediate effect of ethanol)—A reference column that indicates, where known, the trend of the immediate effect of ethanol for that parameter based on the V1 study. (Note that the V1 study used the LA92 (unified cycle), while the study reported here used the FTP.)[*]
- Vehicle model—The year and model of the vehicles tested.
- LFT@WOT—An indicator regarding whether the vehicle model applies long-term or learned fuel trim (LFT) at wide-open throttle (WOT) (see Sect. 3.1).

[*]Keith Knoll et al., *Effects of Intermediate Ethanol Blends on Legacy Vehicles and Small Non-Road Engines*, Report 1—Updated, NREL/TP-540-43543/ORNL/TM-2008/117, February 2009, available at http://www.nrel.gov/docs/fy09osti/43543.pdf.

- Standard—U.S. Environmental Protection Agency Emission standard.
- Ethanol effect (units at zero miles; E0: Δ units versus E0; E10, E15, and E20: percent change versus E0; E10, E15, and E20: overall p-value)—The estimated true performance level at E0 is shown and the E10, E15, and E20 ethanol effect sizes are displayed both as differences relative to E0 level and as percentages of the E0 level. A p-value for the joint test of any ethanol effect.
- Aging effect with RE0 (Δ units per 100,000 miles; RE0/E0: overall p-value)—The estimated aging effect per 100,000 miles of a vehicle driven with RE0 and tested with E0 and the corresponding p-value for the statistical test of whether the aging effect is different from zero.
- REx aging effect on E0 emissions (Δ units per 100,000 miles; RE10/E0, RE15/E0, and RE20/E0: overall p-value)—The estimated aging effects per 100,000 miles for vehicles driven with RE10, RE15, and RE20 and tested with E0. An overall p-value is provided for the test of whether all three ethanol fuel aging effects are statistically indistinguishable from the RE0 aging effect.

Two important special cases are presented for some of the vehicles in Tables D.1 to D.9. If the "Vehicle Model" value is appended with the symbol "#," the data for that vehicle were transformed by the natural logarithm before fitting the model. This special case only occurred for some of the vehicles with acetaldehyde and formaldehyde. In these cases, the ethanol effect increased with increasing test miles, as contrasted with the nontransformed models where the ethanol effect was constant. To enable reporting of only a single ethanol effect, it was decided to present the value as estimated for the zero test mileage. The same is true for the aging effects where the reported slopes of units per 100,000 miles apply to the zero test mileage. If the "Vehicle Model" value is appended with the symbol "##," the data did not support the assumption of a response linear with test mileage. As a consequence, such cases were fit with the test mileage as a categorical variable. This special case only occurred for the 2006 Silverado with fuel economy, all of the vehicle models for ethanol emission, and for a small number of vehicle models for each of acetaldehyde and formaldehyde emissions parameters. The implication of this modeling is that the ethanol effect for each of E10, E15, and E20 has separate results at each of the three mileage test points. Again to facilitate reporting of only a single value, the approach in these models was to average the effects at the three separate time points (SOT, MID, and EOT). For road fuel aging, the lack of linearity prevented the same calculation of slope in emission/performance parameter result with miles driven. As a proxy for the aging effect, the difference in outcome at the final mileage point and the first mileage point (zero miles) was calculated and divided by the number of miles between these two and then adjusted to a reference 100,000 miles. In both of these special cases, care should be exercised to only interpret the results within the limitations of the modeling.

Cell values in Tables D.1 through D.9 that are appended with an asterisk ("*") indicate that the statistical test for this particular result (i.e., different from zero) is significant with 95% confidence. In the overall p-value columns, a value of 0.05 or less is asterisked as significant.

Figures D.1 through D.9 provide specific fleet analysis results for each of the following: CO, NO_X, NMHC, NMOG, fuel economy, ethanol, acetaldehyde, formaldehyde, and CH_4. Each figure contains four quadrant plots and two tables. The components of the figures are as follows.

- Test Fuel Effect (zero miles)
  - The upper left quadrant plot is of the immediate estimated ethanol fuel effect across the tested fleet. Each vehicle model and ethanol level is a separate plotted point. The source of the plotted values is the same as those data in Tables D.1 through D.9, "Ethanol Effect (Δ units versus E0; E10, E15, and E20)." Note that plot symbols are randomly offset horizontally to enhance differentiation of the individual values. Under the plot are statistics for testing whether the entire set of ethanol test fuel vehicle results is statistically different from that of the E0 test fuel. Both a nonparametric result (testing the hypothesis that the median difference is zero versus the

alternative that it is not zero) and a parametric result (testing the hypothesis that the mean difference is zero versus the alternative that it is not zero) are provided. In most cases the two results produce similar statistical conclusions (i.e., whether to reject the hypothesis and conclude the alternative). The parametric test is preferred because of its greater sensitivity. However, the parametric tests shown here are only strictly applicable when the test samples meet certain assumptions dealing with variability and normality of the underlying populations of data. The data collected suggest some concerns with these assumptions. Therefore, while the parametric results are shown, the more conservative nonparametric results are the basis for the discussion of results that follows. The statistical tests include a separate test for each of the three ethanol fuel blends (E10, E15, and E20) and a single test for any fuel differences (overall). If the value for the test is 0.05 or less, it can be interpreted that the hypothesis (denoted with "H:") is unlikely to be true, as the probability of the hypothesis being true and simultaneously collecting a random set of data with the observed characteristics is less than 1 in 20. Therefore it can be concluded that a statistically significant difference exists, and the original hypothesis can be rejected. Note that a p-value greater than 0.05 does not constitute proof that the original hypothesis is necessarily true, only that there is insufficient evidence to reject it.

— The lower left quadrant graph has the same data points as the plot above it, but the data are divided within each ethanol fuel grouping depending on whether the vehicle model was found to apply LFT at WOT. The statistical tests below the graph are the nonparametric and parametric comparisons of whether the test fuel effect among the LFT vehicles is different from those without it. The nonparametric test for this difference cannot be readily extended to the aggregate of all three ethanol test fuels, so this p-value is identified with an "NA."

- Road Fuel Effect on E0 Emission

— The upper right quadrant plot is of the road fuel aging effects for RE0, RE10, RE15, and RE20, evaluated with E0 Federal Test Procedure results. The source of the plotted values is the same as those data in Tables D.1 through D.9, "Aging Effect with RE0 (Δ units per 100,000 miles; RE0/E0)" and "RExx Aging Effect on E0 Emissions (Δ units per 100,000 miles; RE10/E0, RE15/E0, and RE20/E0)." As identified above, base aging is represented by the RE0 results. Under the plot, both nonparametric and parametric test results are shown for the hypothesis that no aging effect for RE0 vehicles exists compared to the alternative hypothesis that some aging effect occurs across all the vehicle models. The RE10, RE15, and RE20 aging effects represent the sum of aging inherent in the vehicle models themselves (same as RE0 aging) and any incremental aging effect (could be positive or negative) from the use of ethanol blends rather than RE0. Separate nonparametric and parametric test statistics are provided for the hypothesis of zero aging across all vehicle models run with each of the fuels, RE10, RE15, and RE20. Additionally, an overall test determines whether there was any evidence of aggregate aging for RE10, RE15, and RE20 versus RE0.

— The lower right quadrant graph has the same data points as the plot above it, but they are divided within each ethanol fuel grouping depending on whether the vehicle model was found to apply LFT at WOT. The statistical tests below the graph are the nonparametric and parametric comparisons of whether the road fuel aging effects among the LFT vehicles are different from those without it. The nonparametric test for this difference cannot be readily extended to the aggregate of all three ethanol test fuels, so this p-value is identified as "not applicable" ("NA").

D.2 Discussion

Considering the 26 vehicle models tested, there were 5 vehicles tested with E10, 26 vehicles tested with E15, and 22 vehicles tested with E20, for a total of 53 ethanol blend test cases, for which there were

53 statistical models which could be used to test the ethanol effect. Each parameter is discussed below in light of these 53 test cases.

D.2.1 Carbon monoxide

Immediate ethanol effect

Consistent with the previously reported V1 results[*], testing with ethanol blends resulted in lower CO levels than E0 in most cases. As shown in Table D.1, across the three ethanol fuel blends, 44 of the 53 statistical models showed lower CO levels when tested with ethanol blends. For 10 of those 44 models, the lower CO levels were statistically significant. Referencing CO results in Table D.1, decreases by fuel and vehicle model ranged to nearly as much as the E0 test results at zero miles, though most reductions were less than 50% of the E0 test results at zero miles. Combining all the vehicles, as shown in Fig. D.1, results in the conclusion that across all three ethanol fuels and over the fleet, ethanol tested CO, on median, is lower than E0 tested CO for the same vehicle models, with a p-value less than 0.0001 based on a sign test. Figure D.1 further shows no differentiation in immediate ethanol effect as a function of LFT (p-values 1.0000, 0.3891, and 0.8447 for the Wilcoxon test with E10, E15, and E20, respectively).

Road fuel aging and differential ethanol road fuel effect on aging

Across the fleet as shown in Table D.1, in 21 of 26 cases, vehicles run with RE0 and subsequently tested with E0 showed a trend of increasing CO emission rates (9 of them statistically significant) with increasing total miles driven. Increases were as great as +7.93 g/mile (2000 Accord). In most cases, though, the positive effect did not exceed about +3.00 g/mile. With a p-value of 0.0025, as shown in Fig. D.1, the median across all tested statistical models for the change in CO levels per 100,000 miles driven under RE0 fuel was greater than zero at the statistically significant level. Hence, there is evidence of systematic aging for CO emissions across the fleet.

When examining aging in vehicles aged with ethanol fuel blends, the same general trend was observed as with RE0. Specifically, 46 of the 53 cases showed a positive aging effect (Table D.1). The observed increases were comparable to the RE0 aging effect. With a p-value less than 0.0001 (Fig. D.1), the median change in CO levels with ethanol test fuels was greater than zero for the fleet overall at the statistically significant level. From Table D.1, only 5 of 26 vehicle models provided some evidence for a different aging effect with ethanol blended aging fuels than with RE0. Hence, it appears reasonable to conclude that the use of ethanol fuels does not change the aging that is observed for CO. Finally, Fig. D.1 provides no strong evidence that the aging effect, regardless of which road fuel is used, is influenced by application of LFT, as evaluated in the nonparametric test statistics.

D.2.2 Oxides of nitrogen

Immediate ethanol effect

The NO_X emissions levels were higher with ethanol blended fuels as compared to E0 in most statistical models, as shown in Table D.2. Across the three ethanol fuel blends, 39 of the 53 cases showed higher NO_X levels when tested with ethanol blends. Five of the 39 higher model results were statistically significant. Referencing NO_X results in Table D.2, the increases by fuel and vehicle model ranged to as much as the E0 test fuel result measured at zero miles. Combining all the vehicles, as shown in Fig. D.2, results in the conclusion that across all three ethanol fuels and over the fleet, ethanol tested NO_X, on

[*]Keith Knoll et al., *Effects of Intermediate Ethanol Blends on Legacy Vehicles and Small Non-Road Engines,* Report 1—Updated, NREL/TP-540-43543/ORNL/TM-2008/117, February 2009, available at http://www.nrel.gov/docs/fy09osti/43543.pdf.

median, is higher than E0 tested NO_X for the same vehicles, with a p-value of 0.0009 based on a sign test. Figure D.2 further shows no differentiation in immediate ethanol effect as a function of LFT (p-values 0.5637, 0.9556, and 0.1364 for the Wilcoxon test with E10, E15, and E20, respectively).

Road fuel aging and differential ethanol road fuel effect on aging

Across the fleet, as shown in Table D.2, in 25 of 26 cases, vehicles run with RE0 and subsequently tested with E0 showed a trend of increasing NO_X emission rates (15 of them statistically significant) with increasing total miles driven. Increases were as great as +0.479 g/mile (2000 Silverado). In most cases, though, the positive effect did not exceed about +0.15 g/mile. With a p-value less than 0.0001, as shown in Fig. D.2, the median of the change in NO_X levels across all tested statistical models per 100,000 miles driven under RE0 fuel was greater than zero at the statistically significant level. Hence, there is evidence of systematic aging for NO_X emissions across the fleet.

When examining aging in vehicles run with ethanol fuel blends, the same general trend was observed as with RE0. Specifically, 51 of the 53 cases showed a positive aging effect (Table D.2). The observed increases were of a comparable magnitude to the RE0 aging effect. With a p-value less than 0.0001 (Fig. D.2), the median change in NO_X levels with ethanol test fuels was greater than zero at the statistically significant level for the fleet overall. From Table D.2, only 5 of 26 vehicle models provided some evidence for a different aging effect under ethanol road fuels than under RE0. Hence, it appears reasonable to conclude that the use of ethanol fuels does not change the aging that is observed for NO_X. Finally, Fig. D.2 provides no strong evidence that the aging effect, regardless of which road fuel is used, is influenced by application of LFT.

D.2.3 Nonmethane hydrocarbons

Immediate ethanol effect

Consistent with the previously reported V1 results, NMHC levels were lower for testing ethanol blend fuels than E0 in most statistical models, as shown in Table D.3. Across the three ethanol fuel blends, 48 of the 53 statistical models showed lower NMHC levels when tested with ethanol blends. Eight of the 48 model results were statistically significant. Referencing NMHC results in Table D.3, the reductions by fuel and vehicle were as great as 42% relative to the E0 test fuel result. Combining all the vehicles, as shown in Fig. D.3, results in the conclusion that across all three ethanol fuels and over the fleet, ethanol-tested NMHCs, on median, are lower than E0-tested NMHCs for the same vehicles, with a p-value less than 0.0001 based on a sign test. Figure D.3 further shows no differentiation in immediate ethanol effect as a function of LFT (p-values 0.5637, 0.3439, and 0.7539 for the Wilcoxon test with E10, E15, and E20, respectively).

Road fuel aging and differential ethanol road fuel effect on aging

Across the fleet, as shown in Table D.3, in 18 of 26 cases, vehicles run with RE0 and subsequently tested with E0 showed a trend of increasing NMHC emission rates (8 of them statistically significant) with increasing total miles driven. One of the eight observed decreasing trends was statistically significant. Where increases were seen, they ranged up to +0.159 g/mile (2000 Accord). In most cases, though, the positive effect did not exceed about +0.05 g/mile. With a p-value of 0.0433, as shown in Fig. D.3, the median across all tested statistical models of the change in NMHC levels per 100,000 miles driven under RE0 fuel was greater than zero at the statistically significant level. Hence, there is evidence of systematic aging for NMHC emissions across the fleet.

When examining aging in vehicles run with ethanol fuel blends, the same general trend was observed as with RE0. Specifically, 39 of the 53 cases showed a positive aging effect (Table D.3). The observed increases were of a comparable magnitude to the RE0 aging effect. With a p-value of 0.0004 (Fig. D.3), the median change in NMHC levels with ethanol test fuels was greater than zero for the fleet overall at the statistically significant level. From Table D.3, only 5 of 26 vehicle models provided some evidence for a different aging effect under ethanol road fuels than under RE0. Hence, it appears reasonable to conclude that the use of ethanol fuels does not change the aging that is observed for NMHCs. Finally, Fig. D.3 provides no strong evidence that the aging effect, regardless of which road fuel is used, is influenced by LFT.

D.2.4 Nonmethane organic gases

Immediate ethanol effect

NMOG levels for ethanol blend test fuels were similar to E0 in most statistical models, as shown in Table D.4. Across the three ethanol fuel blends, 29 of the 53 cases showed lower NMOG levels and 24 of the 53 cases showed higher NMOG levels when tested with ethanol blends. The only statistically significant differences were for three of the cases with lower NMOG with ethanol blends. Referencing Table D.4, NMOG levels for the ethanol fuels were between 33% lower and 25% higher than the E0 test fuel results. Combining all the vehicles, as shown in Fig. D.4, results in the conclusion that across all three ethanol fuels and over the fleet, ethanol tested NMOG, on median, is no different than E0 tested NMOG for the same vehicle models, with a p-value of 0.4799 based on a sign test. Figure D.4 further shows no differentiation in immediate ethanol effect as a function of LFT (p-values 1.0000, 0.4528, and 0.9687 for the Wilcoxon test with E10, E15, and E20, respectively).

Road fuel aging and differential ethanol road fuel effect on aging

Across the fleet, as shown in Table D.4, in 19 of 26 cases, vehicles run with RE0 and subsequently tested with E0 showed a trend of increasing NMOG emission rates with increasing miles driven (8 of the 19 are statistically significant increases). One of the seven observed decreasing trends was statistically significant. Where increases were seen, they were as great as +0.165 g/mile (2000 Accord). In most cases, though, the positive effect did not exceed about +0.05 g/mile. With a p-value of 0.0433, as shown in Fig. D.4, the median across all tested statistical models of the change in NMOG levels per 100,000 miles driven under RE0 fuel was greater than zero at the statistically significant level. Hence, there is evidence of systematic aging for NMOG emissions across the fleet.

When examining aging in vehicles run with ethanol fuel blends, the same general trend was observed as with RE0. Specifically, 39 of the 53 cases showed a positive aging effect (Table D.4). The observed increases were of a comparable magnitude to the RE0 aging effect. With a p-value of 0.0008 (Fig. D.4), the median change in NMOG levels with ethanol test fuels was greater than zero for the fleet overall at the statistically significant level. From Table D.4, only 3 of 26 vehicle models provided some evidence for a different aging effect under ethanol road fuels than under RE0. Hence, it appears reasonable to conclude that the use of ethanol fuels does not change the aging that is observed for NMOG. Finally, Fig. D.4 provides no strong evidence that the aging effect, regardless of which road fuel is used, is influenced by LFT.

D.2.5 Fuel economy

Immediate ethanol effect

As expected, fuel economy was lower with ethanol blended fuels than with E0 in all 53 fuel and statistical model combinations, as shown in Table D.5. Only the reduction in fuel economy with E10 in the 2007 Accord was not statistically significant. Referencing fuel economy results in Table D.5, the reductions by fuel and vehicle model were as great as 7.6% relative to the E0 test fuel result, with larger fuel economy losses as the ethanol content increased from 10% to 15% to 20%. Combining all the vehicles, as shown in Fig. D.5, results in the conclusion that across all three ethanol fuels and over the fleet, ethanol tested fuel economy, on median, is lower than E0 tested fuel economy for the same vehicles, with a p-value less than 0.0001 based on a sign test.

Road fuel aging and differential ethanol road fuel effect on aging

Across the fleet, as shown in Table D.5, in 21 of 26 cases, vehicles run with RE0 and subsequently tested with E0 showed a trend of increasing fuel economy (5 of them statistically significant) with increasing total miles driven. Three of the five observed decreasing trends (2008 Altima, 2003 Cavalier, and 2000 Focus) were statistically significant. Where increases were seen, they ranged up to +1.4 mpg (2003 Taurus), and decreases were as great as –2.3 mpg (2003 Cavalier). With a p-value of 0.0025, as shown in Fig. D.5, the median across all tested statistical models of the change in fuel economy per 100,000 miles driven under RE0 fuel was greater than zero at the statistically significant level. Hence, there is evidence of systematic aging resulting in better fuel economy across the fleet.

When examining aging in vehicles run with ethanol fuel blends, the same general trend was observed as with RE0. Specifically, 38 of the 53 cases showed a positive aging effect (Table D.5). The observed increases were of a comparable magnitude to the RE0 aging effect. With a p-value of 0.0022 (Fig. D.5), the median change in fuel economy with ethanol test fuels was greater than zero for the fleet overall, at the statistically significant level. From Table D.5, only 5 of 26 vehicle models provided some evidence for a different aging effect under ethanol road fuels than under RE0. Hence, it appears reasonable to conclude that the use of ethanol fuels does not change the effect of aging on fuel economy. Finally, Fig. D.5 provides no strong evidence that the aging effect, regardless of which road fuel is used, is influenced by LFT.

D.2.6 Ethanol

Immediate ethanol effect

Due to a lack of reliable ethanol data for some of the vehicle sets from the program, Table D.6 contains results for a smaller number of vehicles than Tables D.1–D.5 and D.7–D.9.

Consistent with the previously reported V1 results, ethanol emission levels were higher for testing ethanol blend fuels than E0 in all 25 cases, as shown in Table D.6. All but 2 of the 25 results were higher at the statistically significant level. Combining all the vehicle models, as shown in Fig. D.6, results in the conclusion that across all three ethanol fuels and over the fleet, ethanol tested ethanol emissions, on median, are higher than E0 tested ethanol emissions for the same vehicles, with a p-value less than 0.0001 based on a sign test. Figure D.6 further shows no differentiation in immediate ethanol effect as a function of LFT (p-values 1.0000, 0.9093, and 0.9093 for the Wilcoxon test with E10, E15, and E20, respectively).

Road fuel aging and differential ethanol road fuel effect on aging

Because the ethanol models demonstrated a lack of linearity with test mileage, a categorical data model was fit to reveal any potential relationship between the zero mileage, middle mileage, and final mileage data points. As a consequence, the modeled road fuel aging effects, as a single slope, are not applicable. As an approximation, road fuel aging effects were determined using only the initial and final mileage data points.

Across the fleet, as shown in Table D.6, in 7 of 10 cases, vehicles run with RE0 and subsequently tested with E0 showed a trend of decreasing ethanol emission rates (none of them statistically significant) with increasing total miles driven. Decreases were as great as −0.299 mg/mile and increases as great as +0.318 mg/mile. With a p-value of 0.5078, as shown in Fig. D.6, the median of the change in ethanol emission levels across all tested statistical models per 100,000 miles driven under RE0 fuel was not significantly different from zero. Hence, there is no evidence of systematic aging for ethanol emissions across the fleet.

When examining aging in vehicles run with ethanol fuel blends, a different trend was observed than with RE0. Specifically, 19 of the 25 cases showed a positive aging effect (Table D.6). With a p-value of 0.0146 (Fig. D.6), the median change in ethanol emission levels with ethanol test fuels was greater than zero for the fleet overall, at the statistically significant level. However, from Table D.6, none of the 10 vehicle models provided any evidence for a different aging effect under ethanol road fuels than under RE0. This finding appears to present a contradiction between the Table D.6 and Fig. D.6 results. In light of the modeling limitation discussed previously, neither can provide a high degree of certainty. Therefore, it would probably be best to interpret the aging effects with regard to ethanol emissions as inconclusive.

D.2.7 Acetaldehyde

Immediate ethanol effect

Due to a lack of reliable ethanol data for some of the vehicle sets from the program, Table D.7 contains results for a smaller number of vehicles than Tables D.1–D.5 and D.9.

Consistent with the previously reported V1 results, acetaldehyde levels were higher for testing ethanol blend fuels than E0 in most cases, as shown in Table D.7. Across the three ethanol fuel blends, all 45 cases showed higher acetaldehyde levels when tested with ethanol blends. Forty-four of the 45 results were higher at the statistically significant level. Referencing acetaldehyde results in Table D.7, the increases were at least +0.5 mg/mile in a majority of the vehicle models. Combining all the vehicles, as shown in Fig. D.7, results in the conclusion that across all three ethanol fuels and over the fleet, ethanol tested acetaldehyde, on median, is higher than E0 tested acetaldehyde for the same models, with a p-value less than 0.0001 based on a sign test. Figure D.7 further shows no differentiation in immediate ethanol effect as a function of LFT (p-values 1.0000, 0.4070, and 0.8273 for the Wilcoxon test with E10, E15, and E20, respectively).

Road fuel aging and differential ethanol road fuel effect on aging

Across the fleet, as shown in Table D.7, in 15 of 20 cases vehicles run with RE0 and subsequently tested with E0 showed a trend of increasing acetaldehyde emission rates (3 of them statistically significant) with increasing total miles driven. The increase was as large as +1.489 mg/mile (2000 Silverado). In most cases, though, the positive effect did not exceed about +0.20 mg/mile. With a p-value of 0.0636, as shown in Fig. D.7, the median of the change in acetaldehyde levels across all tested statistical models per

100,000 miles driven under RE0 fuel was not greater than zero at the statistically significantly level. Hence, there is no evidence of systematic aging for acetaldehyde emissions across the fleet.

When examining aging in vehicles run with ethanol fuel blends, the level of aging was comparable to the vehicles run with E0. Specifically, 29 of the 45 cases showed a positive aging effect (Table D.7), similar to the 15 of 20 positive results with RE0. With a p-value of 0.0725 (Fig. D.7), the median change in acetaldehyde levels with ethanol test fuels was not statistically significant, but it just marginally missed being significant, whereas the difference was significant but only marginally so for the RE0 fuel. From Table D.7, only 1 of 20 cases provided some evidence for a different aging effect under ethanol road fuels than under RE0. Hence, it appears reasonable to conclude that the use of ethanol fuels does not change the aging that is observed for acetaldehyde. Finally, Fig. D.7 provides no strong evidence that the aging effect, regardless of which road fuel is used, is influenced by LFT.

D.2.8 Formaldehyde

Immediate ethanol effect

Due to a lack of reliable ethanol data for some of the vehicle sets from the program, Table D.8 contains results for a smaller number of vehicles than Tables D.1–D.5 and D.9.

Consistent with the previously reported V1 results, formaldehyde levels were higher for ethanol blend fuels than E0 in most cases, as shown in Table D.8. Across the three ethanol fuel blends, 36 of the 45 vehicle models showed higher formaldehyde levels when tested with ethanol blends. For 4 of the 45 cases, results were higher at the statistically significant level. Referencing formaldehyde results in Table D.8, the magnitude of the increases was highly variable. Combining all the vehicles, as shown in Fig. D.8, results in the conclusion that across all three ethanol fuels and over the fleet, ethanol-tested formaldehyde, on median, is higher than E0-tested formaldehyde for the same vehicles, with a p-value of 0.0001 based on a sign test. Figure D.8 further shows no differentiation in immediate ethanol effect as a function of LFT (p-values 0.7671, 0.6945, and 0.3153 for the Wilcoxon test with E10, E15, and E20, respectively).

Road fuel aging and differential ethanol road fuel effect on aging

Across the fleet, as shown in Table D.8, in 16 of 20 cases, vehicles run with RE0 and subsequently tested with E0 showed a trend of increasing formaldehyde emission rates (6 of them statistically significant) with increasing total miles driven. The increase was as large as +4.363 mg/mile (2000 Silverado). In most cases, though, the positive effect did not exceed about +1.00 mg/mile. With a p-value of 0.0118, as shown in Table D.8, the median of the change in formaldehyde levels across all tested statistical models per 100,000 miles driven under RE0 fuel was greater than zero at the statistically significant level. Hence, there is evidence of systematic aging for formaldehyde emissions across the fleet.

When examining aging in vehicles run with ethanol fuel blends, the level of aging was comparable to the models run with E0. Specifically, 33 of the 45 cases showed a positive aging effect (Table D.8), similar to the 16 of 20 positive with RE0. With a p-value of 0.0025 (Fig. D.8), the median change in formaldehyde levels with ethanol test fuels was different from zero at the statistically significant level. From Table D.8, only 3 of 20 cases provided some evidence for a different aging effect under ethanol road fuels than under RE0. Hence, it appears reasonable to conclude that the use of ethanol fuels does not change the effect of aging on formaldehyde emissions. Finally, Fig. D.8 provides no strong evidence that the aging effect, regardless of which road fuel is used, is influenced by LFT.

D.2.9 Methane

Immediate ethanol effect

The CH_4 levels were a close mixture of higher and lower for testing ethanol blend fuels compared to E0, as shown in Table D.9. Across the three ethanol fuel blends, 31 of the 53 cases showed higher CH_4 levels when tested with ethanol blends. Four of the 31 higher model results and one of the 22 lower model results were statistically significant. Referencing CH_4 results in Table D.9, the differences ranged from −0.002 g/mile to 0.006 g/mile. Combining all the vehicles, as shown in Fig. D.9, results in the conclusion that across all three ethanol fuels and over the fleet, ethanol tested CH_4, on median, is not significantly different than E0 tested CH_4 for the same vehicles, with a p-value of 0.2624 based on a sign test. Figure D.9 further shows no differentiation in immediate ethanol effect as a function of LFT (p-values 0.1765, 0.1303, and 0.3903 for the Wilcoxon Test with E10, E15, and E20, respectively).

Road fuel aging and differential ethanol road fuel effect on aging

Across the fleet, as shown in Table D.9, in all 26 cases, vehicles run with RE0 and subsequently tested with E0 showed a trend of increasing CH_4 emission rates (16 of them statistically significant) with increasing total miles driven. The increase was as great as +0.05 g/mile (2000 Accord). In most cases, though, the positive effect did not exceed about +0.02 g/mile. With a p-value less than 0.0001, as shown in Fig. D.9, the median of the change in CH_4 levels across all tested statistical models per 100,000 miles driven under RE0 fuel was greater than zero at the statistically significant level. Hence, there is evidence of systematic aging for CH_4 emissions across the fleet.

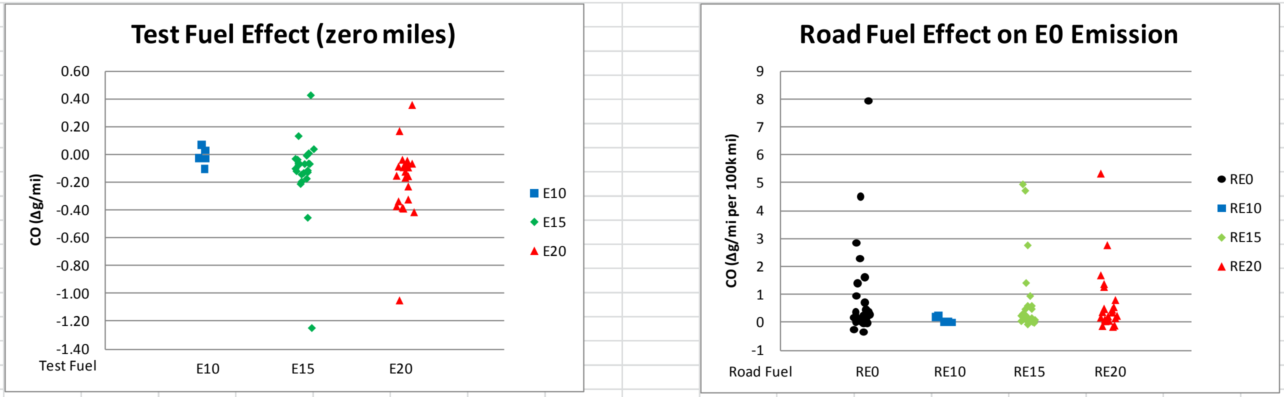
When examining aging in vehicles run with ethanol fuel blends, the same general trend was observed as with RE0. Specifically, all 53 of the cases showed a positive aging effect (Table D.9). The observed increases were of a comparable magnitude to the RE0 aging effect. With a p-value less than 0.0001 (Fig. D.9), the median change in CH_4 levels with ethanol test fuels was greater than zero for the fleet overall, at the statistically significant level. From Table D.9, only 6 of 26 vehicle models provided some evidence for a different aging effect under ethanol road fuels than under RE0. Hence, it appears reasonable to conclude that the use of ethanol fuels does not change the aging that is observed for CH_4. Finally, Fig. D.9 provides no strong evidence that the aging effect, regardless of which road fuel is used, is influenced by LFT, as evaluated in the nonparametric test statistics.

Table D.1. Federal Test Procedure CO emissions by vehicle model

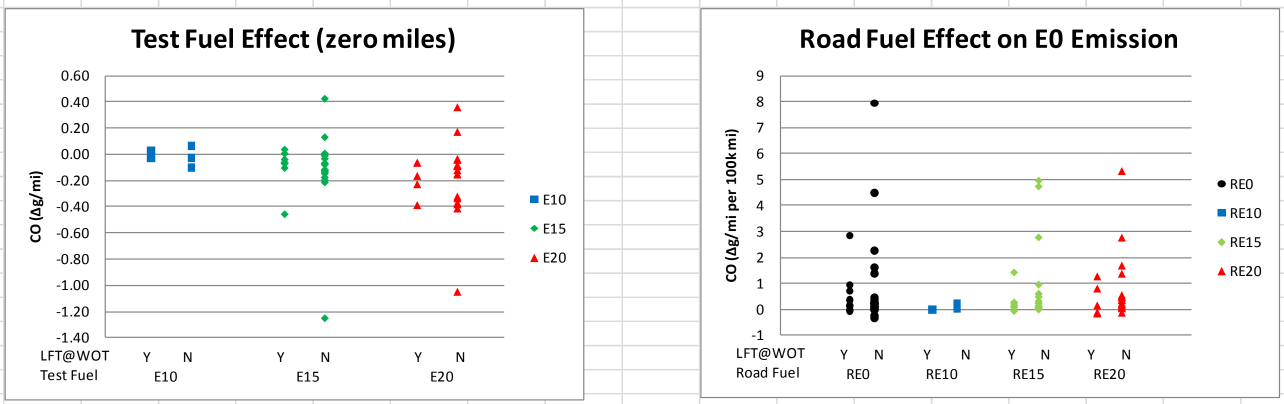
Emissions (units)	V1 Results (Immediate Effect of Ethanol) †	Vehicle Model	Apply LFT @WOT?	Standard	Ethanol Effect ‡								Aging Effect with RE0		RExx Aging Effect on E0 Emissions ‡			
					units at 0k mi	Δ units vs. E0			% change vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value
					E0	E10	E15	E20	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0	
CO (g/mi)	Decrease	2007 Accord	No	T2 B5	0.215	-0.104*	-0.070*	-0.083*	-48.37%*	-32.56%*	-38.60%*	<0.01*	-0.003	0.95	0.027	0.043	0.047	0.77
		2006 Silverado	Yes	T2 B8	0.792	0.028	-0.066	-0.067	3.54%	-8.33%	-8.46%	0.87	-0.055	0.81	0.012	0.071	-0.169	0.73
		2008 Altima	No	T2 B5	0.408	0.066	-0.067	-0.153	16.17%	-16.42%	-37.49%	0.42	0.224	0.54	0.221	0.226	0.161	0.98
		2008 Taurus	Yes	T2 B5	0.410	-0.031	0.037	-0.066	-7.57%	9.03%	-16.11%	0.48	-0.021	0.81	-0.005	0.140*	-0.122	0.07
		2007 Caravan	No	T2 B5	1.143	-0.027	-0.146	-0.383	-2.36%	-12.77%	-33.49%	0.34	0.002	1.00	0.191	0.456	1.360*	0.14
		2006 Cobalt	No	T2 B5	0.526	NA	-0.001	-0.156	NA	-0.19%	-29.65%	0.49	0.268	0.39	NA	-0.033	0.225	0.61
		2007 Caliber	No	T2 B5	0.999	NA	-0.214	-1.049*	NA	-21.43%	-105%*	<0.01*	2.274*	<0.01*	NA	4.729*	2.748*	<0.01*
		2009 Liberty	No	T2 B5	0.770	NA	-0.176	-0.324	NA	-22.86%	-42.08%	0.23	0.223	0.46	NA	0.579*	0.445	0.62
		2009 Explorer	Yes	T2 B4	1.065	NA	-0.070	-0.167*	NA	-6.57%	-15.68%*	0.01*	0.146	0.05	NA	0.082	0.140*	0.60
		2009 Civic	No	T2 B5	0.452	NA	-0.122*	-0.038	NA	-27.01%*	-8.41%	<0.01*	0.044	0.236	NA	0.097*	0.032	0.208
		2009 Corolla	No	T2 B5	0.352	NA	-0.033	-0.087	NA	-9.38%	-24.74%	0.56	0.106	0.42	NA	0.217*	0.204	0.76
		2005 Tundra	No	T2 B5	0.691	NA	-0.078	-0.092	NA	-11.29%	-13.31%	0.23	0.167	0.32	NA	0.293*	0.465*	0.34
		2006 Impala	No	T2 B5	1.058	NA	-0.117	-0.093	NA	-11.06%	-8.79%	0.41	0.097	0.67	NA	0.579*	0.342	0.25
		2005 F150	Yes	T2 B8	1.447	NA	-0.062	-0.389	NA	-4.29%	-26.89%	0.17	2.840*	<0.01*	NA	1.404*	1.257*	0.05*
		2009 Outlook	Yes	T2 B5	0.267	NA	-0.104	NA	NA	-38.91%	NA	0.05	0.936*	<0.01*	NA	0.246*	NA	<0.01*
		2009 Camry	Yes	T2 B5	0.162	NA	0.006	NA	NA	3.71%	NA	0.75	0.120*	<0.01*	NA	0.051	NA	0.12
		2009 Focus	Yes	T2 B4	0.500	NA	-0.039	NA	NA	-7.80%	NA	0.70	0.366	0.05	NA	0.224	NA	0.49
		2009 Odyssey	No	T2 B5	0.224	NA	-0.010	NA	NA	-4.47%	NA	0.76	0.354*	<0.01*	NA	-0.001	NA	0.01*
		2000 Silverado	Yes	T1 L3	2.064	NA	-0.457*	-0.230	NA	-22.14%*	-11.14%	0.03*	0.703	0.21	NA	-0.089	0.789	0.23
		2002 Frontier	No	NLEV LEV	1.447	NA	0.131	0.168	NA	9.05%	11.61%	0.90	4.491*	0.01*	NA	4.958*	5.305*	0.93
		2002 Durango	No	T1 L3	2.287	NA	0.425	0.356	NA	18.59%	15.57%	0.07	-0.345	0.49	NA	0.935	0.537	0.20
		2003 Camry	No	ULEV	0.740	NA	0.007	-0.045	NA	0.95%	-6.08%	0.95	0.450	0.29	NA	0.466	0.096	0.82
		2003 Taurus	No	NLEV LEV	0.593	NA	-0.197*	-0.337*	NA	-33.20%*	-56.80%*	<0.01*	-0.258	0.12	NA	0.055	-0.139	0.25
		2003 Cavalier	No	NLEV LEV	0.743	NA	-0.130	-0.415*	NA	-17.49%	-55.83%*	<0.01*	1.611*	<0.01*	NA	0.120	0.358	<0.01*
		2000 Accord	No	NLEV LEV	1.424	NA	-1.251	-0.124	NA	-87.86%	-8.71%	0.240	7.933*	0.01*	NA	2.760	0.482	0.090
		2000 Focus	No	NLEV LEV	0.491	NA	-0.135	-0.372	NA	-27.51%	-75.80%	0.120	1.389*	0.04*	NA	0.028	1.672*	0.060

* Indicates estimate is different from zero at the 95% confidence level.
# Log-normal model was used. Results are presented as changes in emission at 0k mile.
Data did not support the assumption of linear effects with mileage.
NA="Not Applicable"
† "Effects of Intermediate Ethanol Blends on Legacy Vehicles and Small Non-Road Engines, Report 1 - Updated," ORNL/TM-2008/117
‡ Colors denote ethanol blend: E10, blue; E15, green; E20, red

Ethanol and Road Fuel Effects on CO - overall Effect and by LFT Strategy



P-Values									
Test/Road Fuel	E10	E15	E20	Overall	RE0	RE10	RE15	RE20	Overall[b]
H: Median=0[1]	1.0000	**0.0025**	**0.0001**	**<0.0001**	**0.0025**	0.3750	**0.0001**	**0.0009**	**<0.0001**
H: Mean=0[2]	0.6626	**0.046**	**0.0033**	**0.0004**	**0.0146**	0.1378	**0.012**	**0.0106**	**0.0003**



P-Values									
Test/Road Fuel	E10	E15	E20	Overall	RE0	RE10	RE15	RE20	Overall[b]
H: P(Y>N)=0.5[3]	1.0000	0.3891	0.8447	NA	1.0000	0.0833	0.2911	0.3676	NA
H: Avg(Y)=Avg(N)[2]	0.7835	0.8226	0.9658	0.8191[a]	0.5862	0.1648	0.2646	0.4727	0.1718[a]

1: Sign Test 2: Parametric Ttest 3: Wilcoxon Two-Sample Test a: ANOVA Test (adjusted by Fuel/Road Fuel) b: only include RE10, RE15 and RE20

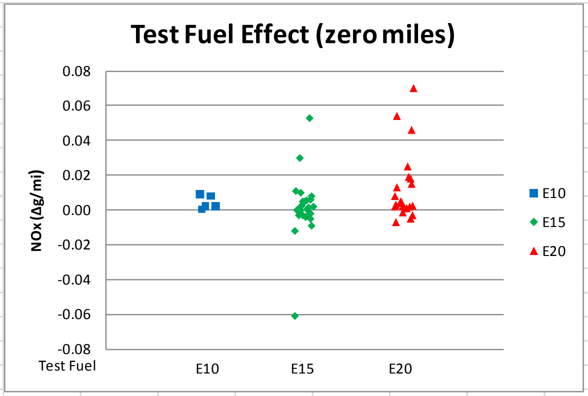
Fig. D.1. Ethanol and road fuel effects on Federal Test Procedure CO emissions.

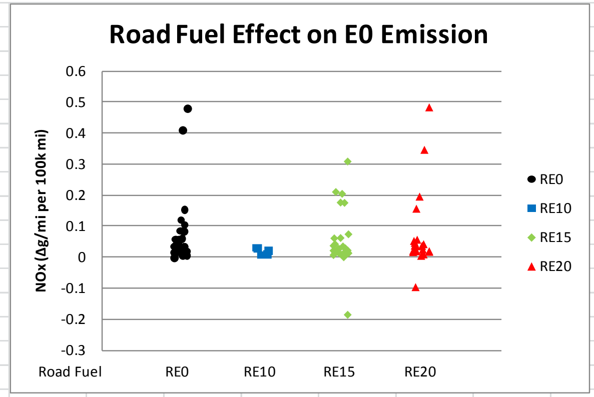
Table D.2. Federal Test Procedure NO_X emissions by vehicle model

Emissions (units)	V1 Results (Immediate Effect of Ethanol) †	Vehicle Model	Apply LFT @WOT?	Standard	Ethanol Effect ‡								Aging Effect with RE0		RExx Aging Effect on E0 Emissions ‡			
					units at 0k mi	Δ units vs. E0			% change vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value
					E0	E10	E15	E20	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0	
NOx (g/mi)	n.s.	2007 Accord	No	T2 B5	0.017	0.002	0.005	0.001	12.08%	30.21%	6.04%	0.20	0.011*	0.03*	0.007*	0.008*	0.003	0.57
		2006 Silverado	Yes	T2 B8	0.023	0.008	0.008	0.001	34.26%	34.26%	4.28%	0.48	0.006	0.64	0.021*	0.013	0.023*	0.69
		2008 Altima	No	T2 B5	0.027	0.0092*	0.0000	0.0040	34.34%*	0.00%	14.93%	0.16	0.0360*	<0.01*	0.0272*	0.0268*	0.0179*	0.23
		2008 Taurus	Yes	T2 B5	0.003	0.0022	0.0056	0.0025	71.11%	181%	80.81%	0.18	0.0073	0.13	0.0094*	0.0087*	0.0076*	0.97
		2007 Caravan	No	T2 B5	0.033	0.0005	0.0027	-0.0014	1.54%	8.30%	-4.30%	0.98	-0.0034	0.85	0.0306*	0.0213	0.0338*	0.39
		2006 Cobalt	No	T2 B5	0.028	NA	0.0015	0.0019	NA	5.37%	6.80%	0.98	0.0180	0.56	NA	0.0001	0.0406	0.50
		2007 Caliber	No	T2 B5	0.031	NA	0.002	0.002	NA	6.51%	6.51%	0.92	0.057*	0.01*	NA	0.037*	0.045*	0.65
		2009 Liberty	No	T2 B5	0.013	NA	-0.009*	-0.005	NA	-71.59%*	-39.77%	0.03*	0.034*	<0.01*	NA	0.035*	0.035*	0.98
		2009 Explorer	Yes	T2 B4	0.010	NA	-0.002	-0.003	NA	-20.69%	-31.03%	0.72	0.020*	0.03*	NA	0.018*	0.016*	0.92
		2009 Civic	No	T2 B5	0.011	NA	0.011*	0.008*	NA	97.06%*	70.59%*	0.02*	0.017*	0.01*	NA	0.013*	0.015*	0.79
		2009 Corolla	No	T2 B5	0.021	NA	-0.003	0.003	NA	-14.17%	14.17%	0.64	0.034*	<0.01*	NA	0.027*	0.018*	0.17
		2005 Tundra	No	T2 B5	0.023	NA	0.000	0.002	NA	0.00%	8.70%	0.65	0.037*	<0.01*	NA	0.014*	0.019*	0.04*
		2006 Impala	No	T2 B5	0.027	NA	0.002	0.046*	NA	7.50%	173%*	0.01*	0.005	0.67	NA	0.022	0.018	0.61
		2005 F150	Yes	T2 B8	0.032	NA	-0.012	-0.007	NA	-37.31%	-21.76%	0.34	0.054*	0.05*	NA	0.062*	0.051*	0.88
		2009 Outlook	Yes	T2 B5	0.011	NA	-0.003	NA	NA	-27.07%	NA	0.41	0.032*	<0.01*	NA	0.007*	NA	<0.01*
		2009 Camry	Yes	T2 B5	0.020	NA	0.006	NA	NA	30.65%	NA	0.12	0.031*	<0.01*	NA	0.016*	NA	0.07
		2009 Focus	Yes	T2 B4	0.012	NA	0.005	NA	NA	41.30%	NA	0.65	0.084*	<0.01*	NA	0.042*	NA	0.08
		2009 Odyssey	No	T2 B5	0.010	NA	0.001	NA	NA	10.03%	NA	0.76	0.058*	<0.01*	NA	0.029*	NA	0.01*
		2000 Silverado	Yes	T1 L3	0.239	NA	-0.002	0.025	NA	-0.84%	10.47%	0.76	0.479*	<0.01*	NA	0.204*	0.345*	0.21
		2002 Frontier	No	NLEV LEV	0.073	NA	-0.061	0.005	NA	-83.05%	6.81%	0.15	0.119	0.33	NA	0.210*	0.055	0.38
		2002 Durango	No	T1 L3	0.334	NA	0.053	0.070	NA	15.89%	20.99%	0.41	0.153	0.49	NA	0.308	0.482*	0.46
		2003 Camry	No	ULEV	0.085	NA	-0.000	0.019	NA	0.00%	22.49%	0.80	0.083	0.34	NA	0.074	0.155	0.81
		2003 Taurus	No	NLEV LEV	0.060	NA	0.010	0.054*	NA	16.81%	90.76%*	<0.01*	0.014	0.73	NA	0.176*	0.022	<0.01*
		2003 Cavalier	No	NLEV LEV	0.116	NA	-0.005	0.018	NA	-4.33%	15.58%	0.80	0.408*	<0.01*	NA	-0.185*	-0.098	<0.01*
		2000 Accord	No	NLEV LEV	0.086	NA	-0.004	0.015	NA	-4.64%	17.40%	0.71	0.104	0.14	NA	0.175*	0.036	0.15
		2000 Focus	No	NLEV LEV	0.086	NA	0.030	0.013	NA	34.84%	15.10%	0.51	0.028	0.77	NA	0.061	0.194*	0.29

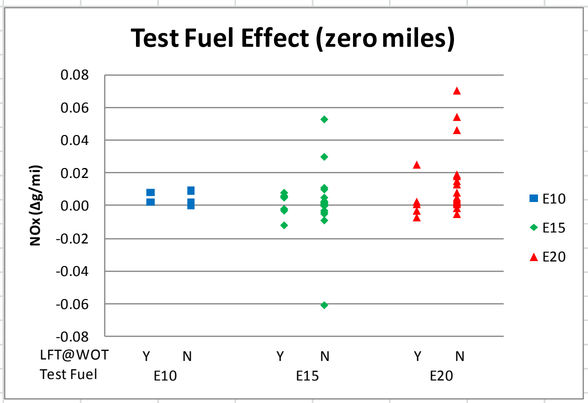
n.s. not statistically significant
* Indicates estimate is different from zero at the 95% confidence level.
# Log-normal model was used. Results are presented as changes in emission at 0k mile.
Data did not support the assumption of linear effects with mileage.
NA="Not Applicable"
† "Effects of Intermediate Ethanol Blends on Legacy Vehicles and Small Non-Road Engines, Report 1 Updated," ORNL/TM-2008/117
‡ Colors denote ethanol blend: E10, blue; E15, green; E20, red

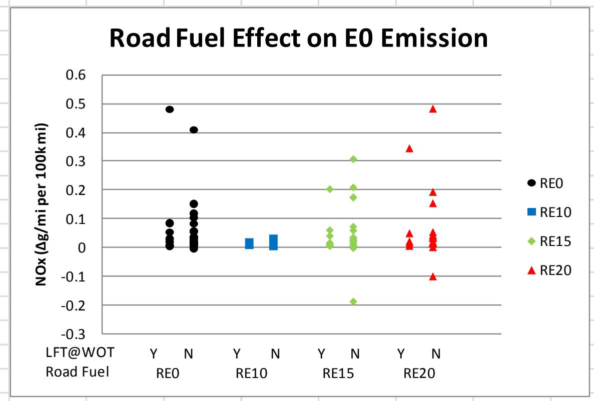
Ethanol and Road Fuel Effects on NOx - overall Effect and by LFT Strategy





P-Values									
Test/Road Fuel	E10	E15	E20	Overall	RE0	RE10	RE15	RE20	Overall[b]
H: Median=0[1]	0.0625	0.4049	**0.0043**	**0.0009**	**<0.0001**	0.0625	**<0.0001**	**<0.0001**	**<0.0001**
H: Mean=0[2]	0.0674	0.6522	**0.0083**	**0.0159**	**0.0032**	**0.0155**	**0.0065**	**0.0166**	**0.0002**





P-Values									
Test/Road Fuel	E10	E15	E20	Overall	RE0	RE10	RE15	RE20	Overall[b]
H: P(Y>N)=0.5[3]	0.5637	0.9556	0.1364	NA	0.7811	0.5637	0.4873	0.9687	NA
H: Avg(Y)=Avg(N)[2]	0.7881	0.8678	0.2771	0.4084[a]	0.6665	0.5834	0.7682	0.7133	0.9560[a]

1: Sign Test 2: Parametric Ttest 3: Wilcoxon Two-Sample Test a: ANOVA Test (adjusted by Fuel/Road Fuel) b: only include RE10, RE15 and RE20

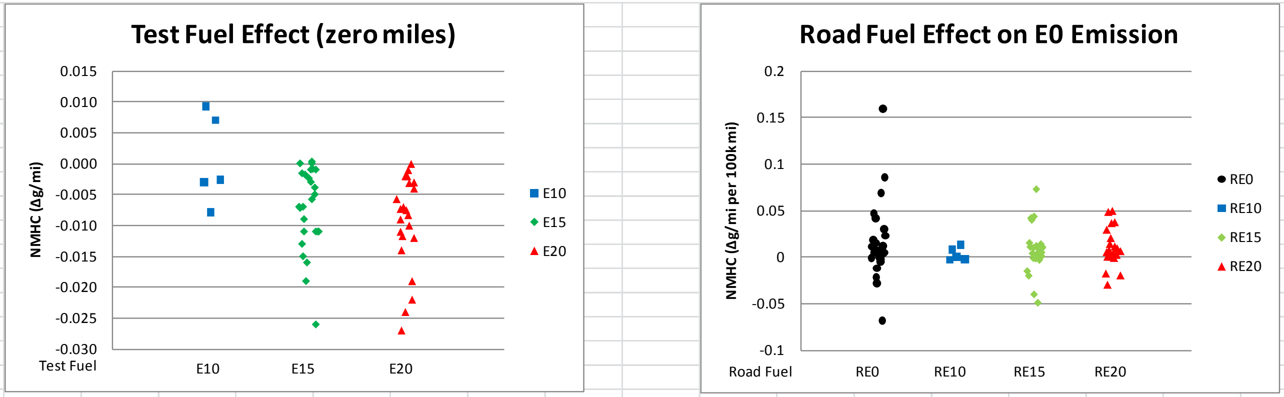
Fig. D.2. Ethanol and road fuel effects on Federal Test Procedure NO_X emissions.

Table D.3. Federal Test Procedure nonmethane hydrocarbon emissions by vehicle model

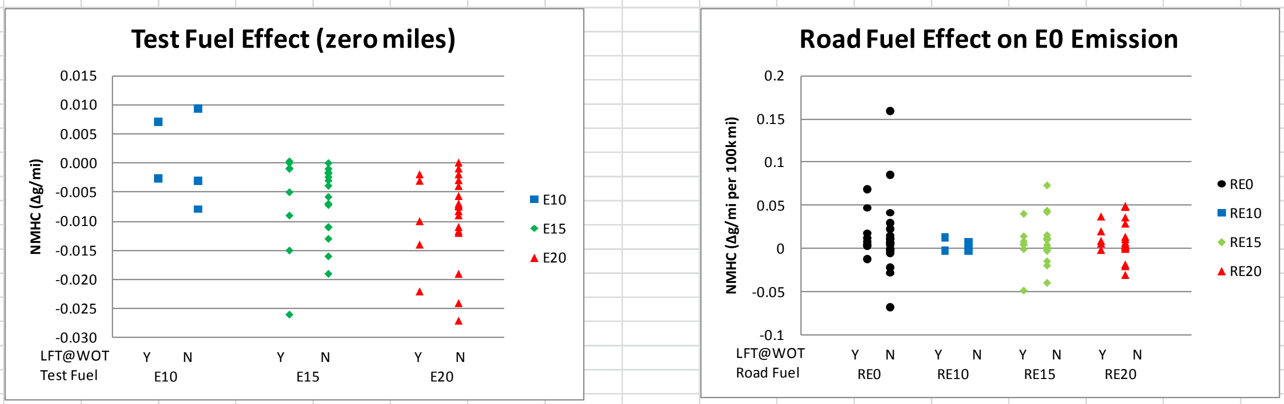
Emissions (units)	V1 Results (Immediate Effect of Ethanol) †	Vehicle Model	Apply LFT @WOT?	Standard	Ethanol Effect ‡								Aging Effect with RE0		RExx Aging Effect on E0 Emissions ‡			
					units at 0k mi	Δ units vs. E0			% change vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value
					E0	E10	E15	E20	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0	
NMHC (g/mi)	Decrease	2007 Accord	No	T2 B5	0.027	-0.0079	-0.0024	-0.0075	-29.36%	-8.92%	-27.87%	0.09	0.0073	0.41	0.0004	0.0005	0.0038	0.89
		2006 Silverado	Yes	T2 B8	0.048	0.007	-0.001	-0.002	14.62%	-2.09%	-4.18%	0.95	0.005	0.82	0.013	0.014	0.006	0.97
		2008 Altima	No	T2 B5	0.057	0.0093	-0.0072	-0.0073	16.42%	-12.71%	-12.89%	0.28	-0.0010	0.97	0.0079	0.0039	0.0001	0.91
		2008 Taurus	Yes	T2 B5	0.022	-0.0026	-0.0009	-0.0031	-11.82%	-4.09%	-14.09%	0.25	0.0036	0.30	-0.0020	0.0080*	-0.0013	0.04*
		2007 Caravan	No	T2 B5	0.043	-0.003	-0.007	-0.007	-7.02%	-16.37%	-16.37%	0.23	0.007	0.58	-0.003	0.010	0.004	0.75
		2006 Cobalt	No	T2 B5	0.040	NA	-0.0039	-0.0083	NA	-9.80%	-20.86%	0.05*	-0.0025	0.73	NA	-0.0015	0.0025	0.80
		2007 Caliber	No	T2 B5	0.048	NA	-0.0016	-0.0117*	NA	-3.36%	-24.59%*	0.02*	0.0416*	<0.01*	NA	0.0437*	0.0289*	0.28
		2009 Liberty	No	T2 B5	0.052	NA	-0.011	-0.019	NA	-21.26%	-36.72%	0.11	-0.000	0.99	NA	-0.003	0.011	0.58
		2009 Explorer	Yes	T2 B4	0.051	NA	-0.005	-0.010*	NA	-9.90%	-19.80%*	<0.01*	0.008	0.08	NA	0.005	0.009*	0.65
		2009 Civic	No	T2 B5	0.026	NA	-0.011*	-0.011*	NA	-41.59%*	-41.59%*	<0.01*	0.011*	0.04*	NA	0.011*	0.007	0.57
		2009 Corolla	No	T2 B5	0.031	NA	-0.0018	-0.0057	NA	-5.74%	-18.16%	0.59	0.0115	0.21	NA	0.0153*	0.0137	0.93
		2005 Tundra	No	T2 B5	0.051	NA	-0.007	-0.009	NA	-13.78%	-17.72%	0.21	0.005	0.72	NA	-0.015	0.000	0.07
		2006 Impala	No	T2 B5	0.039	NA	-0.003	-0.004	NA	-7.61%	-10.14%	0.10	-0.005	0.35	NA	0.010*	0.002	0.05
		2005 F150	Yes	T2 B8	0.052	NA	-0.015*	-0.014*	NA	-29.00%*	-27.07%*	<0.01*	0.047*	<0.01*	NA	0.040*	0.020*	0.12
		2009 Outlook	Yes	T2 B5	0.026	NA	0.000	NA	NA	0.00%	NA	0.95	0.018*	<0.01*	NA	0.004	NA	0.04*
		20009 Camry	Yes	T2 B5	0.020	NA	0.0003	NA	NA	1.49%	NA	0.89	0.0122*	0.01*	NA	0.0045	NA	0.13
		2009 Focus	Yes	T2 B4	0.037	NA	-0.009	NA	NA	-24.62%	NA	0.07	-0.012	0.13	NA	-0.001	NA	0.23
		2009 Camry	No	T2 B5	0.021	NA	-0.000	NA	NA	0.00%	NA	0.97	0.023*	<0.01*	NA	0.001	NA	<0.01*
		2000 Silverado	Yes	T1 L3	0.201	NA	-0.026	-0.022	NA	-12.92%	-10.93%	0.12	0.069	0.21	NA	-0.049	0.037	0.15
		2002 Frontier	No	NLEV LEV	0.084	NA	-0.019*	-0.027*	NA	-22.72%*	-32.29%*	<0.01*	-0.022	0.15	NA	0.042*	0.005	<0.01*
		2002 Durango	No	T1 L3	0.145	NA	-0.011	-0.012	NA	-7.57%	-8.26%	0.13	-0.068*	0.02*	NA	0.011	-0.020	0.07
		2003 Camry	No	ULEV	0.042	NA	-0.001	-0.003	NA	-2.38%	-7.14%	0.84	0.030	0.11	NA	0.012	-0.018	0.28
		2003 Taurus	No	NLEV LEV	0.082	NA	-0.016	-0.024	NA	-19.51%	-29.26%	0.12	-0.028	0.50	NA	-0.020	-0.030	0.97
		2003 Cavalier	No	NLEV LEV	0.069	NA	-0.0058	0.0000	NA	-8.46%	0.00%	0.67	0.0854*	<0.01*	NA	0.0012	0.0491*	0.04*
		2000 Accord	No	NLEV LEV	0.048	NA	-0.011	-0.001	NA	-22.71%	-2.06%	0.80	0.159*	0.03*	NA	0.073	0.036	0.28
		2000 Focus	No	NLEV LEV	0.061	NA	-0.013	-0.002	NA	-21.23%	-3.27%	0.68	0.015	0.78	NA	-0.040	0.048	0.28

* Indicates estimate is different from zero at the 95% confidence level.
# Log-normal model was used. Results are presented as changes in emission at 0k mile.
Data did not support the assumption of linear effects with mileage.
NA="Not Applicable"
† "Effects of Intermediate Ethanol Blends on Legacy Vehicles and Small Non-Road Engines, Report 1 Updated," ORNL/TM-2008/117
‡ Colors denote ethanol blend: E10, blue; E15, green; E20, red

Ethanol and Road Fuel Effects on NMHC - overall Effect and by LFT Strategy



P-Values									
Test/Road Fuel	E10	E15	E20	Overall	RE0	RE10	RE15	RE20	Overall[b]
H: Median=0[1]	1.0000	**<0.0001**	**<0.0001**	**<0.0001**	**0.0433**	1.0000	**0.0290**	**0.0072**	**0.0004**
H: Mean=0[2]	0.8718	**<0.0001**	**<0.0001**	**<0.0001**	0.0585	0.3515	0.1626	**0.0361**	**0.0117**



P-Values									
Test/Road Fuel	E10	E15	E20	Overall	RE0	RE10	RE15	RE20	Overall[b]
H: P(Y>N)=0.5[3]	0.5637	0.3439	0.7539	NA	0.4873	0.5637	0.9115	0.4567	NA
H: Avg(H)=Avg(N)[2]	0.7401	0.9193	0.8347	0.9429[a]	0.8308	0.6292	0.6138	0.5930	0.9617[a]

1: Sign Test 2: Parametric Ttest 3: Wilcoxon Two-Sample Test a: ANOVA Test (adjusted by Fuel/Road Fuel) b: only include RE10, RE15 and RE20

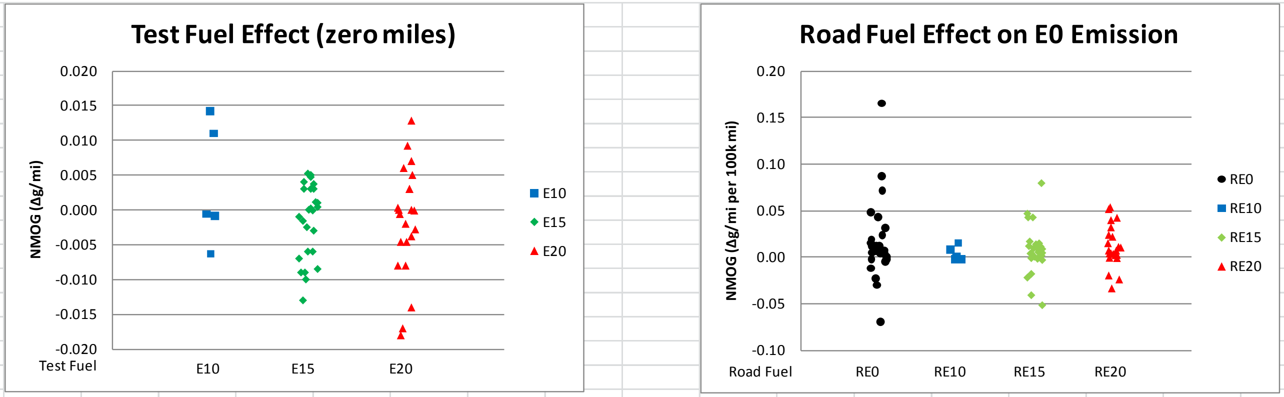
Fig. D.3. Ethanol and road fuel effects on Federal Test Procedure nonmethan hydrocarbon (NMHC) emissions.

Table D.4. Federal Test Procedure nonmethane organic gas (NMOG) emissions by vehicle model

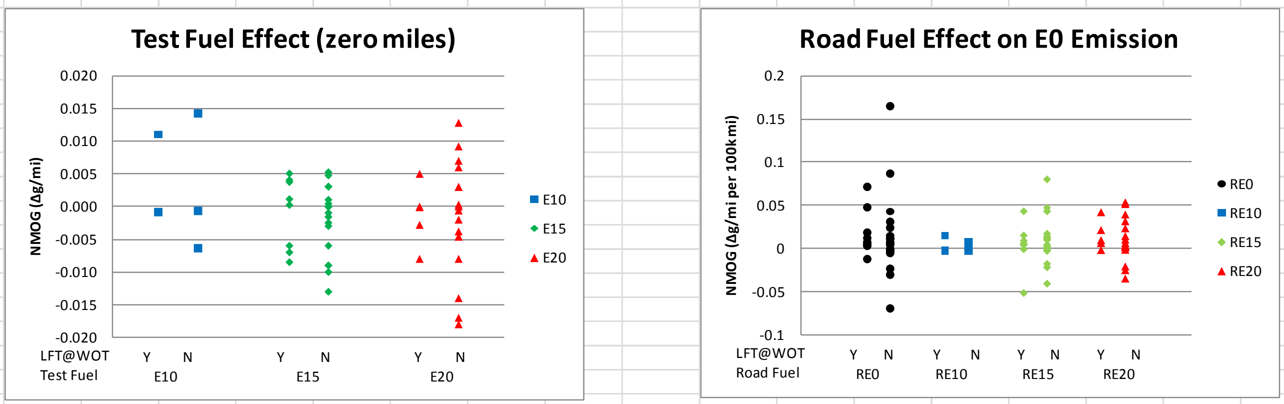
Emissions (units)	V1 Results (Immediate Effect of Ethanol) †	Vehicle Model	Apply LFT @WOT?	Standard	Ethanol Effect ‡								Aging Effect with RE0		RExx Aging Effect on E0 Emissions ‡			
					units at 0k mi	Δ units vs. E0			% change vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value
					E0	E10	E15	E20	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0	
NMOG (g/mi)	n.s.	2007 Accord	No	T2 B5	0.028	-0.0063	0.0000	-0.0046	-22.77%	0.00%	-16.63%	0.40	0.0079	0.43	0.0002	0.0005	0.0034	0.90
		2006 Silverado	Yes	T2 B8	0.049	0.011	0.005	0.005	22.38%	10.17%	10.17%	0.77	0.005	0.82	0.015	0.015	0.007	0.97
		2008 Altima	No	T2 B5	0.059	0.0142	-0.0016	0.0003	24.26%	-2.73%	0.51%	0.30	-0.0021	0.93	0.0083	0.0041	-0.0008	0.89
		2008 Taurus	Yes	T2 B5	0.023	-0.0008	0.0011	-0.0001	-3.53%	4.86%	-0.44%	0.94	0.0036	0.36	-0.0020	0.0089*	-0.0011	0.06
		2007 Caravan	No	T2 B5	0.044	-0.0006	-0.0025	-0.0006	-1.36%	-5.68%	-1.36%	0.96	0.0067	0.62	-0.0027	0.0097	0.0040	0.80
		2006 Cobalt	No	T2 B5	0.041	NA	0.0004	-0.0038	NA	0.98%	-9.26%	0.50	-0.0026	0.74	NA	-0.0017	0.0023	0.82
		2007 Caliber	No	T2 B5	0.049	NA	0.0052	-0.0046	NA	10.62%	-9.39%	0.38	0.0428*	<0.01*	NA	0.0471*	0.0322*	0.41
		2009 Liberty	No	T2 B5	0.054	NA	-0.006	-0.014	NA	-11.21%	-26.16%	0.37	0.000	1.00	NA	-0.003	0.011	0.59
		2009 Explorer	Yes	T2 B4	0.052	NA	0.0002	-0.0028	NA	0.38%	-5.37%	0.60	0.0076	0.09	NA	0.0056	0.0103*	0.53
		2009 Civic	No	T2 B5	0.027	NA	-0.009*	-0.008*	NA	-33.00%*	-29.33%*	0.02*	0.012*	0.04*	NA	0.012*	0.007	0.54
		2009 Corolla	No	T2 B5	0.032	NA	0.003	0.000	NA	9.25%	0.00%	0.90	0.012	0.24	NA	0.017*	0.015*	0.90
		2005 Tundra	No	T2 B5	0.052	NA	-0.001	-0.002	NA	-1.91%	-3.82%	0.96	0.005	0.73	NA	-0.018	0.024	0.06
		2006 Impala	No	T2 B5	0.040	NA	0.001	0.003	NA	2.47%	7.41%	0.53	-0.005	0.41	NA	0.010*	0.002	0.08
		2005 F150	Yes	T2 B8	0.053	NA	-0.007	-0.008	NA	-13.12%	-14.99%	0.09	0.048*	<0.01*	NA	0.043*	0.022*	0.13
		2009 Outlook	Yes	T2 B5	0.027	NA	0.004	NA	NA	15.09%	NA	0.23	0.019*	<0.01*	NA	0.004	NA	0.04*
		2009 Camry	Yes	T2 B5	0.021	NA	0.0037	NA	NA	17.72%	NA	0.16	0.0123*	0.01*	NA	0.0047	NA	0.15
		2009 Focus	Yes	T2 B4	0.038	NA	-0.006	NA	NA	-15.88%	NA	0.21	-0.012	0.13	NA	-0.001	NA	0.23
		2009 Odyssey	No	T2 B5	0.022	NA	0.003	NA	NA	13.88%	NA	0.17	0.024*	<0.01*	NA	0.002	NA	<0.01*
		2000 Silverado	Yes	T1 L3	0.207	NA	-0.0085	-0.0000	NA	-4.11%	0.00%	0.84	0.0715	0.21	NA	-0.0518	0.0426	0.14
		2002 Frontier	No	NLEV LEV	0.086	NA	-0.013	-0.018*	NA	-15.10%	-20.91%*	0.03*	-0.023	0.17	NA	0.043*	0.004	<0.01*
		2002 Durango	No	T1 L3	0.149	NA	0.0047	0.0092	NA	3.15%	6.16%	0.46	-0.0693*	0.02*	NA	0.0115	-0.0243	0.08
		2003 Camry	No	ULEV	0.043	NA	0.003	0.003	NA	6.91%	6.91%	0.77	0.031	0.13	NA	0.014	-0.020	0.30
		2003 Taurus	No	NLEV LEV	0.084	NA	-0.009	-0.017	NA	-10.66%	-20.14%	0.35	-0.030	0.50	NA	-0.022	-0.034	0.96
		2003 Cavalier	No	NLEV LEV	0.071	NA	-0.0001	0.0128	NA	-0.14%	18.11%	0.28	0.0872*	0.01*	NA	0.0018	0.0540*	0.06
		2000 Accord	No	NLEV LEV	0.050	NA	-0.003	0.007	NA	-6.03%	14.07%	0.91	0.165*	0.03*	NA	0.080	0.040	0.30
		2000 Focus	No	NLEV LEV	0.063	NA	-0.010	0.006	NA	-15.93%	9.56%	0.77	0.015	0.78	NA	-0.041	0.052	0.27

n.s. not statistically significant
* Indicates estimate is different from zero at the 95% confidence level.
# Log-normal model was used. Results are presented as changes in emission at 0k mile.
Data did not support the assumption of linear effects with mileage.
NA="Not Applicable"
† "Effects of Intermediate Ethanol Blends on Legacy Vehicles and Small Non-Road Engines, Report 1 Updated," ORNL/TM-2008/117
‡ Colors denote ethanol blend: E10, blue; E15, green; E20, red

Ethanol and Road Fuel Effects on NMOG - overall Effect and by LFT Strategy



P-Values									
Test/Road Fuel	E10	E15	E20	Overall	RE0	RE10	RE15	RE20	Overall[b]
H: Median=0[1]	1.0000	1.0000	0.5034	0.4799	**0.0433**	1.0000	**0.0290**	**0.0169**	**0.0008**
H: Mean=0[2]	0.4187	0.1305	0.3285	0.2195	0.0599	0.3339	0.1586	**0.0283**	**0.0089**



P-Values									
Test/Road Fuel	E10	E15	E20	Overall	RE0	RE10	RE15	RE20	Overall[b]
H: P(Y>N)=0.5[3]	1.0000	0.4528	0.9687	NA	0.5228	0.5637	0.8895	0.5832	NA
H: Avg(Y)=Avg(N)[2]	0.7870	0.6668	0.8744	0.6160[a]	0.8313	0.5916	0.6192	0.6149	0.9712[a]

1: Sign Test 2: Parametric Ttest 3: Wilcoxon Two-Sample Test a: ANOVA Test (adjusted by Fuel/Road Fuel) b: only include RE10, RE15 and RE20

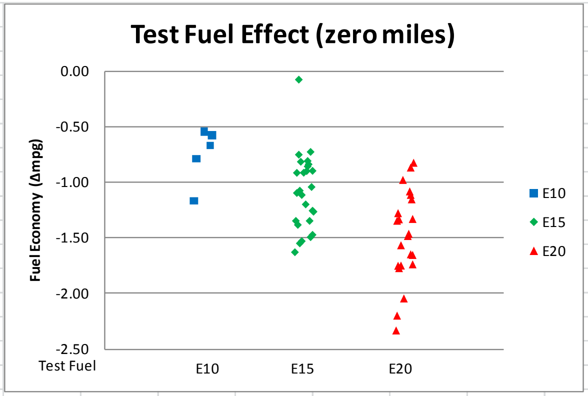
Fig. D.4. Ethanol and road fuel effects on Federal Test Procedure nonmethane organic gas (NMOG) emissions.

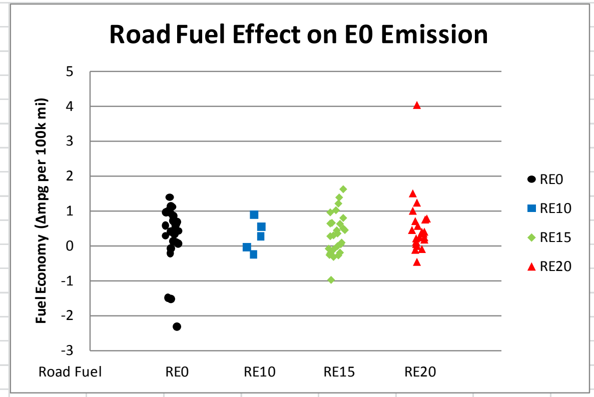
Table D.5. Federal Test Procedure fuel economy by vehicle model

	V1 Results (Immediate Effect of Ethanol) †	Vehicle Model	Apply LFT @WOT?	Standard	Ethanol Effect ‡								Aging Effect with RE0		RExx Aging Effect on E0 Emissions ‡			
					units at 0k mi	Δ units vs. E0			% change vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value
					E0	E10	E15	E20	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0	
Fuel Economy (mpg)	Decrease	2007 Accord	No	T2 B5	26.77	-0.549	-0.915*	-2.046*	-2.05%	-3.42%*	-7.64%*	<0.01*	1.105	0.11	0.886	0.431	0.229	0.59
		2006 Silverado##	Yes	T2 B8	15.81	-0.580*	-0.898*	-1.157*	-3.67%*	-5.68%*	-7.32%*	<0.01*	0.606	0.21	0.267	0.079	0.163	0.79
		2008 Altima	No	T2 B5	28.27	-1.168*	-1.553*	-1.751*	-4.13%*	-5.49%*	-6.19%*	<0.01*	-1.534*	0.02*	-0.247	-0.226	-0.020	0.20
		2008 Taurus	Yes	T2 B5	20.61	-0.669*	-1.044*	-1.333*	-3.25%*	-5.07%*	-6.47%*	<0.01*	0.421	0.10	0.529*	-0.288	0.338	0.02*
		2007 Caravan	No	T2 B5	19.63	-0.790*	-1.098*	-1.336*	-4.02%*	-5.59%*	-6.81%*	<0.01*	-0.230	0.41	-0.058	-0.333	0.556*	0.03*
		2006 Cobalt	No	T2 B5	27.73	NA	-1.258*	-1.656*	NA	-4.54%*	-5.97%*	<0.01*	0.651	0.33	NA	0.033	0.390	0.71
		2007 Caliber	No	T2 B5	27.57	NA	-1.386*	-1.774*	NA	-5.03%*	-6.43%*	<0.01*	0.994*	0.04*	NA	0.288	-0.131	0.15
		2009 Liberty	No	T2 B5	17.60	NA	-0.858*	-1.086*	NA	-4.88%*	-6.17%*	<0.01*	0.848	0.06	NA	0.787*	0.768*	0.99
		2009 Explorer	Yes	T2 B4	16.43	NA	-0.900*	-1.117*	NA	-5.48%*	-6.80%*	<0.01*	0.337	0.32	NA	0.342	0.385	0.99
		2009 Civic	No	T2 B5	31.07	NA	-1.633*	-2.200*	NA	-5.26%*	-7.08%*	<0.01*	0.388	0.36	NA	-0.095	0.037	0.63
		2009 Corolla	No	T2 B5	32.25	NA	-1.533*	-2.333*	NA	-4.75%*	-7.23%*	<0.01*	0.957	0.11	NA	0.948*	1.224*	0.85
		2005 Tundra	No	T2 B5	19.33	NA	-1.077*	-1.281*	NA	-5.57%*	-6.63%*	<0.01*	-0.077	0.89	NA	-0.275	-0.477	0.83
		2006 Impala	No	T2 B5	21.00	NA	-1.267*	-1.486*	NA	-6.03%*	-7.08%*	<0.01*	0.109	0.84	NA	0.439	-0.108	0.60
		2005 F150	Yes	T2 B8	14.67	NA	-0.816*	-0.983*	NA	-5.56%*	-6.70%*	<0.01*	0.565*	0.02*	NA	1.009*	0.438*	0.04*
		2009 Outlook	Yes	T2 B5	17.98	NA	-0.916*	NA	NA	-5.10%*	NA	<0.01*	0.279	0.14	NA	0.628*	NA	0.13
		2009 Camry	Yes	T2 B5	27.42	NA	-1.497*	NA	NA	-5.46%*	NA	<0.01*	0.113	0.80	NA	-0.020	NA	0.81
		2009 Focus	Yes	T2 B4	30.68	NA	-1.350*	NA	NA	-4.40%*	NA	<0.01*	1.127	0.10	NA	0.263	NA	0.27
		2009 Odyssey	No	T2 B5	19.48	NA	-0.839*	NA	NA	-4.31%*	NA	0.03*	0.518	0.33	NA	0.617	NA	0.88
		2000 Silverado	Yes	T1 L3	14.28	NA	-0.727*	-0.829*	NA	-5.09%*	-5.81%*	<0.01*	0.594	0.35	NA	1.201*	0.230	0.29
		2002 Frontier	No	NLEV LEV	22.48	NA	-0.074*	-1.569*	NA	-0.33%*	-6.98%*	<0.01*	0.953*	0.02*	NA	-0.119	0.990*	0.01*
		2002 Durango	No	T1 L3	15.69	NA	-0.809*	-0.872*	NA	-5.16%*	-5.56%*	<0.01*	0.673	0.06	NA	0.485	0.739*	0.71
		2003 Camry	No	ULEV	25.97	NA	-1.350*	-1.650*	NA	-5.20%*	-6.35%*	<0.01*	0.699	0.55	NA	1.376	4.029*	0.27
		2003 Taurus	No	NLEV LEV	21.75	NA	-1.116*	-1.349*	NA	-5.13%*	-6.20%*	<0.01*	1.385*	<0.01*	NA	0.646*	1.491*	0.06
		2003 Cavalier	No	NLEV LEV	24.23	NA	-1.476*	-1.466*	NA	-6.09%*	-6.05%*	<0.01*	-2.320*	<0.01*	NA	1.613*	0.694	<0.01*
		2000 Accord	No	NLEV LEV	26.98	NA	-1.201*	-1.740*	NA	-4.45%*	-6.45%*	<0.01*	0.043	0.96	NA	-0.208	0.105	0.91
		2000 Focus	No	NLEV LEV	27.87	NA	-0.752*	-1.753*	NA	-2.70%*	-6.29%*	<0.01*	-1.494*	0.05*	NA	-0.992	0.198	0.11

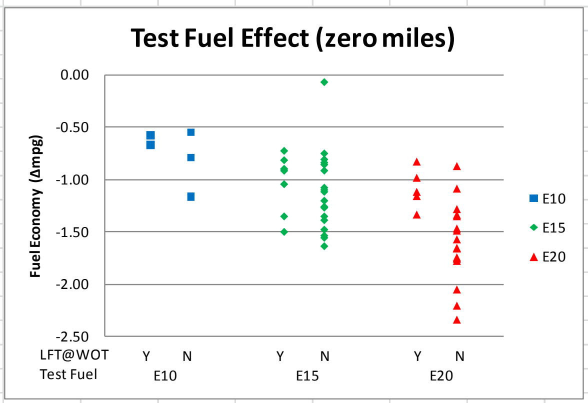
* Indicates estimate is different from zero at the 95% confidence level.
# Log-normal model was used. Results are presented as changes in emission at 0k mile.
Data did not support the assumption of linear effects with mileage.
NA="Not Applicable"
† "Effects of Intermediate Ethanol Blends on Legacy Vehicles and Small Non-Road Engines, Report 1 Updated," ORNL/TM-2008/117
‡ Colors denote ethanol blend: E10, blue; E15, green; E20, red

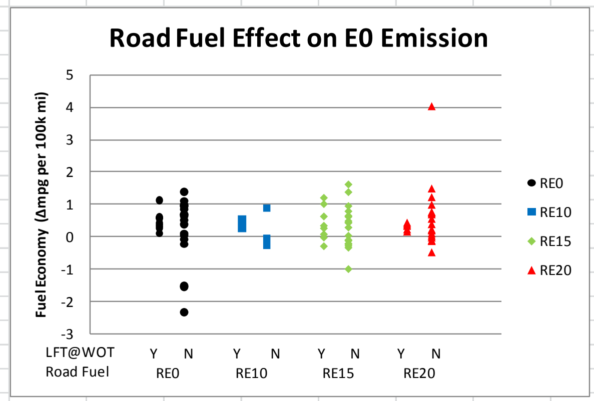
Ethanol and Road Fuel Effects on Fuel Economy - overall Effect and by LFT Strategy





P-Values									
Test/Road Fuel	E10	E15	E20	Overall	RE0	RE10	RE15	RE20	Overall[b]
H: Median=0[1]	0.0625	**<0.0001**	**<0.0001**	**<0.0001**	**0.0025**	1.0000	0.1686	**0.0043**	**0.0022**
H: Mean=0[2]	**0.0026**	**<0.0001**	**<0.0001**	**<0.0001**	0.0943	0.2457	**0.0095**	**0.0085**	**0.0001**





P-Values									
Test/Road Fuel	E10	E15	E20	Overall	RE0	RE10	RE15	RE20	Overall[b]
H: P(Y>N)=0.5[3]	0.5637	0.3040	**0.0069**	NA	0.9557	0.5637	0.6974	0.7839	NA
H: Avg(Y)=Avg(N)[2]	0.435	0.4935	**0.0074**	**0.0152[a]**	0.4257	0.6887	0.7017	0.4995	0.8593[a]

1: Sign Test   2: Parametric Ttest   3: Wilcoxon Two-Sample Test   a: ANOVA Test (adjusted by Fuel/Road Fuel)   b: only include RE10, RE15 and RE20

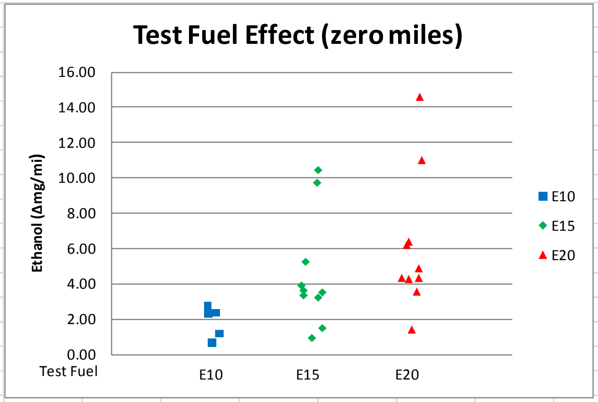
Fig. D.5. Ethanol and road fuel effects on Federal Test Procedure fuel economy.

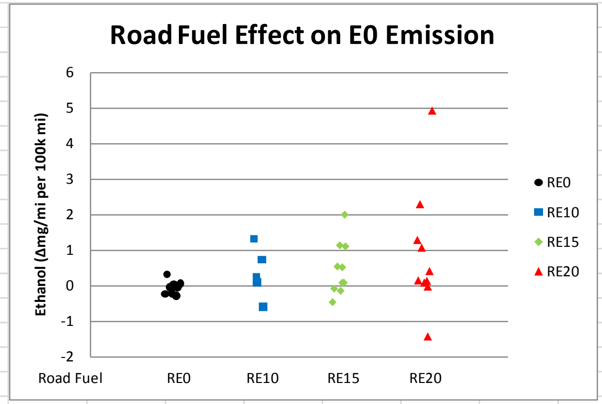
Table D.6. Federal Test Procedure ethanol emissions by vehicle model

Emissions (units)	V1 Results (Immediate Effect of Ethanol) †	Vehicle Model	Apply LFT @WOT?	Standard	Ethanol Effect ‡								Aging Effect with RE0		RExx Aging Effect on E0 Emissions ‡			
					units at 0k mi	Δ units vs. E0			% change vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value
					E0	E10	E15	E20	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0	
Ethanol (mg/mi)	Increase	2007 Accord##	No	T2 B5	0.097	0.656*	0.901*	1.445*	674%*	926%*	1485%*	<0.01*	0.033	0.92	0.098	-0.163	0.095	0.81
		2006 Silverado##	Yes	T2 B8	0.167	2.349*	3.499*	4.366*	1404%*	2092%*	2610%*	<0.01*	-0.058	0.97	0.732	0.505	0.418	0.97
		2008 Altima##	No	T2 B5	0.016	2.335*	3.328*	4.369*	14751%*	21024%*	27600%*	<0.01*	0.318	0.72	0.230	1.131	1.076	0.68
		2008 Taurus##	Yes	T2 B5	0.098	1.185	1.463	3.593*	1211%	1496%	3673%*	<0.01*	-0.037	0.97	-0.608	0.065	-0.018	0.92
		2007 Caravan##	No	T2 B5	0.264	2.743*	3.602*	6.241*	1038%*	1363%*	2361%*	<0.01*	-0.235	0.92	1.312	-0.486	1.292	0.81
		2006 Cobalt##	No	T2 B5	0.070	NA	3.204*	4.915*	NA	4551%*	6981%*	0.01*	0.046	0.99	NA	0.068	-1.420	0.86
		2007 Caliber##	No	T2 B5	0.034	NA	3.888*	4.307*	NA	11370%*	12600%*	<0.01*	-0.056	0.97	NA	-0.100	2.298	0.30
		2000 Silverado##	Yes	T1 L3	0.000	NA	10.453*	14.629*	NA	NA	NA	<0.01*	-0.000	1.00	NA	2.003	4.930	0.76
		2002 Frontier##	No	NLEV LEV	0.114	NA	5.237*	6.422*	NA	4575%*	5610%*	<0.01*	-0.220	0.89	NA	0.528	0.155	0.92
		2002 Durango##	No	T1 L3	0.366	NA	9.733*	11.046*	NA	2663%*	3022%*	<0.01*	-0.299	0.88	NA	1.100	0.142	0.77

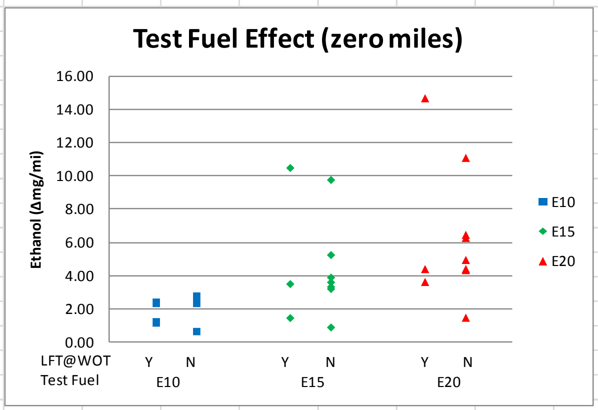
* Indicates estimate is different from zero at the 95% confidence level.
\# Log-normal model was used. Results are presented as changes in emission at 0k mile.
\## Data did not support the assumption of linear effects with mileage.
NA="Not Applicable"
† "Effects of Intermediate Ethanol Blends on Legacy Vehicles and Small Non-Road Engines, Report 1 Updated," ORNL/TM-2008/117
‡ Colors denote ethanol blend: E10, blue; E15, green; E20, red

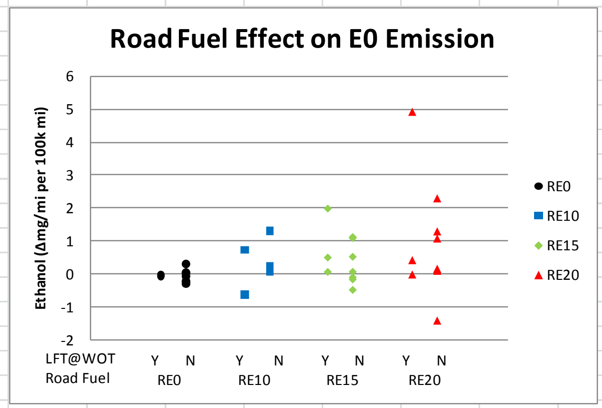
Ethanol and Road Fuel Effects on Ethanol - overall Effect and by LFT Strategy





P-Values									
Test/Road Fuel	E10	E15	E20	Overall	RE0	RE10	RE15	RE20	Overall[b]
H: Median=0[1]	0.0625	**0.0020**	**0.0020**	**<0.0001**	0.5078	0.3750	0.3438	0.1094	**0.0146**
H: Mean=0[2]	**0.0095**	**0.0015**	**0.0007**	**<0.0001**	0.3857	0.3341	0.0838	0.1335	**0.018**





P-Values									
Test/Road Fuel	E10	E15	E20	Overall	RE0	RE10	RE15	RE20	Overall[b]
H: P(Y>N)=0.5[3]	1.0000	0.9093	0.9093	NA	0.9093	0.5637	0.4250	0.7324	NA
H: Avg(Y)=Avg(N)[2]	0.8867	0.7162	0.4898	0.4499[a]	0.837	0.5407	0.3098	0.3169	0.2713[a]

1: Sign Test 2: Parametric Ttest 3: Wilcoxon Two-Sample Test a: ANOVA Test (adjusted by Fuel/Road Fuel) b: only include RE10, RE15 and RE20

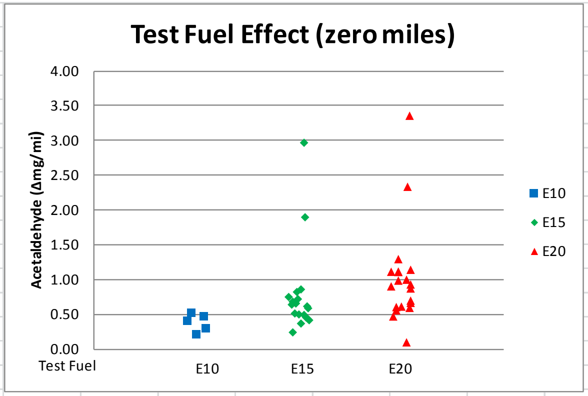
Fig. D.6. Ethanol and road fuel effects on Federal Test Procedure ethanol emissions.

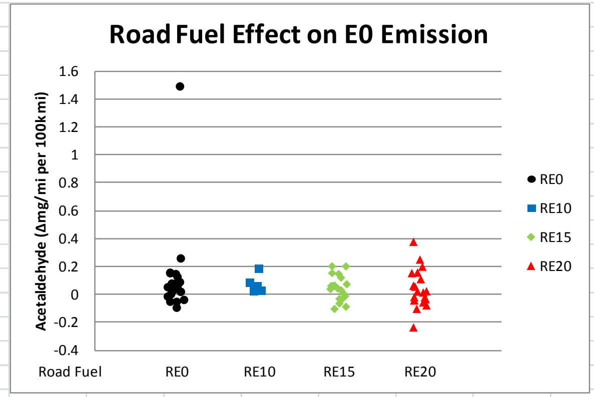
Table D.7. Federal Test Procedure acetaldehyde emissions by vehicle model

Emissions (units)	V1 Results (Immediate Effect of Ethanol) †	Vehicle Model	Apply LFT @WOT?	Standard	Ethanol Effect ‡								Aging Effect with RE0		RExx Aging Effect on E0 Emissions ‡			
					units at 0k mi	Δ units vs. E0			% change vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value
					E0	E10	E15	E20	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0	
Acetaldehyde (mg/mi)	Increase	2007 Accord ##	No	T2 B5	0.126	0.215*	0.497*	0.610*	171%*	394%*	484%*	<0.01*	0.145	0.28	0.058	0.146	0.249*	0.52
		2006 Silverado #	Yes	T2 B8	0.224	0.468*	0.857*	0.997*	209%*	382%*	444%*	<0.01*	0.124*	0.02*	0.184*	0.119*	0.109*	0.59
		2008 Altima#	No	T2 B5	0.194	0.409*	0.656*	0.901*	211%*	339%*	465%*	<0.01*	0.151*	0.02*	0.083*	0.058	0.055	0.62
		2008 Taurus#	Yes	T2 B5	0.087	0.296*	0.366*	0.696*	340%*	420%*	799%*	<0.01*	0.087*	<0.01*	0.026	0.029	0.022	0.18
		2007 Caravan#	No	T2 B5	0.212	0.521*	0.718*	1.293*	246%*	339%*	610%*	<0.01*	0.023	0.79	0.023	0.059	-0.020	0.88
		2006 Cobalt##	No	T2 B5	0.099	NA	0.490	1.140*	NA	496%	1153%*	0.04*	0.059	0.94	NA	0.072	0.013	1.00
		2007 Caliber#	No	T2 B5	0.233	NA	0.820*	1.111*	NA	352%*	477%*	<0.01*	0.155	0.12	NA	0.201*	0.152*	0.85
		2009 Liberty#	No	T2 B5	0.237	NA	0.586*	0.664*	NA	247%*	280%*	<0.01*	0.018	0.73	NA	-0.042	-0.022	0.67
		2009 Explorer#	Yes	T2 B4	0.243	NA	0.613*	0.871*	NA	252%*	358%*	<0.01*	0.018	0.80	NA	-0.033	-0.034	0.81
		2009 Civic#	No	T2 B5	0.137	NA	0.239*	0.468*	NA	175%*	342%*	<0.01*	0.077	0.12	NA	0.063	0.020	0.51
		2009 Corolla#	No	T2 B5	0.175	NA	0.511*	0.556*	NA	292%*	318%*	<0.01*	0.073	0.34	NA	0.060	0.062	0.97
		2005 Tundra#	No	T2 B5	0.252	NA	0.748*	0.984*	NA	297%*	390%*	<0.01*	-0.053	0.40	NA	-0.105*	-0.044	0.54
		2006 Impala#	No	T2 B5	0.287	NA	0.453*	0.928*	NA	158%*	324%*	<0.01*	-0.040	0.60	NA	-0.089	-0.079	0.87
		2005 F150#	Yes	T2 B8	0.195	NA	0.655*	0.603*	NA	336%*	309%*	<0.01*	-0.016	0.73	NA	0.037	-0.042	0.30
		2000 Silverado#	Yes	T1 L3	1.019	NA	2.967*	3.356*	NA	291%*	329%*	<0.01*	1.489	0.27	NA	-0.013	-0.058	0.55
		2002 Frontier#	No	NLEV LEV	0.230	NA	0.638*	1.108*	NA	278%*	483%*	<0.01*	0.000	1.00	NA	0.152	0.156	0.70
		2002 Durango#	No	T1 L3	0.777	NA	1.895*	2.334*	NA	244%*	300%*	<0.01*	-0.096	0.32	NA	0.200*	0.198*	0.11
		2003 Camry#	No	ULEV	0.253	NA	0.428*	0.096*	NA	169%*	37.9%*	<0.01*	-0.054	0.73	NA	-0.001	-0.237	0.56
		2003 Taurus	No	NLEV LEV	0.268	NA	0.680*	1.114*	NA	253%*	415%*	<0.01*	0.051	0.63	NA	0.041	-0.104*	0.20
		2003 Cavalier#	No	NLEV LEV	0.273	NA	0.414*	0.592*	NA	151%*	217%*	<0.01*	0.257	0.15	NA	-0.066	0.376*	0.04*

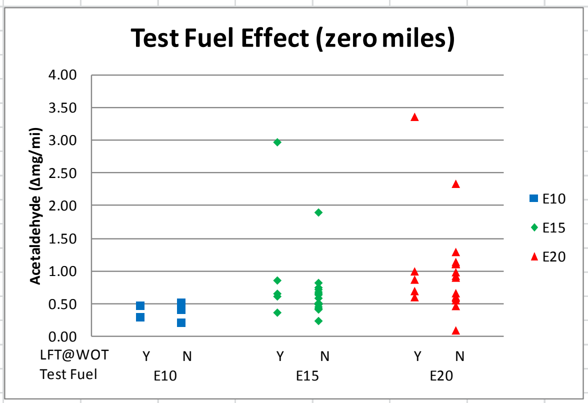
* Indicates estimate is different from zero at the 95% confidence level.
\# Log-normal model was used. Results are presented as changes in emission at 0k mile.
\## Data did not support the assumption of linear effects with mileage.
NA="Not Applicable"
† "Effects of Intermediate Ethanol Blends on Legacy Vehicles and Small Non-Road Engines, Report 1 Updated," ORNL/TM-2008/117
‡ Colors denote ethanol blend: E10, blue; E15, green; E20, red

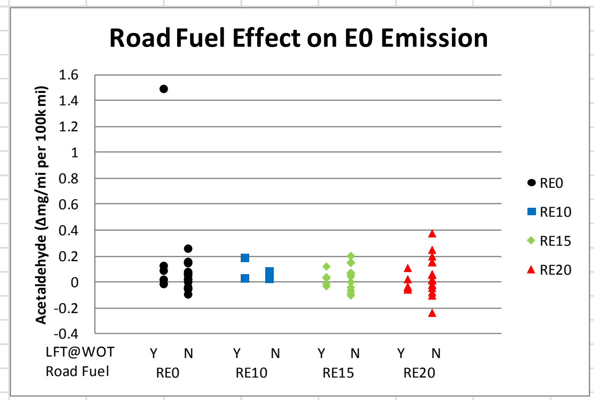
Ethanol and Road Fuel Effects on Acetaldehyde - overall Effect and by LFT Strategy





P-Values									
Test/Road Fuel	E10	E15	E20	Overall	RE0	RE10	RE15	RE20	Overall[b]
H: Median=0[1]	0.0625	**<0.0001**	**<0.0001**	**<0.0001**	0.0636	0.0625	0.2632	0.8238	0.0725
H: Mean=0[2]	**0.0024**	**<0.0001**	**<0.0001**	**<0.0001**	0.1137	0.064	**0.0373**	0.2265	**0.0086**





P-Values									
Test/Road Fuel	E10	E15	E20	Overall	RE0	RE10	RE15	RE20	Overall[b]
H: P(Y>N)=0.5[3]	1.0000	0.4070	0.8273	NA	0.4319	0.5637	0.4581	0.4581	NA
H: Avg(Y)=Avg(N)[2]	0.9981	0.1732	0.3127	0.1002[a]	0.0926	0.4829	0.6416	0.4786	0.5156[a]

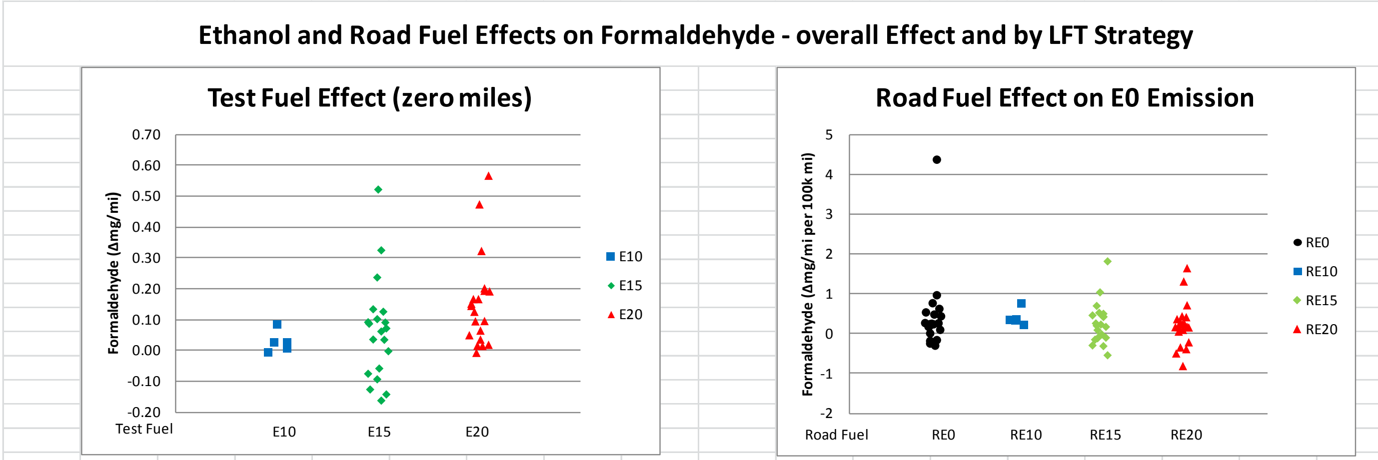
1: Sign Test 2: Parametric Ttest 3: Wilcoxon Two-Sample Test a: ANOVA Test (adjusted by Fuel/Road Fuel) b: only include RE10, RE15 and RE20

Fig. D.7. Ethanol and road fuel effects on Federal Test Procedure acetaldehyde emissions.

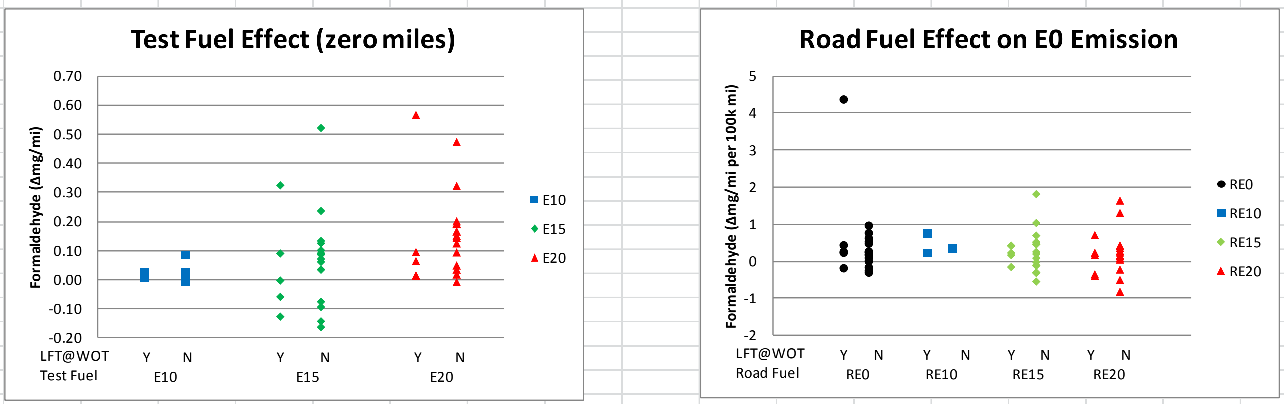
Table D.8. Federal Test Procedure formaldehyde emissions by vehicle model

Emissions (units)	V1 Results (Immediate Effect of Ethanol) †	Vehicle Model	Apply LFT @WOT?	Standard	Ethanol Effect ‡								Aging Effect with RE0		RExx Aging Effect on E0 Emissions ‡			
					units at 0k mi	Δ units vs. E0			% change vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value
					E0	E10	E15	E20	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0	
Formaldehyde (mg/mi)	Increase	2007 Accord#	No	T2 B5	0.430	0.084	0.521*	0.473*	19.55%	121%*	110%*	<0.01*	0.761	0.20	0.360	1.033*	1.307*	0.07
		2006 Silverado#	Yes	T2 B8	1.169	0.025	-0.059	0.064	2.14%	-5.05%	5.47%	0.80	0.432*	0.02*	0.756*	0.425*	0.710*	0.21
		2008 Altima#	No	T2 B5	0.488	-0.006	-0.076	-0.008	-1.23%	-15.56%	-1.64%	0.63	0.002	0.99	0.341*	0.254*	0.282*	0.25
		2008 Taurus#	Yes	T2 B5	0.199	0.007	-0.003	0.014	3.52%	-1.51%	7.05%	0.94	0.257*	<0.01*	0.219*	0.167*	0.171*	0.65
		2007 Caravan#	No	T2 B5	0.643	0.025	-0.094	0.125	3.89%	-14.63%	19.45%	0.80	0.246	0.56	0.335	0.693	0.161	0.80
		2006 Cobalt#	No	T2 B5	0.226	NA	-0.143	0.018	NA	-63.38%	7.98%	0.72	0.476	0.40	NA	0.496	0.411	0.98
		2007 Caliber#	No	T2 B5	0.637	NA	0.086	0.151	NA	13.50%	23.70%	0.17	0.530	0.15	NA	0.520*	0.433*	0.98
		2009 Liberty#	No	T2 B5	0.454	NA	0.061	0.035	NA	13.43%	7.70%	0.96	0.092	0.79	NA	-0.022	0.154	0.90
		2009 Explorer#	Yes	T2 B4	0.485	NA	0.090	0.095	NA	18.56%	19.59%	0.09	0.231*	0.03*	NA	0.226*	0.234*	0.98
		2009 Civic#	No	T2 B5	0.282	NA	0.091	0.049	NA	32.31%	17.40%	0.69	0.263	0.24	NA	0.197	0.241	0.96
		2009 Corolla#	No	T2 B5	0.233	NA	0.101	0.094	NA	43.29%	40.29%	0.74	0.181	0.56	NA	0.086	0.050	0.94
		2005 Tundra##	No	T2 B5	0.314	NA	0.133*	0.144*	NA	42.36%*	45.86%*	<0.01*	0.170*	0.05*	NA	-0.119	0.093	0.01*
		2006 Impala#	No	T2 B5	0.648	NA	-0.163	0.201	NA	-25.14%	31.00%	0.40	-0.165	0.55	NA	-0.316	-0.219	0.95
		2005 F150#	Yes	T2 B8	0.662	NA	-0.127	0.015	NA	-19.19%	2.27%	0.65	-0.187	0.39	NA	-0.154	-0.348*	0.46
		2000 Silverado##	Yes	T1 L3	3.691	NA	0.324	0.566	NA	8.78%	15.33%	0.18	4.363*	<0.01*	NA	0.414	-0.391	0.02*
		2002 Frontier#	No	NLEV LEV	0.618	NA	0.035	0.166	NA	5.67%	26.87%	0.43	0.236	0.51	NA	0.455	0.361	0.96
		2002 Durango#	No	T1 L3	2.198	NA	0.071	0.322	NA	3.23%	14.65%	0.03*	0.961*	<0.01*	NA	1.811*	1.641*	0.45
		2003 Camry#	No	ULEV	0.692	NA	0.125	0.193	NA	18.07%	27.90%	0.56	-0.305	0.54	NA	-0.105	-0.815*	0.33
		2003 Taurus	No	NLEV LEV	0.847	NA	0.236	0.166	NA	27.87%	19.61%	0.15	-0.252	0.51	NA	-0.299	-0.498*	0.61
		2003 Cavalier#	No	NLEV LEV	0.745	NA	0.034	0.191	NA	4.56%	25.64%	0.15	0.619	0.26	NA	-0.546*	0.161	0.04*

* Indicates estimate is different from zero at the 95% confidence level.
# Log-normal model was used. Results are presented as changes in emission at 0k mile.
Data did not support the assumption of linear effects with mileage.
NA="Not Applicable"
† "Effects of Intermediate Ethanol Blends on Legacy Vehicles and Small Non-Road Engines, Report 1 Updated," ORNL/TM-2008/117
‡ Colors denote ethanol blend: E10, blue; E15, green; E20, red



P-Values									
Test/Road Fuel	E10	E15	E20	Overall	RE0	RE10	RE15	RE20	Overall[b]
H: Median=0[1]	0.3750	0.2632	**<0.0001**	**0.0001**	**0.0118**	0.0625	0.2632	**0.0414**	**0.0025**
H: Mean=0[2]	0.1545	0.1076	**0.0002**	**0.0001**	0.0562	**0.0119**	**0.0392**	0.1182	**0.0020**



P-Values									
Test/Road Fuel	E10	E15	E20	Overall	RE0	RE10	RE15	RE20	Overall[b]
H: P(Y>N)=0.5[3]	0.7671	0.6945	0.3153	NA	0.6312	1.0000	0.8958	0.6944	NA
H: Avg(Y)=Avg(N)[2]	0.6342	0.7960	0.9619	0.7865[a]	0.1341	0.5292	0.8314	0.5618	0.6494[a]

1: Sign Test 2: Parametric Ttest 3: Wilcoxon Two-Sample Test a: ANOVA Test (adjusted by Fuel/Road Fuel) b: only include RE10, RE15 and RE20

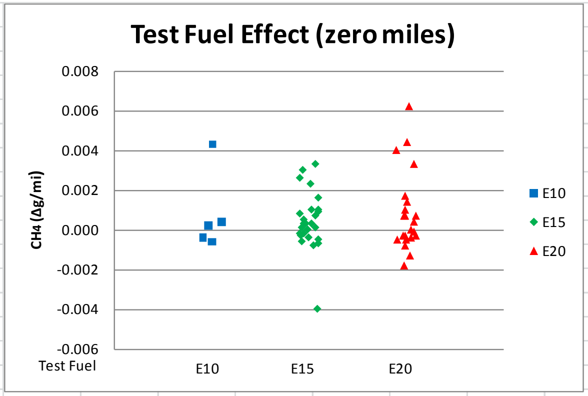
Fig. D.8. Ethanol and road fuel effects on Federal Test Procedure formaldehyde emissions.

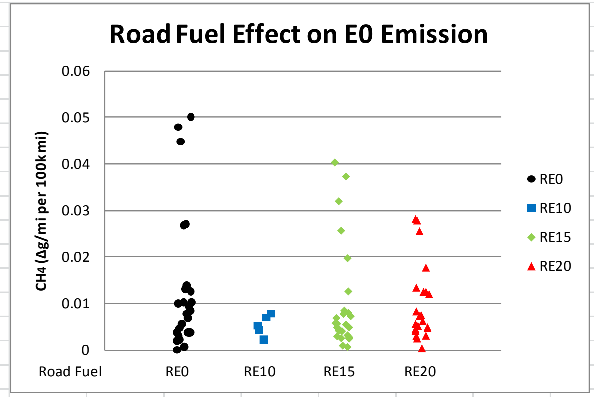
Table D.9. Federal Test Procedure methane (CH_4) emissions by vehicle model

Emissions (units)	V1 Results (Immediate Effect of Ethanol) †	Vehicle Model	Apply LFT @WOT?	Standard	Ethanol Effect ‡								Aging Effect with RE0		RExx Aging Effect on E0 Emissions ‡			
					units at 0k mi	Δ units vs. E0			% change vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value
					E0	E10	E15	E20	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0	
CH4 (g/mi)	NA	2007 Accord	No	T2 B5	0.004	-0.0006	-0.0004	-0.0005	-15.93%	-10.62%	-13.28%	0.29	0.0007	0.44	0.0023*	0.0010	0.0003	0.18
		2006 Silverado	Yes	T2 B8	0.013	0.0043	0.0009	0.0014	32.08%	6.72%	10.45%	0.58	0.0103	0.12	0.0070	0.0126*	0.0124*	0.78
		2008 Altima	No	T2 B5	0.006	0.0002	0.0003	-0.0005	3.17%	4.75%	-7.92%	0.95	0.0000	0.99	0.0052*	0.0042*	0.0044*	0.61
		2008 Taurus	Yes	T2 B5	0.004	0.0004	0.0023	0.0004	11.02%	63.35%	11.02%	0.41	0.0093*	<0.01*	0.0078*	0.0085*	0.0048*	0.31
		2007 Caravan	No	T2 B5	0.009	-0.0004	-0.0002	-0.0003	-4.70%	-2.35%	-3.53%	0.99	0.0037	0.31	0.0042	0.0049	0.0082*	0.62
		2006 Cobalt	No	T2 B5	0.006	NA	-0.0005	-0.0001	NA	-8.76%	-1.75%	0.91	0.0037	0.20	NA	0.0007	0.0030	0.59
		2007 Caliber	No	T2 B5	0.007	NA	-0.0002	-0.0018	NA	-2.83%	-25.44%	0.89	0.0268*	0.02*	NA	0.0402*	0.0254*	0.27
		2009 Liberty	No	T2 B5	0.009	NA	-0.0007	-0.0004	NA	-8.03%	-4.59%	0.60	0.0038*	0.02*	NA	0.0080*	0.0046*	0.03
		2009 Explorer	Yes	T2 B4	0.010	NA	0.0010	0.0007	NA	10.17%	7.12%	0.75	0.0038	0.14	NA	0.0032	0.0061*	0.49
		2009 Civic	No	T2 B5	0.004	NA	0.0000	0.0007	NA	0.00%	20.00%	0.67	0.0030*	0.03*	NA	0.0026*	0.0024*	0.90
		2009 Corolla	No	T2 B5	0.003	NA	0.0008	0.0010	NA	25.26%	31.58%	0.34	0.0047*	<0.01*	NA	0.0058*	0.0074*	0.25
		2005 Tundra	No	T2 B5	0.008	NA	0.0001	0.0017	NA	1.27%	21.52%	0.42	0.0102*	0.02*	NA	0.0069*	0.0072*	0.69
		2006 Impala	No	T2 B5	0.014	NA	0.0010	0.0033*	NA	7.23%	23.86%*	<0.01*	0.0139*	<0.01*	NA	0.0197*	0.0124*	<0.01*
		2005 F150	Yes	T2 B8	0.022	NA	0.0030	0.0007	NA	13.85%	3.23%	0.68	0.0448*	<0.01*	NA	0.0319*	0.0277*	0.33
		2009 Outlook	Yes	T2 B5	0.006	NA	0.0003	NA	NA	5.03%	NA	0.73	0.0100*	<0.01*	NA	0.0057*	NA	0.04*
		2009 Camry	Yes	T2 B5	0.002	NA	0.0001	NA	NA	4.19%	NA	0.92	0.0078*	<0.01*	NA	0.0055*	NA	0.17
		2009 Focus	Yes	T2 B4	0.006	NA	-0.0006	NA	NA	-10.89%	NA	0.48	0.0022	0.13	NA	0.0041*	NA	0.25
		2009 Odyssey	No	T2 B5	0.002	NA	0.0007	NA	NA	28.68%	NA	0.41	0.0085*	<0.01*	NA	0.0025*	NA	<0.01*
		2000 Silverado	Yes	T1 L3	0.024	NA	0.0016	0.0044*	NA	6.61%	18.19%*	<0.01*	0.0130*	<0.01*	NA	0.0049	0.0119*	0.15
		2002 Frontier	No	NLEV LEV	0.015	NA	0.0026	0.0040	NA	17.05%	26.23%	0.09	0.0479*	<0.01*	NA	0.0256*	0.0280*	0.05
		2002 Durango	No	T1 L3	0.027	NA	0.0033*	0.0062*	NA	12.38%*	23.27%*	<0.01*	0.0068	0.09	NA	0.0078*	0.0176*	0.05*
		2003 Camry	No	ULEV	0.008	NA	0.0003	-0.0003	NA	3.60%	-3.60%	0.93	0.0126*	0.01*	NA	0.0073*	0.0029	0.30
		2003 Taurus	No	NLEV LEV	0.008	NA	-0.0003	-0.0008*	NA	-4.00%	-10.67%*	0.07	0.0020	0.12	NA	0.0030*	0.0040*	0.41
		2003 Cavalier	No	NLEV LEV	0.007	NA	-0.0008	-0.0013	NA	-12.00%	-19.50%	0.56	0.0271*	<0.01*	NA	0.0028	0.0055	0.01*
		2000 Accord	No	NLEV LEV	0.010	NA	-0.0040	-0.0000	NA	-41.35%	0.00%	0.60	0.0500*	<0.01*	NA	0.0372*	0.0051	0.05*
		2000 Focus	No	NLEV LEV	0.008	NA	0.0005	-0.0003	NA	6.41%	-3.85%	0.87	0.0055	0.20	NA	0.0047	0.0133*	0.13

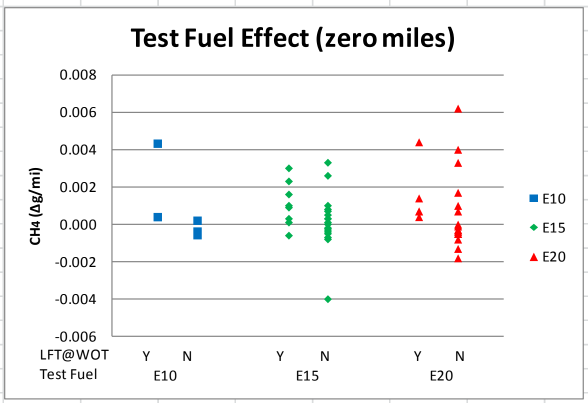
n.s. not statistically significant
* Indicates estimate is different from zero at the 95% confidence level.
# Log-normal model was used. Results are presented as changes in emission at 0k mile.
Data did not support the assumption of linear effects with mileage.
NA="Not Applicable"
† "Effects of Intermediate Ethanol Blends on Legacy Vehicles and Small Non-Road Engines, Report 1 Updated," ORNL/TM-2008/117
‡ Colors denote ethanol blend: E10, blue; E15, green; E20, red

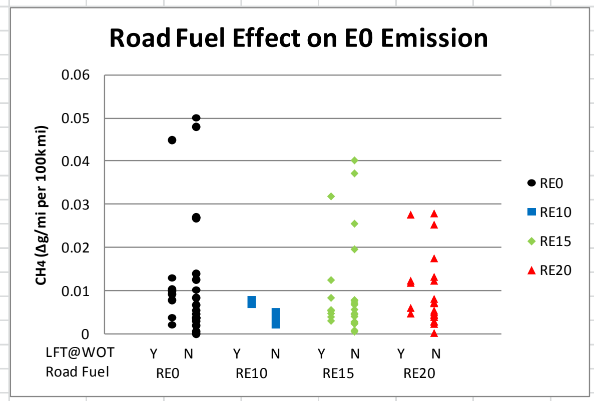
Ethanol and Road Fuel Effects on CH_4 - overall Effect and by LFT Strategy





P-Values									
Test/Road Fuel	E10	E15	E20	Overall	RE0	RE10	RE15	RE20	Overall[b]
H: Median=0[1]	1.0000	0.2295	1.0000	0.2624	**<0.0001**	0.0625	**<0.0001**	**<0.0001**	**<0.0001**
H: Mean=0[2]	0.4346	0.1449	0.0654	**0.0107**	**0.0001**	**0.0057**	**0.0001**	**<0.0001**	**<0.0001**





P-Values									
Test/Road Fuel	E10	E15	E20	Overall	RE0	RE10	RE15	RE20	Overall[b]
H: P(Y>N)=0.5[3]	0.0833	0.0847	0.1074	NA	0.5595	0.0833	0.5596	0.2726	NA
H: Avg(Y)=Avg(N)[2]	0.1765	0.1303	0.3903	**0.0366[a]**	0.9776	0.0543	0.8830	0.3933	0.6497[a]

1: Sign Test   2: Parametric Ttest   3: Wilcoxon Two-Sample Test   a: ANOVA Test (adjusted by Fuel/Road Fuel)   b: only include RE10, RE15 and RE20

Fig. D.9. Ethanol and road fuel effects on Federal Test Procedure methane (CH_4) emissions.

APPENDIX E.
DETAILED STATISTICAL RESULTS BY VEHICLE MODEL

APPENDIX E. DETAILED STATISTICAL RESULTS BY VEHICLE MODEL

This appendix contains the results for the statistical analysis of each individual vehicle model. The results for each vehicle include a summary table plus nine additional figures that detail the various characteristics that were analyzed. These characteristics generally include CO, oxides of nitrogen (NO_X), nonmethane hydrocarbons (NMHC), nonmethane organic gases (NMOG), ethanol, acetaldehyde, formaldehyde, and methane emissions and fuel economy measured on the Federal Test Procedure (FTP). The FTP cycle consists of three phases, and the results of each phase are used to compute a weighted result.* This weighted FTP composite is frequently referred to as the composite to distinguish it from the individual phases. In this appendix, composite refers to the weighted FTP result.

Note that ethanol, acetaldehyde, and formaldehyde results are missing for some cases in which data were not available. Table E.1 lists the page numbers of this appendix for each vehicle model.

Table E.1. Contents of Appendix E

* CFR 40, Part 86.144-94, Calculations; Exhaust emissions

2007 Honda Accord - Composite Emissions Summary

Emisssion Parameter (units)	Ethanol Effect				Aging Effect with RE0		RExx Aging Effect on E0 Emissions				RExx Aging Effect on Exx Emissions			Road and Test Fuel Effects are Additive
	Δ units vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value	Δ units per 100K mi			Overall p-value
Fuels	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0		RE10/E10	RE15/E15	RE20/E20	
CO (g/mi)	-0.104*	-0.070*	-0.083*	<0.01*	-0.003	0.95	0.027	0.043	0.047	0.77	NA	NA	NA	0.32
NOx (g/mi)	0.002	0.005	0.001	0.20	0.011*	0.03*	0.007*	0.008*	0.003	0.57	NA	NA	NA	0.55
NMHC (g/mi)[a]	-0.0079	-0.0024	-0.0075	0.09	0.0073	0.41	0.0004	0.0005	0.0038	0.89	NA	NA	NA	0.81
NMOG (g/mi)[a]	-0.0063	0.0000	-0.0046	0.40	0.0079	0.43	0.0002	0.0005	0.0034	0.90	NA	NA	NA	0.83
Fuel Econ (mi/gal)	-0.549	-0.915*	-2.046*	<0.01*	1.105	0.11	0.886	0.431	0.229	0.59	NA	NA	NA	0.72
Ethanol (mg/mi)[##]	0.656*	0.901*	1.445*	<0.01*	0.033	0.92	0.098	-0.163	0.095	0.81	NA	NA	NA	NA
Acetaldehyde (mg/mi)[##]	0.215*	0.497*	0.610*	<0.01*	0.145	0.28	0.058	0.146	0.249*	0.52	NA	NA	NA	NA
Formaldehyde (mg/mi)[#]	0.084	0.521*	0.473*	<0.01*	0.761	0.20	0.360	1.033*	1.307*	0.07	0.045	0.512	0.323	0.04*
CH4 (g/mi)	-0.0006	-0.0004	-0.0005	0.29	0.0007	0.44	0.0023*	0.0010	0.0003	0.18	NA	NA	NA	0.14

\# Log-normal model was used. Results are presented as changes in emissions at 0k mile.

\## Data did not support the assumption of linear effects with mileage.

* Indicates estimate is different from zero at the 95% confidence level.

a Test "SW022793" is identified as an outlier and excluded from the analysis.

2007 Honda Accord (Composite CO)

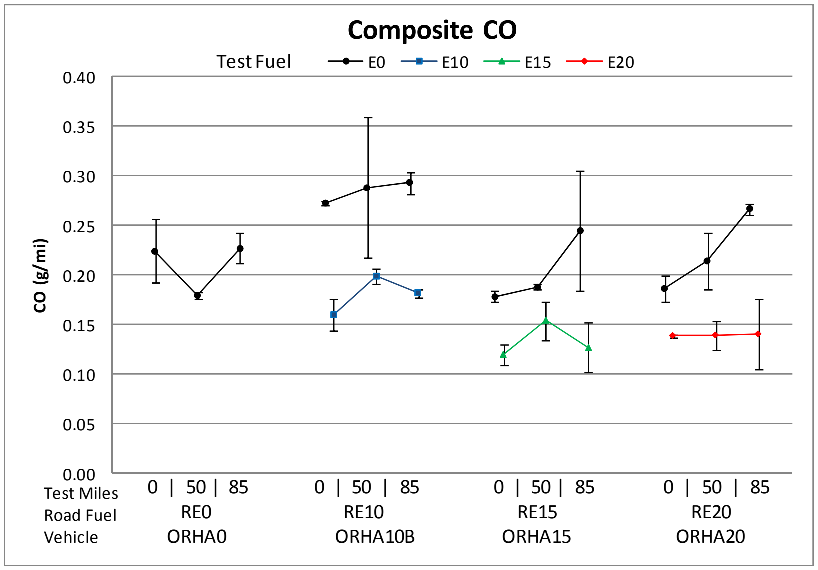
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δg/mi)	-0.104*	-0.144	-0.065
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.070*	-0.111	-0.029
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.083*	-0.124	-0.042
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	-0.003	-0.087	0.082
Aging Effect with RE10 (Δg/mi per 100k mi)	0.027	-0.030	0.083
Aging Effect with RE15 (Δg/mi per 100k mi)	0.043	-0.016	0.102
Aging Effect with RE20 (Δg/mi per 100k mi)	0.047	-0.012	0.106

* Indicates estimate is different from zero at the 95% confidence level.

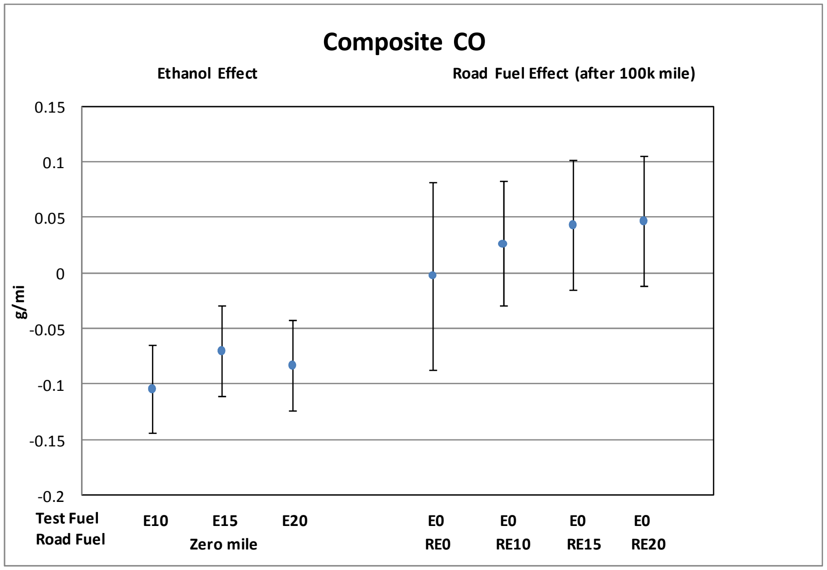
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.95
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.77

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 32k-35k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2007 Honda Accord (Composite NOx)

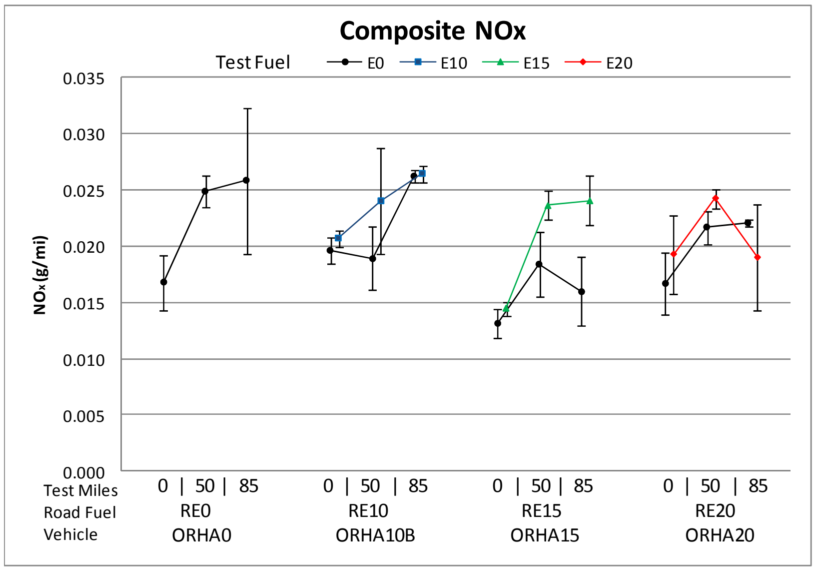
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δg/mi)	0.002	-0.0030	0.0068
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.005	-0.0001	0.0099
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.001	-0.0043	0.0057
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.011*	0.0010	0.0214
Aging Effect with RE10 (Δg/mi per 100k mi)	0.007*	0.0003	0.0143
Aging Effect with RE15 (Δg/mi per 100k mi)	0.008*	0.0007	0.0149
Aging Effect with RE20 (Δg/mi per 100k mi)	0.003	-0.0037	0.0106

* Indicates estimate is different from zero at the 95% confidence level.

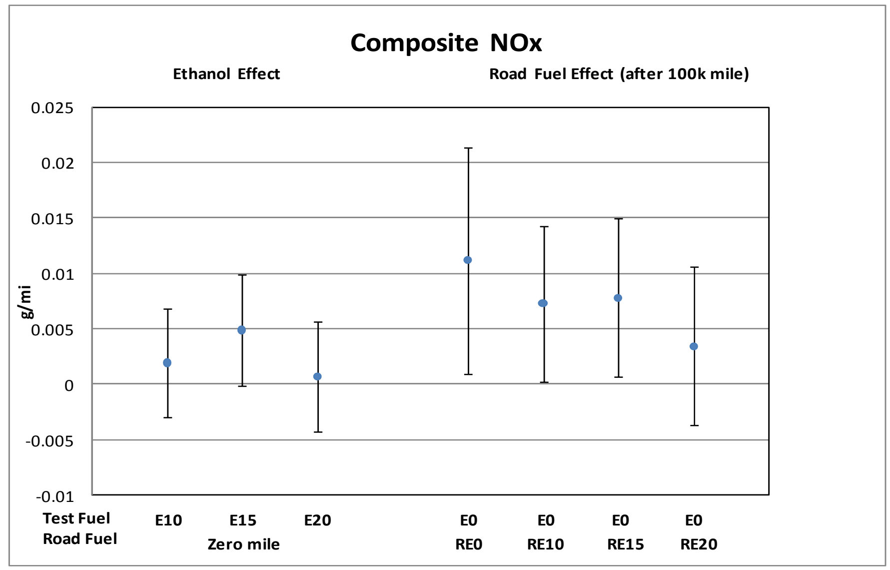
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.20
No Aging Effect with RE0 (Beta0 = 0)	0.03*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.57

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 32k-35k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2007 Honda Accord (Composite Nonmethane Hydrocarbons)

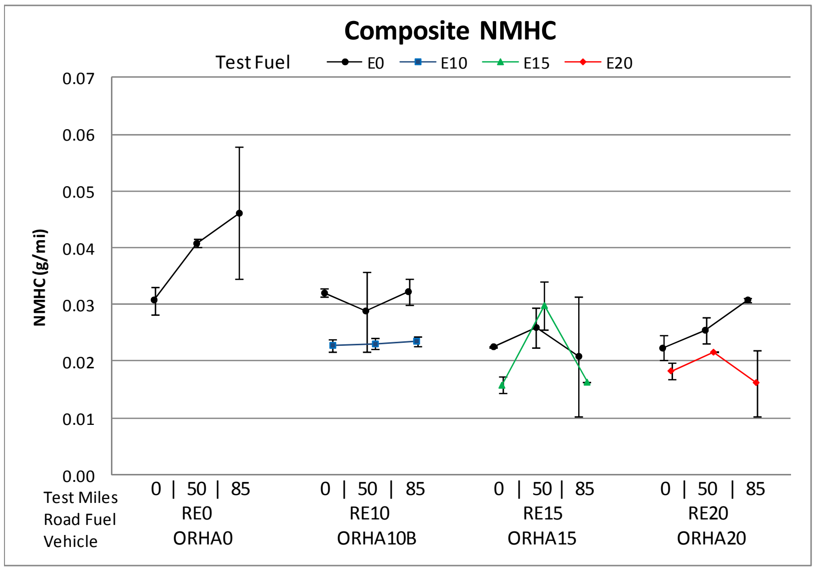
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δg/mi)	-0.0079	-0.0164	0.0006
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.0024	-0.0110	0.0062
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.0075	-0.0161	0.0011
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0073	-0.0114	0.0261
Aging Effect with RE10 (Δg/mi per 100k mi)	0.0004	-0.0118	0.0126
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0005	-0.0117	0.0128
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0038	-0.0084	0.0161

* Indicates estimate is different from zero at the 95% confidence level.

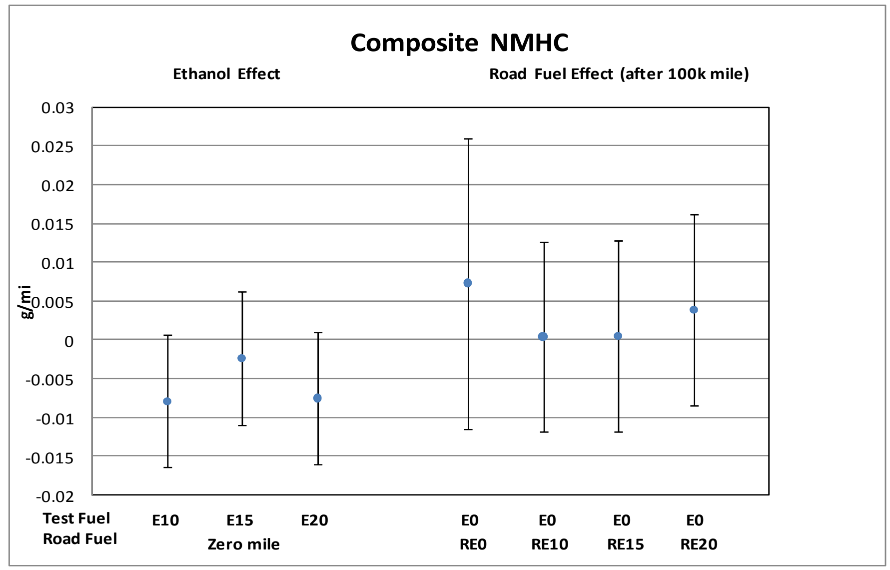
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.09
No Aging Effect with RE0 (Beta0 = 0)	0.41
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.89

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 32k-35k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2007 Honda Accord (Composite Nonmethane Organic Gases)

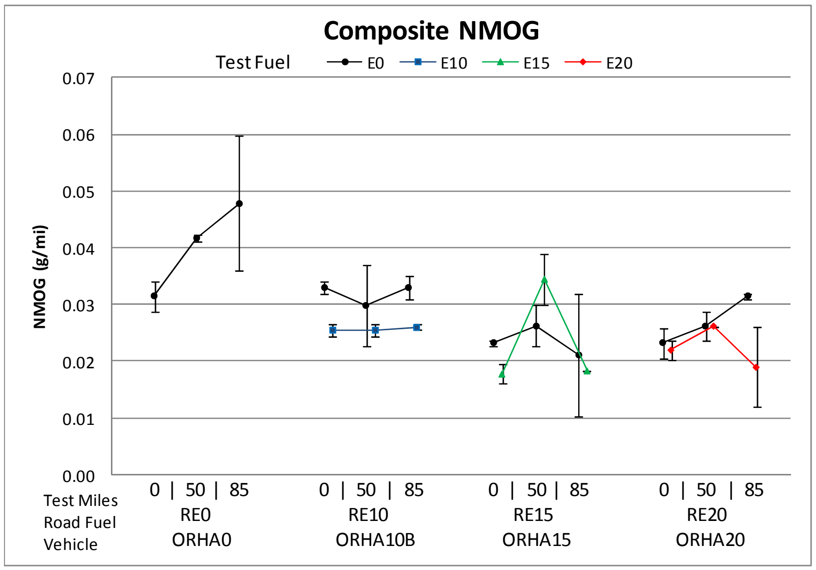
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δg/mi)	-0.0063	-0.0159	0.0034
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0000	-0.0097	0.0097
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.0046	-0.0143	0.0051
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0079	-0.0131	0.0289
Aging Effect with RE10 (Δg/mi per 100k mi)	0.0002	-0.0136	0.0139
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0005	-0.0134	0.0143
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0034	-0.0105	0.0173

* Indicates estimate is different from zero at the 95% confidence level.

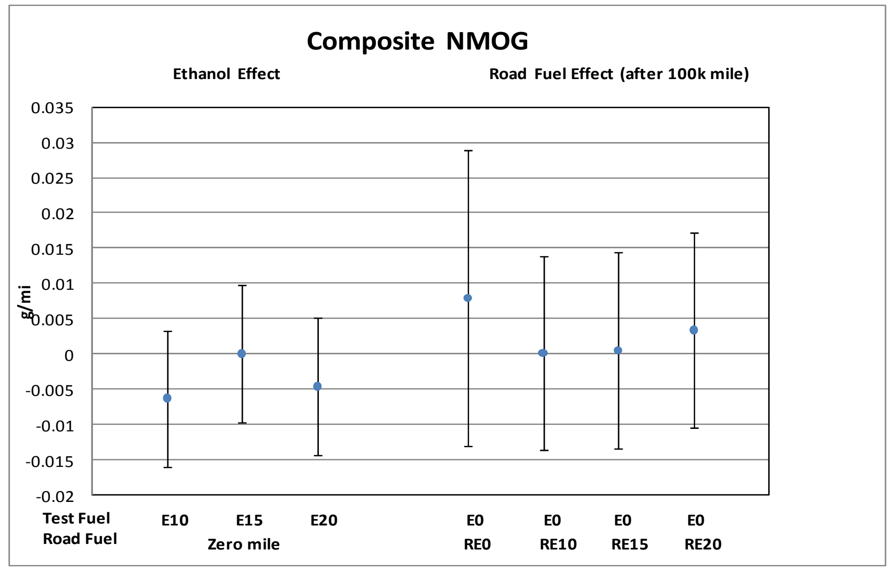
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.40
No Aging Effect with RE0 (Beta0 = 0)	0.43
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.90

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 32k-35k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2007 Honda Accord (Composite Fuel Economy)

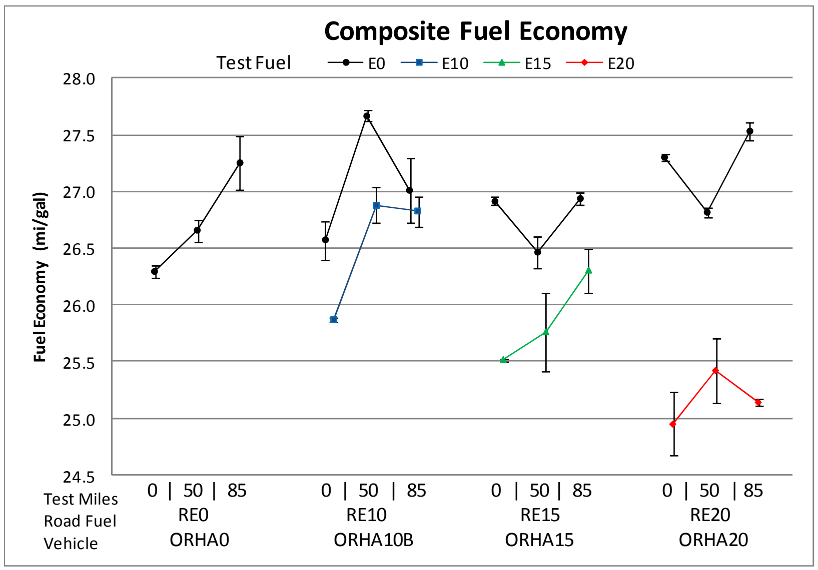
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δmi/gal)	-0.549	-1.221	0.124
Ethanol Effect (E15 vs. E0) (Δmi/gal)	-0.915*	-1.588	-0.241
Ethanol Effect (E20 vs. E0) (Δmi/gal)	-2.046*	-2.720	-1.372
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmi/gal per 100k mi)	1.105	-0.276	2.487
Aging Effect with RE10 (Δmi/gal per 100k mi)	0.886	-0.073	1.845
Aging Effect with RE15 (Δmi/gal per 100k mi)	0.431	-0.533	1.394
Aging Effect with RE20 (Δmi/gal per 100k mi)	0.229	-0.735	1.193

* Indicates estimate is different from zero at the 95% confidence level.

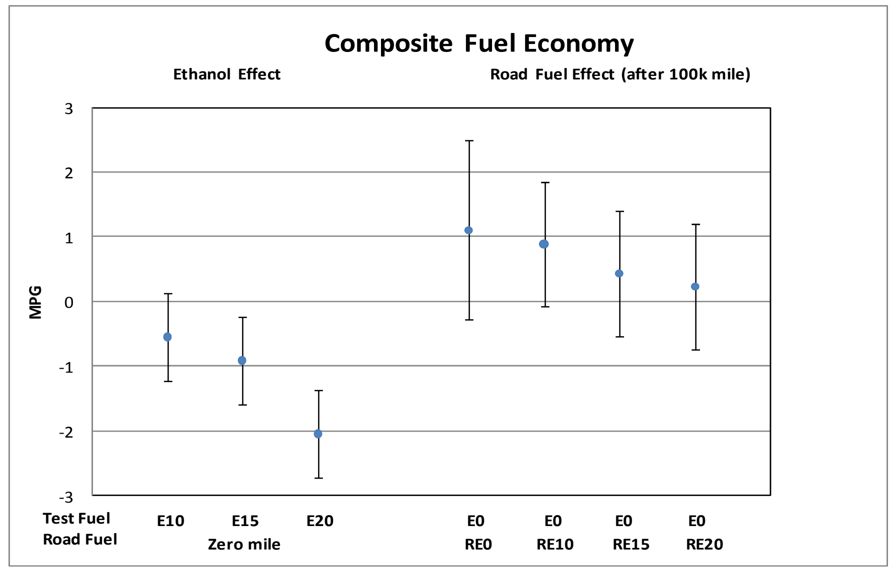
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.11
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.59

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 32k-35k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2007 Honda Accord (Composite Ethanol)

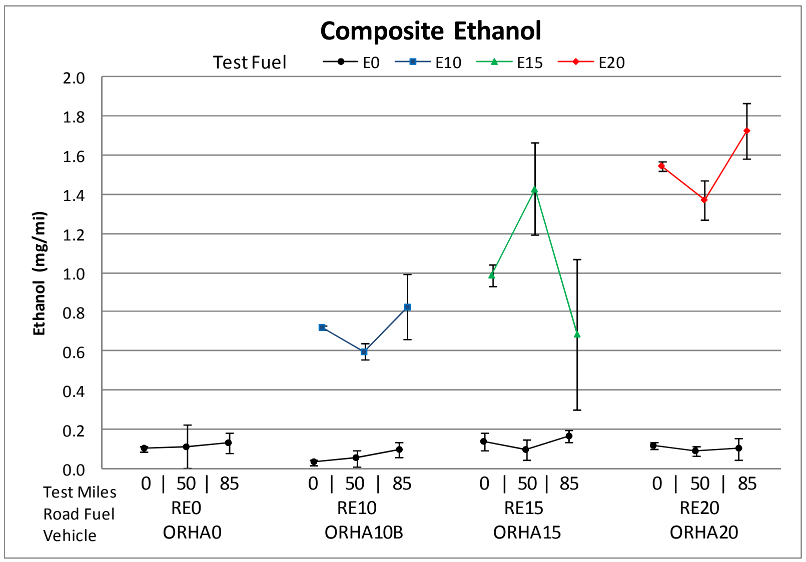
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δmg/mi)	0.656*	0.285	1.026
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.901*	0.531	1.271
Ethanol Effect (E20 vs. E0) (Δmg/mi)	1.445*	1.075	1.815
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.033	-0.729	0.794
Aging Effect with RE10 (Δmg/mi per 100k mi)	0.098	-0.433	0.630
Aging Effect with RE15 (Δmg/mi per 100k mi)	-0.163	-0.694	0.368
Aging Effect with RE20 (Δmg/mi per 100k mi)	0.095	-0.436	0.626

* Indicates estimate is different from zero at the 95% confidence level.

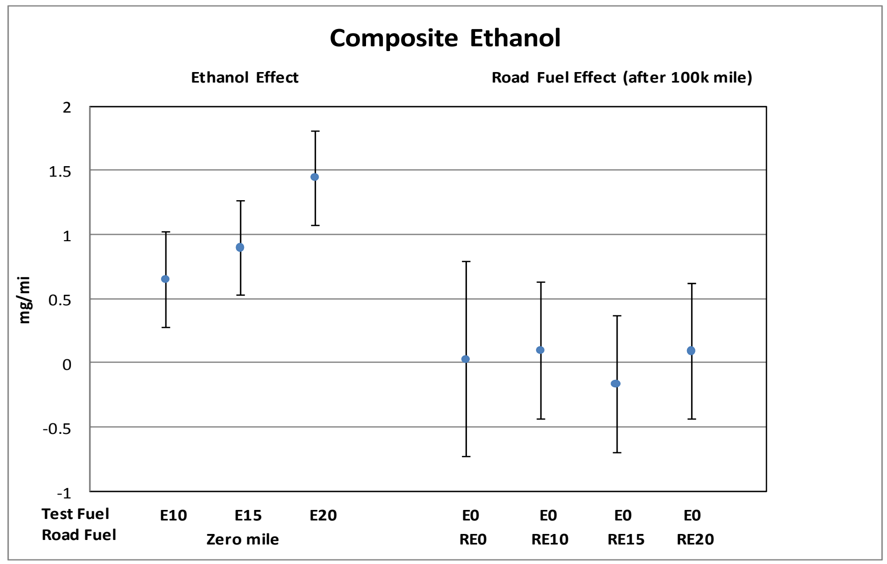
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.92
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.81

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 32k-35k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2007 Honda Accord (Composite Acetaldehyde)

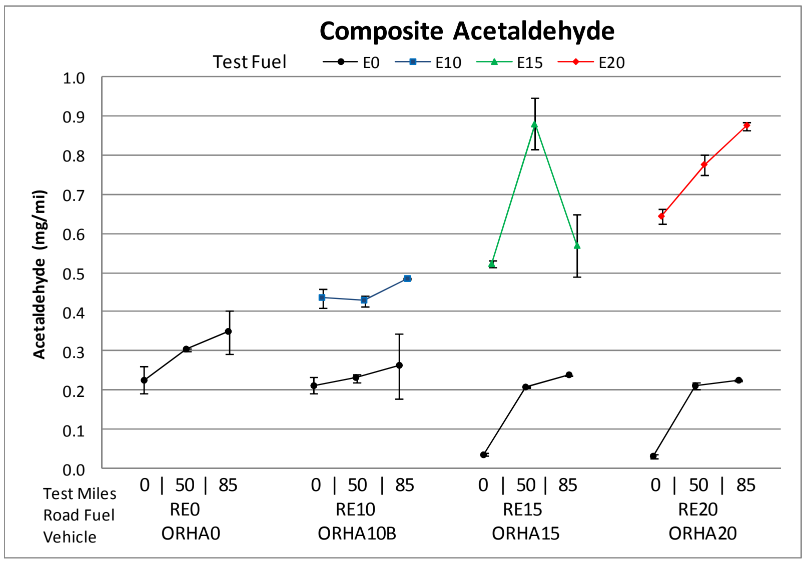
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δmg/mi)	0.215*	0.070	0.360
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.497*	0.353	0.642
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.610*	0.465	0.754
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.145	-0.153	0.443
Aging Effect with RE10 (Δmg/mi per 100k mi)	0.058	-0.149	0.266
Aging Effect with RE15 (Δmg/mi per 100k mi)	0.146	-0.062	0.354
Aging Effect with RE20 (Δmg/mi per 100k mi)	0.249*	0.041	0.456

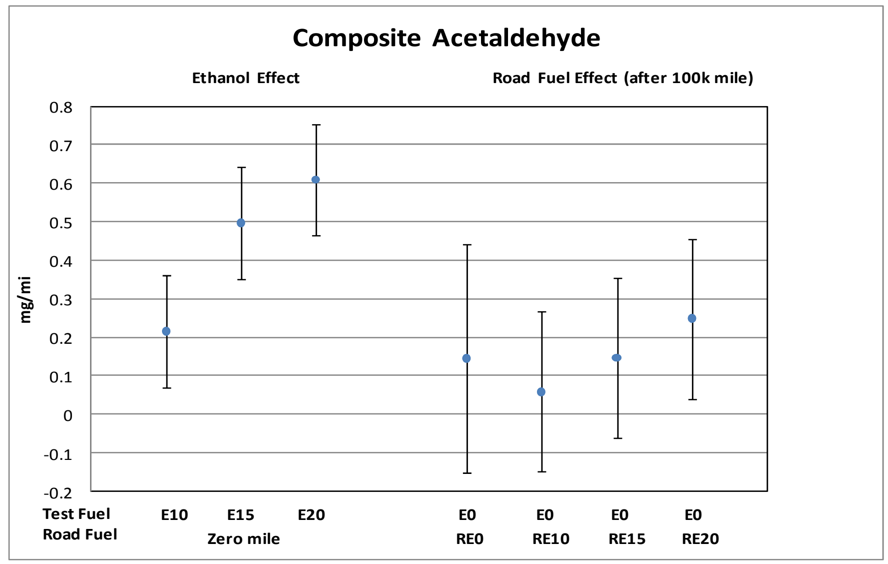
* Indicates estimate is different from zero at the 95% confidence level.

Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.28
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.52

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 32k-35k





Error bars represent min and max measurements

Error bars represent 95% confidence intervals on the estimated effects

* The statistical model for Acetaldehyde does not assume the linear relationship between emission and mileage.

2007 Honda Accord (Composite Formaldehyde)

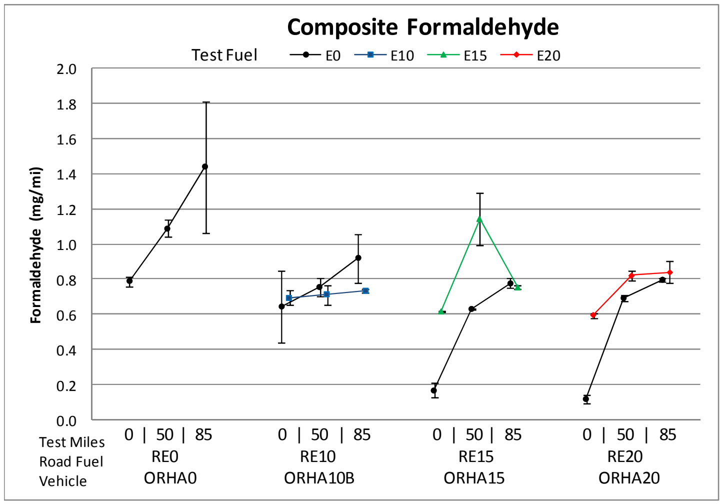
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δmg/mi)	0.084	-0.508	0.676
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.521*	0.053	0.990
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.473*	0.069	0.878
Road Fuel Aging Effect			
Aging Effect E0 Emissions with RE0 (Δmg/mi per 100k mi)	0.761	-0.500	2.021
Aging Effect on E0 Emissions with RE10 (Δmg/mi per 100k mi)	0.360	-0.451	1.172
Aging Effect on E0 Emissions with RE15 (Δmg/mi per 100k mi)	1.033*	0.134	1.933
Aging Effect on E0 Emissions with RE20 (Δmg/mi per 100k mi)	1.307*	0.245	2.370

* Indicates estimate is different from zero at the 95% confidence level.

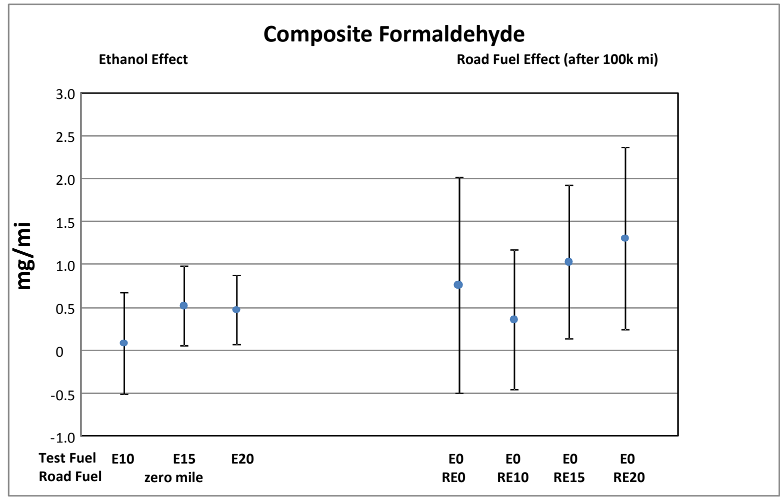
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.20
No Effect of Ethanol on Road Fuel Aging (Beta 1s = 0)	0.07

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 32k-35k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2007 Honda Accord (Composite CH_4)

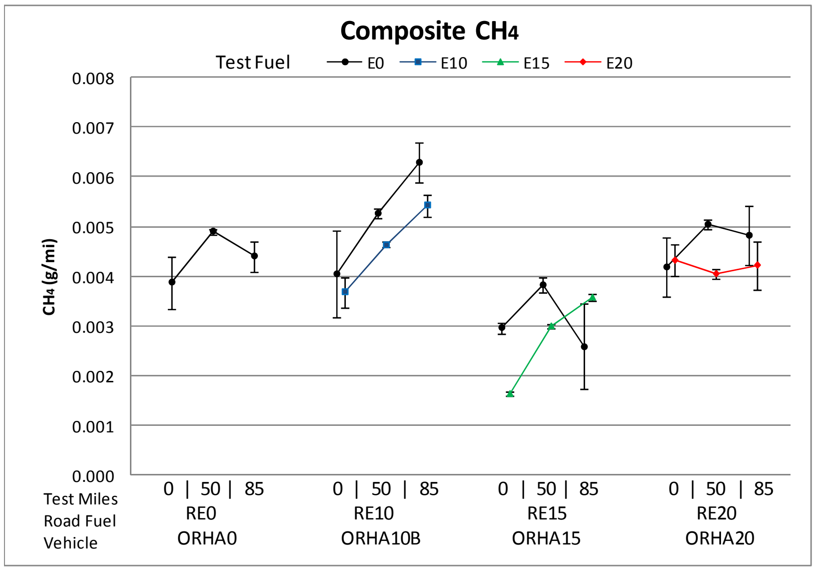
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δg/mi)	-0.0006	-0.0016	0.0003
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.0004	-0.0014	0.0006
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.0005	-0.0015	0.0005
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0007	-0.0013	0.0027
Aging Effect with RE10 (Δg/mi per 100k mi)	0.0023*	0.0010	0.0037
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0010	-0.0004	0.0024
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0003	-0.0010	0.0017

* Indicates estimate is different from zero at the 95% confidence level.

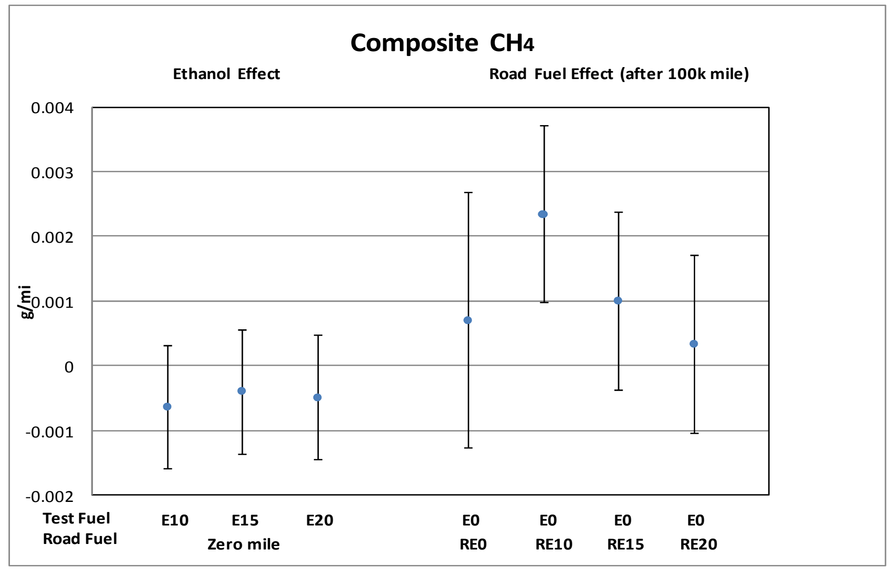
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.29
No Aging Effect with RE0 (Beta0 = 0)	0.44
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.18

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 32k-35k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2006 Chevrolet Silverado - Composite Emissions Summary

Emisssion Parameter (units)	Ethanol Effect				Aging Effect with RE0		RExx Aging Effect on E0 Emissions				RExx Aging Effect on Exx Emissions			Road and Test Fuel Effects are Additive
	Δ units vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value	Δ units per 100K mi			Overall p-value
Fuels	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0		RE10/E10	RE15/E15	RE20/E20	
CO (g/mi)	0.028	-0.066	-0.067	0.87	-0.055	0.81	0.012	0.071	-0.169	0.73	NA	NA	NA	0.96
NOx (g/mi)	0.008	0.008	0.001	0.48	0.006	0.64	0.021*	0.013	0.023*	0.69	NA	NA	NA	0.92
NMHC (g/mi)	0.007	-0.001	-0.002	0.95	0.005	0.82	0.013	0.014	0.006	0.97	NA	NA	NA	0.99
NMOG (g/mi)	0.011	0.005	0.005	0.77	0.005	0.82	0.015	0.015	0.007	0.97	NA	NA	NA	0.99
Fuel Econ (mi/gal)[##]	-0.580*	-0.898*	-1.157*	<0.01*	0.606	0.21	0.267	0.079	0.163	0.79	NA	NA	NA	NA
Ethanol (mg/mi)[##]	2.349*	3.499*	4.366*	<0.01*	-0.058	0.97	0.732	0.505	0.418	0.97	NA	NA	NA	NA
Acetaldehyde (mg/mi)[#]	0.468*	0.857*	0.997*	<0.01*	0.124*	0.02*	0.184*	0.119*	0.109*	0.59	NA	NA	NA	0.23
Formaldehyde (mg/mi)[#a]	0.025	-0.059	0.064	0.80	0.432*	0.02*	0.756*	0.425*	0.710*	0.21	NA	NA	NA	0.20
CH_4 (g/mi)	0.0043	0.0009	0.0014	0.58	0.0103	0.12	0.0070	0.0126*	0.0124*	0.78	NA	NA	NA	0.64

Log-normal model was used. Results are presented as changes in emissions at 0k mile.

Data did not support the assumption of linear effects with mileage.

* Indicates estimate is different from zero at the 95% confidence level.

a Test "SW021494" is identified as an outlier and excluded from the analysis.

2006 Chevrolet Silverado (Composite CO)

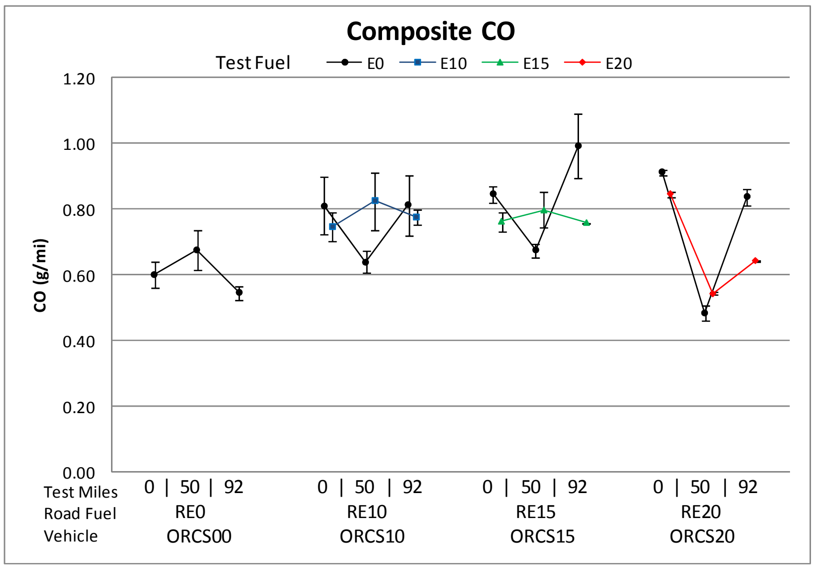
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δg/mi)	0.028	-0.233	0.288
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.066	-0.326	0.195
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.067	-0.328	0.193
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	-0.055	-0.544	0.434
Aging Effect with RE10 (Δg/mi per 100k mi)	0.012	-0.334	0.358
Aging Effect with RE15 (Δg/mi per 100k mi)	0.071	-0.275	0.417
Aging Effect with RE20 (Δg/mi per 100k mi)	-0.169	-0.515	0.177

* Indicates estimate is different from zero at the 95% confidence level.

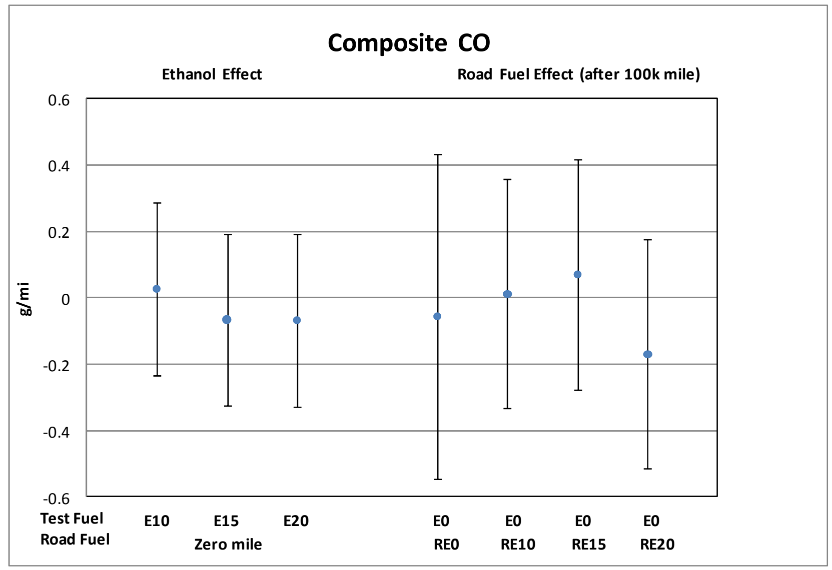
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.87
No Aging Effect with RE0 (Beta0 = 0)	0.81
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.73

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 14k-28k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2006 Chevrolet Silverado (Composite NOx)

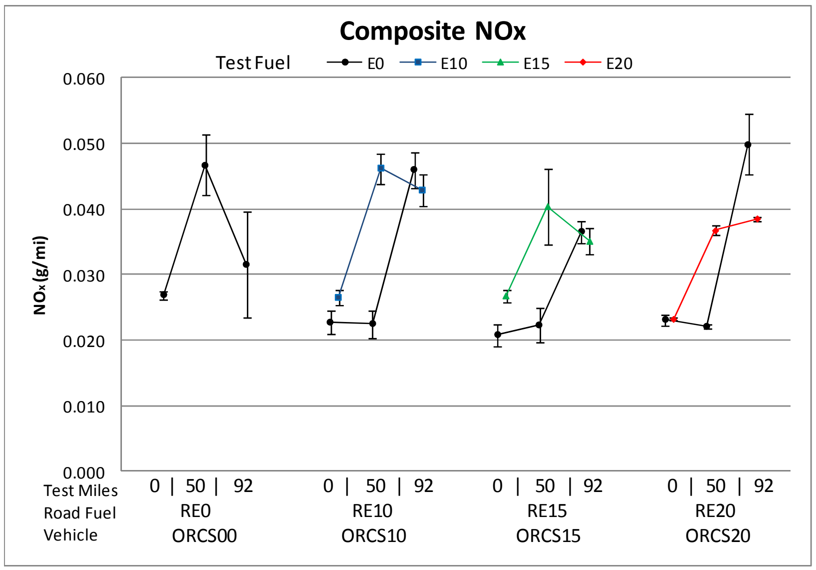
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δg/mi)	0.008	-0.007	0.023
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.008	-0.008	0.023
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.001	-0.014	0.016
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.006	-0.022	0.035
Aging Effect with RE10 (Δg/mi per 100k mi)	0.021*	0.001	0.042
Aging Effect with RE15 (Δg/mi per 100k mi)	0.013	-0.007	0.033
Aging Effect with RE20 (Δg/mi per 100k mi)	0.023*	0.002	0.043

* Indicates estimate is different from zero at the 95% confidence level.

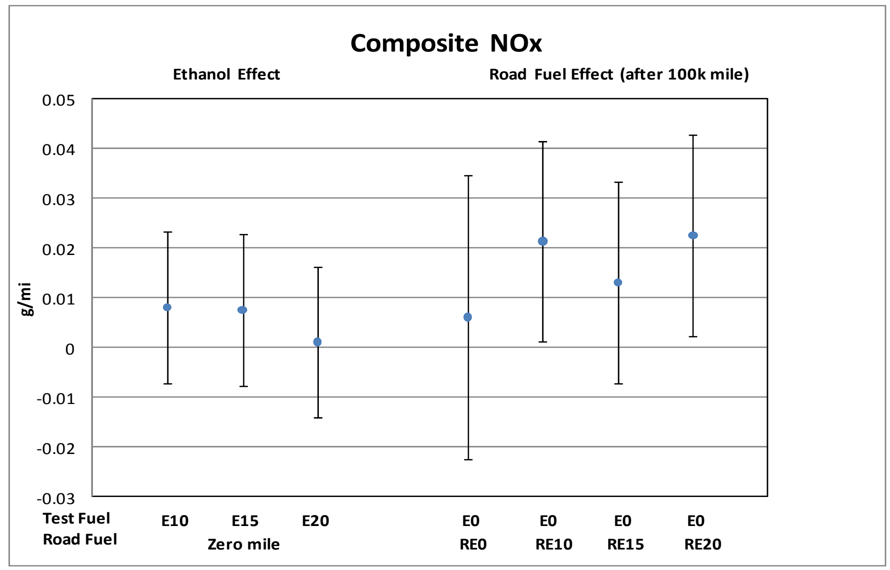
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.48
No Aging Effect with RE0 (Beta0 = 0)	0.64
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.69

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 14k-28k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2006 Chevrolet Silverado (Composite Nonmethane Hydrocarbons)

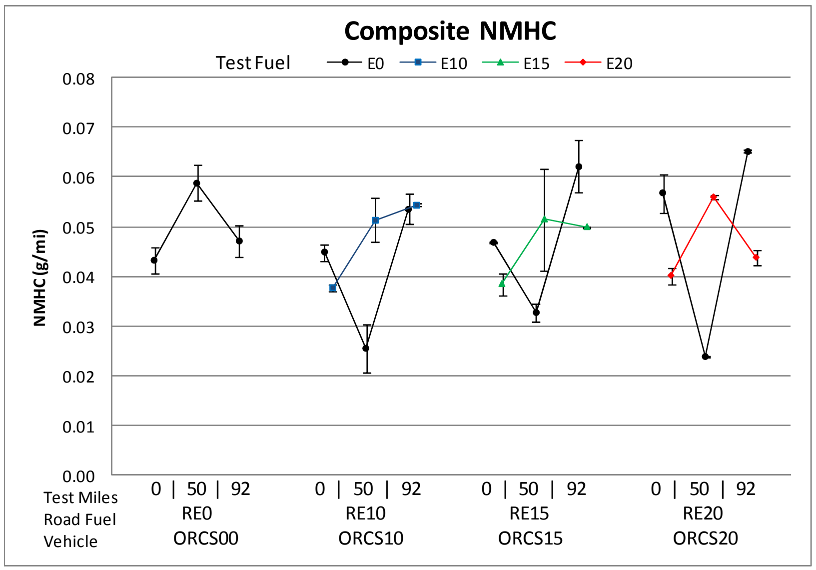
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δg/mi)	0.007	-0.019	0.032
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.001	-0.026	0.025
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.002	-0.028	0.024
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.005	-0.043	0.053
Aging Effect with RE10 (Δg/mi per 100k mi)	0.013	-0.021	0.047
Aging Effect with RE15 (Δg/mi per 100k mi)	0.014	-0.020	0.048
Aging Effect with RE20 (Δg/mi per 100k mi)	0.006	-0.028	0.040

* Indicates estimate is different from zero at the 95% confidence level.

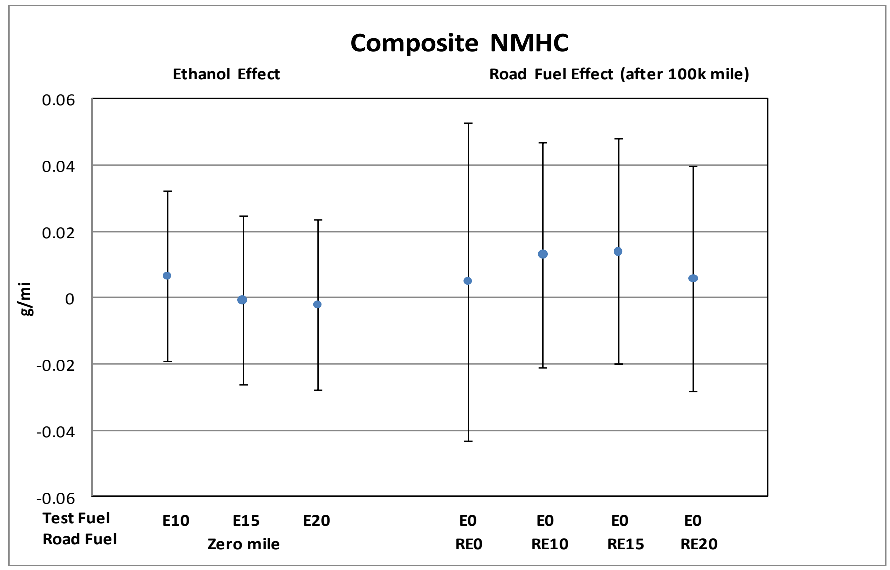
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.95
No Aging Effect with RE0 (Beta0 = 0)	0.82
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.97

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 14k-28k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2006 Chevrolet Silverado (Composite Nonmethane Organic Gases)

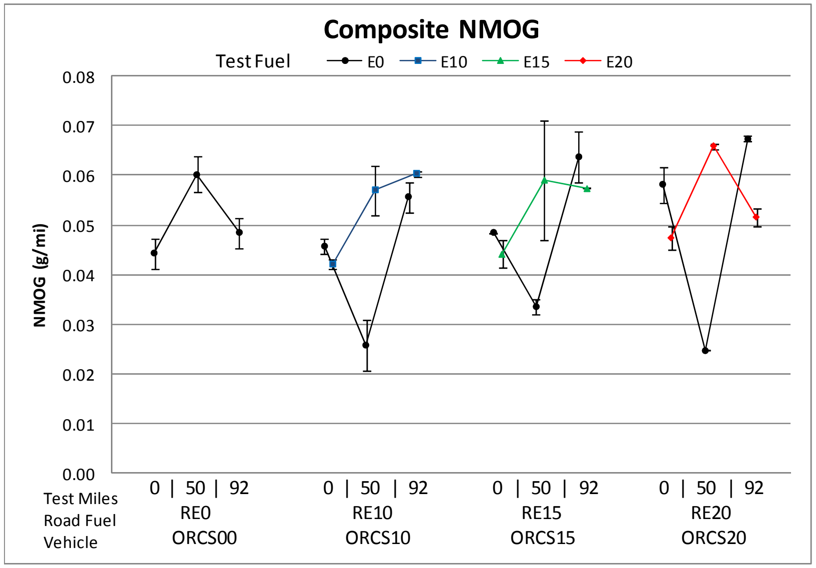
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δg/mi)	0.011	-0.016	0.038
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.005	-0.022	0.032
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.005	-0.022	0.032
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.005	-0.045	0.055
Aging Effect with RE10 (Δg/mi per 100k mi)	0.015	-0.021	0.050
Aging Effect with RE15 (Δg/mi per 100k mi)	0.015	-0.021	0.051
Aging Effect with RE20 (Δg/mi per 100k mi)	0.007	-0.029	0.042

* Indicates estimate is different from zero at the 95% confidence level.

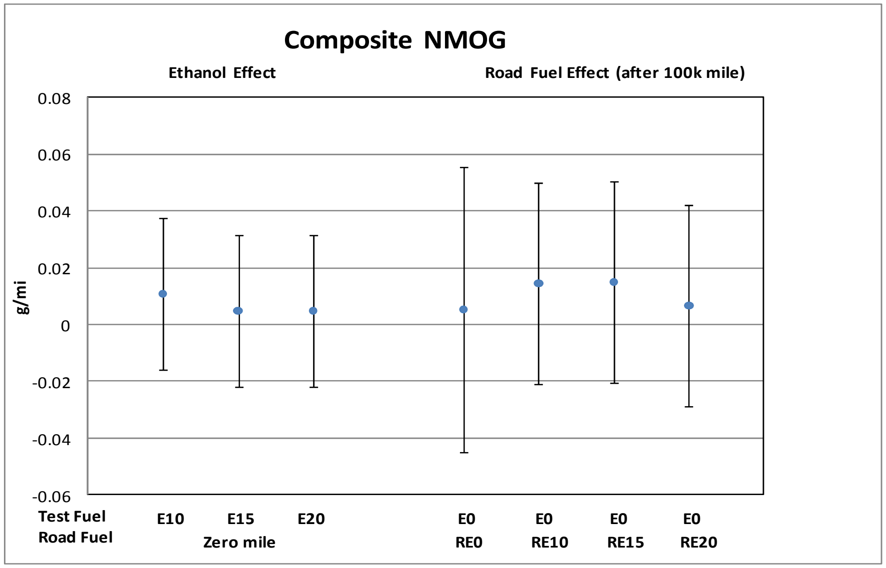
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.77
No Aging Effect with RE0 (Beta0 = 0)	0.82
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.97

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 14k-28k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2006 Chevrolet Silverado (Composite Fuel Economy)

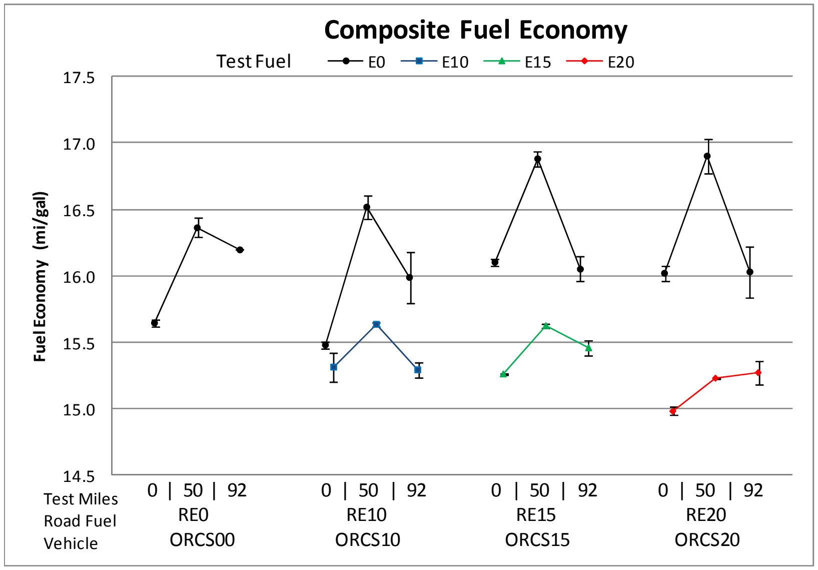
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δmi/gal)	-0.580*	-1.141	-0.020
Ethanol Effect (E15 vs. E0) (Δmi/gal)	-0.898*	-1.459	-0.338
Ethanol Effect (E20 vs. E0) (Δmi/gal)	-1.157*	-1.718	-0.596
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmi/gal per 100k mi)	0.606	-0.448	1.661
Aging Effect with RE10 (Δmi/gal per 100k mi)	0.267	-0.479	1.013
Aging Effect with RE15 (Δmi/gal per 100k mi)	0.079	-0.667	0.825
Aging Effect with RE20 (Δmi/gal per 100k mi)	0.163	-0.583	0.909

* Indicates estimate is different from zero at the 95% confidence level.

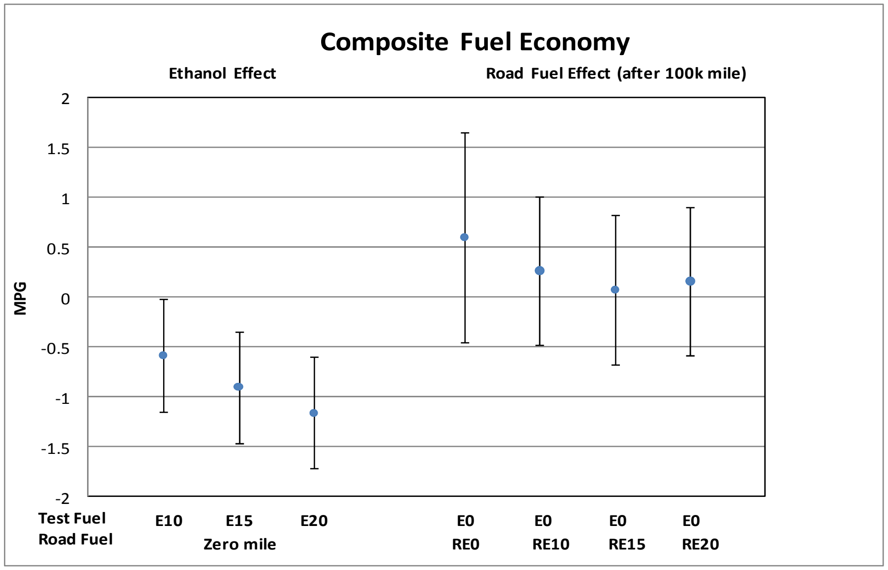
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.21
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.79

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 14k-28k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2006 Chevrolet Silverado (Composite Ethanol)

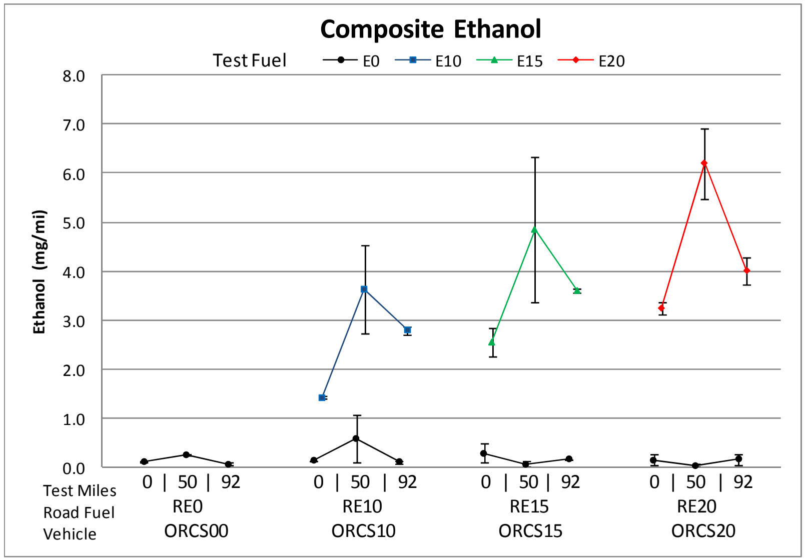
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δmg/mi)	2.349*	0.520	4.178
Ethanol Effect (E15 vs. E0) (Δmg/mi)	3.499*	1.670	5.328
Ethanol Effect (E20 vs. E0) (Δmg/mi)	4.366*	2.537	6.194
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	-0.058	-3.498	3.382
Aging Effect with RE10 (Δmg/mi per 100k mi)	0.732	-1.701	3.166
Aging Effect with RE15 (Δmg/mi per 100k mi)	0.505	-1.928	2.939
Aging Effect with RE20 (Δmg/mi per 100k mi)	0.418	-2.016	2.851

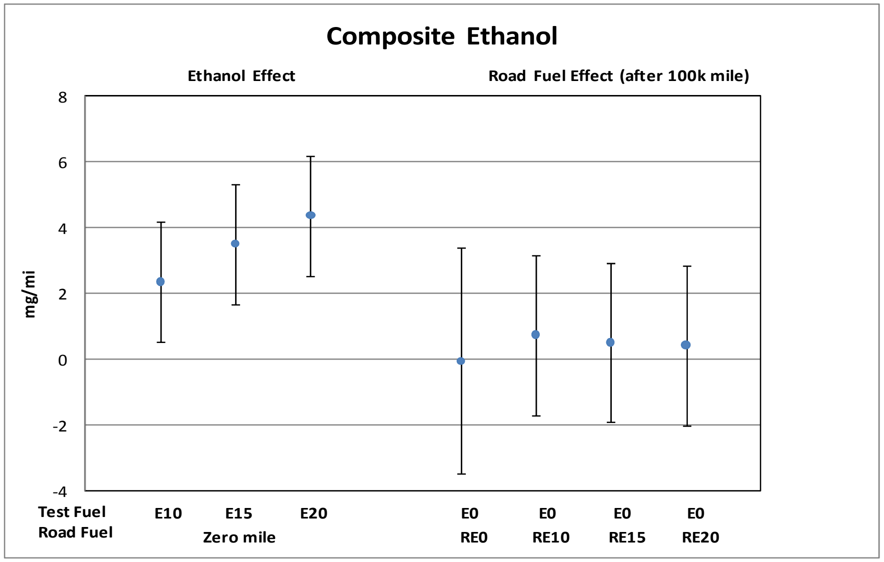
* Indicates estimate is different from zero at the 95% confidence level.

Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.97
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.97

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 14k-28k





Error bars represent min and max measurements

Error bars represent 95% confidence intervals on the estimated effects

* The statistical model for Acetaldehyde does not assume the linear relationship between emission and mileage.

2006 Chevrolet Silverado (Composite Acetaldehyde)

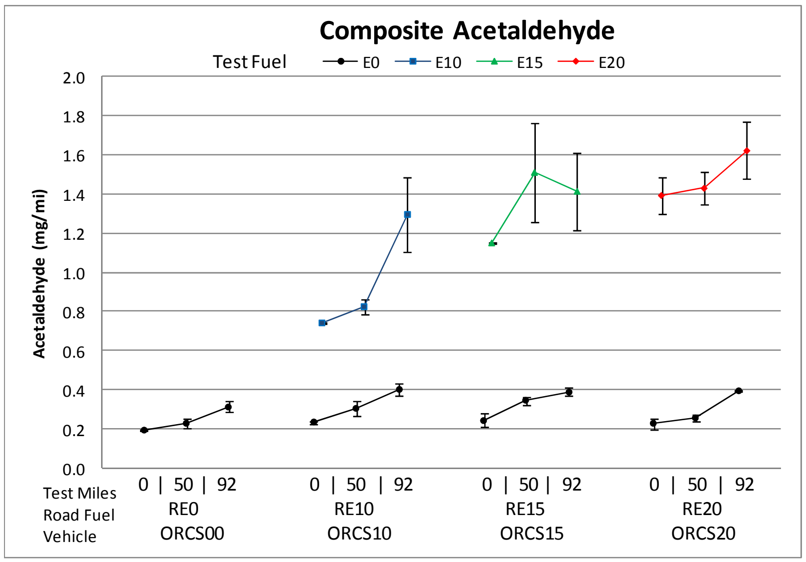
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δmg/mi)	0.468*	0.322	0.614
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.857*	0.627	1.087
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.997*	0.747	1.247
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.124*	0.033	0.215
Aging Effect with RE10 (Δmg/mi per 100k mi)	0.184*	0.086	0.282
Aging Effect with RE15 (Δmg/mi per 100k mi)	0.119*	0.023	0.216
Aging Effect with RE20 (Δmg/mi per 100k mi)	0.109*	0.023	0.196

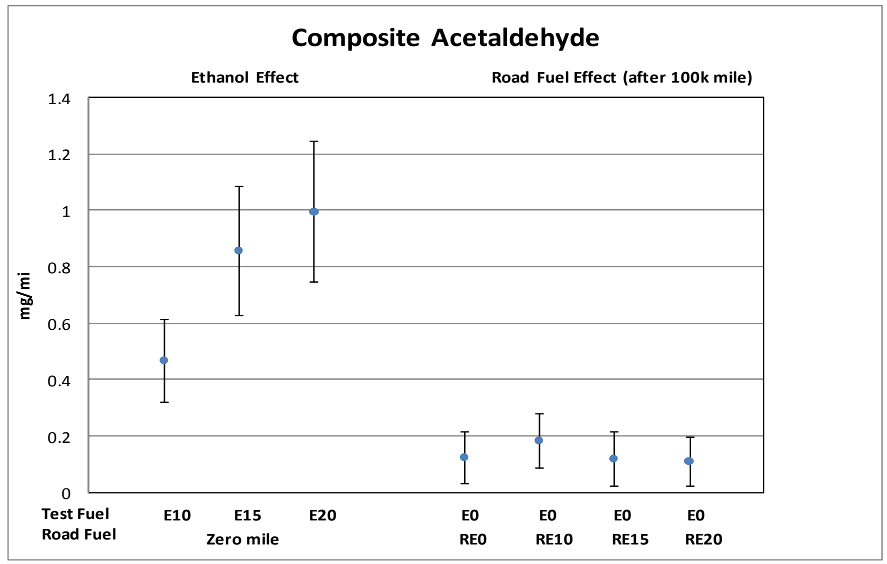
* Indicates estimate is different from zero at the 95% confidence level.

Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.02*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.59

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 14k-28k





Error bars represent min and max measurements

Error bars represent 95% confidence intervals on the estimated effects

* The statistical model for Acetaldehyde does not assume the linear relationship between emission and mileage.

2006 Chevrolet Silverado (Composite Formaldehyde)

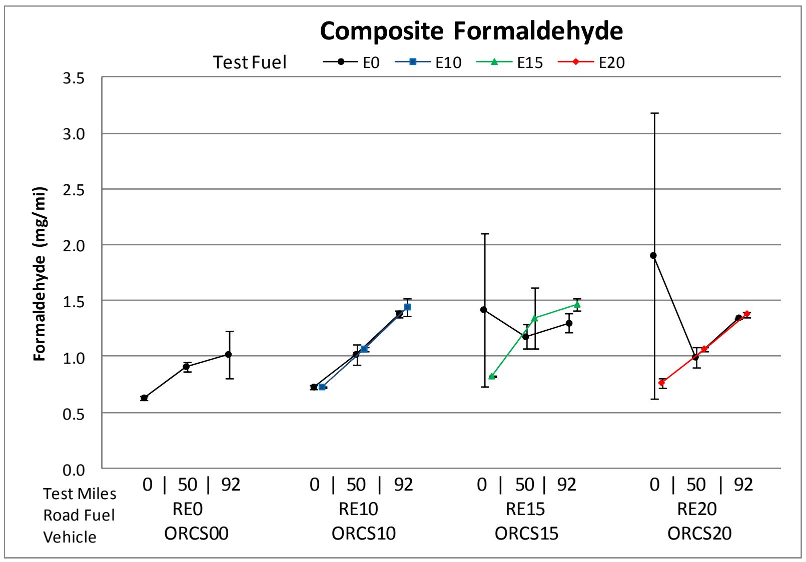
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δmg/mi)	0.025	-0.188	0.238
Ethanol Effect (E15 vs. E0) (Δmg/mi)	-0.059	-0.360	0.242
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.064	-0.168	0.295
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.432*	0.100	0.763
Aging Effect with RE10 (Δmg/mi per 100k mi)	0.756*	0.403	1.109
Aging Effect with RE15 (Δmg/mi per 100k mi)	0.425*	0.035	0.815
Aging Effect with RE20 (Δmg/mi per 100k mi)	0.710*	0.364	1.056

* Indicates estimate is different from zero at the 95% confidence level.

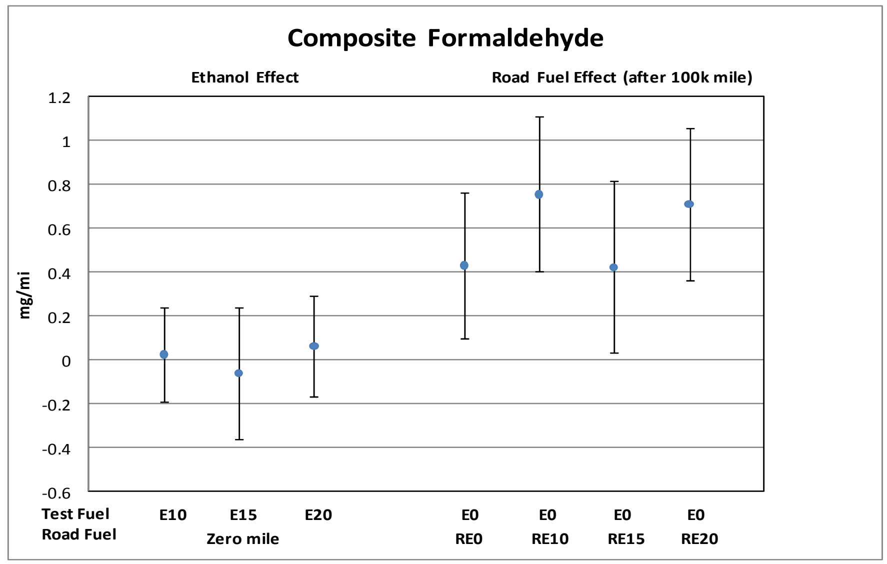
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.80
No Aging Effect with RE0 (Beta0 = 0)	0.02*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.21

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 14k-28k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2006 Chevrolet Silverado (Composite CH_4)

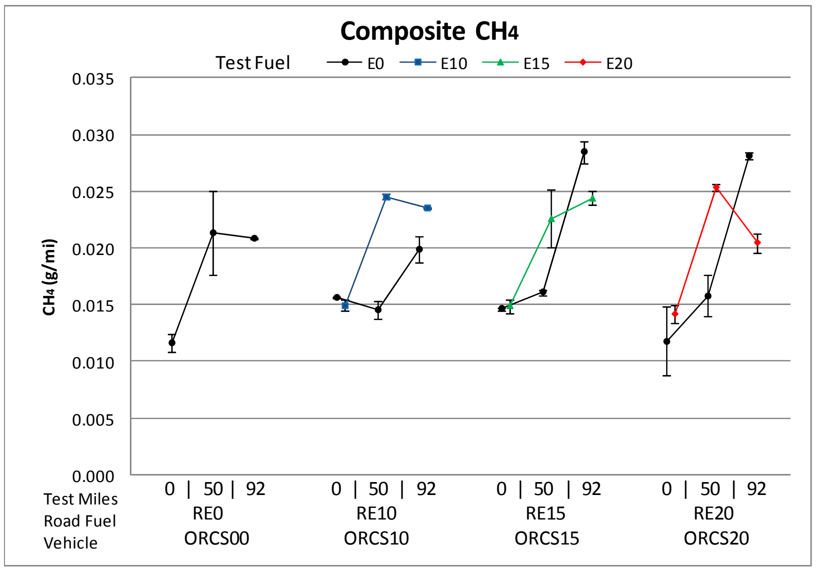
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δg/mi)	0.0043	-0.0028	0.0115
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0009	-0.0062	0.0081
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.0014	-0.0058	0.0085
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0103	-0.0031	0.0238
Aging Effect with RE10 (Δg/mi per 100k mi)	0.0070	-0.0025	0.0165
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0126*	0.0031	0.0221
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0124*	0.0029	0.0219

* Indicates estimate is different from zero at the 95% confidence level.

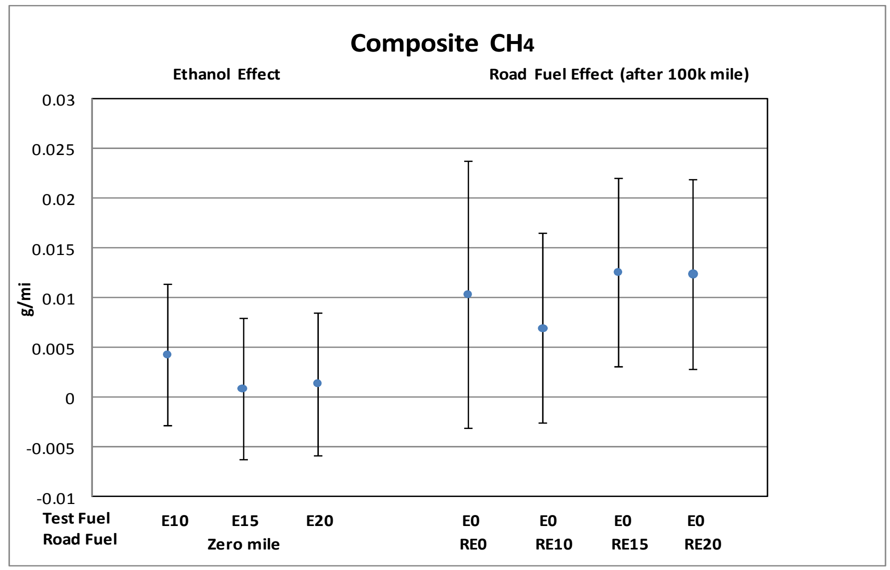
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.58
No Aging Effect with RE0 (Beta0 = 0)	0.12
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.78

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 14k-28k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2008 Nissan Altima - Composite Emissions Summary

Emisssion Parameter (units)	Ethanol Effect				Aging Effect with RE0		RExx Aging Effect on E0 Emissions				RExx Aging Effect on Exx Emissions			Road and Test Fuel Effects are Additive
	Δ units vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value	Δ units per 100K mi			Overall p-value
Fuels	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0		RE10/E10	RE15/E15	RE20/E20	
CO (g/mi)[a]	0.066	-0.067	-0.153	0.42	0.224	0.54	0.221	0.226	0.161	0.98	NA	NA	NA	0.99
NOx (g/mi)	0.0092*	0.0000	0.0040	0.16	0.0360*	<0.01*	0.0272*	0.0268*	0.0179*	0.23	NA	NA	NA	0.88
NMHC (g/mi)[a]	0.0093	-0.0072	-0.0073	0.28	-0.0010	0.97	0.0079	0.0039	0.0001	0.91	NA	NA	NA	0.98
NMOG (g/mi)[a]	0.0142	-0.0016	0.0003	0.30	-0.0021	0.93	0.0083	0.0041	-0.0008	0.89	NA	NA	NA	0.98
Fuel Econ (mi/gal)	-1.168*	-1.553*	-1.751*	<0.01*	-1.534*	0.02*	-0.247	-0.226	-0.020	0.20	NA	NA	NA	0.65
Ethanol (mg/mi)[##]	2.335*	3.328*	4.369*	<0.01*	0.318	0.72	0.230	1.131	1.076	0.68	NA	NA	NA	NA
Acetaldehyde (mg/mi)[#]	0.409*	0.656*	0.901*	<0.01*	0.151*	0.02*	0.083*	0.058	0.055	0.62	NA	NA	NA	0.12
Formaldehyde (mg/mi)[#]	-0.006	-0.076	-0.008	0.63	0.002	0.99	0.341*	0.254*	0.282*	0.25	NA	NA	NA	0.86
CH_4 (g/mi)[a]	0.0002	0.0003	-0.0005	0.95	0.0000	0.99	0.0052*	0.0042*	0.0044*	0.61	NA	NA	NA	0.32

Log-normal model was used. Results are presented as changes in emissions at 0k mile.

Data did not support the assumption of linear effects with mileage.

* Indicates estimate is different from zero at the 95% confidence level.

a Test "SW023589", "SW023600" and "SW023669" are identified as outliers and excluded from the analysis.

2008 Nissan Altima (Composite CO)

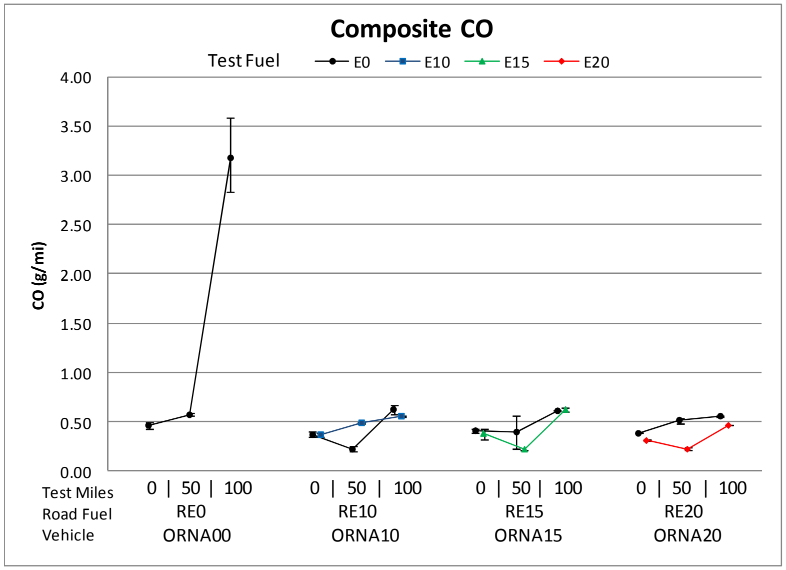
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δg/mi)	0.066	-0.162	0.295
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.067	-0.296	0.161
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.153	-0.381	0.076
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.224	-0.571	1.018
Aging Effect with RE10 (Δg/mi per 100k mi)	0.221	-0.059	0.501
Aging Effect with RE15 (Δg/mi per 100k mi)	0.226	-0.054	0.506
Aging Effect with RE20 (Δg/mi per 100k mi)	0.161	-0.119	0.441

* Indicates estimate is different from zero at the 95% confidence level.

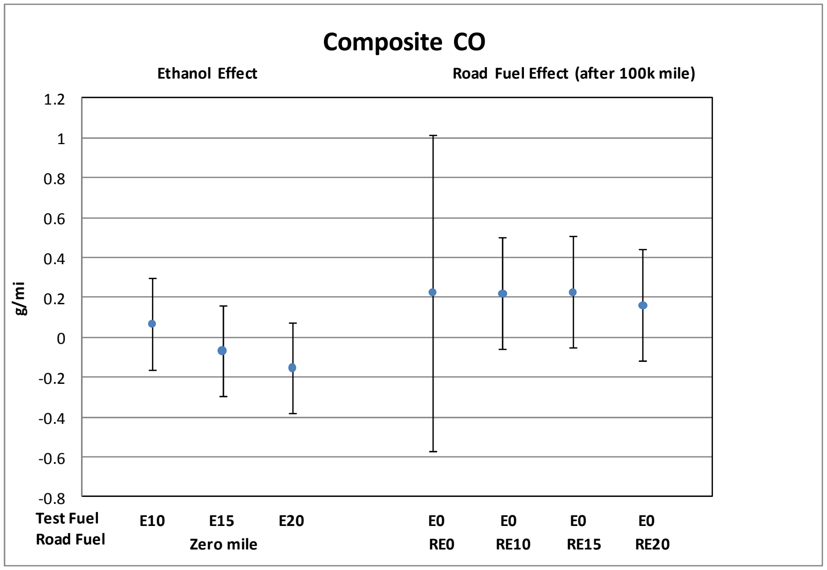
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.42
No Aging Effect with RE0 (Beta0 = 0)	0.54
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.98

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 10k-20k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2008 Nissan Altima (Composite NOx)

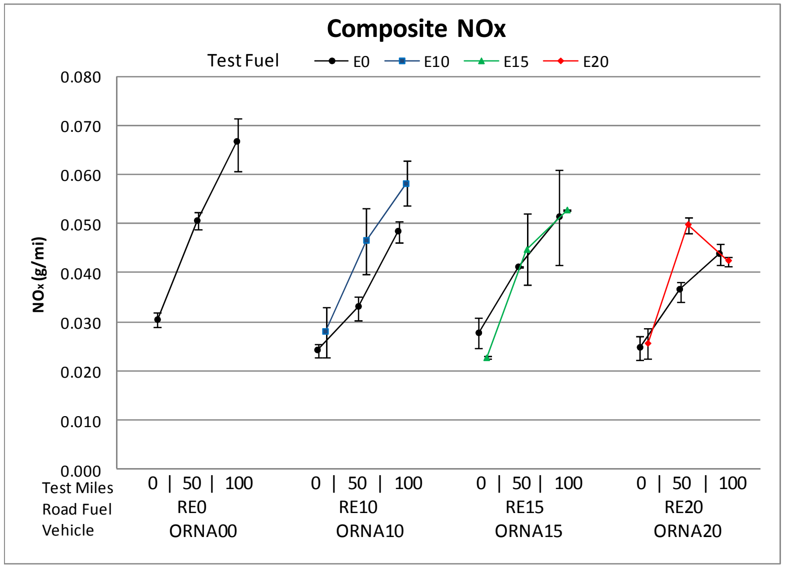
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δg/mi)	0.0092*	0.0004	0.0180
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0000	-0.0088	0.0089
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.0040	-0.0048	0.0128
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0360*	0.0209	0.0511
Aging Effect with RE10 (Δg/mi per 100k mi)	0.0272*	0.0163	0.0380
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0268*	0.0159	0.0376
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0179*	0.0070	0.0288

* Indicates estimate is different from zero at the 95% confidence level.

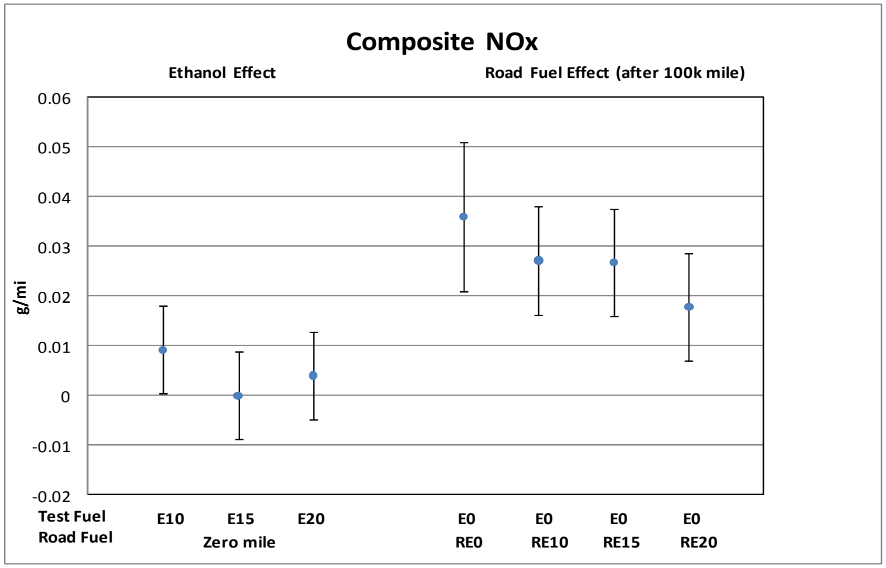
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.16
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.23

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 10k-20k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2008 Nissan Altima (Composite Nonmethane Hydrocarbons)

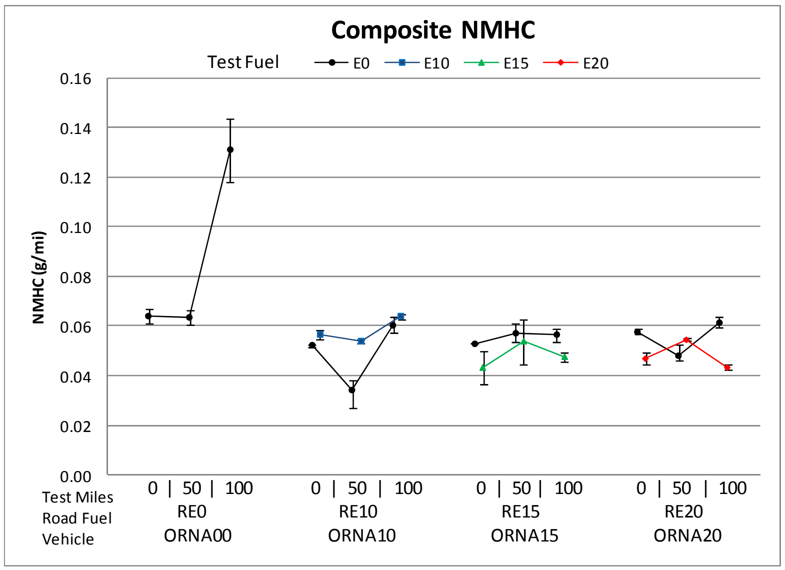
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δg/mi)	0.0093	-0.0054	0.0241
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.0072	-0.0220	0.0076
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.0073	-0.0220	0.0075
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	-0.0010	-0.0523	0.0504
Aging Effect with RE10 (Δg/mi per 100k mi)	0.0079	-0.0102	0.0260
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0039	-0.0142	0.0220
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0001	-0.0180	0.0182

* Indicates estimate is different from zero at the 95% confidence level.

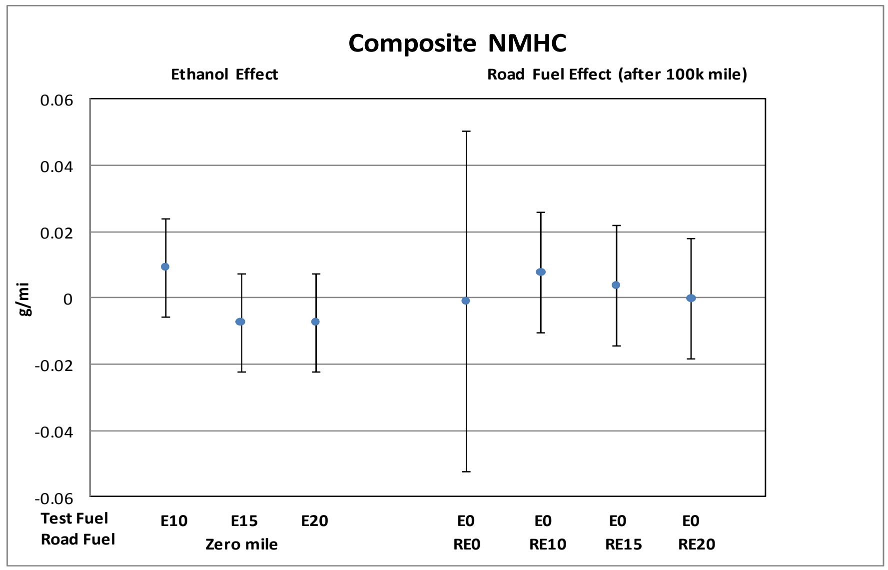
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.28
No Aging Effect with RE0 (Beta0 = 0)	0.97
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.91

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 10k-20k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2008 Nissan Altima (Composite Nonmethane Organic Gases)

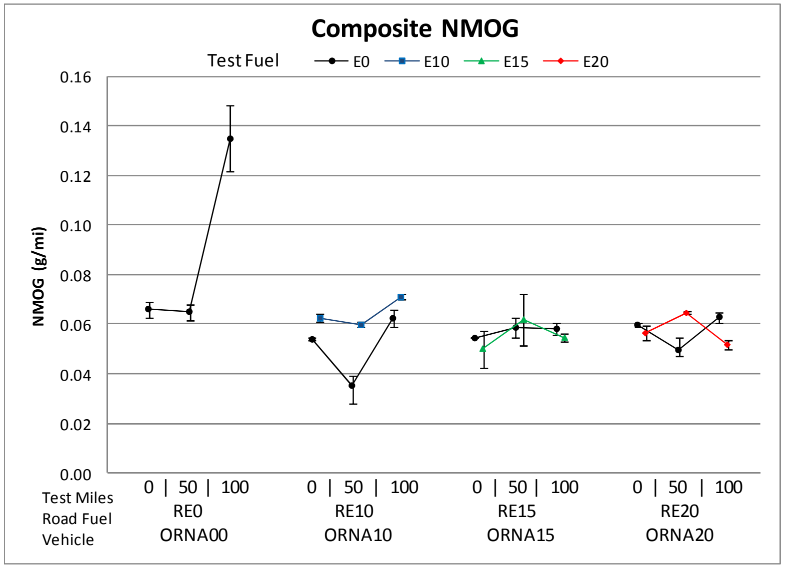
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δg/mi)	0.0142	-0.0014	0.0299
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.0016	-0.0173	0.0140
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.0003	-0.0153	0.0160
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	-0.0021	-0.0565	0.0523
Aging Effect with RE10 (Δg/mi per 100k mi)	0.0083	-0.0109	0.0275
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0041	-0.0151	0.0232
Aging Effect with RE20 (Δg/mi per 100k mi)	-0.0008	-0.0200	0.0183

* Indicates estimate is different from zero at the 95% confidence level.

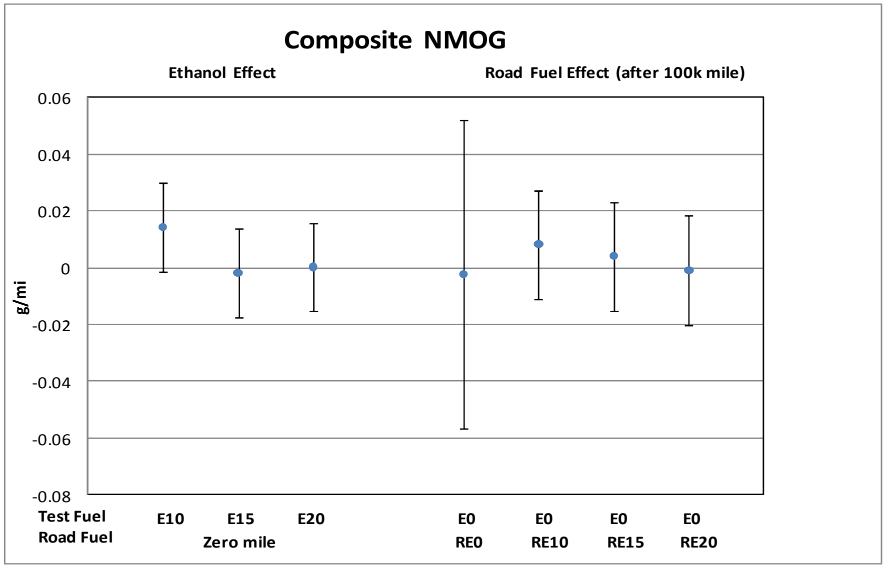
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.30
No Aging Effect with RE0 (Beta0 = 0)	0.93
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.89

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 10k-20k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2008 Nissan Altima (Composite Fuel Economy)

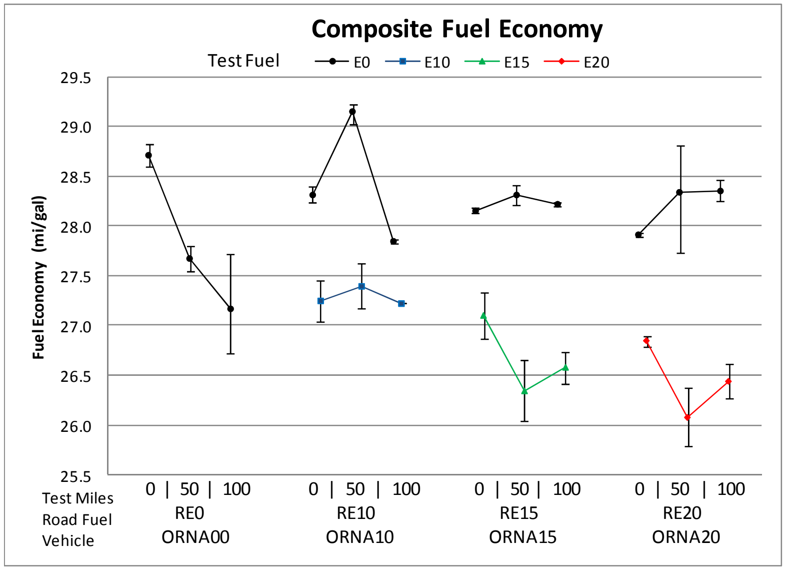
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δmi/gal)	-1.168*	-1.892	-0.445
Ethanol Effect (E15 vs. E0) (Δmi/gal)	-1.553*	-2.279	-0.827
Ethanol Effect (E20 vs. E0) (Δmi/gal)	-1.751*	-2.475	-1.027
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmi/gal per 100k mi)	-1.534*	-2.777	-0.291
Aging Effect with RE10 (Δmi/gal per 100k mi)	-0.247	-1.135	0.641
Aging Effect with RE15 (Δmi/gal per 100k mi)	-0.226	-1.114	0.661
Aging Effect with RE20 (Δmi/gal per 100k mi)	-0.020	-0.868	0.908

* Indicates estimate is different from zero at the 95% confidence level.

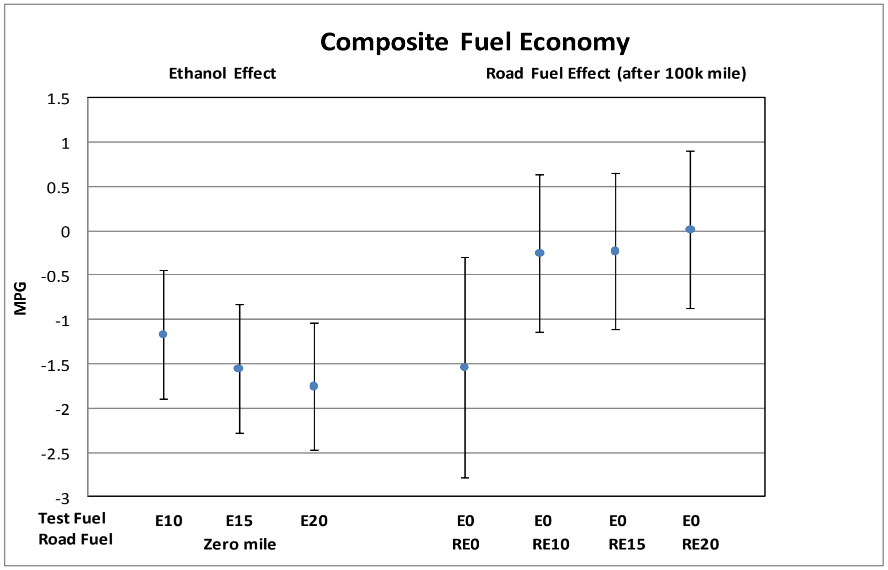
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.02*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.20

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 10k-20k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2008 Nissan Altima (Composite Ethanol)

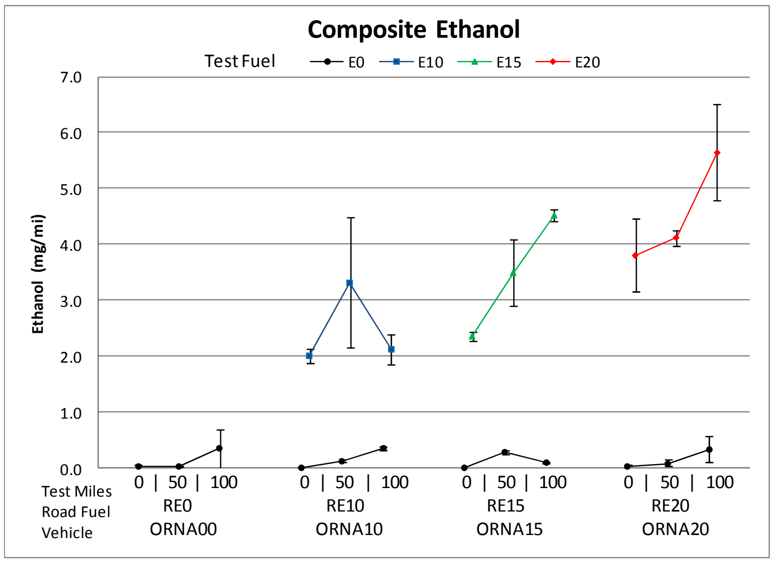
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δmg/mi)	2.335*	1.097	3.574
Ethanol Effect (E15 vs. E0) (Δmg/mi)	3.328*	2.091	4.566
Ethanol Effect (E20 vs. E0) (Δmg/mi)	4.369*	3.131	5.608
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.318	-1.824	2.460
Aging Effect with RE10 (Δmg/mi per 100k mi)	0.230	-1.284	1.744
Aging Effect with RE15 (Δmg/mi per 100k mi)	1.131	-0.382	2.644
Aging Effect with RE20 (Δmg/mi per 100k mi)	1.076	-0.438	2.589

* Indicates estimate is different from zero at the 95% confidence level.

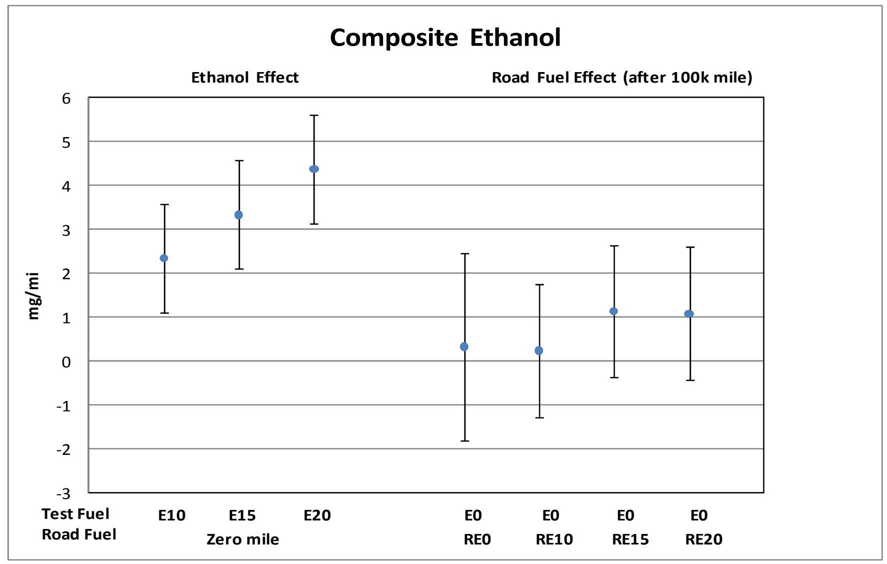
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.72
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.68

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 10k-20k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2008 Nissan Altima (Composite Acetaldehyde)

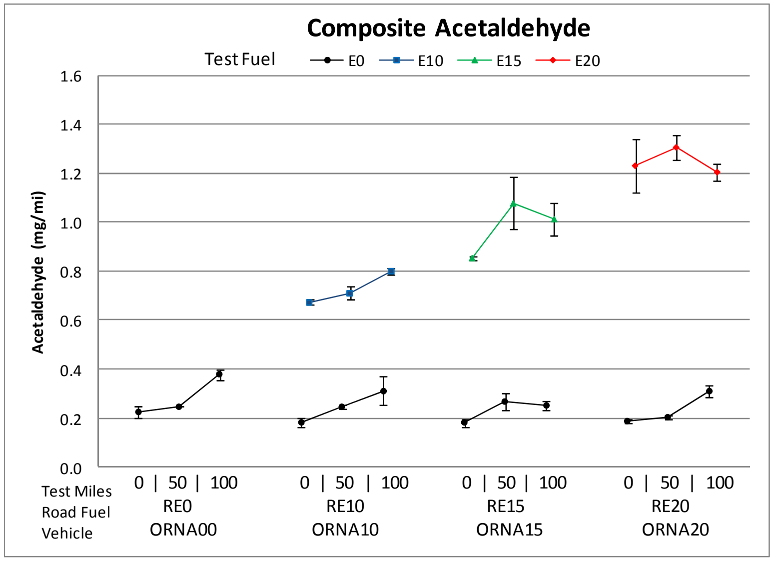
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δmg/mi)	0.409*	0.256	0.563
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.656*	0.447	0.865
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.901*	0.634	1.168
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.151*	0.033	0.269
Aging Effect with RE10 (Δmg/mi per 100k mi)	0.083*	0.001	0.166
Aging Effect with RE15 (Δmg/mi per 100k mi)	0.058	-0.020	0.136
Aging Effect with RE20 (Δmg/mi per 100k mi)	0.055	-0.021	0.132

* Indicates estimate is different from zero at the 95% confidence level.

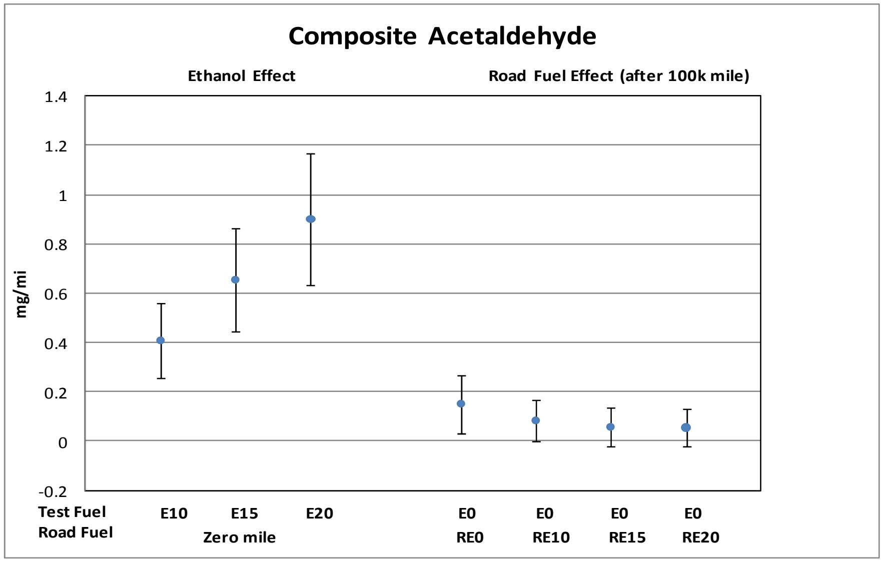
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.02*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.62

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 10k-20k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2008 Nissan Altima (Composite Formaldehyde)

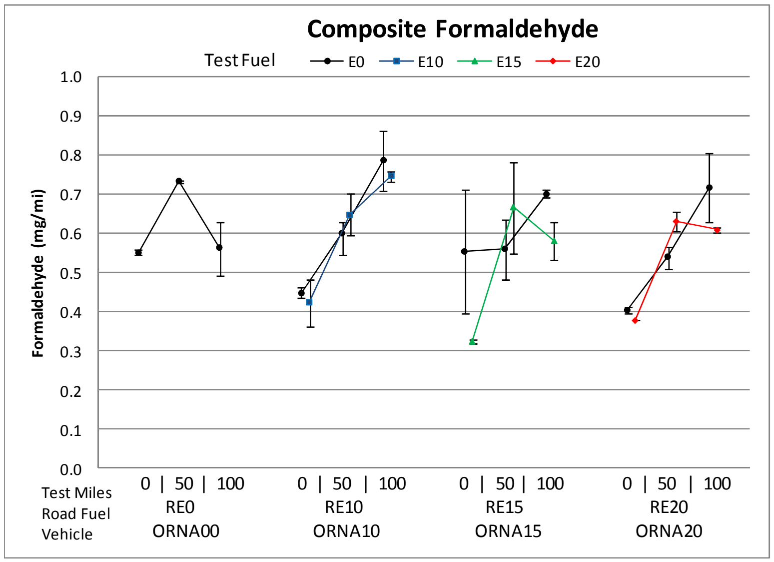
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δmg/mi)	-0.006	-0.178	0.166
Ethanol Effect (E15 vs. E0) (Δmg/mi)	-0.076	-0.246	0.094
Ethanol Effect (E20 vs. E0) (Δmg/mi)	-0.008	-0.167	0.150
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.002	-0.280	0.284
Aging Effect with RE10 (Δmg/mi per 100k mi)	0.341*	0.094	0.587
Aging Effect with RE15 (Δmg/mi per 100k mi)	0.254*	0.016	0.493
Aging Effect with RE20 (Δmg/mi per 100k mi)	0.282*	0.062	0.502

* Indicates estimate is different from zero at the 95% confidence level.

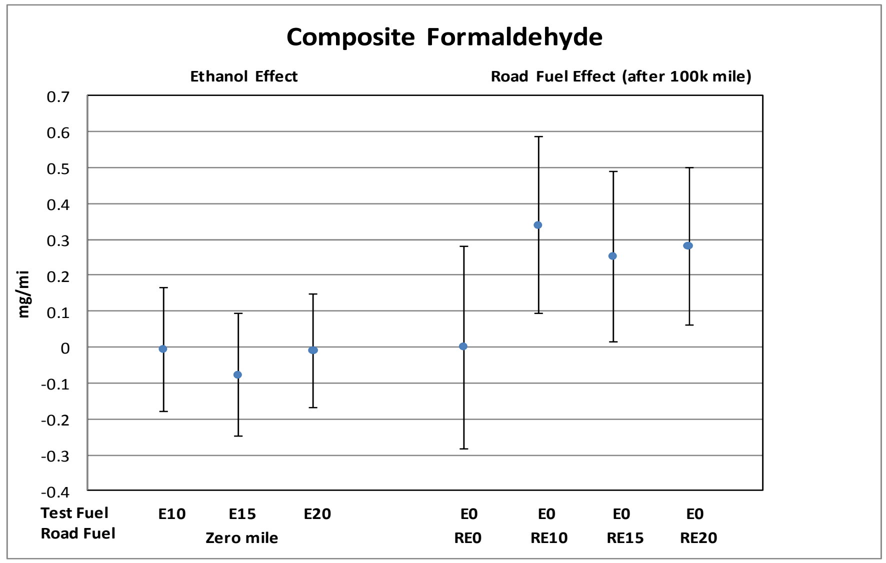
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.63
No Aging Effect with RE0 (Beta0 = 0)	0.99
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.25

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 10k-20k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2008 Nissan Altima (Composite CH_4)

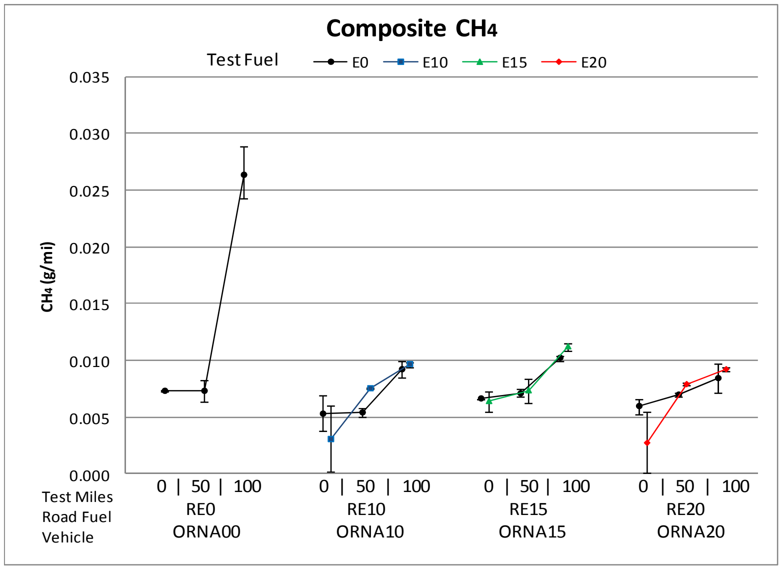
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δg/mi)	0.0002	-0.0021	0.0025
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0003	-0.0020	0.0027
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.0005	-0.0028	0.0018
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0000	-0.0080	0.0081
Aging Effect with RE10 (Δg/mi per 100k mi)	0.0052*	0.0023	0.0080
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0042*	0.0013	0.0070
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0044*	0.0016	0.0073

* Indicates estimate is different from zero at the 95% confidence level.

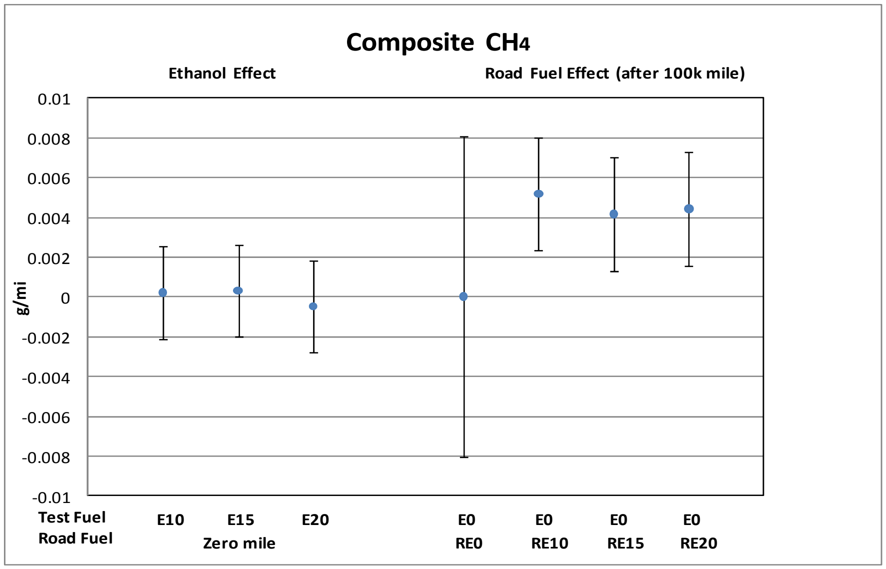
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.95
No Aging Effect with RE0 (Beta0 = 0)	0.99
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.61

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 10k-20k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2008 Ford Taurus - Composite Emissions Summary

Emisssion Parameter (units)	Ethanol Effect				Aging Effect with RE0		RExx Aging Effect on E0 Emissions				RExx Aging Effect on Exx Emissions			Road and Test Fuel Effects are Additive
	Δ units vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value	Δ units per 100K mi			Overall p-value
Fuels	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0		RE10/E10	RE15/E15	RE20/E20	
CO (g/mi)[a]	-0.031	0.037	-0.066	0.48	-0.021	0.81	-0.005	0.140*	-0.122	0.07	NA	NA	NA	0.85
NOx (g/mi)	0.0022	0.0056	0.0025	0.18	0.0073	0.13	0.0094*	0.0087*	0.0076*	0.97	NA	NA	NA	0.60
NMHC (g/mi)	-0.0026	-0.0009	-0.0031	0.25	0.0036	0.30	-0.0020	0.0080*	-0.0013	0.04*	NA	NA	NA	0.56
NMOG (g/mi)	-0.0008	0.0011	-0.0001	0.94	0.0036	0.36	-0.0020	0.0089*	-0.0011	0.06	NA	NA	NA	0.56
Fuel Econ (mi/gal)	-0.669*	-1.044*	-1.333*	<0.01*	0.421	0.10	0.529*	-0.288	0.338	0.02*	NA	NA	NA	0.63
Ethanol (mg/mi)[##]	1.185	1.463	3.593*	<0.01*	-0.037	0.97	-0.608	0.065	-0.018	0.92	NA	NA	NA	NA
Acetaldehyde (mg/mi)[#]	0.296*	0.366*	0.696*	<0.01*	0.087*	<0.01*	0.026	0.029	0.022	0.18	NA	NA	NA	0.50
Formaldehyde (mg/mi)[#]	0.007	-0.003	0.014	0.94	0.257*	<0.01*	0.219*	0.167*	0.171*	0.65	NA	NA	NA	0.65
CH_4 (g/mi)	0.0004	0.0023	0.0004	0.41	0.0093*	<0.01*	0.0078*	0.0085*	0.0048*	0.31	NA	NA	NA	0.98

Log-normal model was used. Results are presented as changes in emissions at 0k mile.

Data did not support the assumption of linear effects with mileage.

* Indicates estimate is different from zero at the 95% confidence level.

a Test "SW023476" is identified as an outlier and excluded from the analysis.

2008 Ford Taurus (Composite CO)

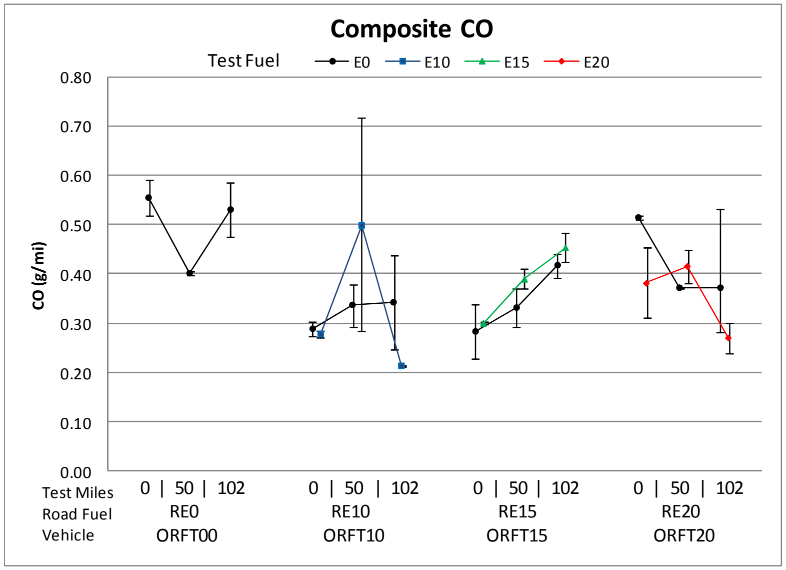
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δg/mi)	-0.031	-0.144	0.081
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.037	-0.076	0.151
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.066	-0.178	0.047
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	-0.021	-0.213	0.171
Aging Effect with RE10 (Δg/mi per 100k mi)	-0.005	-0.139	0.130
Aging Effect with RE15 (Δg/mi per 100k mi)	0.140*	0.004	0.275
Aging Effect with RE20 (Δg/mi per 100k mi)	-0.122	-0.256	0.013

* Indicates estimate is different from zero at the 95% confidence level.

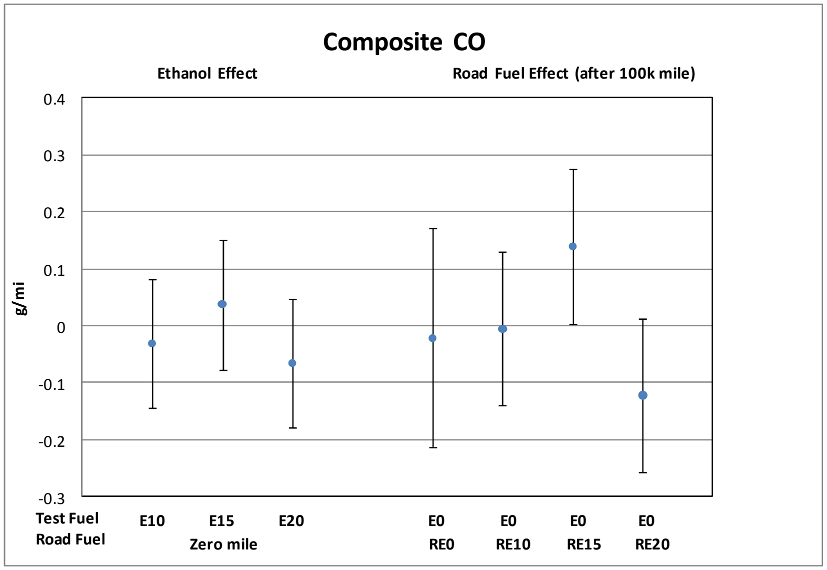
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.48
No Aging Effect with RE0 (Beta0 = 0)	0.81
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.07

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 9k-17k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2008 Ford Taurus (Composite NOx)

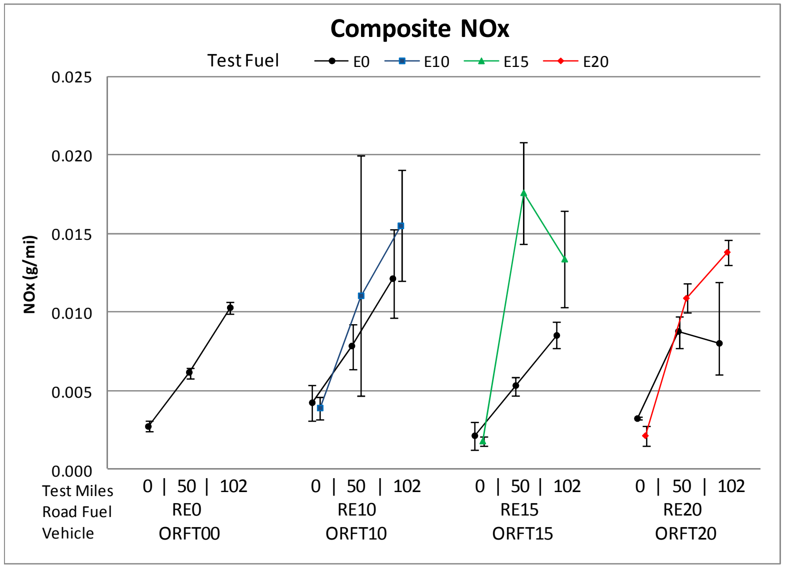
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δg/mi)	0.0022	-0.0037	0.0080
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0056	-0.0003	0.0115
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.0025	-0.0033	0.0084
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0073	-0.0026	0.0173
Aging Effect with RE10 (Δg/mi per 100k mi)	0.0094*	0.0025	0.0164
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0087*	0.0016	0.0157
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0076*	0.0006	0.0146

* Indicates estimate is different from zero at the 95% confidence level.

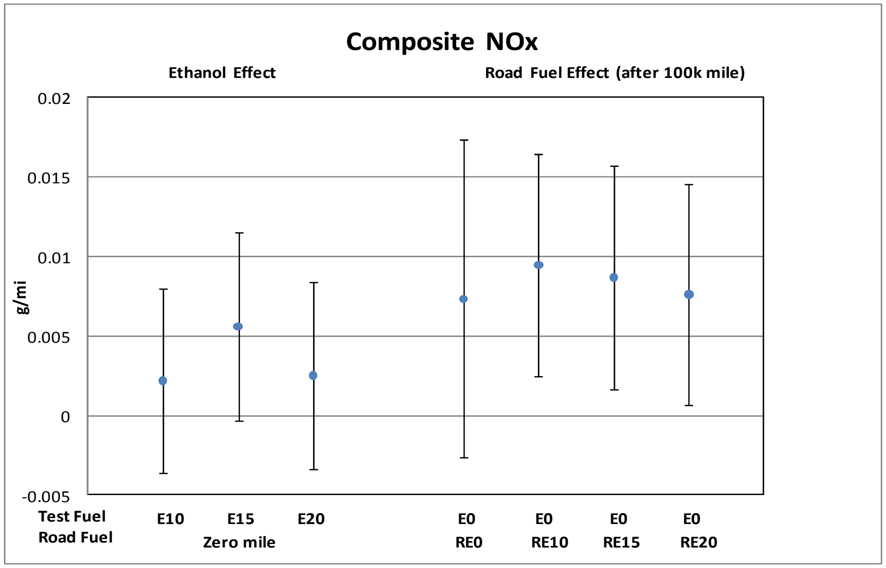
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.18
No Aging Effect with RE0 (Beta0 = 0)	0.13
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.97

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 9k-17k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2008 Ford Taurus (Composite Nonmethane Hydrocarbons)

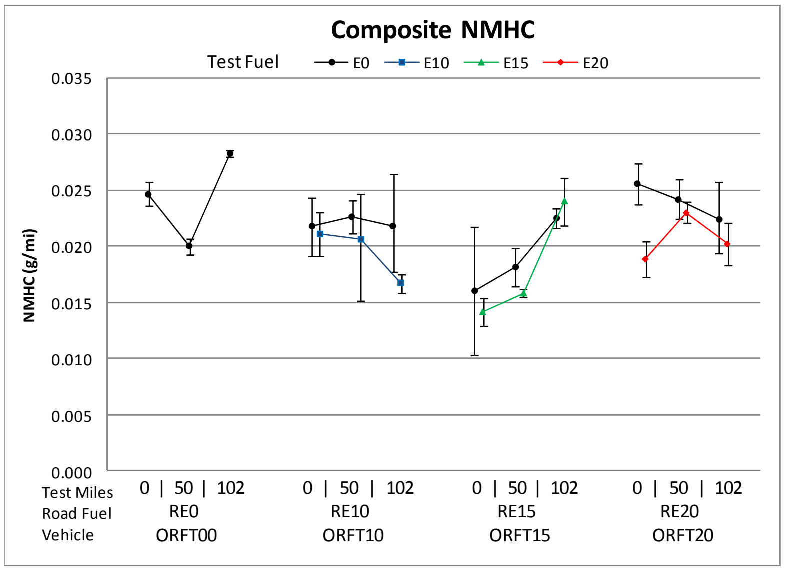
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δg/mi)	-0.0026	-0.0068	0.0017
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.0009	-0.0052	0.0034
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.0031	-0.0074	0.0012
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0036	-0.0037	0.0109
Aging Effect with RE10 (Δg/mi per 100k mi)	-0.0020	-0.0071	0.0031
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0080*	0.0028	0.0132
Aging Effect with RE20 (Δg/mi per 100k mi)	-0.0013	-0.0064	0.0038

* Indicates estimate is different from zero at the 95% confidence level.

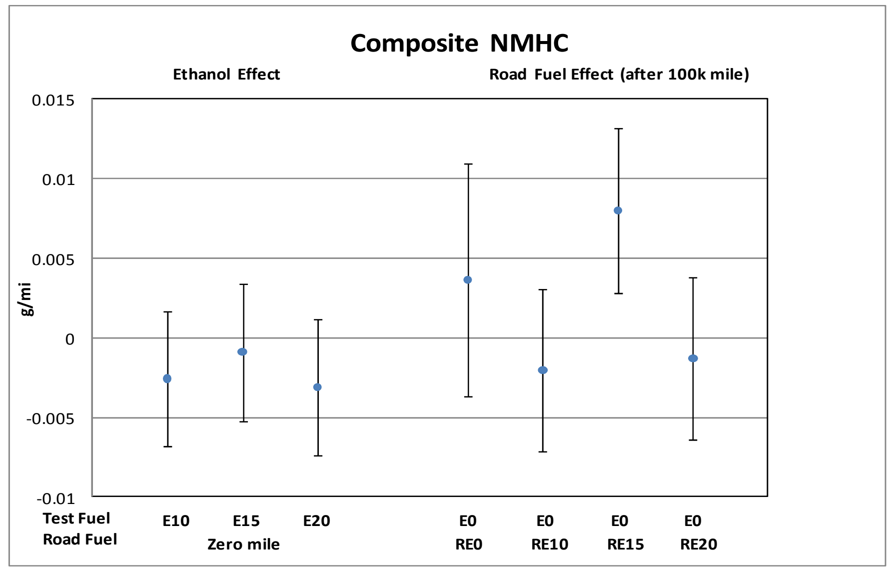
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.25
No Aging Effect with RE0 (Beta0 = 0)	0.30
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.04*

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 9k-17k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2008 Ford Taurus (Composite Nonmethane Organic Gases)

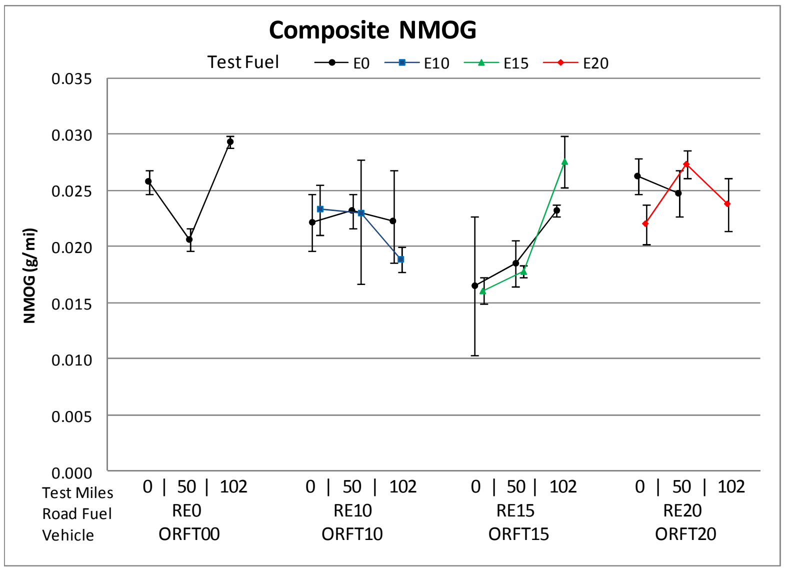
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δg/mi)	-0.0008	-0.0057	0.0041
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0011	-0.0039	0.0061
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.0001	-0.0050	0.0049
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0036	-0.0048	0.0120
Aging Effect with RE10 (Δg/mi per 100k mi)	-0.0020	-0.0078	0.0039
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0089*	0.0030	0.0149
Aging Effect with RE20 (Δg/mi per 100k mi)	-0.0011	-0.0070	0.0048

* Indicates estimate is different from zero at the 95% confidence level.

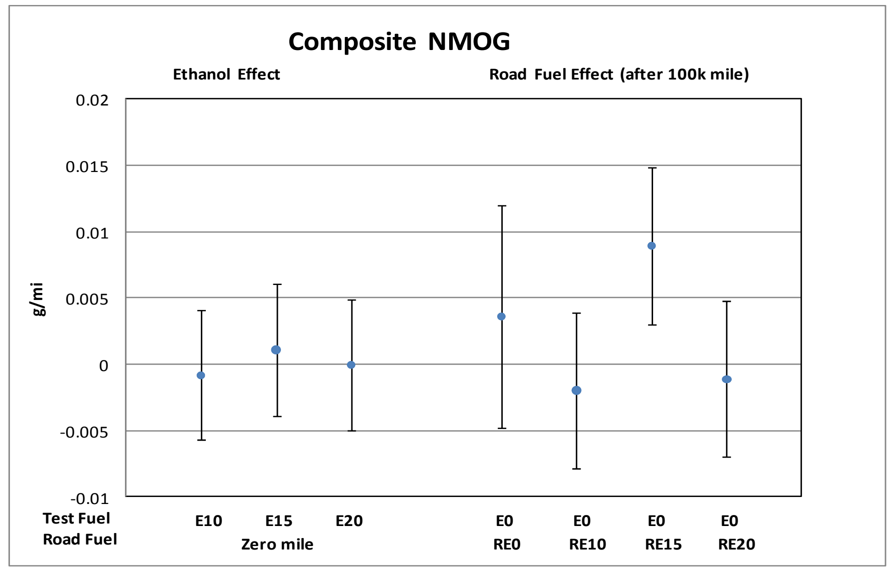
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.94
No Aging Effect with RE0 (Beta0 = 0)	0.36
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.06

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 9k-17k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2008 Ford Taurus (Composite Fuel Economy)

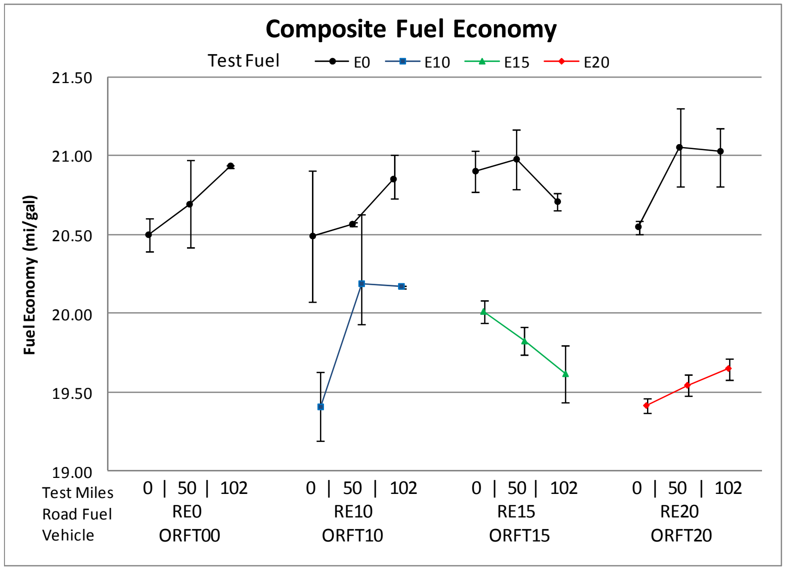
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δmi/gal)	-0.669*	-0.966	-0.373
Ethanol Effect (E15 vs. E0) (Δmi/gal)	-1.044*	-1.350	-0.738
Ethanol Effect (E20 vs. E0) (Δmi/gal)	-1.333*	-1.632	-1.034
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmi/gal per 100k mi)	0.421	-0.096	0.939
Aging Effect with RE10 (Δmi/gal per 100k mi)	0.529*	0.172	0.886
Aging Effect with RE15 (Δmi/gal per 100k mi)	-0.288	-0.654	0.078
Aging Effect with RE20 (Δmi/gal per 100k mi)	0.338	-0.016	0.692

* Indicates estimate is different from zero at the 95% confidence level.

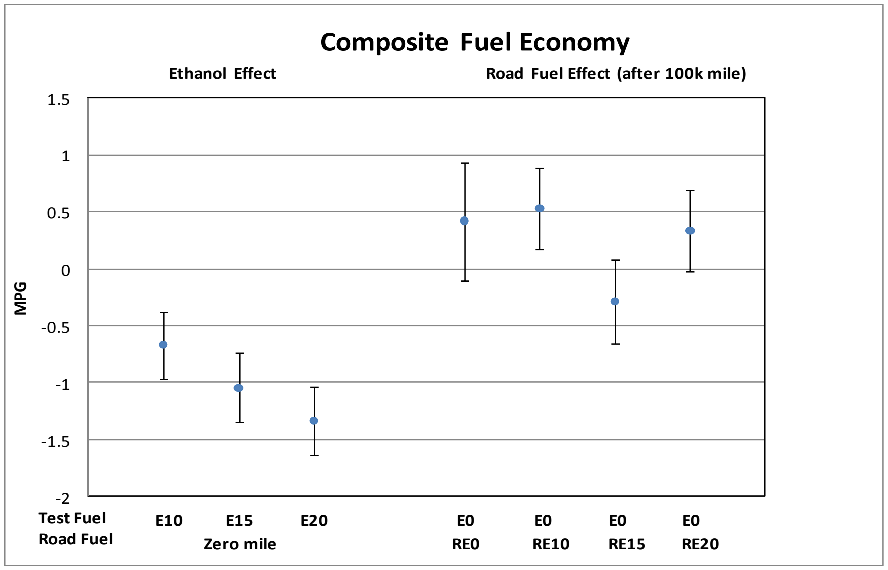
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.10
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.02*

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 9k-17k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2008 Ford Taurus (Composite Ethanol)

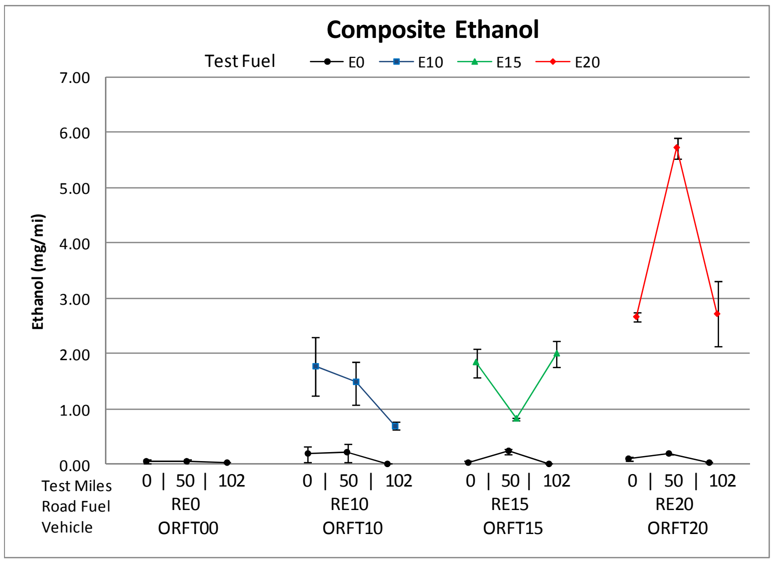
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δmg/mi)	1.185	-0.358	2.728
Ethanol Effect (E15 vs. E0) (Δmg/mi)	1.463	-0.080	3.006
Ethanol Effect (E20 vs. E0) (Δmg/mi)	3.593*	2.050	5.136
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	-0.037	-2.645	2.571
Aging Effect with RE10 (Δmg/mi per 100k mi)	-0.608	-2.451	1.235
Aging Effect with RE15 (Δmg/mi per 100k mi)	0.065	-1.779	1.909
Aging Effect with RE20 (Δmg/mi per 100k mi)	-0.018	-1.865	1.829

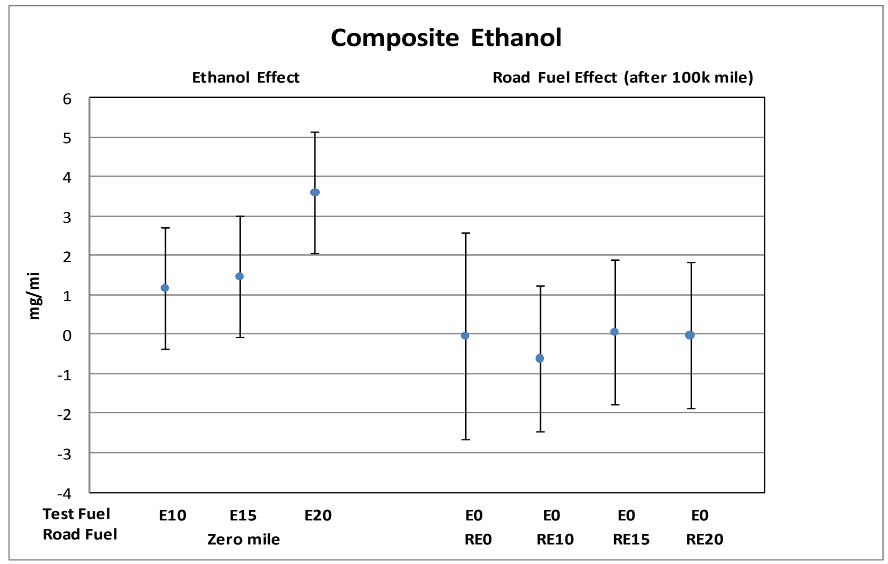
* Indicates estimate is different from zero at the 95% confidence level.

Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.97
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.92

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 9k-17k





Error bars represent min and max measurements

Error bars represent 95% confidence intervals on the estimated effects

* The statistical model for Acetaldehyde does not assume the linear relationship between emission and mileage.

2008 Ford Taurus (Composite Acetaldehyde)

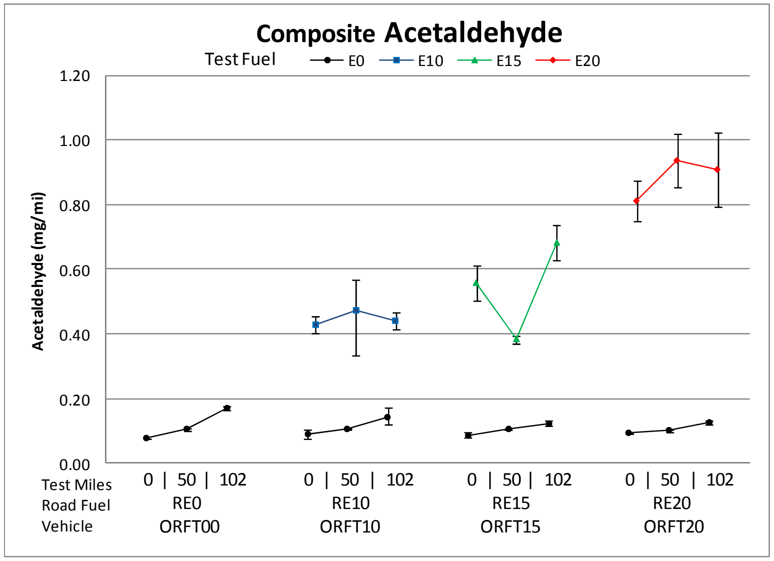
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δmg/mi)	0.296*	0.194	0.397
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.366*	0.249	0.483
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.696*	0.496	0.895
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.087*	0.034	0.140
Aging Effect with RE10 (Δmg/mi per 100k mi)	0.026	-0.014	0.065
Aging Effect with RE15 (Δmg/mi per 100k mi)	0.029	-0.009	0.066
Aging Effect with RE20 (Δmg/mi per 100k mi)	0.022	-0.016	0.060

* Indicates estimate is different from zero at the 95% confidence level.

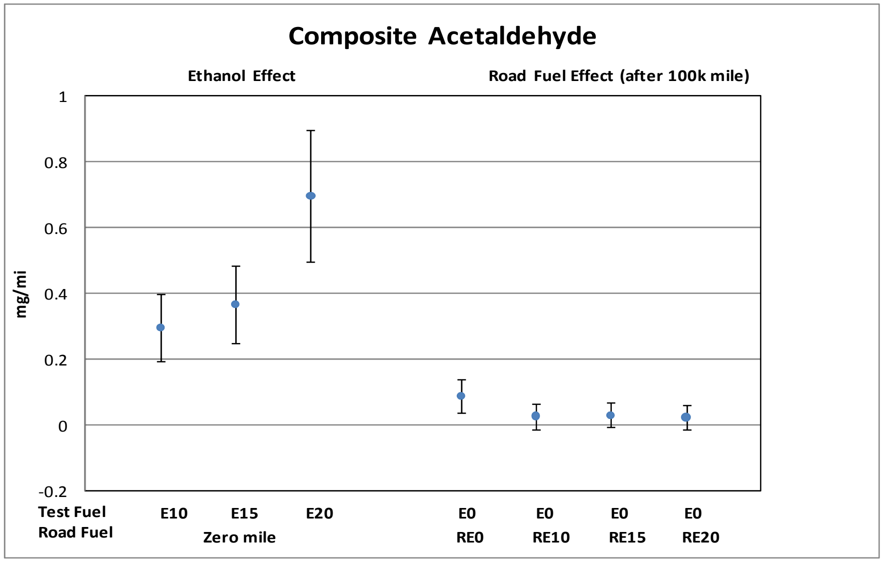
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.18

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 9k-17k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2008 Ford Taurus (Composite Formaldehyde)

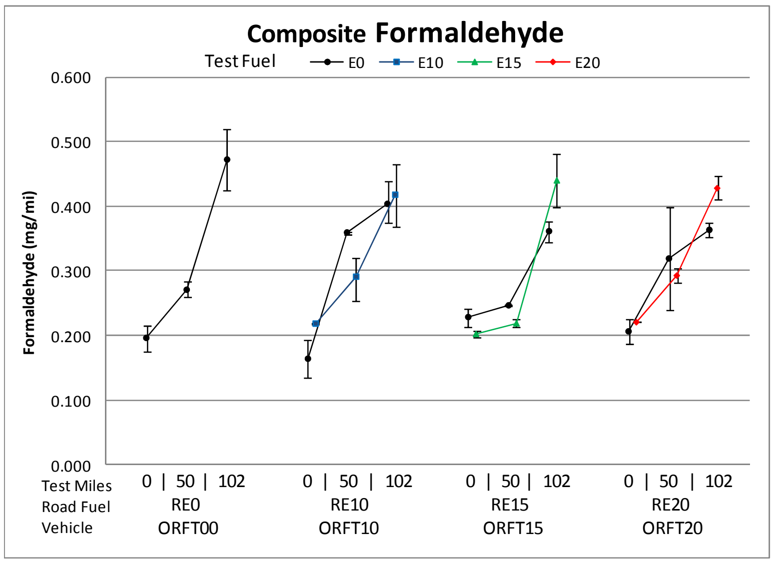
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δmg/mi)	0.007	-0.063	0.078
Ethanol Effect (E15 vs. E0) (Δmg/mi)	-0.003	-0.073	0.067
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.014	-0.063	0.090
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.257*	0.116	0.399
Aging Effect with RE10 (Δmg/mi per 100k mi)	0.219*	0.107	0.330
Aging Effect with RE15 (Δmg/mi per 100k mi)	0.167*	0.064	0.270
Aging Effect with RE20 (Δmg/mi per 100k mi)	0.171*	0.064	0.278

* Indicates estimate is different from zero at the 95% confidence level.

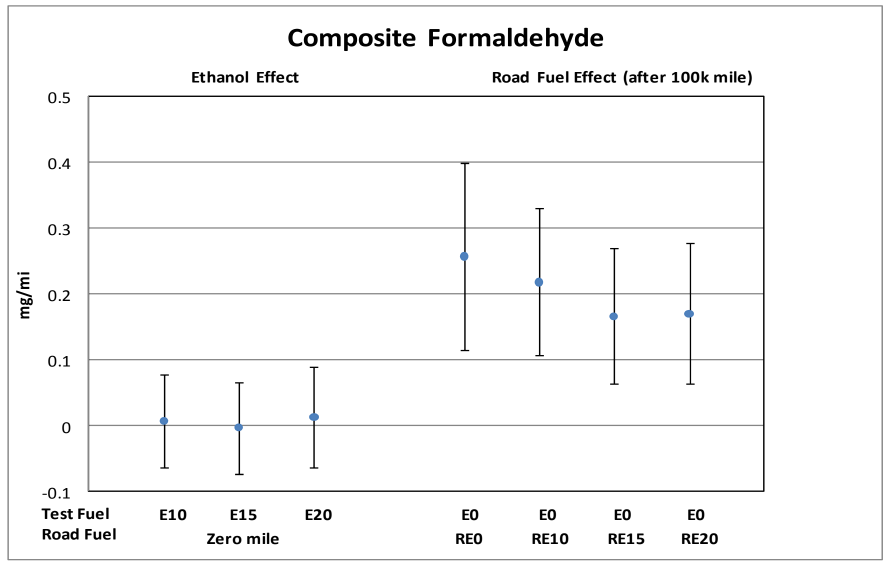
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.94
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.65

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 9k-17k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2008 Ford Taurus (Composite CH_4)

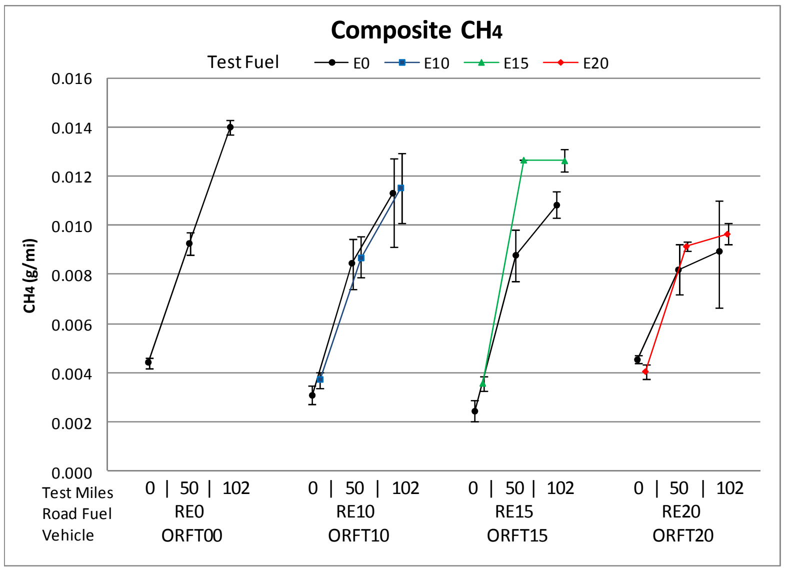
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δg/mi)	0.0004	-0.0025	0.0033
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0023	-0.0007	0.0052
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.0004	-0.0025	0.0033
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0093*	0.0044	0.0143
Aging Effect with RE10 (Δg/mi per 100k mi)	0.0078*	0.0043	0.0112
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0085*	0.0050	0.0119
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0048*	0.0013	0.0083

* Indicates estimate is different from zero at the 95% confidence level.

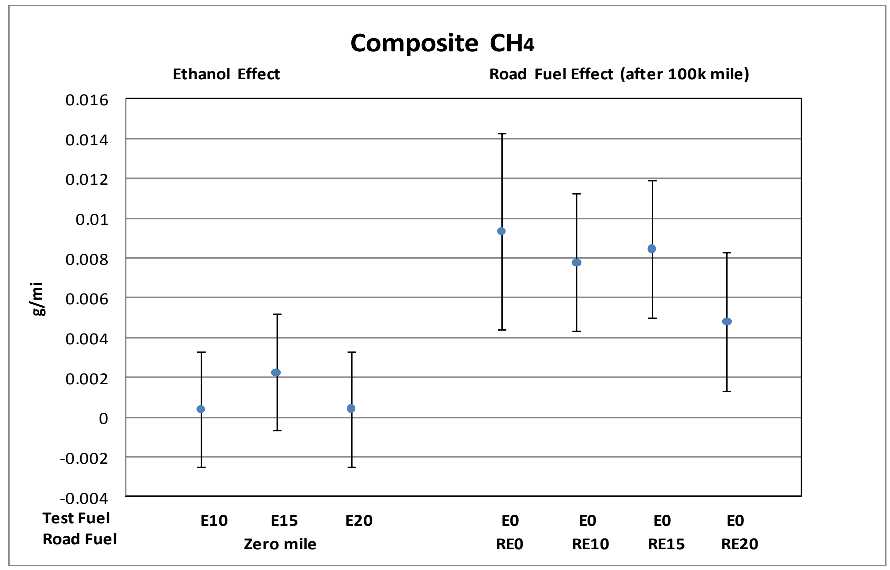
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.41
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.31

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 9k-17k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2007 Dodge Caravan - Composite Emissions Summary

Emisssion Parameter (units)	Ethanol Effect				Aging Effect with RE0		RExx Aging Effect on E0 Emissions				RExx Aging Effect on Exx Emissions			Road and Test Fuel Effects are Additive
	Δ units vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value	Δ units per 100K mi			Overall p-value
Fuels	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0		RE10/E10	RE15/E15	RE20/E20	
CO (g/mi)	-0.027	-0.146	-0.383	0.34	0.002	1.00	0.191	0.456	1.360*	0.14	NA	NA	NA	0.16
NOx (g/mi)[a]	0.0005	0.0027	-0.0014	0.98	-0.0034	0.85	0.0306*	0.0213	0.0338*	0.39	NA	NA	NA	0.19
NMHC (g/mi)	-0.003	-0.007	-0.007	0.23	0.007	0.58	-0.003	0.010	0.004	0.75	NA	NA	NA	0.65
NMOG (g/mi)	-0.0006	-0.0025	-0.0006	0.96	0.0067	0.62	-0.0027	0.0097	0.0040	0.80	NA	NA	NA	0.69
Fuel Econ (mi/gal)	-0.790*	-1.098*	-1.336*	<0.01*	-0.230	0.41	-0.058	-0.333	0.556*	0.03*	NA	NA	NA	0.85
Ethanol (mg/mi)[##]	2.743*	3.602*	6.241*	<0.01*	-0.235	0.92	1.312	-0.486	1.292	0.81	NA	NA	NA	NA
Acetaldehyde (mg/mi)[#]	0.521*	0.718*	1.293*	<0.01*	0.023	0.79	0.023	0.059	-0.020	0.88	NA	NA	NA	0.83
Formaldehyde (mg/mi)[#]	0.025	-0.094	0.125	0.80	0.246	0.56	0.335	0.693	0.161	0.80	NA	NA	NA	0.99
CH_4 (g/mi)	-0.0004	-0.0002	-0.0003	0.99	0.0037	0.31	0.0042	0.0049	0.0082*	0.62	NA	NA	NA	0.58

Log-normal model was used. Results are presented as changes in emissions at 0k mile.

Data did not support the assumption of linear effects with mileage.

* Indicates estimate is different from zero at the 95% confidence level.

a Test "SW024446" is identified as an outlier and excluded from the analysis.

2007 Dodge Caravan (Composite CO)

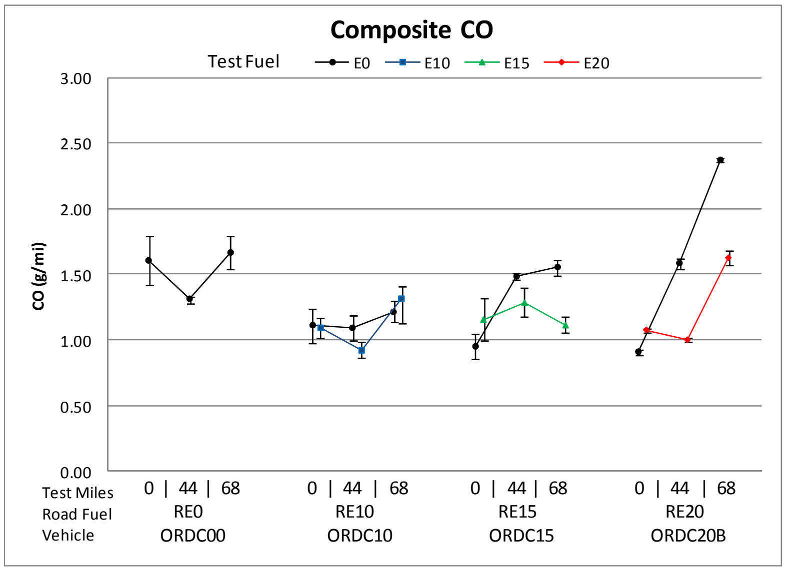
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δg/mi)	-0.027	-0.499	0.444
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.146	-0.617	0.326
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.383	-0.855	0.088
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.002	-1.174	1.178
Aging Effect with RE10 (Δg/mi per 100k mi)	0.191	-0.640	1.022
Aging Effect with RE15 (Δg/mi per 100k mi)	0.456	-0.375	1.287
Aging Effect with RE20 (Δg/mi per 100k mi)	1.360*	0.534	2.187

* Indicates estimate is different from zero at the 95% confidence level.

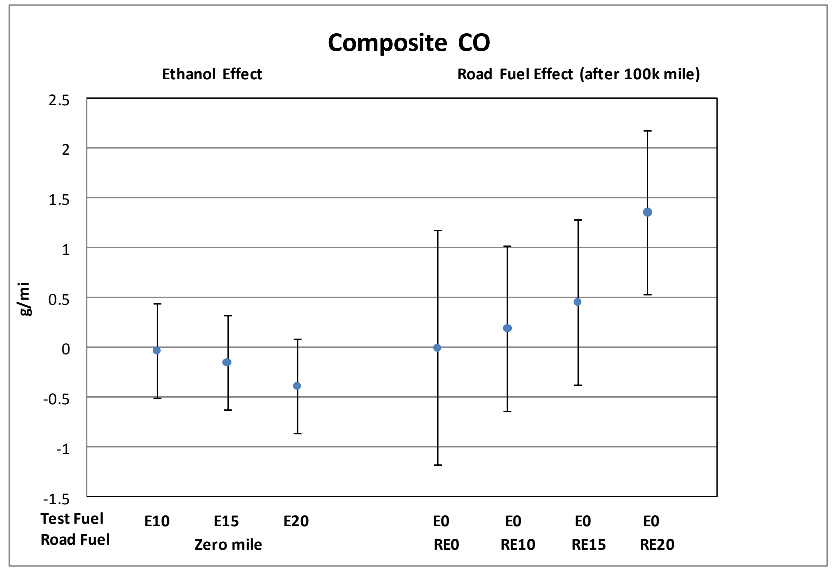
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.34
No Aging Effect with RE0 (Beta0 = 0)	1.00
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.14

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 40k-50k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2007 Dodge Caravan (Composite NOx)

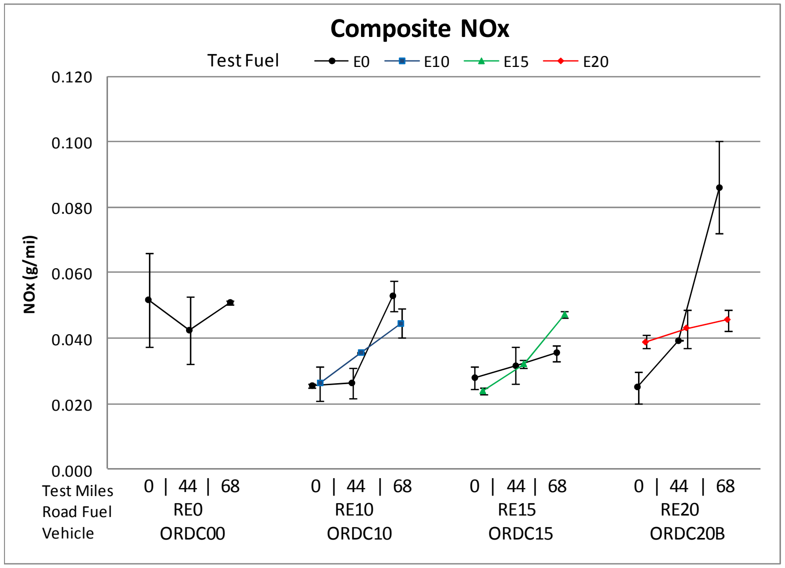
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δg/mi)	0.0005	-0.0155	0.0166
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0027	-0.0133	0.0187
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.0014	-0.0177	0.0148
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	-0.0034	-0.0434	0.0366
Aging Effect with RE10 (Δg/mi per 100k mi)	0.0306*	0.0024	0.0589
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0213	-0.0069	0.0496
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0338*	0.0053	0.0624

* Indicates estimate is different from zero at the 95% confidence level.

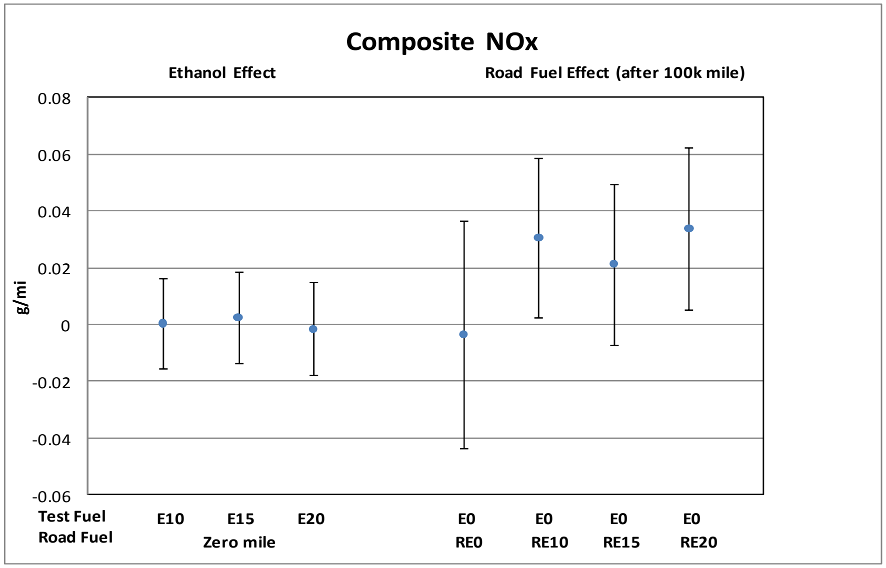
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.98
No Aging Effect with RE0 (Beta0 = 0)	0.85
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.39

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 40k-50k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2007 Dodge Caravan (Composite Nonmethane Hydrocarbons)

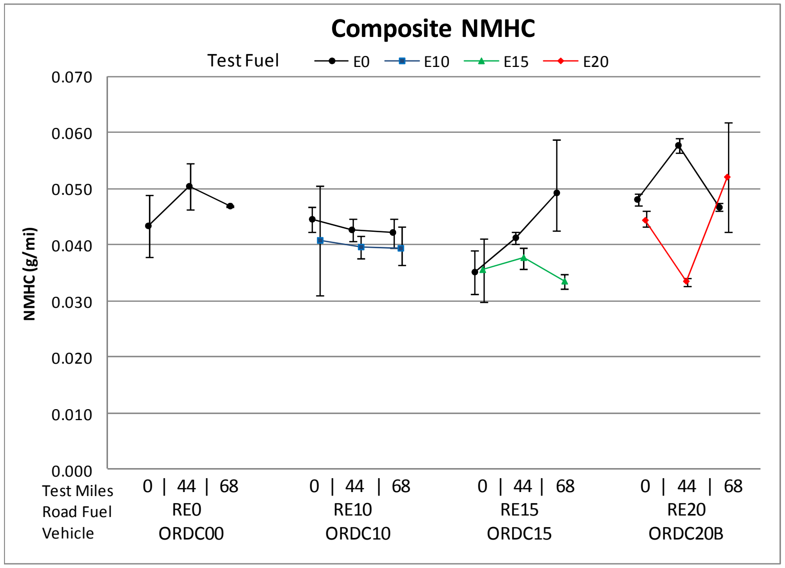
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δg/mi)	-0.003	-0.013	0.007
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.007	-0.017	0.004
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.007	-0.018	0.003
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.007	-0.019	0.032
Aging Effect with RE10 (Δg/mi per 100k mi)	-0.003	-0.021	0.015
Aging Effect with RE15 (Δg/mi per 100k mi)	0.010	-0.009	0.028
Aging Effect with RE20 (Δg/mi per 100k mi)	0.004	-0.014	0.022

* Indicates estimate is different from zero at the 95% confidence level.

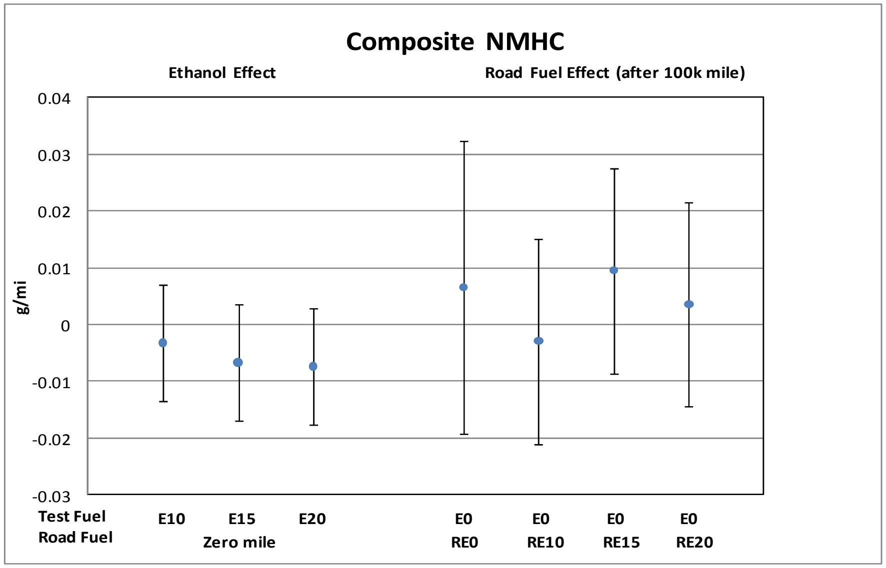
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.23
No Aging Effect with RE0 (Beta0 = 0)	0.58
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.75

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 40k-50k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2007 Dodge Caravan (Composite Nonmethane Organic Gases)

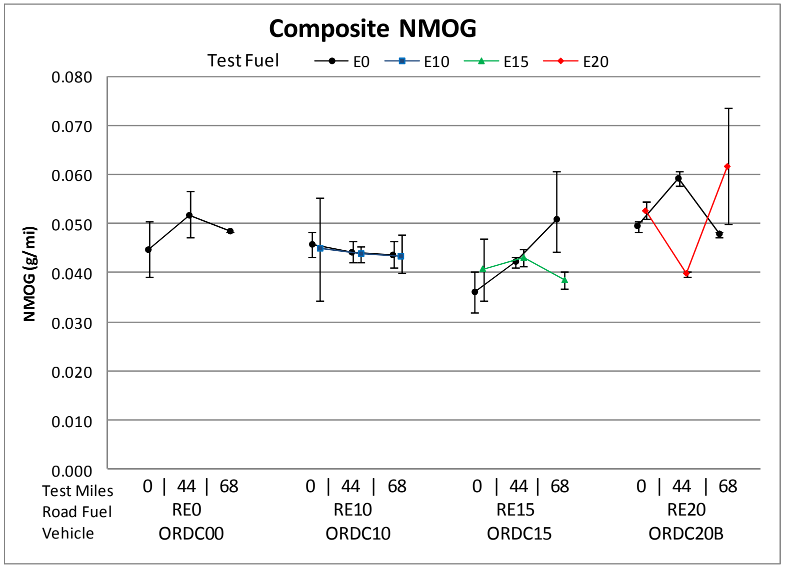
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δg/mi)	-0.0006	-0.0121	0.0108
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.0025	-0.0140	0.0089
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.0006	-0.0121	0.0109
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0067	-0.0220	0.0354
Aging Effect with RE10 (Δg/mi per 100k mi)	-0.0027	-0.0229	0.0175
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0097	-0.0104	0.0299
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0040	-0.0160	0.0241

* Indicates estimate is different from zero at the 95% confidence level.

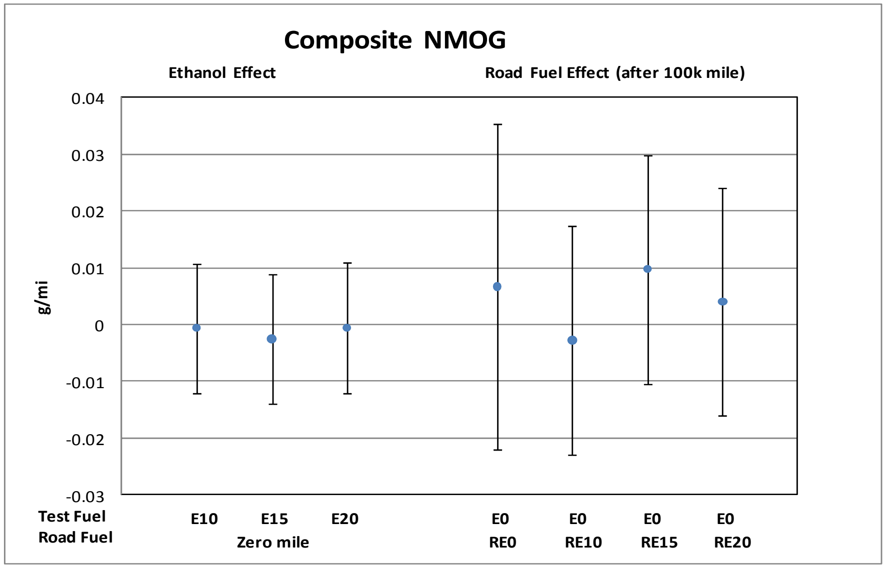
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.96
No Aging Effect with RE0 (Beta0 = 0)	0.62
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.80

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 40k-50k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2007 Dodge Caravan (Composite Fuel Economy)

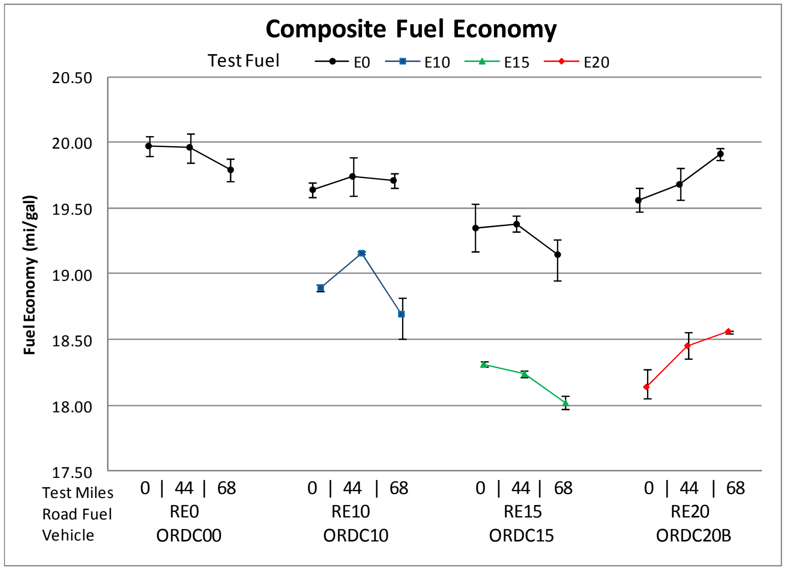
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δmi/gal)	-0.790*	-1.023	-0.556
Ethanol Effect (E15 vs. E0) (Δmi/gal)	-1.098*	-1.332	-0.865
Ethanol Effect (E20 vs. E0) (Δmi/gal)	-1.336*	-1.570	-1.103
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmi/gal per 100k mi)	-0.230	-0.815	0.354
Aging Effect with RE10 (Δmi/gal per 100k mi)	-0.058	-0.469	0.353
Aging Effect with RE15 (Δmi/gal per 100k mi)	-0.333	-0.744	0.078
Aging Effect with RE20 (Δmi/gal per 100k mi)	0.556*	0.149	0.964

* Indicates estimate is different from zero at the 95% confidence level.

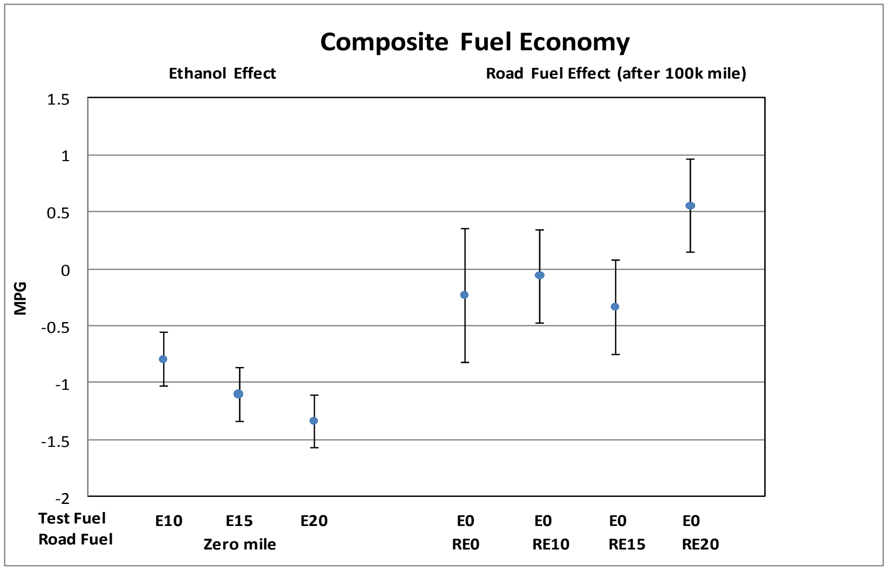
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.41
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.03*

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 40k-50k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2007 Dodge Caravan (Composite Ethanol)

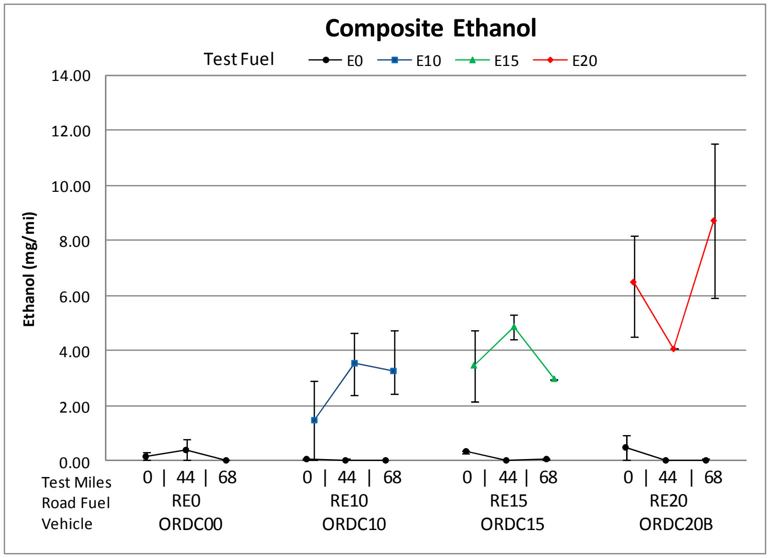
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δmg/mi)	2.743*	0.496	4.990
Ethanol Effect (E15 vs. E0) (Δmg/mi)	3.602*	1.354	5.849
Ethanol Effect (E20 vs. E0) (Δmg/mi)	6.241*	3.994	8.488
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	-0.235	-5.889	5.418
Aging Effect with RE10 (Δmg/mi per 100k mi)	1.312	-2.706	5.331
Aging Effect with RE15 (Δmg/mi per 100k mi)	-0.486	-4.502	3.531
Aging Effect with RE20 (Δmg/mi per 100k mi)	1.292	-2.707	5.292

* Indicates estimate is different from zero at the 95% confidence level.

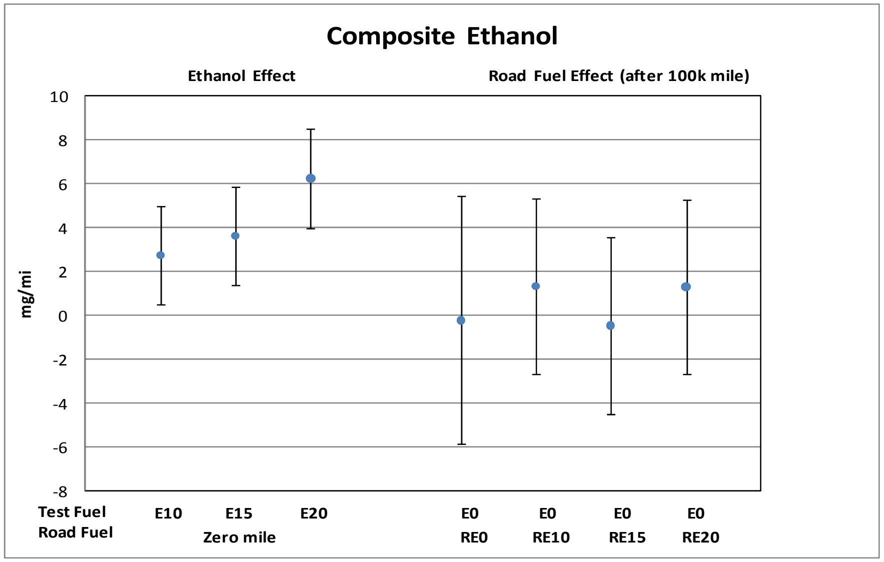
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.92
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.81

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 40k-50k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2007 Dodge Caravan (Composite Acetaldehyde)

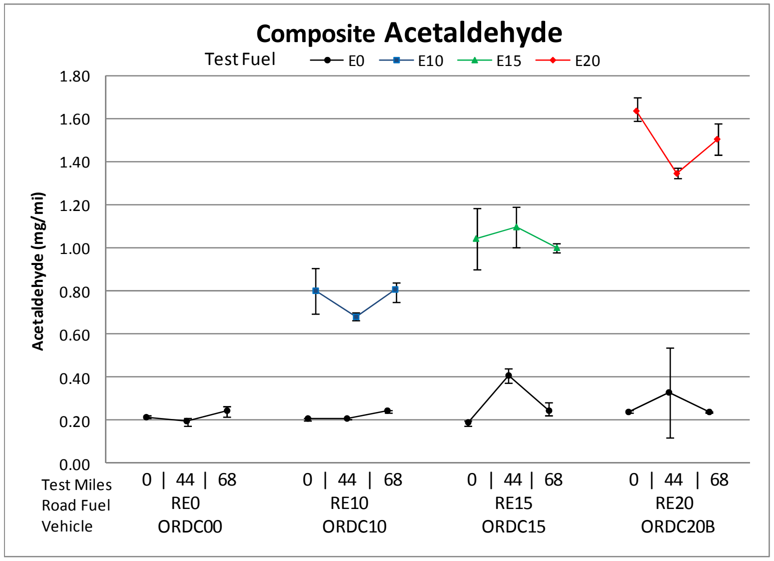
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δmg/mi)	0.521*	0.268	0.775
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.718*	0.392	1.045
Ethanol Effect (E20 vs. E0) (Δmg/mi)	1.293*	0.782	1.803
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.023	-0.135	0.182
Aging Effect with RE10 (Δmg/mi per 100k mi)	0.023	-0.102	0.147
Aging Effect with RE15 (Δmg/mi per 100k mi)	0.059	-0.096	0.215
Aging Effect with RE20 (Δmg/mi per 100k mi)	-0.020	-0.152	0.113

* Indicates estimate is different from zero at the 95% confidence level.

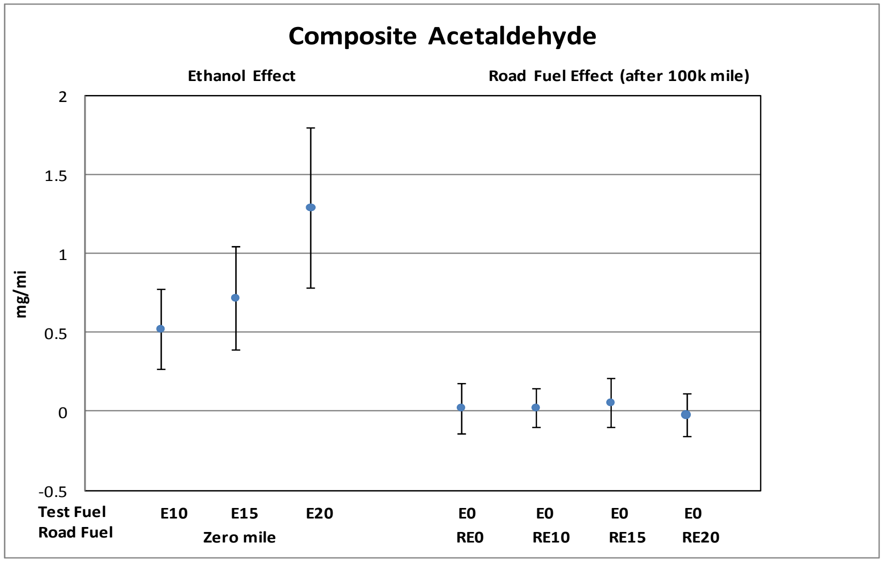
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.79
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.88

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 40k-50k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2007 Dodge Caravan (Composite Formaldehyde)

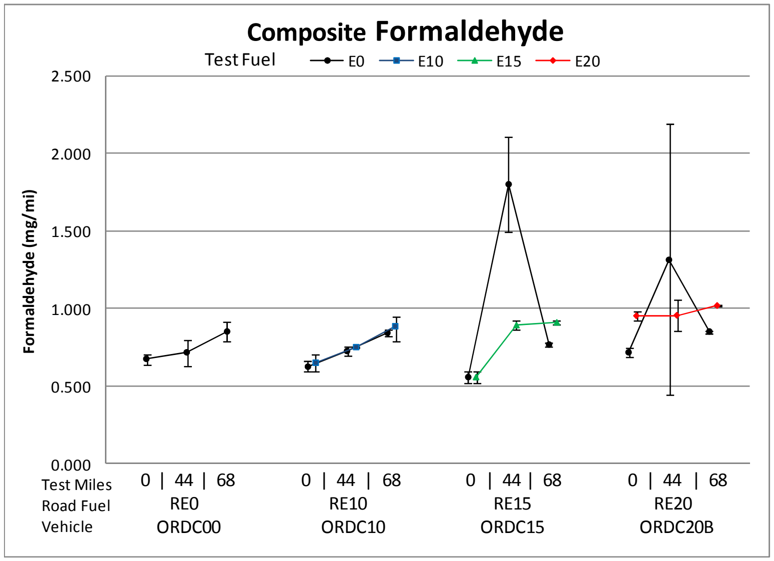
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δmg/mi)	0.025	-0.384	0.434
Ethanol Effect (E15 vs. E0) (Δmg/mi)	-0.094	-0.509	0.321
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.125	-0.425	0.675
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.246	-0.570	1.062
Aging Effect with RE10 (Δmg/mi per 100k mi)	0.335	-0.318	0.987
Aging Effect with RE15 (Δmg/mi per 100k mi)	0.693	-0.207	1.594
Aging Effect with RE20 (Δmg/mi per 100k mi)	0.161	-0.520	0.842

* Indicates estimate is different from zero at the 95% confidence level.

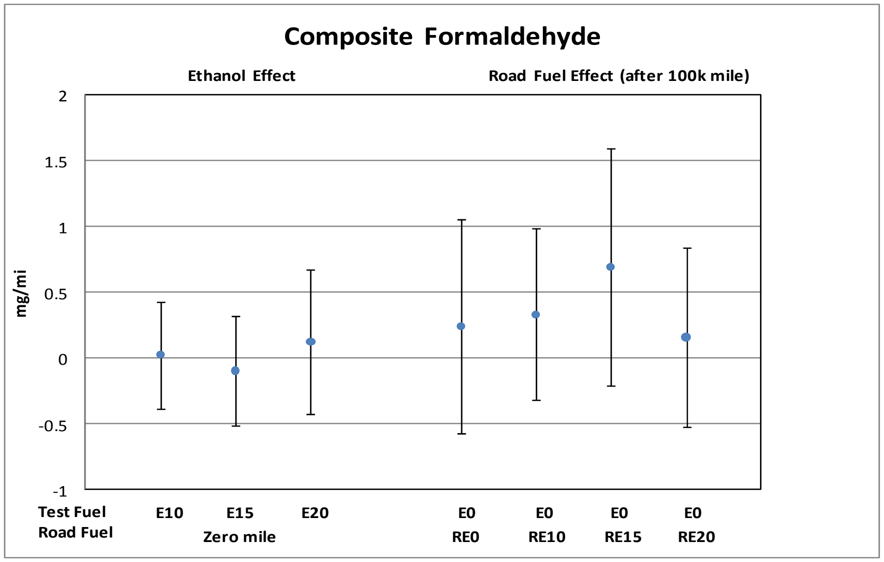
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.80
No Aging Effect with RE0 (Beta0 = 0)	0.56
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.80

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 40k-50k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2007 Dodge Caravan (Composite CH_4)

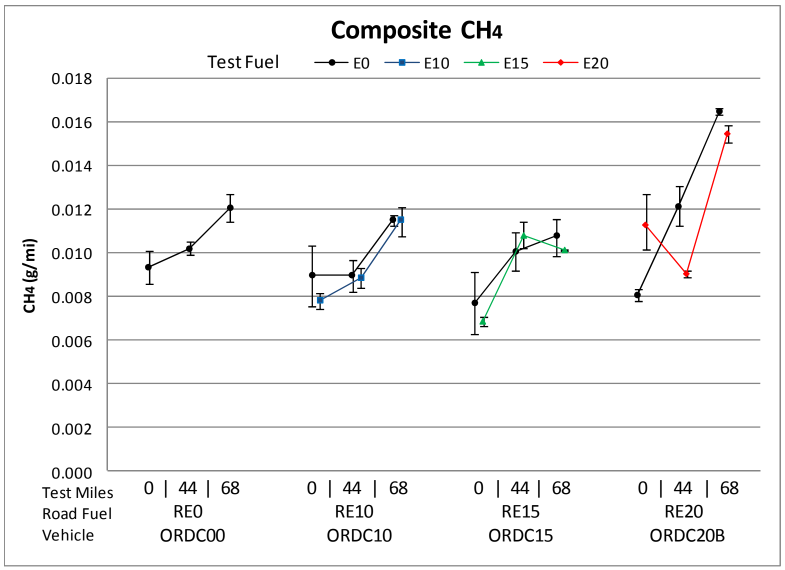
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E10 vs. E0) (Δg/mi)	-0.0004	-0.0035	0.0027
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.0002	-0.0033	0.0029
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.0003	-0.0034	0.0028
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0037	-0.0040	0.0115
Aging Effect with RE10 (Δg/mi per 100k mi)	0.0042	-0.0013	0.0097
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0049	-0.0005	0.0104
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0082*	0.0028	0.0137

* Indicates estimate is different from zero at the 95% confidence level.

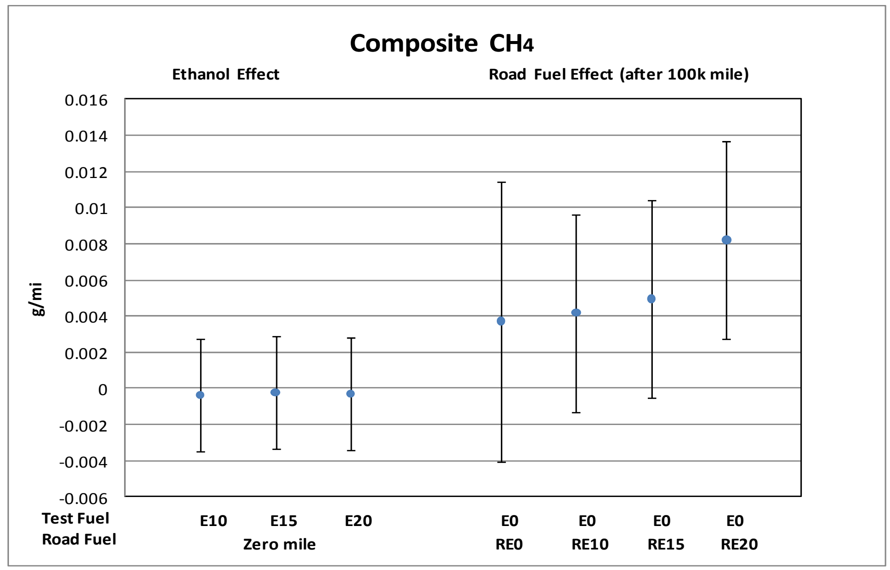
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.99
No Aging Effect with RE0 (Beta0 = 0)	0.31
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.62

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 40k-50k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2006 Chevrolet Cobalt - Composite Emissions Summary

Emisssion Parameter (units)	Ethanol Effect				Aging Effect with RE0		RExx Aging Effect on E0 Emissions				RExx Aging Effect on Exx Emissions			Road and Test Fuel Effects are Additive
	Δ units vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value	Δ units per 100K mi			Overall p-value
Fuels	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0		RE10/E10	RE15/E15	RE20/E20	
CO (g/mi)	NA	-0.001	-0.156	0.49	0.268	0.39	NA	-0.033	0.225	0.61	NA	NA	NA	0.68
NOx (g/mi)[a]	NA	0.0015	0.0019	0.98	0.0180	0.56	NA	0.0001	0.0406	0.50	NA	NA	NA	0.36
NMHC (g/mi)	NA	-0.0039	-0.0083	0.05*	-0.0025	0.73	NA	-0.0015	0.0025	0.80	NA	NA	NA	0.81
NMOG (g/mi)	NA	0.0004	-0.0038	0.50	-0.0026	0.74	NA	-0.0017	0.0023	0.82	NA	NA	NA	0.80
Fuel Econ (mi/gal)	NA	-1.258*	-1.656*	<0.01*	0.651	0.33	NA	0.033	0.390	0.71	NA	NA	NA	0.57
Ethanol (mg/mi)[##]	NA	3.204*	4.915*	0.01*	0.046	0.99	NA	0.068	-1.420	0.86	NA	NA	NA	NA
Acetaldehyde (mg/mi)[##b]	NA	0.490	1.140*	0.04*	0.059	0.94	NA	0.072	0.013	1.00	NA	NA	NA	NA
Formaldehyde (mg/mi)[#]	NA	-0.143	0.018	0.72	0.476	0.40	NA	0.496	0.411	0.98	NA	NA	NA	0.93
CH_4 (g/mi)	NA	-0.0005	-0.0001	0.91	0.0037	0.20	NA	0.0007	0.0030	0.59	NA	NA	NA	0.96

Log-normal model was used. Results are presented as changes in emissions at 0k mile.

Data did not support the assumption of linear effects with mileage.

* Indicates estimate is different from zero at the 95% confidence level.

a test "SW024668" and "SW024673" are identified as outliers and excluded from the analysis

b test "SW024056" is identified as an outlier and excluded from the analysis

2006 Chevrolet Cobalt (Composite CO)

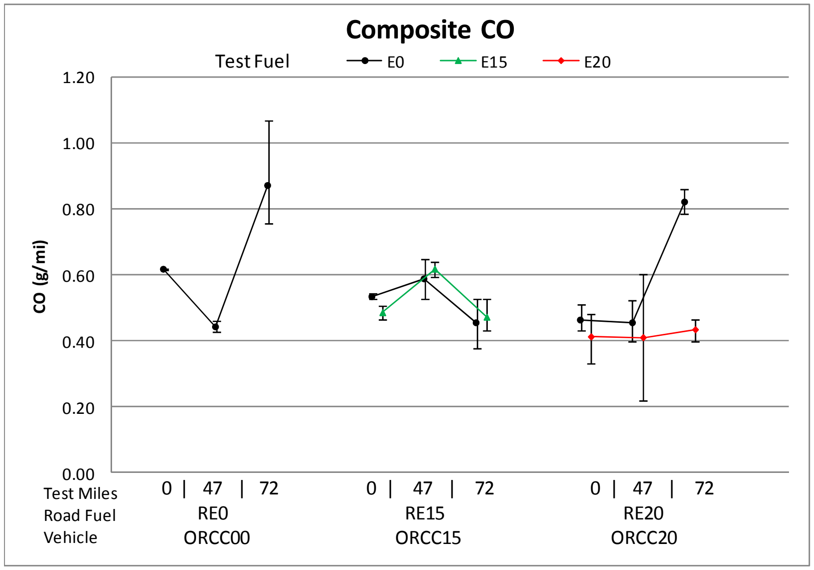
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.001	-0.293	0.291
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.156	-0.448	0.136
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.268	-0.422	0.958
Aging Effect with RE15 (Δg/mi per 100k mi)	-0.033	-0.522	0.456
Aging Effect with RE20 (Δg/mi per 100k mi)	0.225	-0.263	0.713

* Indicates estimate is different from zero at the 95% confidence level.

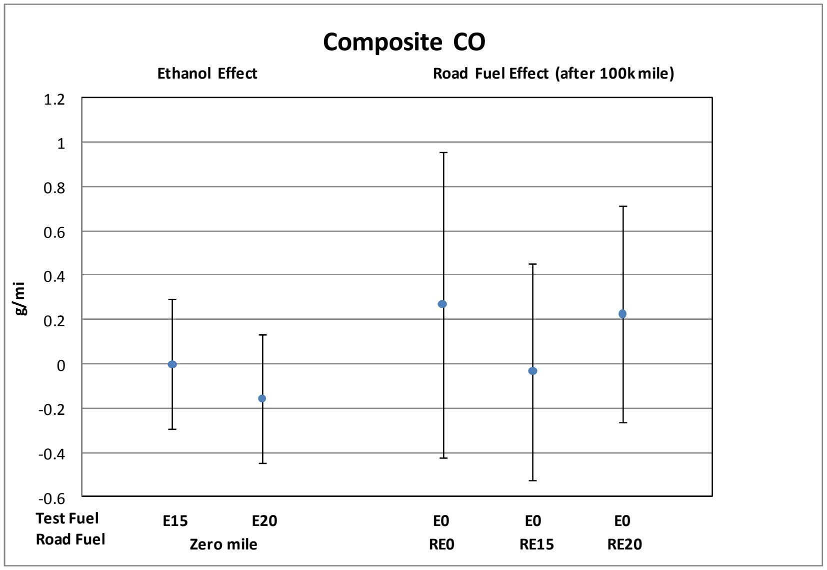
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.49
No Aging Effect with RE0 (Beta0 = 0)	0.39
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.61

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 38k-48k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2006 Chevrolet Cobalt (Composite NOx)

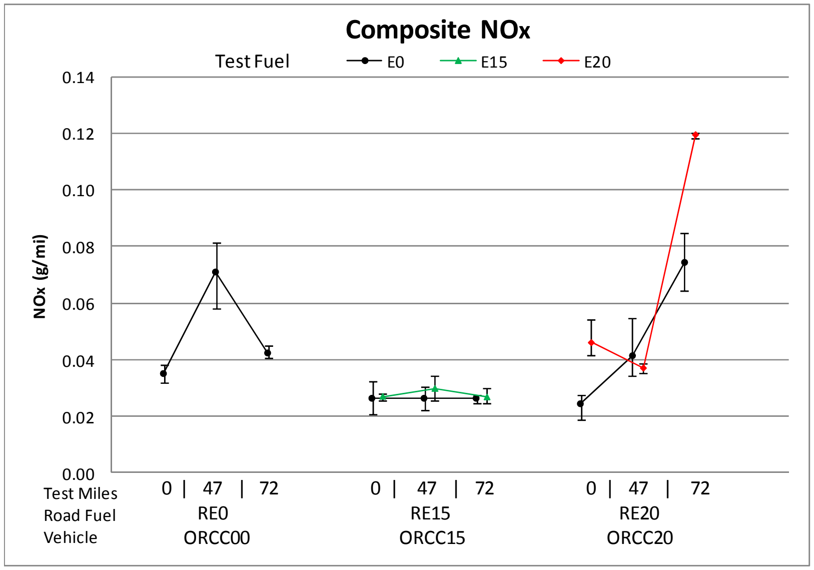
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0015	-0.0288	0.0317
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.0019	-0.0333	0.0371
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0180	-0.0536	0.0896
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0001	-0.0505	0.0507
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0406	-0.0195	0.1008

* Indicates estimate is different from zero at the 95% confidence level.

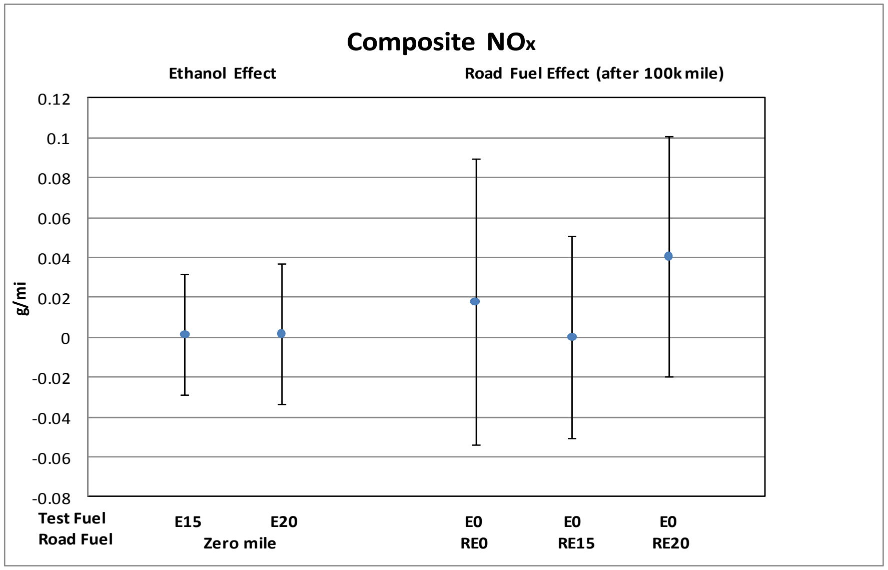
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.98
No Aging Effect with RE0 (Beta0 = 0)	0.56
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.50

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 38k-48k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2006 Chevrolet Cobalt (Composite Nonmethane Hydrocarbons)

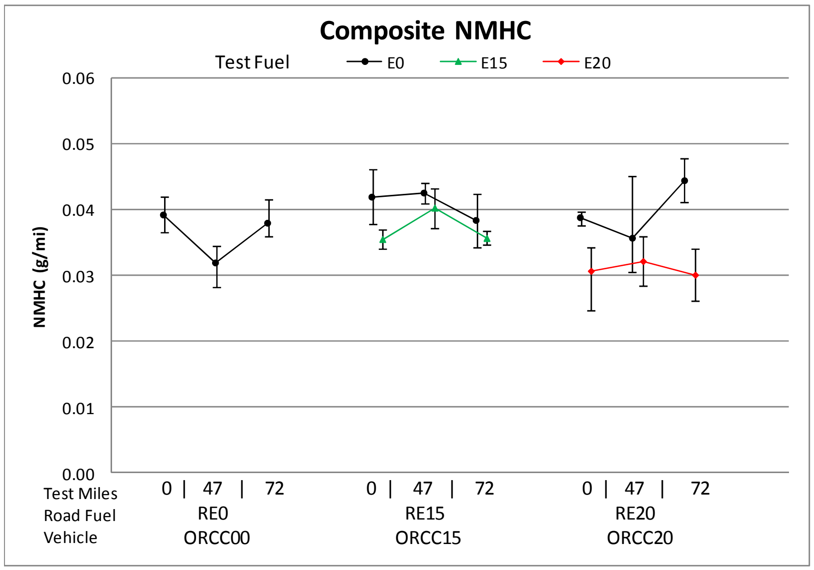
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.0039	-0.0110	0.0032
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.0083	-0.0153	-0.0012
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	-0.0025	-0.0191	0.0141
Aging Effect with RE15 (Δg/mi per 100k mi)	-0.0015	-0.0134	0.0103
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0025	-0.0093	0.0142

* Indicates estimate is different from zero at the 95% confidence level.

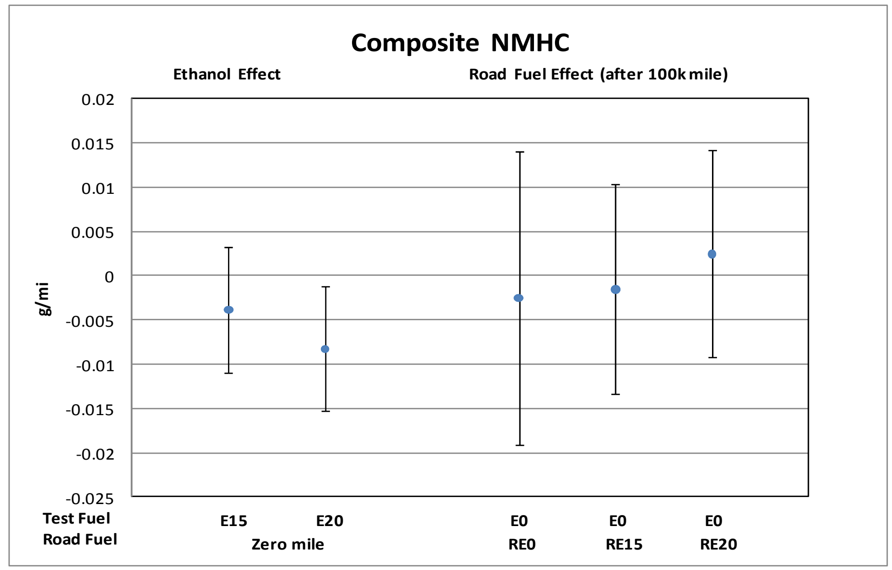
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.05*
No Aging Effect with RE0 (Beta0 = 0)	0.73
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.80

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 38k-48k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2006 Chevrolet Cobalt (Composite Nonmethane Organic Gases)

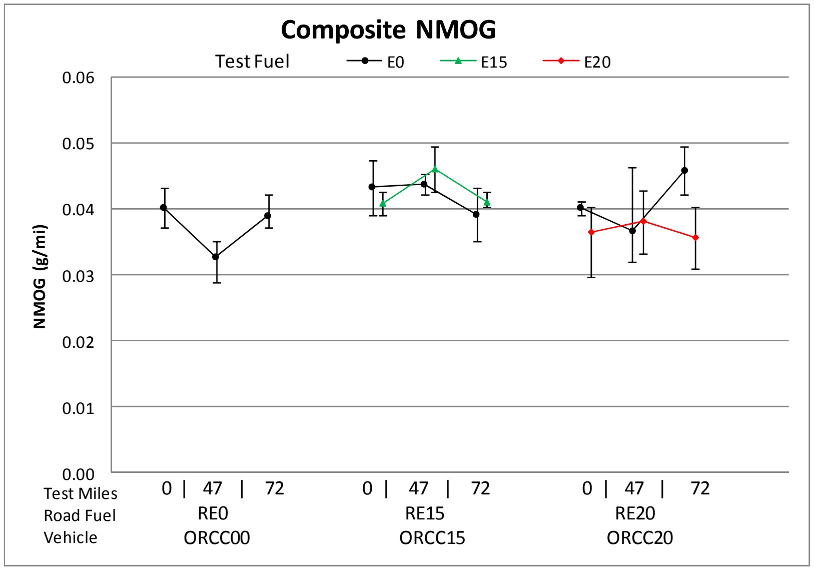
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0004	-0.0071	0.0079
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.0038	-0.0112	0.0036
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	-0.0026	-0.0201	0.0150
Aging Effect with RE15 (Δg/mi per 100k mi)	-0.0017	-0.0142	0.0108
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0023	-0.0100	0.0146

* Indicates estimate is different from zero at the 95% confidence level.

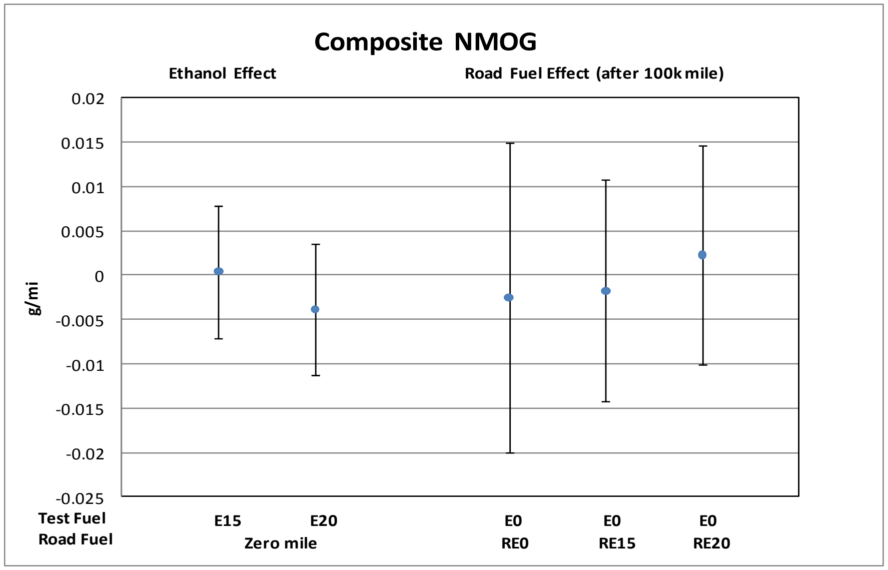
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.50
No Aging Effect with RE0 (Beta0 = 0)	0.74
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.82

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 38k-48k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2006 Chevrolet Cobalt (Composite Fuel Economy)

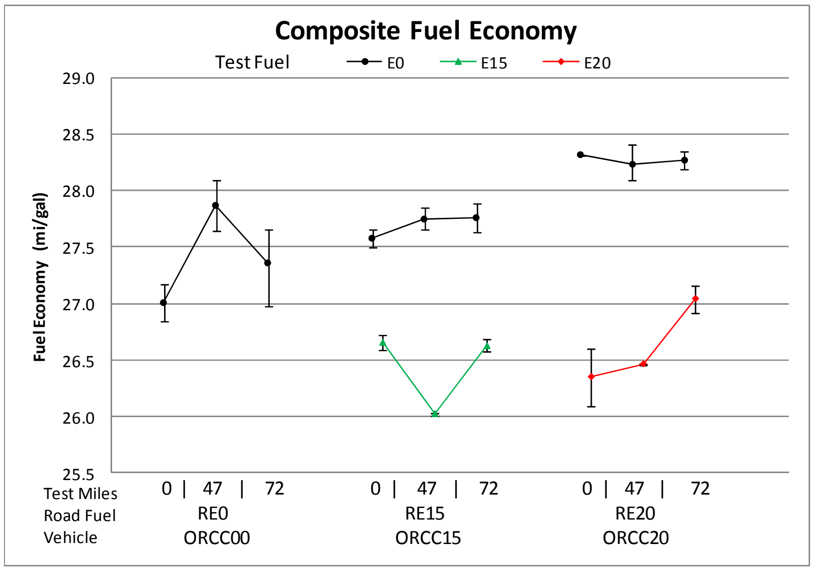
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmi/gal)	-1.258*	-1.884	-0.632
Ethanol Effect (E20 vs. E0) (Δmi/gal)	-1.656*	-2.282	-1.031
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmi/gal per 100k mi)	0.651	-0.829	2.130
Aging Effect with RE15 (Δmi/gal per 100k mi)	0.033	-1.014	1.081
Aging Effect with RE20 (Δmi/gal per 100k mi)	0.390	-0.657	1.437

* Indicates estimate is different from zero at the 95% confidence level.

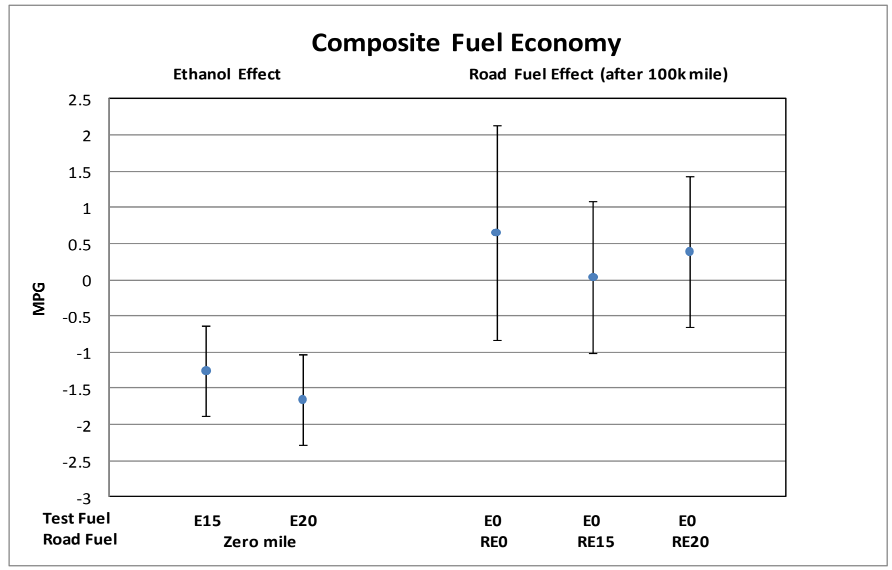
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.33
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.71

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 38k-48k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2006 Chevrolet Cobalt (Composite Ethanol)

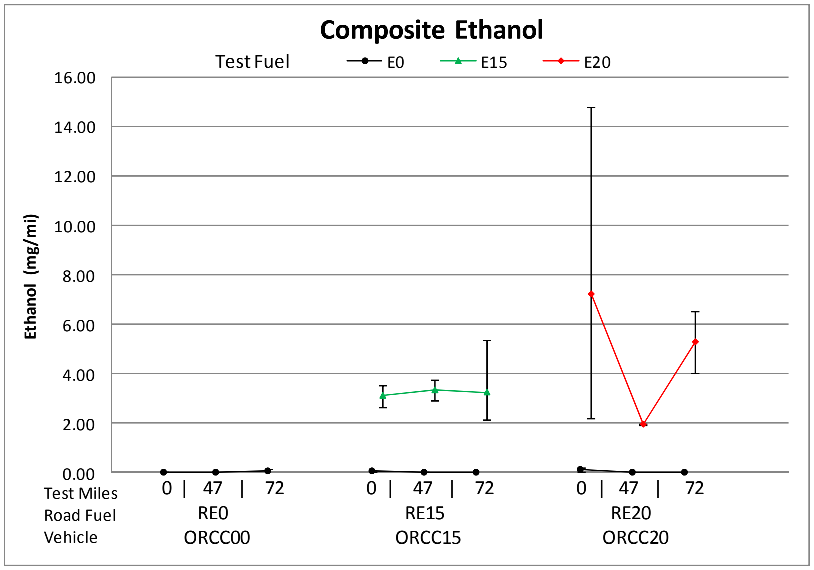
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	3.204*	0.102	6.307
Ethanol Effect (E20 vs. E0) (Δmg/mi)	4.915*	1.739	8.092
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.046	-7.429	7.520
Aging Effect with RE15 (Δmg/mi per 100k mi)	0.068	-5.214	5.351
Aging Effect with RE20 (Δmg/mi per 100k mi)	-1.420	-6.707	3.867

* Indicates estimate is different from zero at the 95% confidence level.

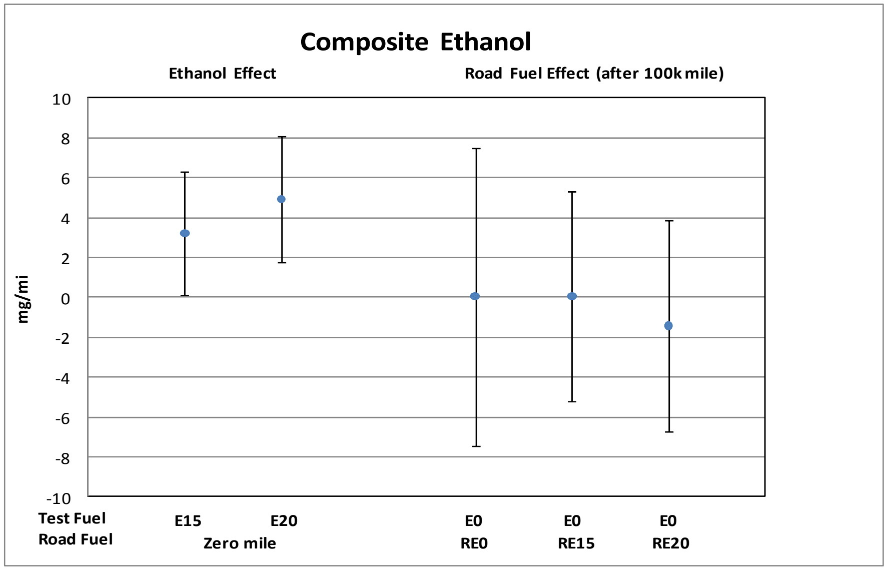
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.99
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.86

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 38k-48k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2006 Chevrolet Cobalt (Composite Acetaldehyde)

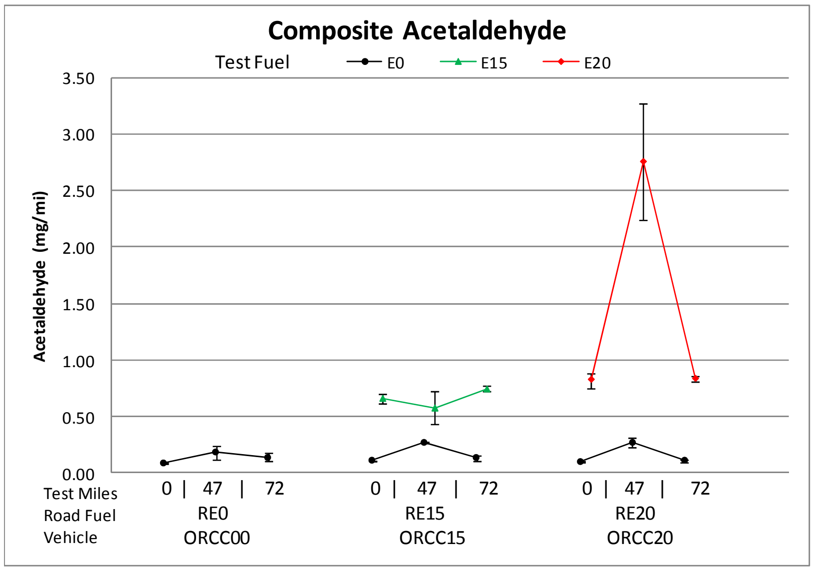
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.490	-0.348	1.329
Ethanol Effect (E20 vs. E0) (Δmg/mi)	1.140*	0.301	1.979
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.059	-1.958	2.076
Aging Effect with RE15 (Δmg/mi per 100k mi)	0.072	-1.353	1.498
Aging Effect with RE20 (Δmg/mi per 100k mi)	0.013	-1.413	1.440

* Indicates estimate is different from zero at the 95% confidence level.

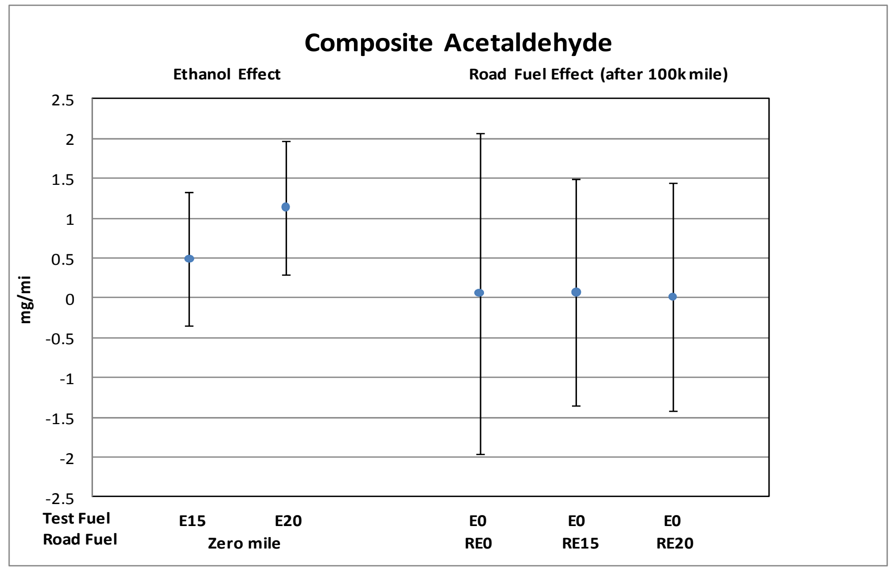
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.04*
No Aging Effect with RE0 (Beta0 = 0)	0.94
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	1.00

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 38k-48k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2006 Chevrolet Cobalt (Composite Formaldehyde)

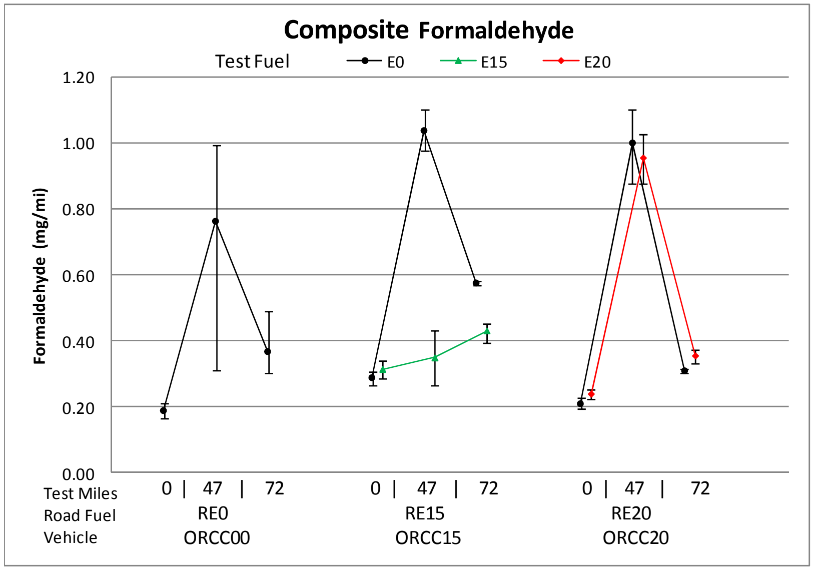
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	-0.143	-0.723	0.438
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.018	-0.481	0.516
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.476	-0.961	1.913
Aging Effect with RE15 (Δmg/mi per 100k mi)	0.496	-0.968	1.959
Aging Effect with RE20 (Δmg/mi per 100k mi)	0.411	-0.713	1.534

* Indicates estimate is different from zero at the 95% confidence level.

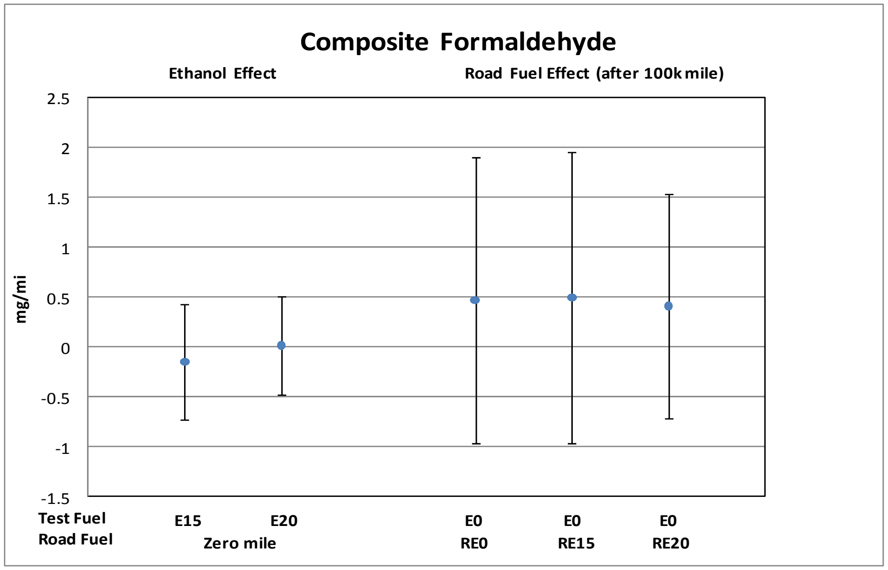
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.72
No Aging Effect with RE0 (Beta0 = 0)	0.40
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.98

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 38k-48k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2006 Chevrolet Cobalt (Composite CH_4)

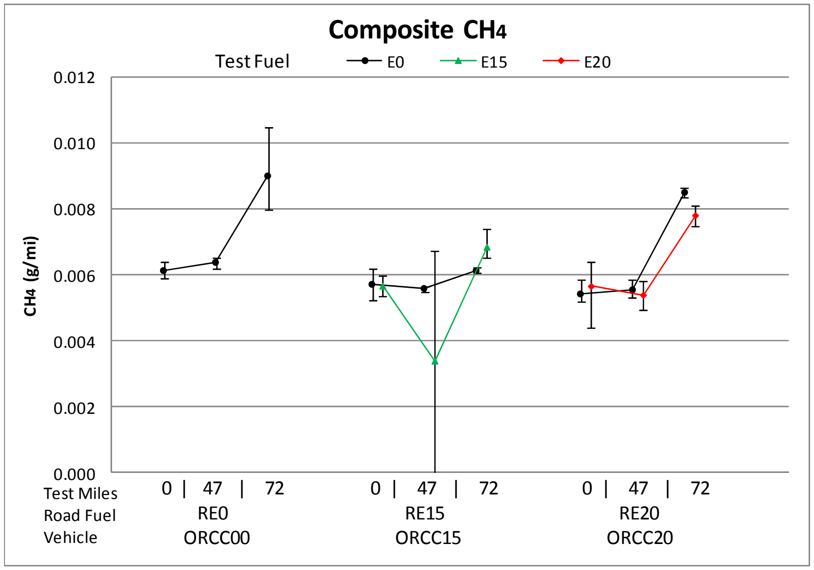
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.0005	-0.0030	0.0021
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.0001	-0.0027	0.0024
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0037	-0.0024	0.0097
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0007	-0.0036	0.0051
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0030	-0.0013	0.0073

* Indicates estimate is different from zero at the 95% confidence level.

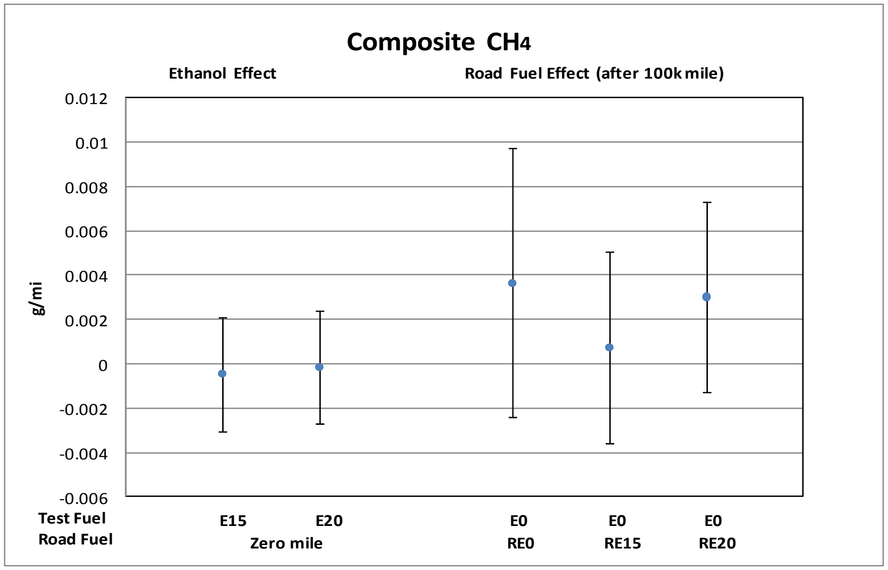
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.91
No Aging Effect with RE0 (Beta0 = 0)	0.20
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.59

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 38k-48k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2007 Dodge Caliber - Composite Emissions Summary

Emisssion Parameter (units)	Ethanol Effect				Aging Effect with RE0		RExx Aging Effect on E0 Emissions				RExx Aging Effect on Exx Emissions			Road and Test Fuel Effects are Additive
	Δ units vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value	Δ units per 100K mi			Overall p-value
Fuels	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0		RE10/E10	RE15/E15	RE20/E20	
CO (g/mi)	NA	-0.214	-1.049*	<0.01*	2.274*	<0.01*	NA	4.729*	2.748*	<0.01*	NA	NA	NA	0.22
NOx (g/mi)	NA	0.002	0.002	0.92	0.057*	0.01*	NA	0.037*	0.045*	0.65	NA	NA	NA	0.97
NMHC (g/mi)	NA	-0.0016	-0.0117*	0.02*	0.0416*	<0.01*	NA	0.0437*	0.0289*	0.28	NA	NA	NA	0.99
NMOG (g/mi)	NA	0.0052	-0.0046	0.38	0.0428*	<0.01*	NA	0.0471*	0.0322*	0.41	NA	NA	NA	0.89
Fuel Econ (mi/gal)	NA	-1.386*	-1.774*	<0.01*	0.994*	0.04*	NA	0.288	-0.131	0.15	NA	NA	NA	0.99
Ethanol (mg/mi)##	NA	3.888*	4.307*	<0.01*	-0.056	0.97	NA	-0.100	2.298	0.30	NA	NA	NA	NA
Acetaldehyde (mg/mi)#	NA	0.820*	1.111*	<0.01*	0.155	0.12	NA	0.201*	0.152*	0.85	NA	NA	NA	0.67
Formaldehyde (mg/mi)#	NA	0.086	0.151	0.17	0.530	0.15	NA	0.520*	0.433*	0.98	NA	NA	NA	0.99
CH_4 (g/mi)	NA	-0.0002	-0.0018	0.89	0.0268*	0.02*	NA	0.0402*	0.0254*	0.27	NA	NA	NA	0.98

Log-normal model was used. Results are presented as changes in emissions at 0k mile.

Data did not support the assumption of linear effects with mileage.

* Indicates estimate is different from zero at the 95% confidence level.

2007 Dodge Caliber (Composite CO)

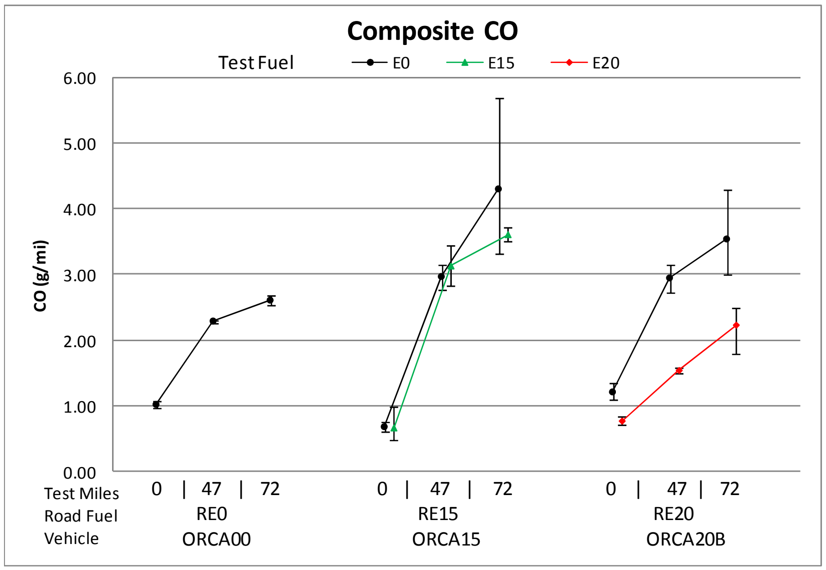
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.214	-0.741	0.312
Ethanol Effect (E20 vs. E0) (Δg/mi)	-1.049*	-1.554	-0.544
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	2.274*	0.937	3.611
Aging Effect with RE15 (Δg/mi per 100k mi)	4.729*	3.861	5.596
Aging Effect with RE20 (Δg/mi per 100k mi)	2.748*	1.929	3.566

* Indicates estimate is different from zero at the 95% confidence level.

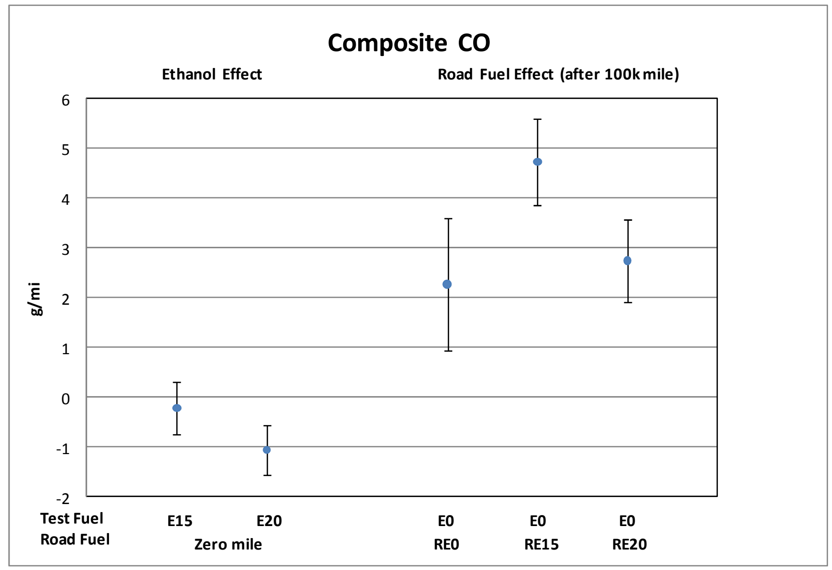
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	<0.01*

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 41k-48k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2007 Dodge Caliber (Composite NOx)

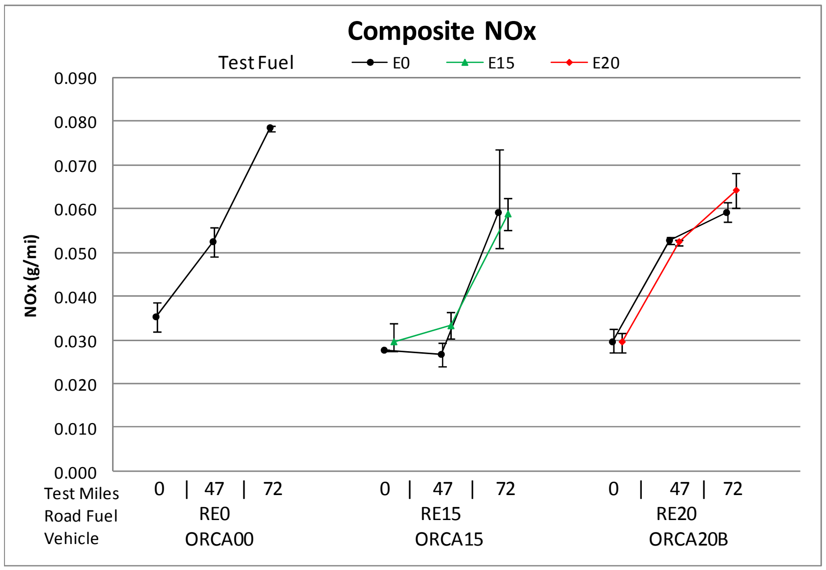
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.002	-0.015	0.019
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.002	-0.015	0.019
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.057*	0.017	0.098
Aging Effect with RE15 (Δg/mi per 100k mi)	0.037*	0.008	0.066
Aging Effect with RE20 (Δg/mi per 100k mi)	0.045*	0.017	0.074

* Indicates estimate is different from zero at the 95% confidence level.

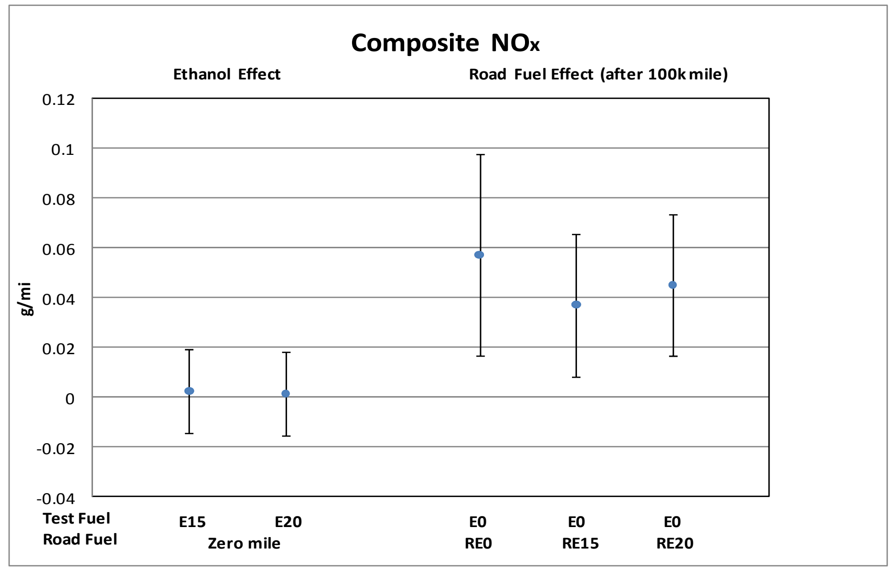
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.92
No Aging Effect with RE0 (Beta0 = 0)	0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.65

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 41k-48k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2007 Dodge Caliber (Composite Nonmethane Hydrocarbons)

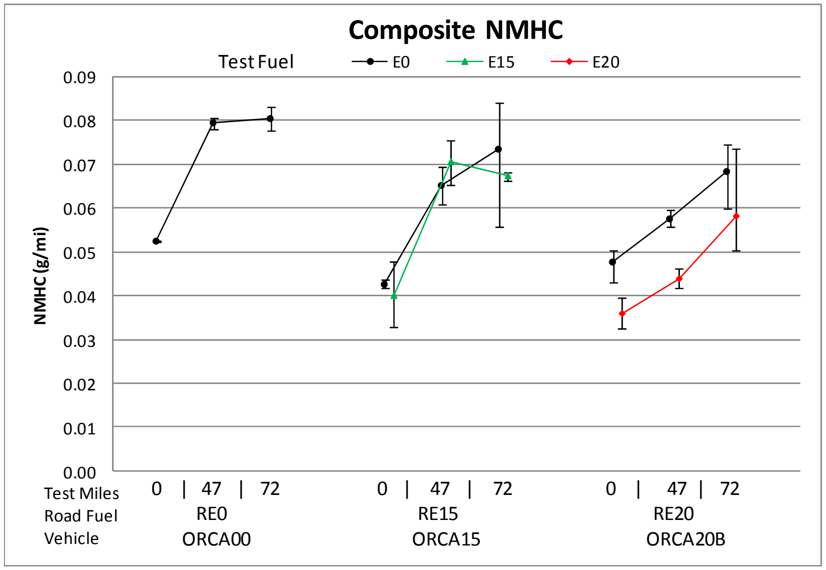
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.0016	-0.0102	0.0070
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.0117*	-0.0199	-0.0035
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0416*	0.0198	0.0634
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0437*	0.0295	0.0578
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0289*	0.0156	0.0423

* Indicates estimate is different from zero at the 95% confidence level.

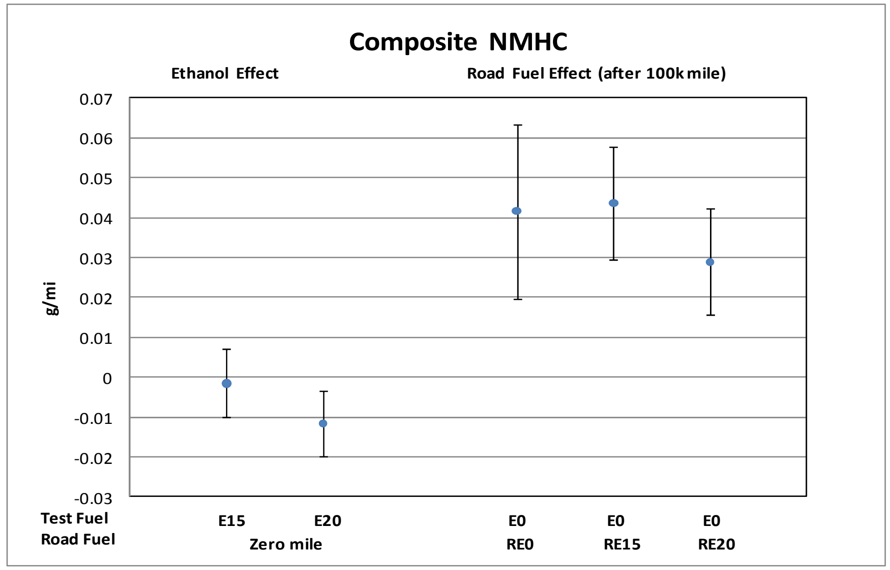
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.02*
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.28

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 41k-48k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2007 Dodge Caliber (Composite Nonmethane Organic Gases)

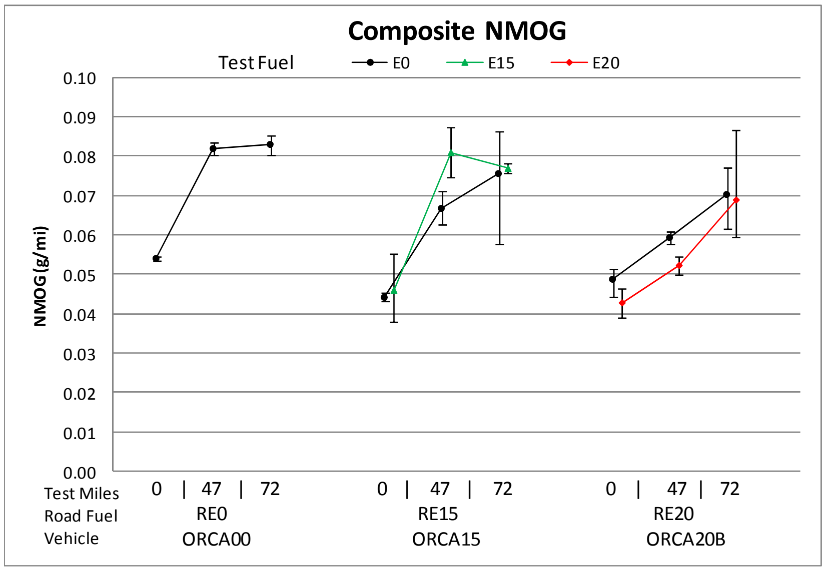
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0052	-0.0059	0.0164
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.0046	-0.0158	0.0067
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0428*	0.0158	0.0697
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0471*	0.0281	0.0661
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0322*	0.0130	0.0513

* Indicates estimate is different from zero at the 95% confidence level.

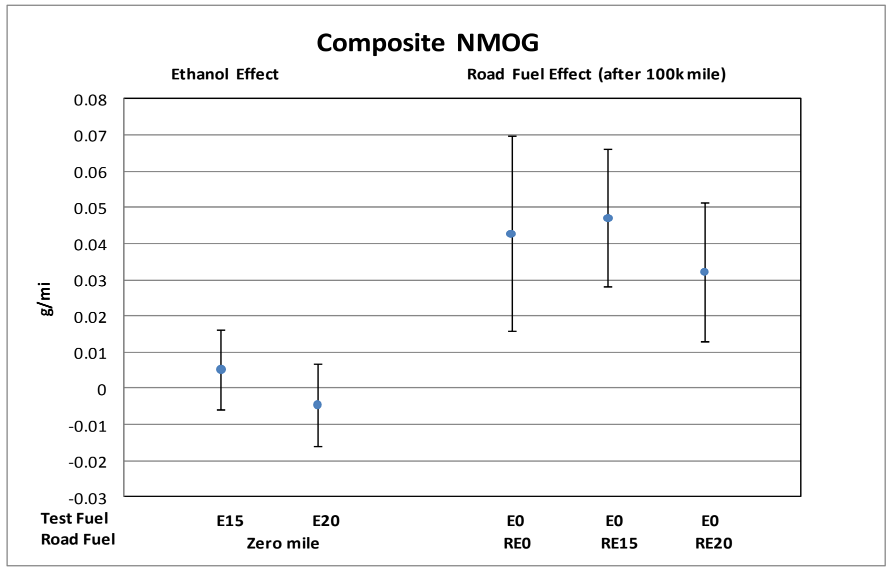
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.38
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.41

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 41k-48k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2007 Dodge Caliber (Composite Fuel Economy)

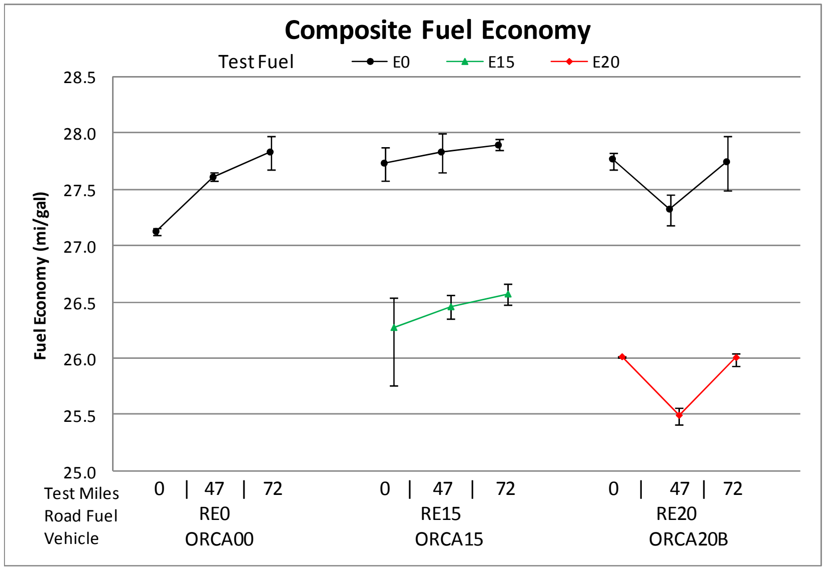
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmi/gal)	-1.386*	-1.788	-0.984
Ethanol Effect (E20 vs. E0) (Δmi/gal)	-1.774*	-2.177	-1.371
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmi/gal per 100k mi)	0.994*	0.031	1.957
Aging Effect with RE15 (Δmi/gal per 100k mi)	0.288	-0.394	0.970
Aging Effect with RE20 (Δmi/gal per 100k mi)	-0.131	-0.808	0.545

* Indicates estimate is different from zero at the 95% confidence level.

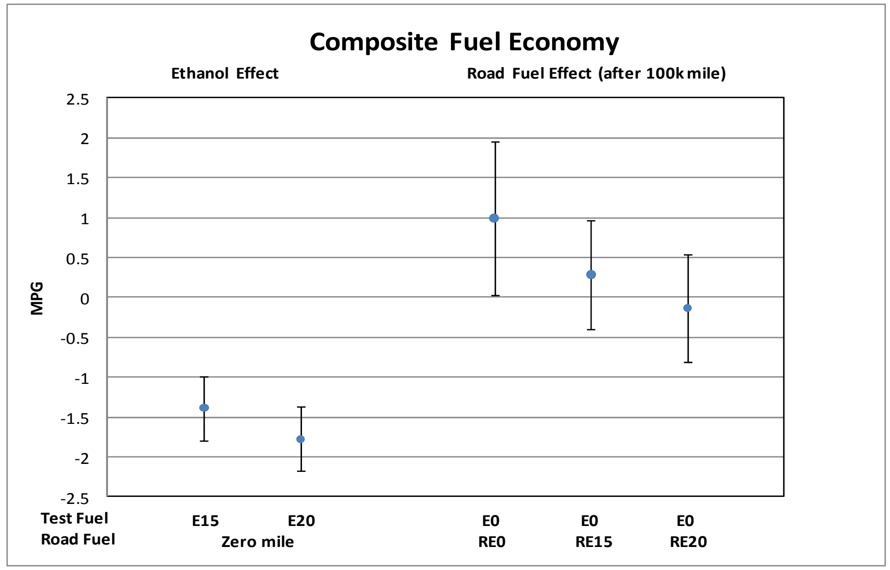
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.04*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.15

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 41k-48k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2007 Dodge Caliber (Composite Ethanol)

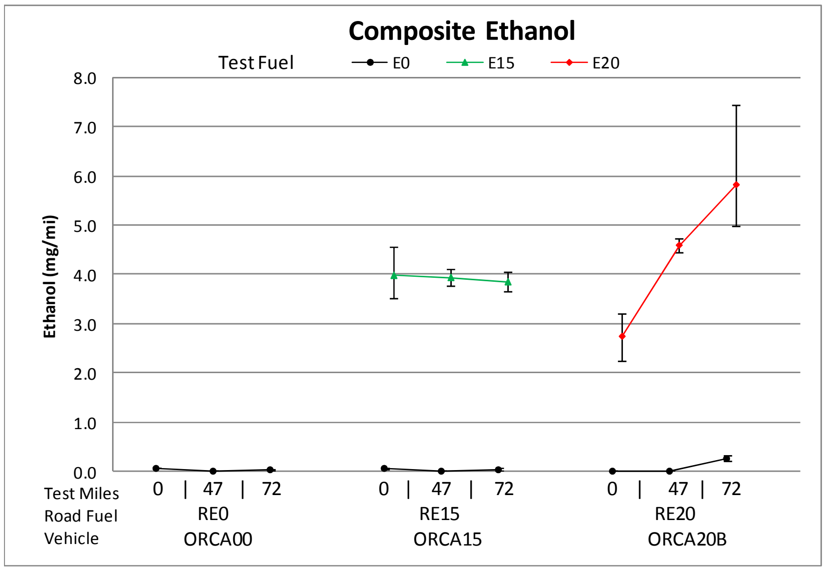
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	3.888*	2.243	5.534
Ethanol Effect (E20 vs. E0) (Δmg/mi)	4.307*	2.652	5.963
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	-0.056	-4.013	3.900
Aging Effect with RE15 (Δmg/mi per 100k mi)	-0.100	-2.922	2.723
Aging Effect with RE20 (Δmg/mi per 100k mi)	2.298	-0.538	5.135

* Indicates estimate is different from zero at the 95% confidence level.

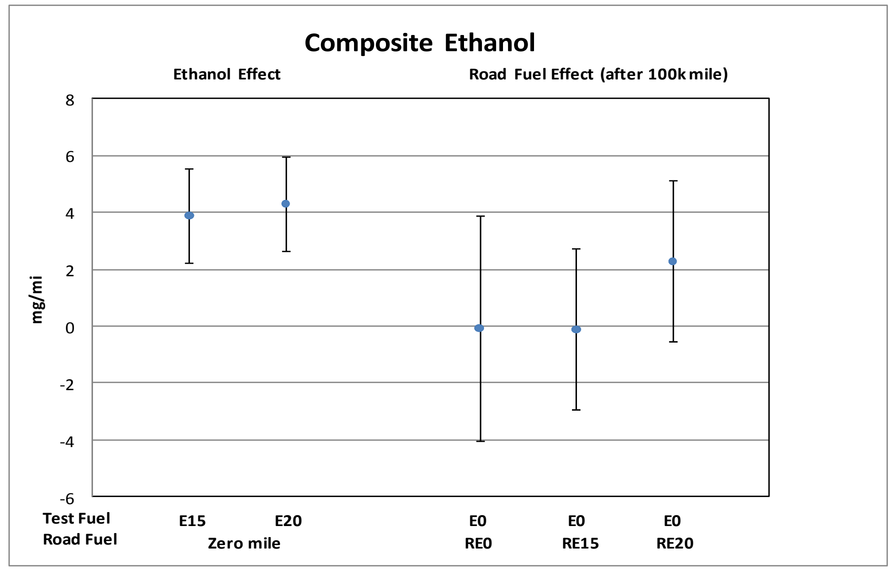
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.97
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.30

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 41k-48k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2007 Dodge Caliber (Composite Acetaldehyde)

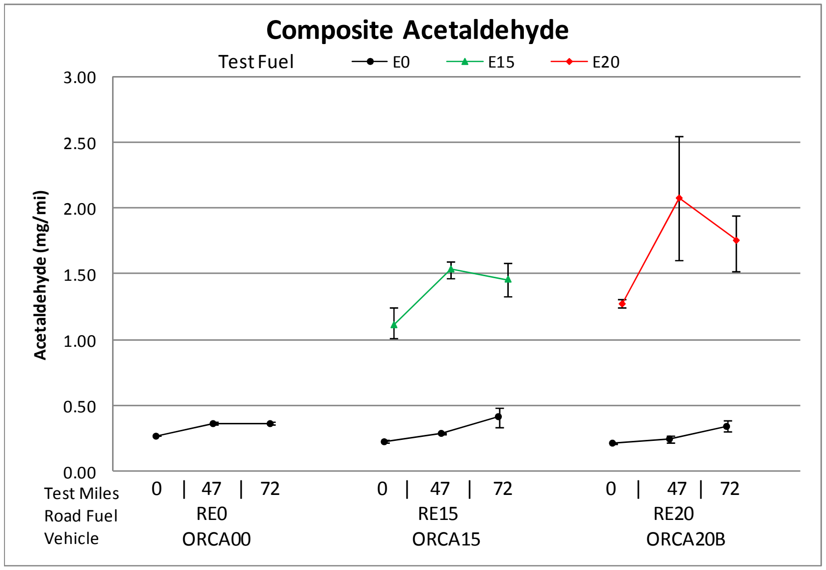
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.820*	0.560	1.080
Ethanol Effect (E20 vs. E0) (Δmg/mi)	1.111*	0.779	1.443
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.155	-0.033	0.344
Aging Effect with RE15 (Δmg/mi per 100k mi)	0.201*	0.056	0.346
Aging Effect with RE20 (Δmg/mi per 100k mi)	0.152*	0.030	0.275

* Indicates estimate is different from zero at the 95% confidence level.

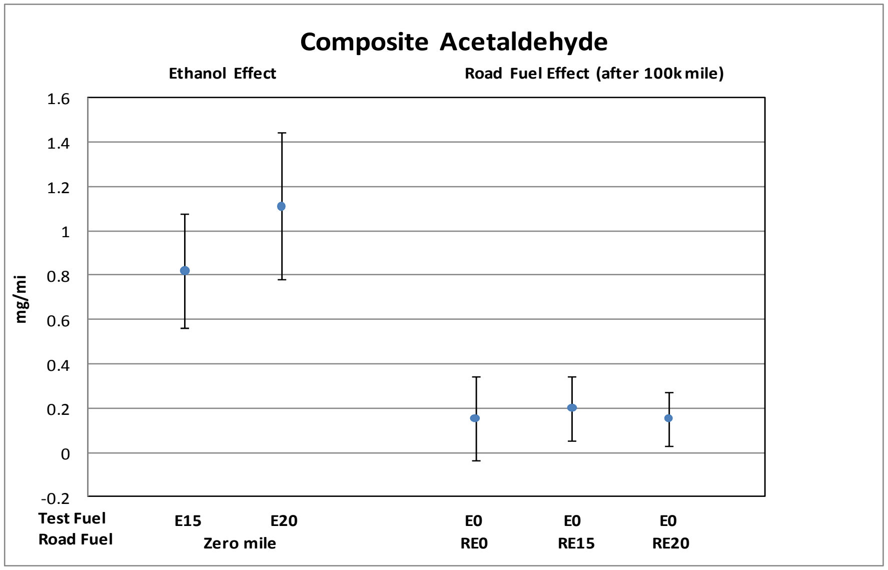
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.12
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.85

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 41k-48k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2007 Dodge Caliber (Composite Formaldehyde)

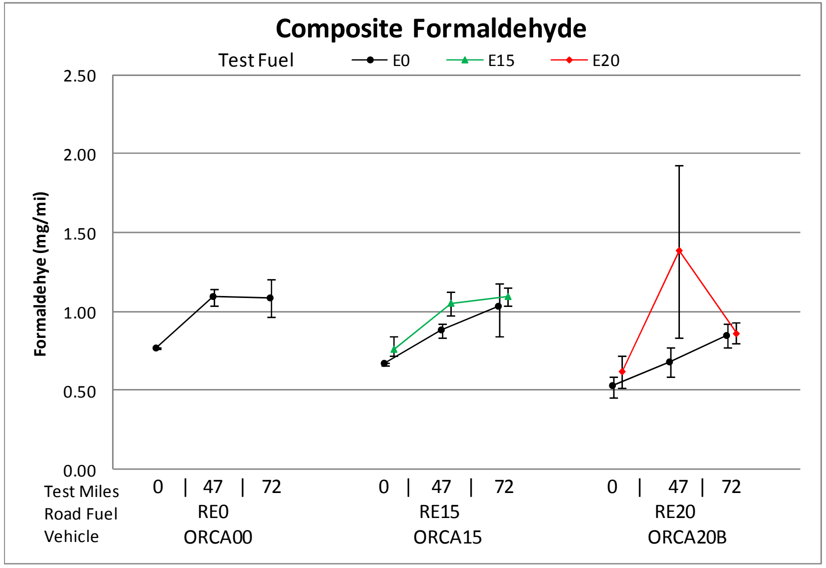
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.086	-0.233	0.404
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.151	-0.119	0.422
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.530	-0.199	1.258
Aging Effect with RE15 (Δmg/mi per 100k mi)	0.520*	0.007	1.033
Aging Effect with RE20 (Δmg/mi per 100k mi)	0.433*	0.024	0.843

* Indicates estimate is different from zero at the 95% confidence level.

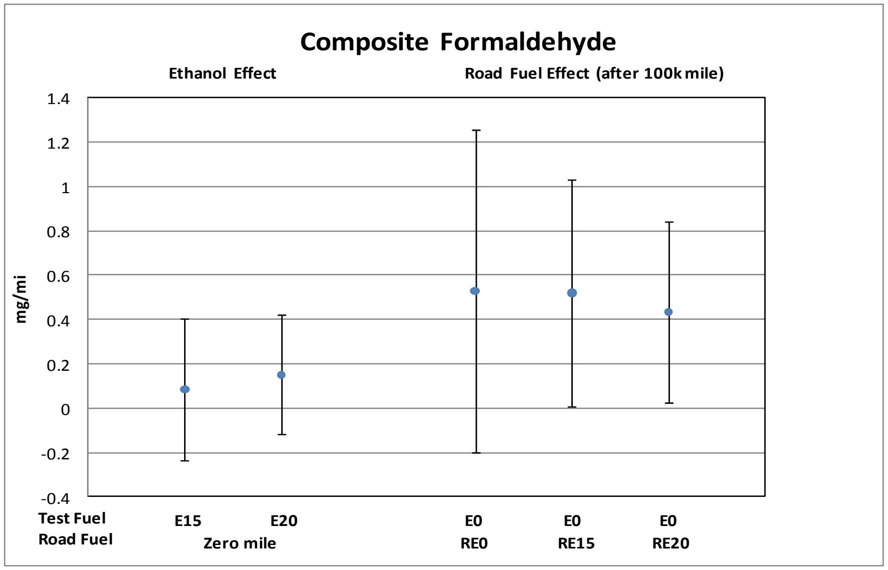
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.17
No Aging Effect with RE0 (Beta0 = 0)	0.15
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.98

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 41k-48k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2007 Dodge Caliber (Composite CH_4)

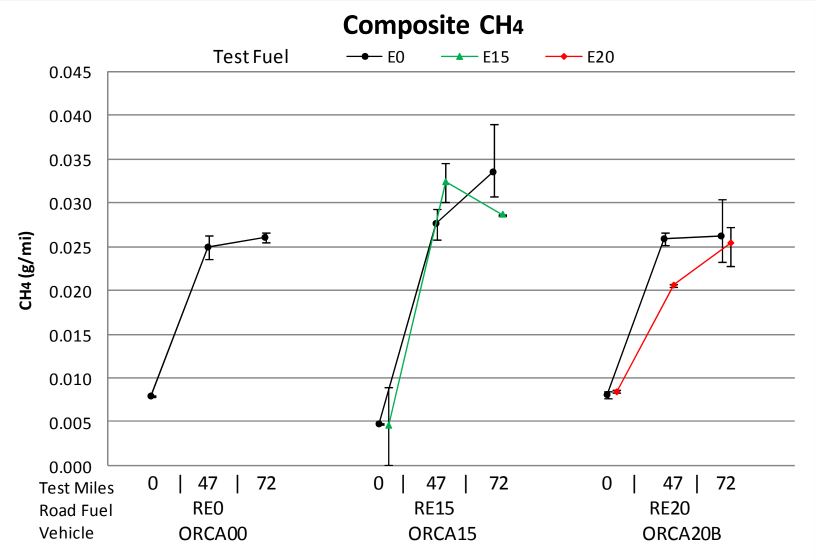
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.0002	-0.0091	0.0086
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.0018	-0.0107	0.0070
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0268*	0.0056	0.0480
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0402*	0.0252	0.0553
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0254*	0.0104	0.0403

* Indicates estimate is different from zero at the 95% confidence level.

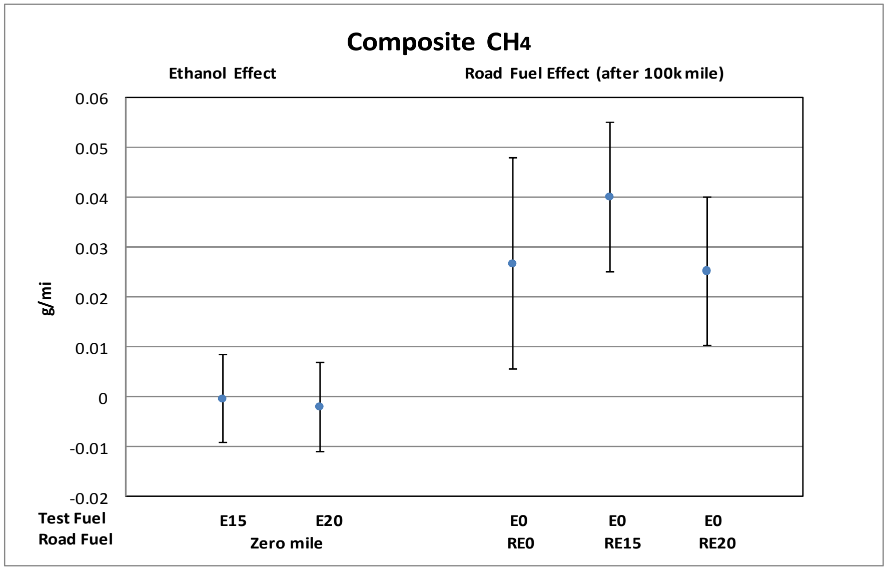
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.89
No Aging Effect with RE0 (Beta0 = 0)	0.02*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.27

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 41k-48k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Jeep Liberty - Composite Emissions Summary

Emisssion Parameter (units)	Ethanol Effect				Aging Effect with RE0		RExx Aging Effect on E0 Emissions				RExx Aging Effect on Exx Emissions			Road and Test Fuel Effects are Additive
	Δ units vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value	Δ units per 100K mi			Overall p-value
Fuels	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0		RE10/E10	RE15/E15	RE20/E20	
CO (g/mi)	NA	-0.176	-0.324	0.23	0.223	0.46	NA	0.579*	0.445	0.62	NA	NA	NA	0.08
NOx (g/mi)	NA	-0.009*	-0.005	0.03*	0.034*	<0.01*	NA	0.035*	0.035*	0.98	NA	NA	NA	0.31
NMHC (g/mi)	NA	-0.011	-0.019	0.11	-0.000	0.99	NA	-0.003	0.011	0.58	NA	NA	NA	0.11
NMOG (g/mi)	NA	-0.006	-0.014	0.37	0.000	1.00	NA	-0.003	0.011	0.59	NA	NA	NA	0.14
Fuel Econ (mi/gal)	NA	-0.858*	-1.086*	<0.01*	0.848	0.06	NA	0.787*	0.768*	0.99	NA	NA	NA	0.80
Acetaldehyde (mg/mi)#	NA	0.586*	0.664*	<0.01*	0.018	0.73	NA	-0.042	-0.022	0.67	NA	NA	NA	0.50
Formaldehyde (mg/mi)#	NA	0.061	0.035	0.96	0.092	0.79	NA	-0.022	0.154	0.90	NA	NA	NA	0.98
CH_4 (g/mi)	NA	-0.0007	-0.0004	0.60	0.0038*	0.02*	NA	0.0080*	0.0046*	0.03	NA	NA	NA	0.16

Log-normal model was used. Results are presented as changes in emissions at 0k mile.

Data did not support the assumption of linear effects with mileage.

* Indicates estimate is different from zero at the 95% confidence level.

2009 Jeep Liberty (Composite CO)

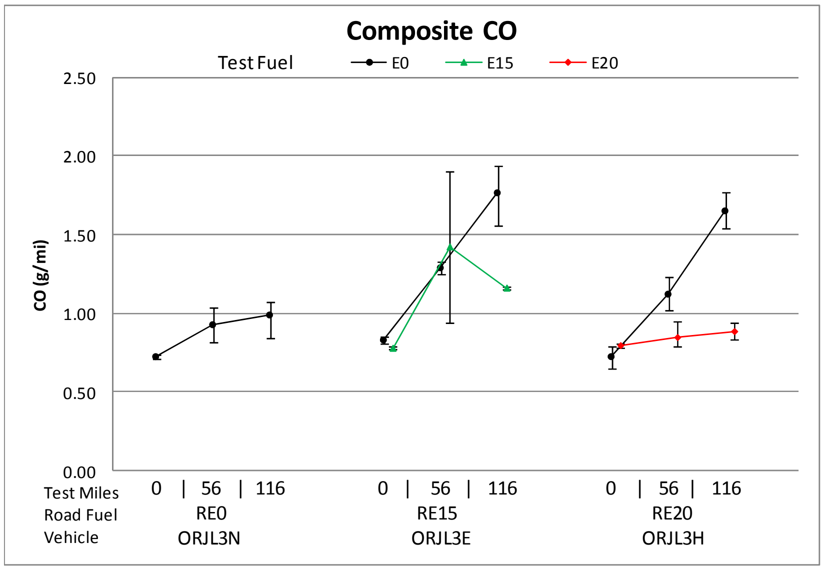
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.176	-0.635	0.283
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.324	-0.783	0.136
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.223	-0.466	0.913
Aging Effect with RE15 (Δg/mi per 100k mi)	0.579*	0.091	1.067
Aging Effect with RE20 (Δg/mi per 100k mi)	0.445	-0.044	0.934

* Indicates estimate is different from zero at the 95% confidence level.

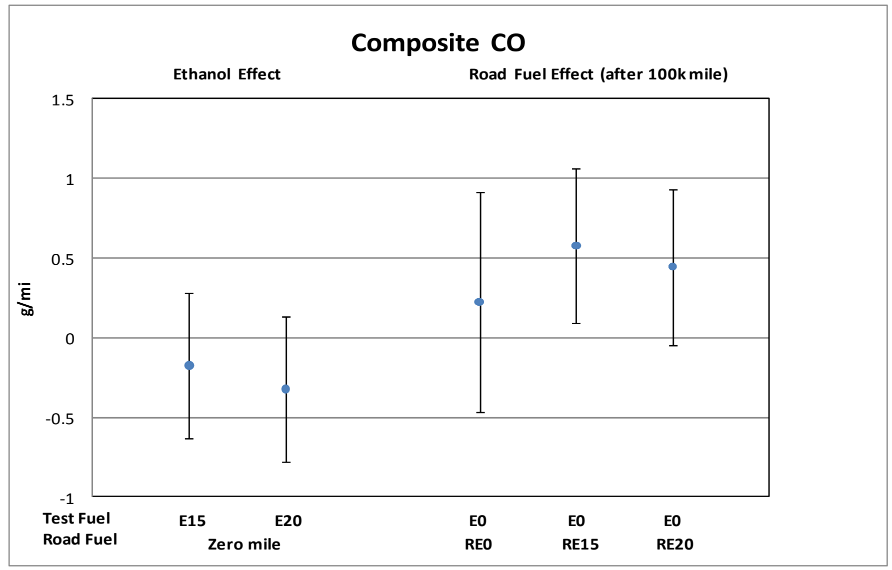
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.23
No Aging Effect with RE0 (Beta0 = 0)	0.46
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.62

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Jeep Liberty (Composite NOx)

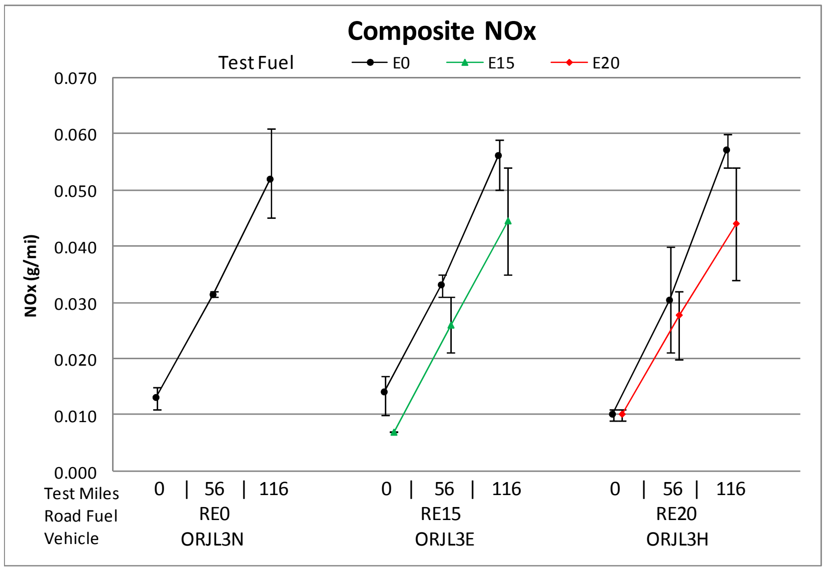
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.009*	-0.016	-0.001
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.005	-0.012	0.002
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.034*	0.024	0.044
Aging Effect with RE15 (Δg/mi per 100k mi)	0.035*	0.028	0.042
Aging Effect with RE20 (Δg/mi per 100k mi)	0.035*	0.027	0.043

* Indicates estimate is different from zero at the 95% confidence level.

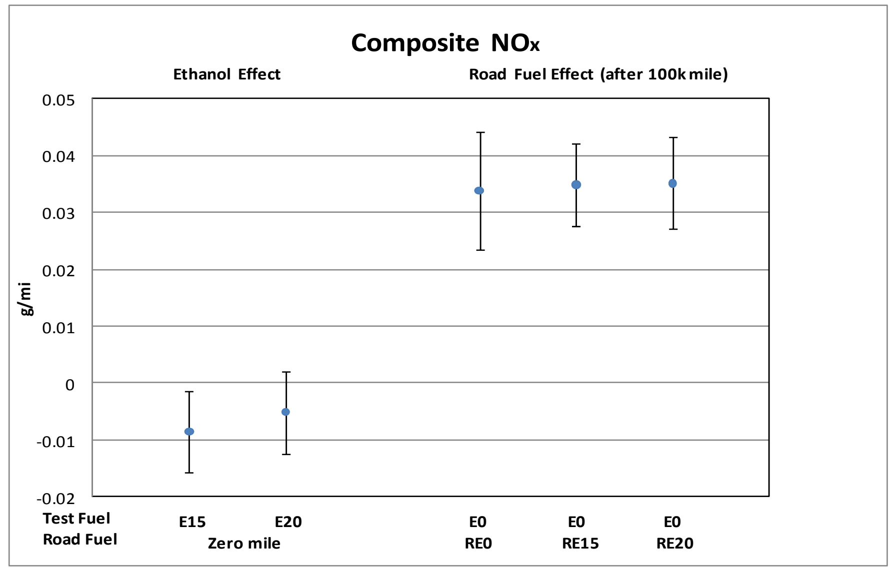
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.03*
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.98

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Jeep Liberty (Composite Nonmethane Hydrocarbons)

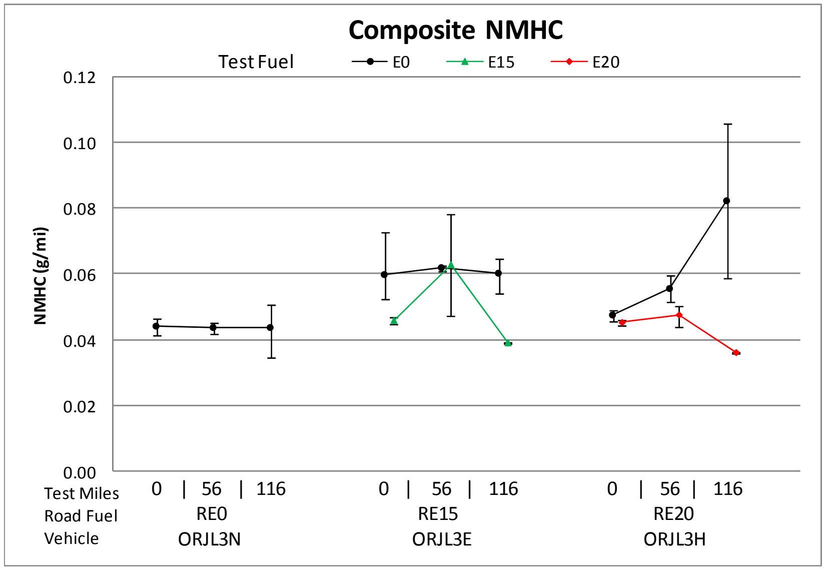
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.011	-0.0324	0.0096
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.019	-0.0396	0.0025
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	-0.000	-0.0318	0.0313
Aging Effect with RE15 (Δg/mi per 100k mi)	-0.003	-0.0250	0.0198
Aging Effect with RE20 (Δg/mi per 100k mi)	0.011	-0.0111	0.0336

* Indicates estimate is different from zero at the 95% confidence level.

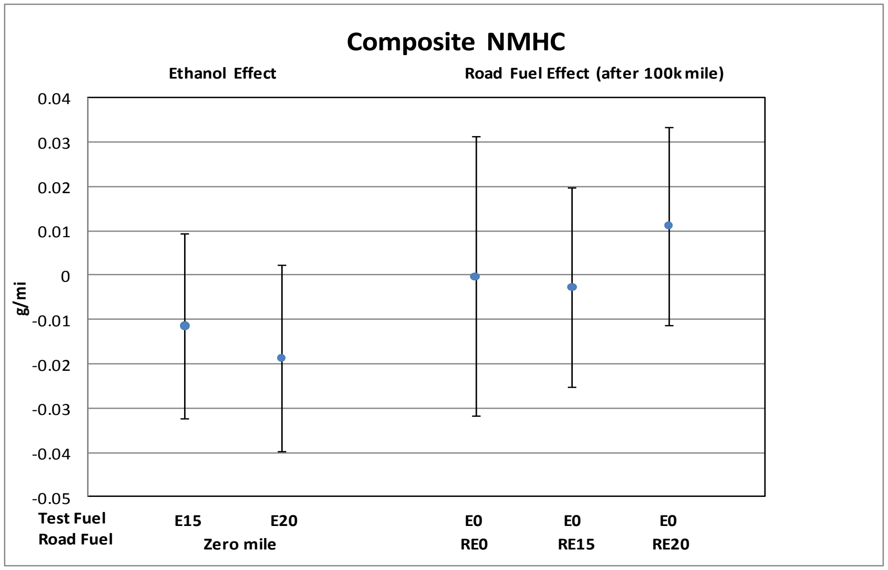
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.11
No Aging Effect with RE0 (Beta0 = 0)	0.99
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.58

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Jeep Liberty (Composite Nonmethane Organic Gases)

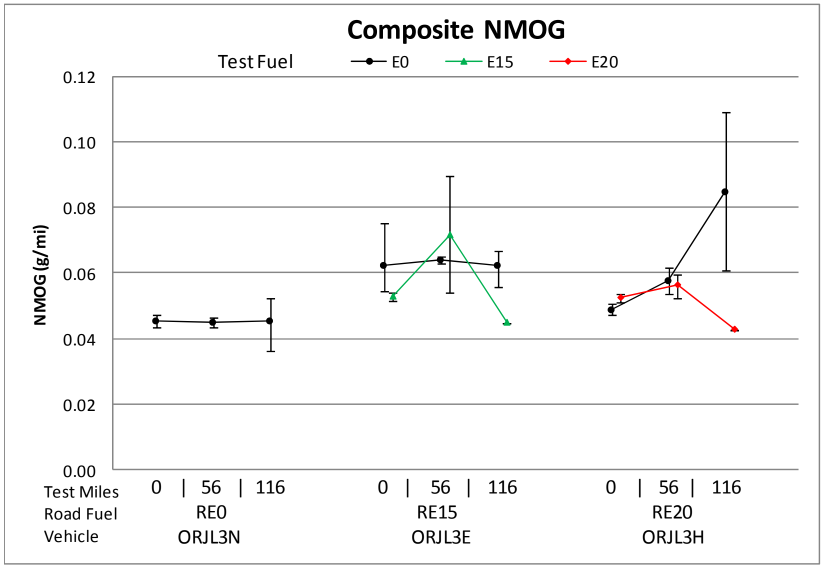
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.006	-0.029	0.016
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.014	-0.036	0.010
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.000	-0.034	0.034
Aging Effect with RE15 (Δg/mi per 100k mi)	-0.003	-0.028	0.021
Aging Effect with RE20 (Δg/mi per 100k mi)	0.011	-0.013	0.036

* Indicates estimate is different from zero at the 95% confidence level.

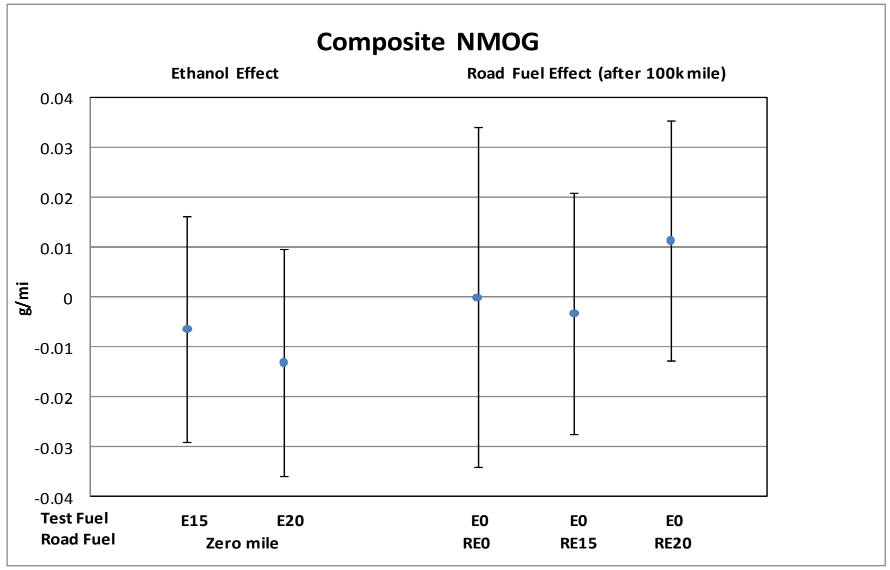
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.37
No Aging Effect with RE0 (Beta0 = 0)	1.00
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.59

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Jeep Liberty (Composite Fuel Economy)

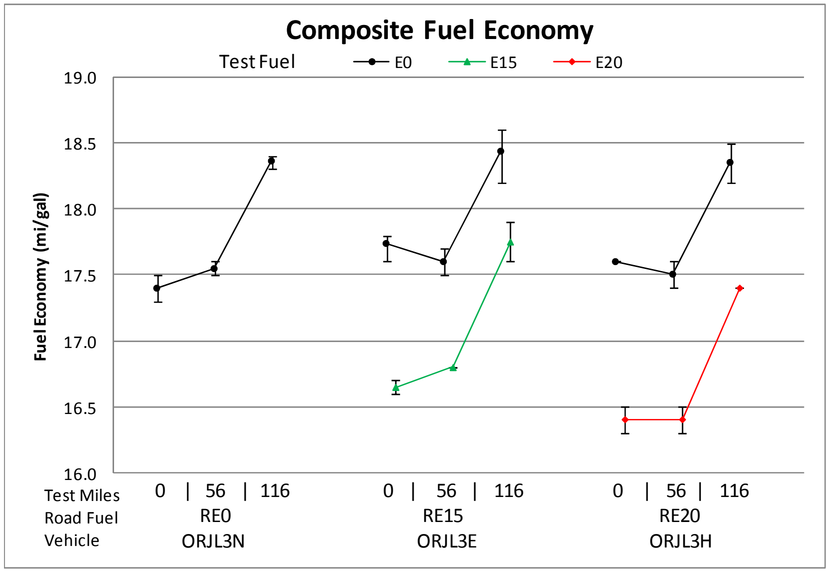
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmi/gal)	-0.858*	-1.455	-0.261
Ethanol Effect (E20 vs. E0) (Δmi/gal)	-1.086*	-1.684	-0.489
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmi/gal per 100k mi)	0.848	-0.050	1.745
Aging Effect with RE15 (Δmi/gal per 100k mi)	0.787*	0.152	1.422
Aging Effect with RE20 (Δmi/gal per 100k mi)	0.768*	0.133	1.403

* Indicates estimate is different from zero at the 95% confidence level.

Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.06
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.99

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



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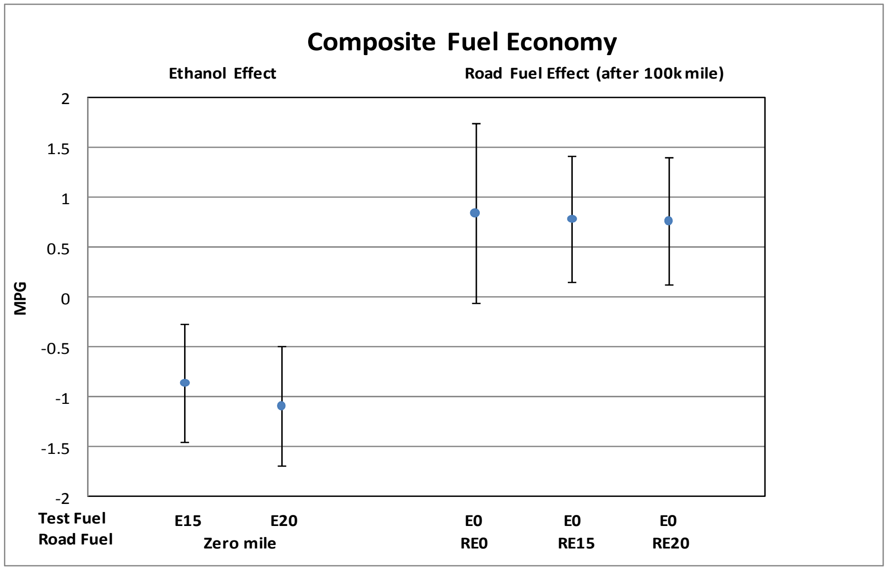


Error bars represent 95% confidence intervals on the estimated effects

2009 Jeep Liberty (Composite Acetaldehyde)

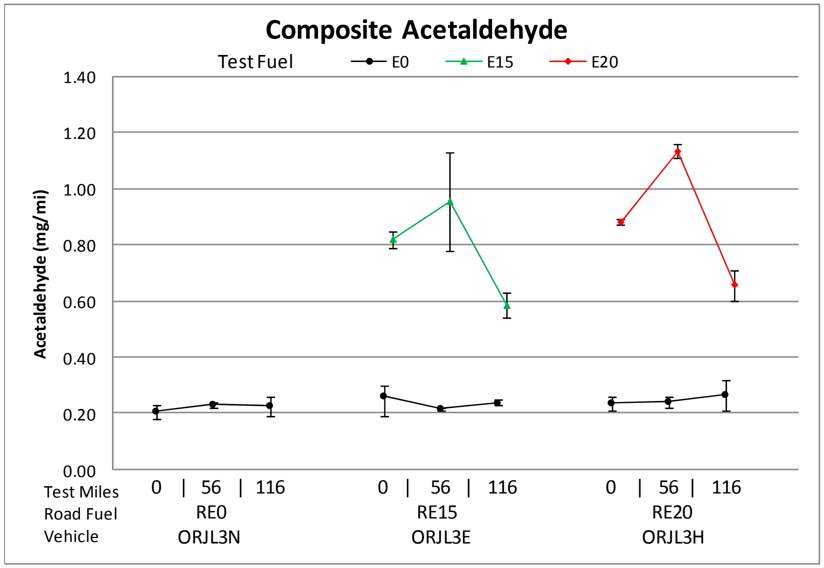
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.586*	0.281	0.890
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.664*	0.340	0.988
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.018	-0.100	0.136
Aging Effect with RE15 (Δmg/mi per 100k mi)	-0.042	-0.152	0.069
Aging Effect with RE20 (Δmg/mi per 100k mi)	-0.022	-0.134	0.091

* Indicates estimate is different from zero at the 95% confidence level.

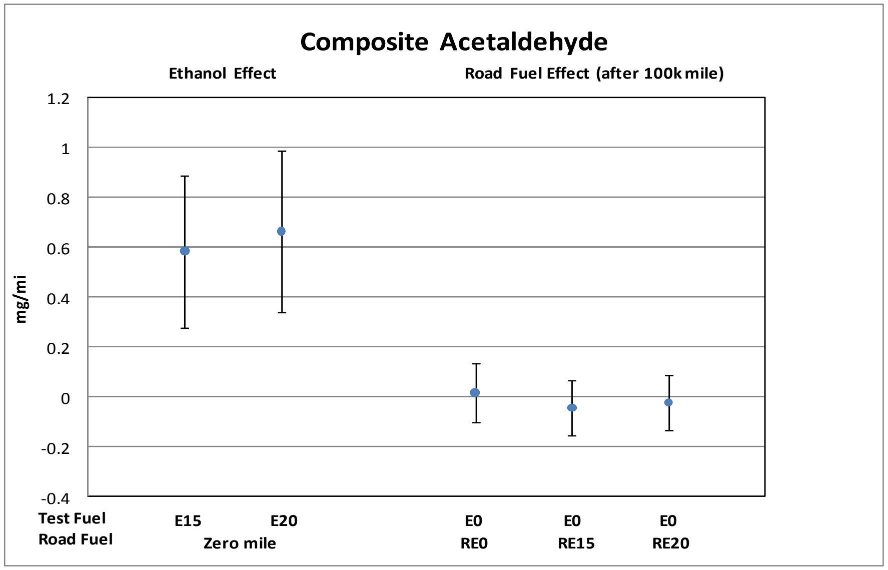
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.73
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.67

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Jeep Liberty (Composite Formaldehyde)

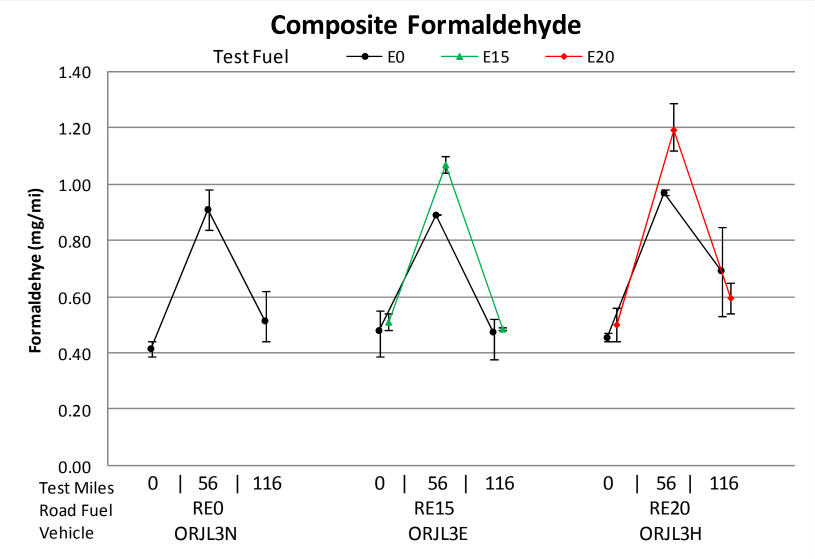
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.061	-0.704	0.827
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.035	-0.700	0.769
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.092	-0.679	0.863
Aging Effect with RE15 (Δmg/mi per 100k mi)	-0.022	-0.703	0.658
Aging Effect with RE20 (Δmg/mi per 100k mi)	0.154	-0.611	0.918

* Indicates estimate is different from zero at the 95% confidence level.

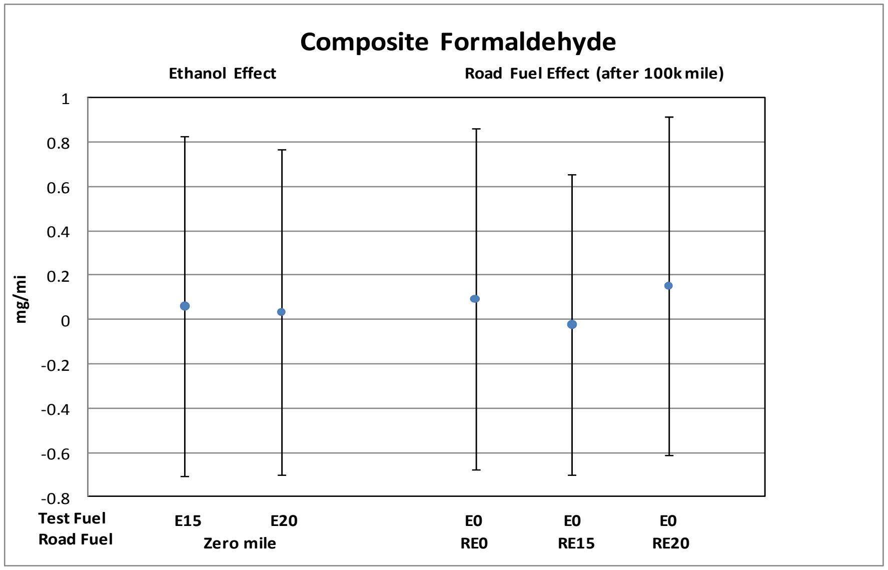
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.96
No Aging Effect with RE0 (Beta0 = 0)	0.79
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.90

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Jeep Liberty (Composite CH_4)

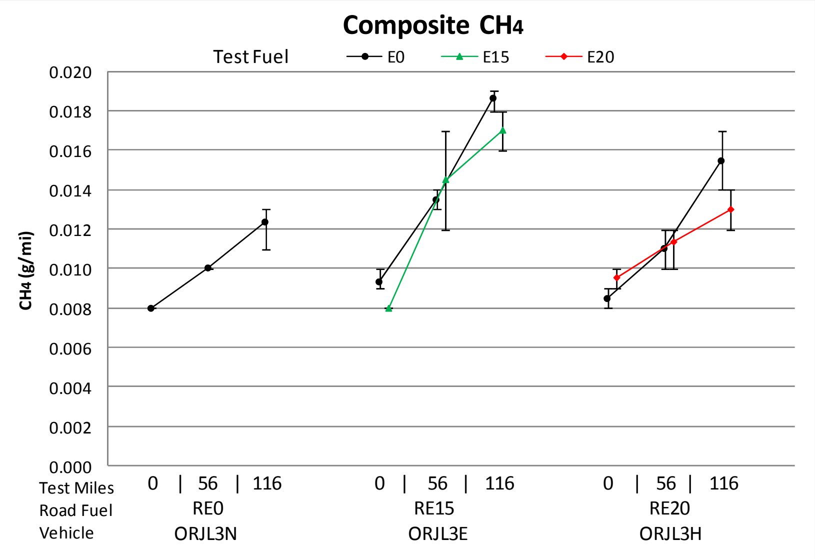
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.0007	-0.0025	0.0012
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.0004	-0.0022	0.0015
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0038*	0.0010	0.0066
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0080*	0.0059	0.0100
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0046*	0.0026	0.0065

* Indicates estimate is different from zero at the 95% confidence level.

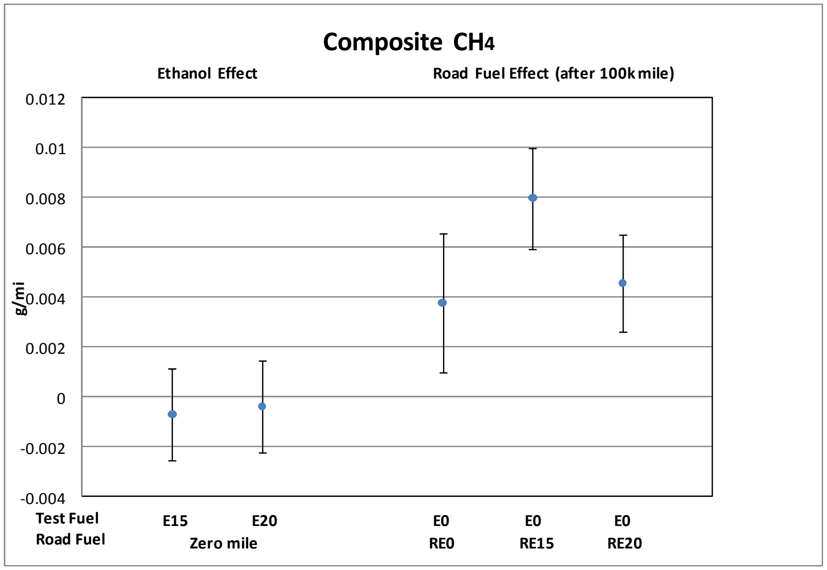
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.60
No Aging Effect with RE0 (Beta0 = 0)	0.02*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.03

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Ford Explorer - Composite Emissions Summary

Emisssion Parameter (units)	Ethanol Effect				Aging Effect with RE0		RExx Aging Effect on E0 Emissions				RExx Aging Effect on Exx Emissions			Road and Test Fuel Effects are Additive
	Δ units vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value	Δ units per 100K mi			Overall p-value
Fuels	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0		RE10/E10	RE15/E15	RE20/E20	
CO (g/mi)	NA	-0.070	-0.167*	0.01*	0.146	0.05	NA	0.082	0.140*	0.60	NA	NA	NA	0.55
NOx (g/mi)	NA	-0.002	-0.003	0.72	0.020*	0.03*	NA	0.018*	0.016*	0.92	NA	NA	NA	0.96
NMHC (g/mi)[a]	NA	-0.005	-0.010*	<0.01*	0.008	0.08	NA	0.005	0.009*	0.65	NA	NA	NA	0.98
NMOG (g/mi)[a]	NA	0.0002	-0.0028	0.60	0.0076	0.09	NA	0.0056	0.0103*	0.53	NA	NA	NA	0.93
Fuel Econ (mi/gal)	NA	-0.900*	-1.117*	<0.01*	0.337	0.32	NA	0.342	0.385	0.99	NA	NA	NA	0.87
Acetaldehyde (mg/mi)[#]	NA	0.613*	0.871*	<0.01*	0.018	0.80	NA	-0.033	-0.034	0.81	NA	NA	NA	0.97
Formaldehyde (mg/mi)[#a]	NA	0.090	0.095	0.09	0.231*	0.03*	NA	0.226*	0.234*	0.98	NA	NA	NA	0.69
CH_4 (g/mi)	NA	0.0010	0.0007	0.75	0.0038	0.14	NA	0.0032	0.0061*	0.49	NA	NA	NA	0.90

Log-normal model was used. Results are presented as changes in emissions at 0k mile.

Data did not support the assumption of linear effects with mileage.

* Indicates estimate is different from zero at the 95% confidence level.

a test "9748" is identified as a outlier and excluded from the analysis

2009 Ford Explorer (Composite CO)

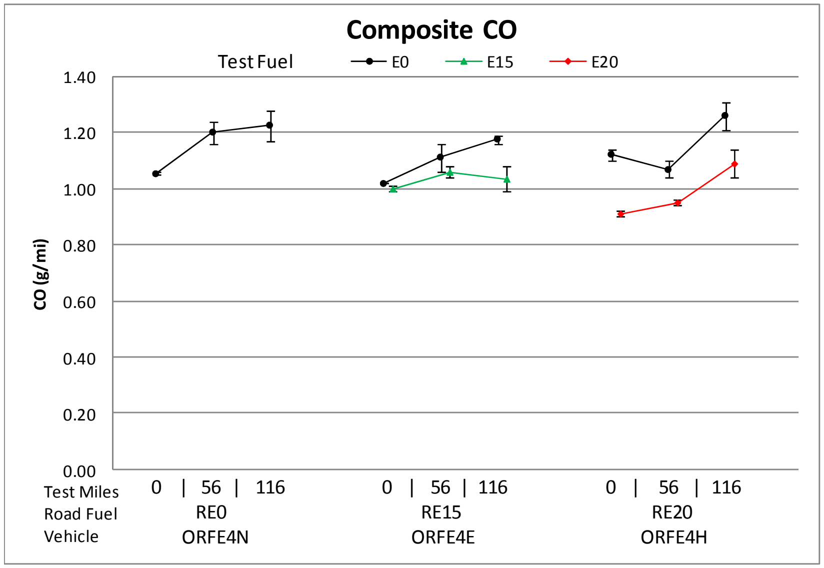
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.070	-0.170	0.030
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.167*	-0.267	-0.067
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.146	-0.004	0.297
Aging Effect with RE15 (Δg/mi per 100k mi)	0.082	-0.024	0.188
Aging Effect with RE20 (Δg/mi per 100k mi)	0.140*	0.034	0.246

* Indicates estimate is different from zero at the 95% confidence level.

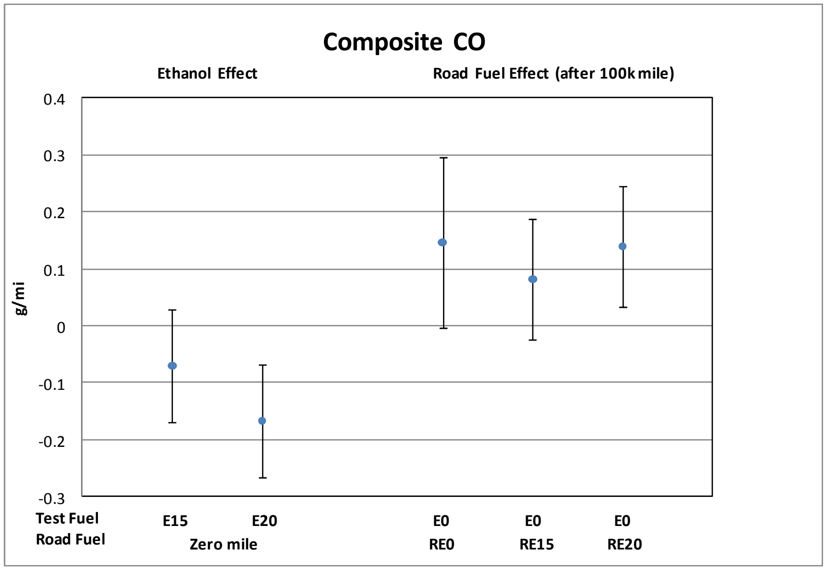
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.05
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.60

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Ford Explorer (Composite NOx)

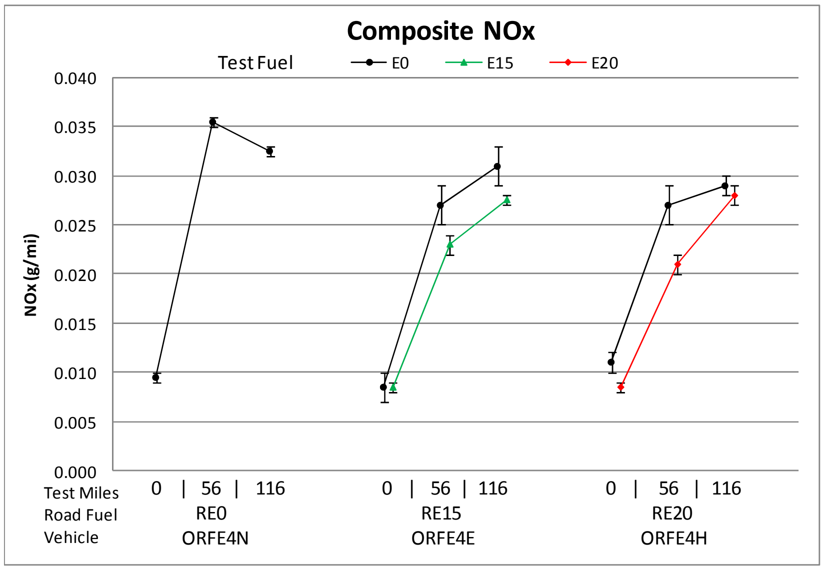
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.002	-0.014	0.009
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.003	-0.015	0.008
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.020*	0.002	0.037
Aging Effect with RE15 (Δg/mi per 100k mi)	0.018*	0.006	0.030
Aging Effect with RE20 (Δg/mi per 100k mi)	0.016*	0.004	0.028

* Indicates estimate is different from zero at the 95% confidence level.

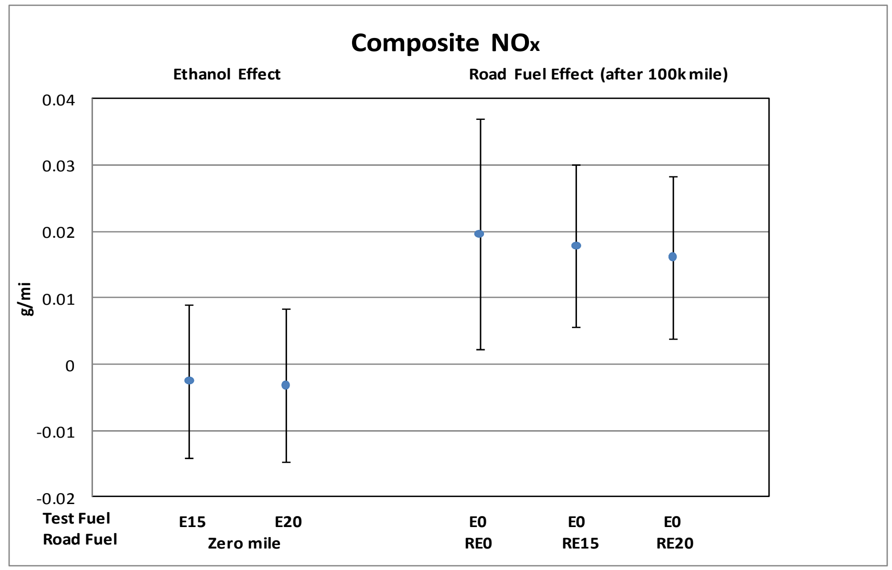
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.72
No Aging Effect with RE0 (Beta0 = 0)	0.03*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.92

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Ford Explorer (Composite Nonmethane Hydrocarbons)

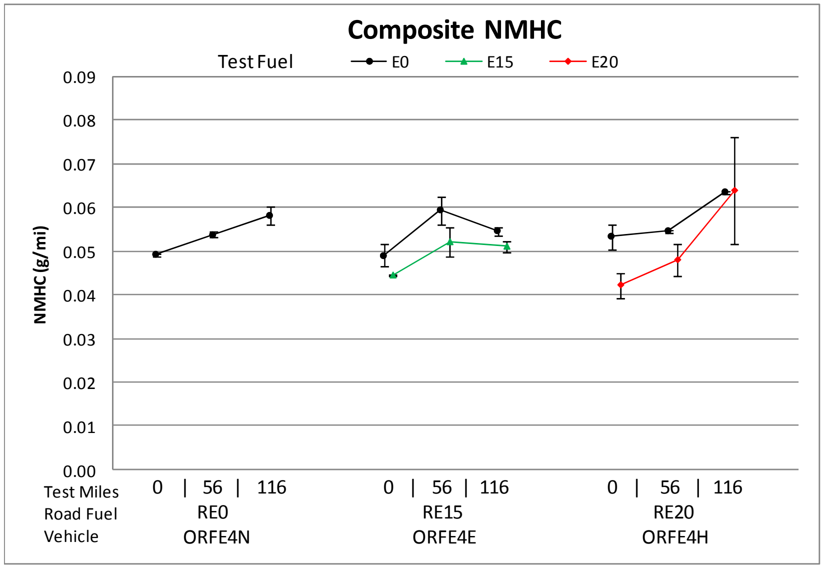
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.005	-0.011	0.001
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.010*	-0.016	-0.004
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.008	-0.001	0.017
Aging Effect with RE15 (Δg/mi per 100k mi)	0.005	-0.001	0.011
Aging Effect with RE20 (Δg/mi per 100k mi)	0.009*	0.002	0.015

* Indicates estimate is different from zero at the 95% confidence level.

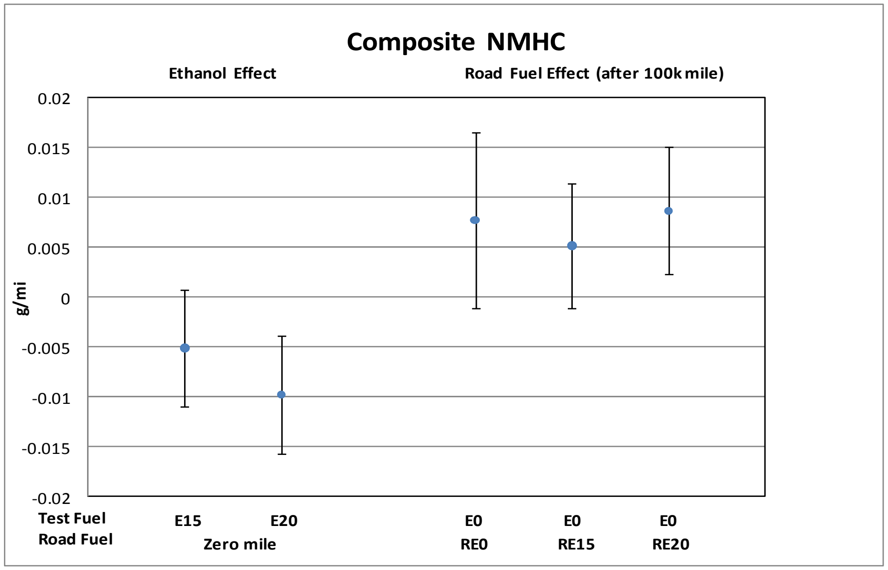
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.08
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.65

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Ford Explorer (Composite Nonmethane Organic Gases)

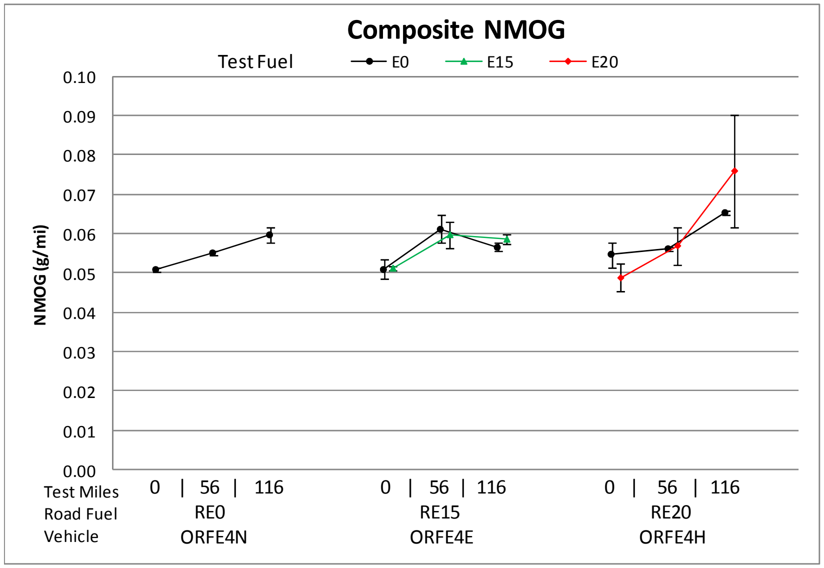
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0002	-0.0059	0.0063
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.0028	-0.0090	0.0034
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0076	-0.0016	0.0168
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0056	-0.0009	0.0121
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0103*	0.0036	0.0170

* Indicates estimate is different from zero at the 95% confidence level.

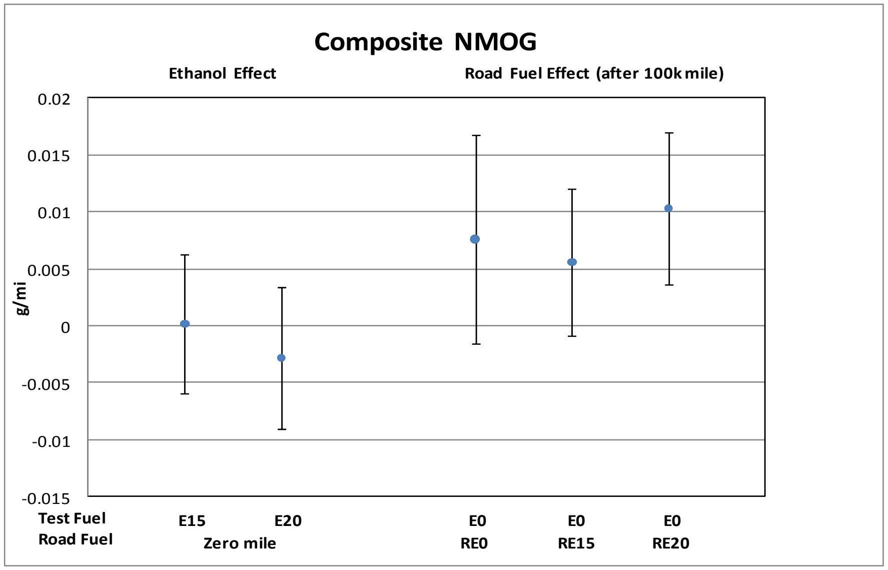
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.60
No Aging Effect with RE0 (Beta0 = 0)	0.09
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.53

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Ford Explorer (Composite Fuel Economy)

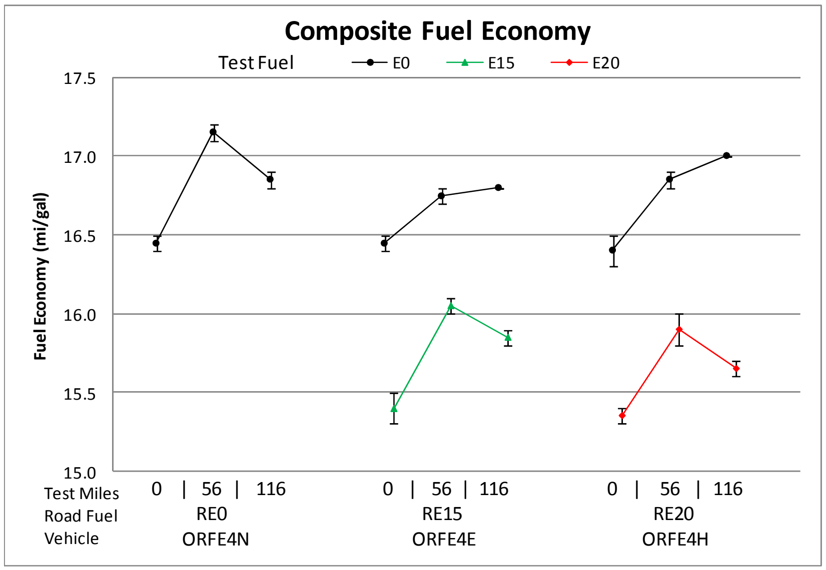
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmi/gal)	-0.900*	-1.394	-0.406
Ethanol Effect (E20 vs. E0) (Δmi/gal)	-1.117*	-1.611	-0.623
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmi/gal per 100k mi)	0.337	-0.405	1.079
Aging Effect with RE15 (Δmi/gal per 100k mi)	0.342	-0.183	0.866
Aging Effect with RE20 (Δmi/gal per 100k mi)	0.385	-0.140	0.910

* Indicates estimate is different from zero at the 95% confidence level.

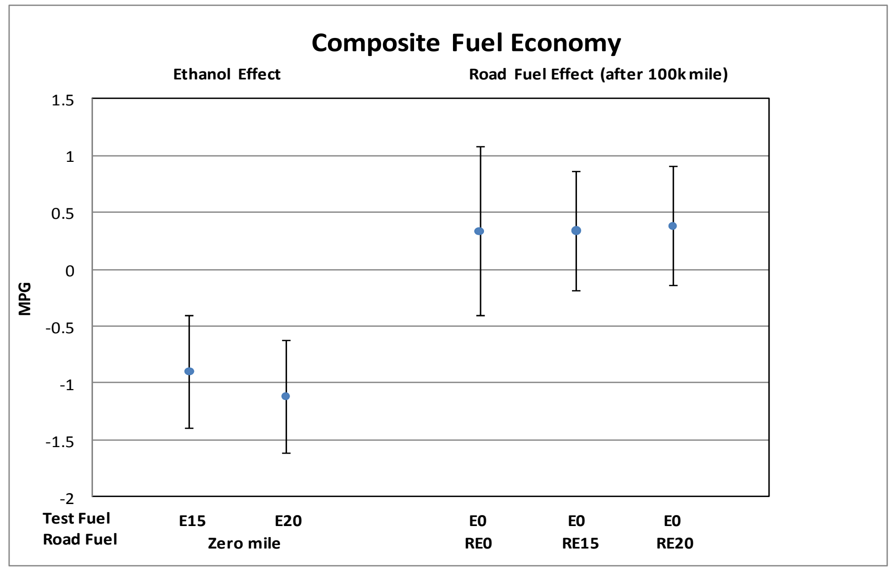
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.32
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.99

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Ford Explorer (Composite Acetaldehyde)

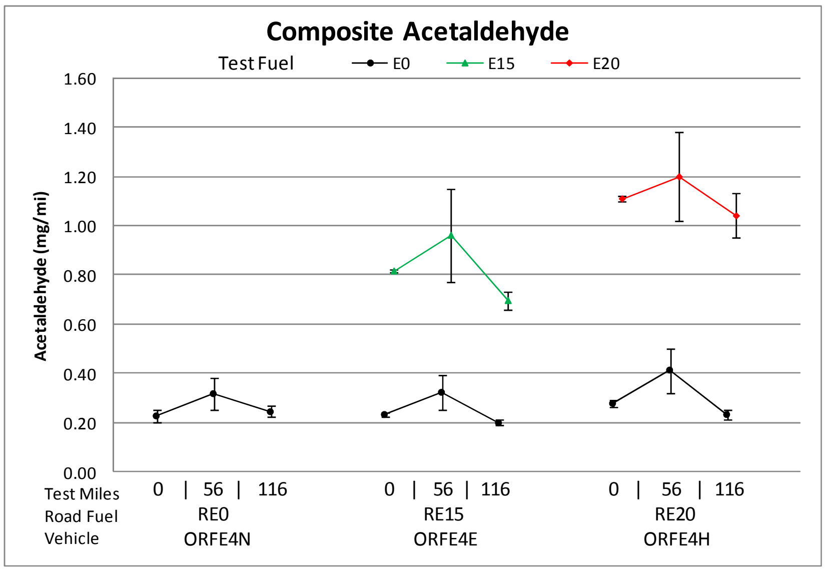
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.613*	0.255	0.971
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.871*	0.391	1.350
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.018	-0.139	0.174
Aging Effect with RE15 (Δmg/mi per 100k mi)	-0.033	-0.164	0.098
Aging Effect with RE20 (Δmg/mi per 100k mi)	-0.034	-0.191	0.124

* Indicates estimate is different from zero at the 95% confidence level.

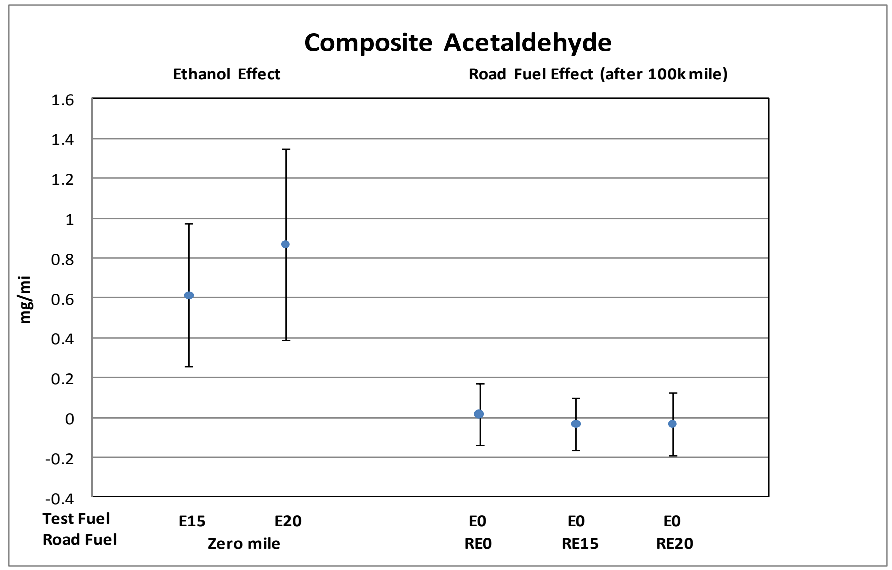
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.80
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.81

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Ford Explorer (Composite Formaldehyde)

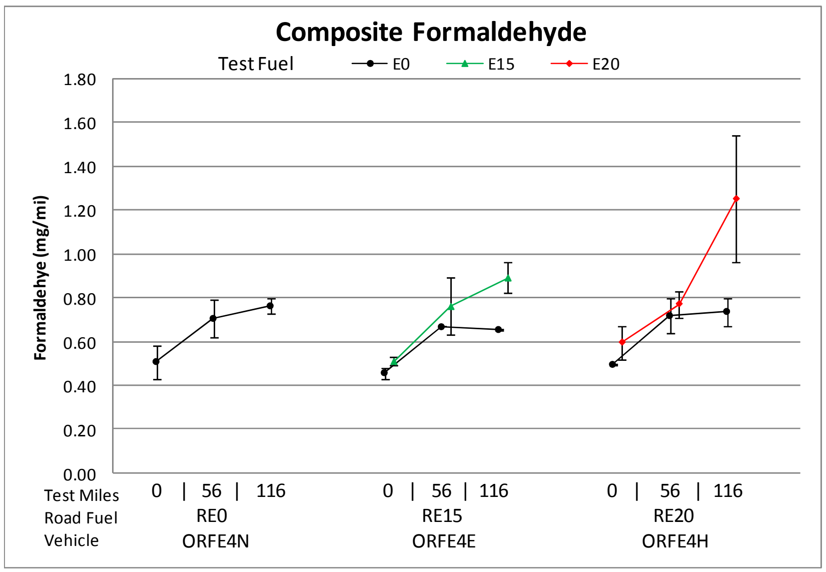
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.090	-0.055	0.235
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.095	-0.066	0.257
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.231*	0.033	0.430
Aging Effect with RE15 (Δmg/mi per 100k mi)	0.226*	0.071	0.382
Aging Effect with RE20 (Δmg/mi per 100k mi)	0.234*	0.062	0.406

* Indicates estimate is different from zero at the 95% confidence level.

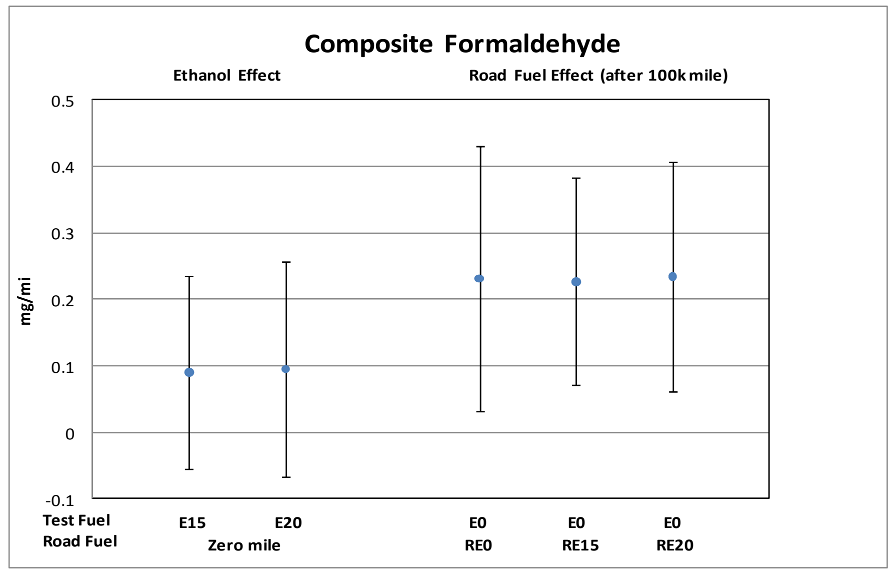
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.09
No Aging Effect with RE0 (Beta0 = 0)	0.03*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.98

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Ford Explorer (Composite CH_4)

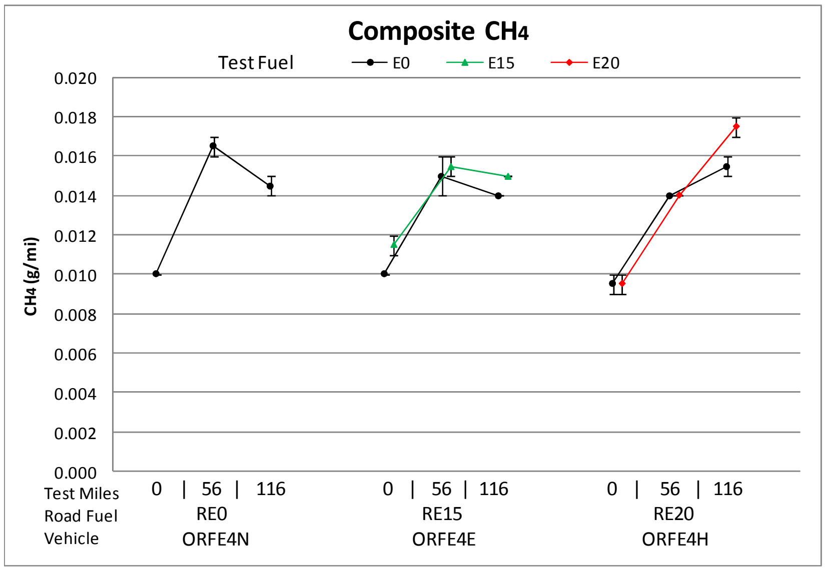
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0010	-0.0027	0.0047
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.0007	-0.0030	0.0043
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0038	-0.0017	0.0093
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0032	-0.0007	0.0071
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0061*	0.0022	0.0100

* Indicates estimate is different from zero at the 95% confidence level.

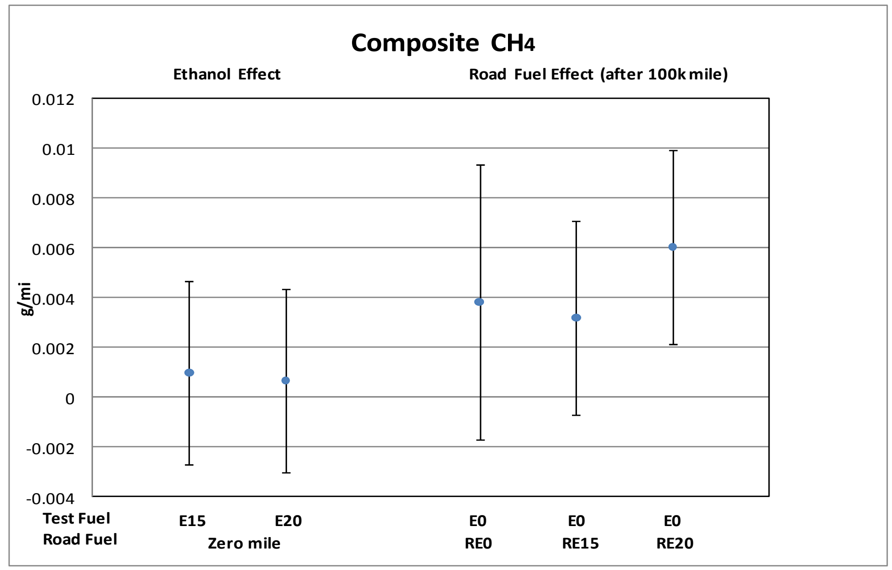
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.75
No Aging Effect with RE0 (Beta0 = 0)	0.14
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.49

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Honda Civic - Composite Emissions Summary

Emisssion Parameter (units)	Ethanol Effect				Aging Effect with RE0		RExx Aging Effect on E0 Emissions				RExx Aging Effect on Exx Emissions			Road and Test Fuel Effects are Additive
	Δ units vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value	Δ units per 100K mi			Overall p-value
Fuels	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0		RE10/E10	RE15/E15	RE20/E20	
CO (g/mi)	NA	-0.122*	-0.038	<0.01*	0.044	0.24	NA	0.097*	0.032	0.21	NA	NA	NA	0.54
NOx (g/mi)	NA	0.011*	0.008*	0.02*	0.017*	0.01*	NA	0.013*	0.015*	0.79	NA	NA	NA	0.68
NMHC (g/mi)	NA	-0.011*	-0.011*	<0.01*	0.011*	0.04*	NA	0.011*	0.007	0.57	NA	NA	NA	0.10
NMOG (g/mi)	NA	-0.009*	-0.008*	0.02*	0.012*	0.04*	NA	0.012*	0.007	0.54	NA	NA	NA	0.13
Fuel Econ (mi/gal)	NA	-1.633*	-2.200*	<0.01*	0.388	0.36	NA	-0.095	0.037	0.63	NA	NA	NA	0.60
Acetaldehyde (mg/mi)#	NA	0.239*	0.468*	<0.01*	0.077	0.12	NA	0.063	0.020	0.51	NA	NA	NA	0.89
Formaldehyde (mg/mi)#	NA	0.091	0.049	0.69	0.263	0.24	NA	0.197	0.241	0.96	NA	NA	NA	0.86
CH_4 (g/mi)	NA	0.0000	0.0007	0.67	0.0030*	0.03*	NA	0.0026*	0.0024*	0.90	NA	NA	NA	0.87

Log-normal model was used. Results are presented as changes in emissions at 0k mile.

Data did not support the assumption of linear effects with mileage.

* Indicates estimate is different from zero at the 95% confidence level.

2009 Honda Civic (Composite CO)

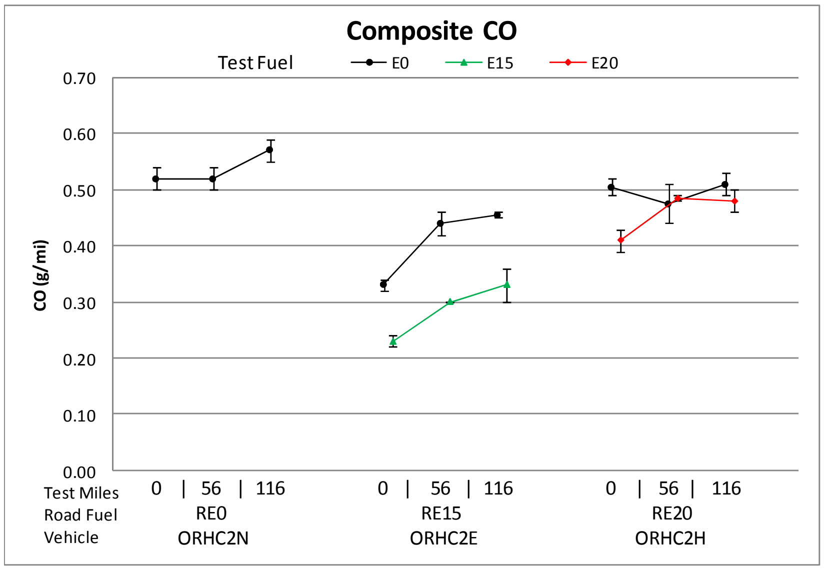
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.122*	-0.1748	-0.0685
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.038	-0.0915	0.0148
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.044	-0.0360	0.1236
Aging Effect with RE15 (Δg/mi per 100k mi)	0.097*	0.0405	0.1534
Aging Effect with RE20 (Δg/mi per 100k mi)	0.032	-0.0240	0.0888

* Indicates estimate is different from zero at the 95% confidence level.

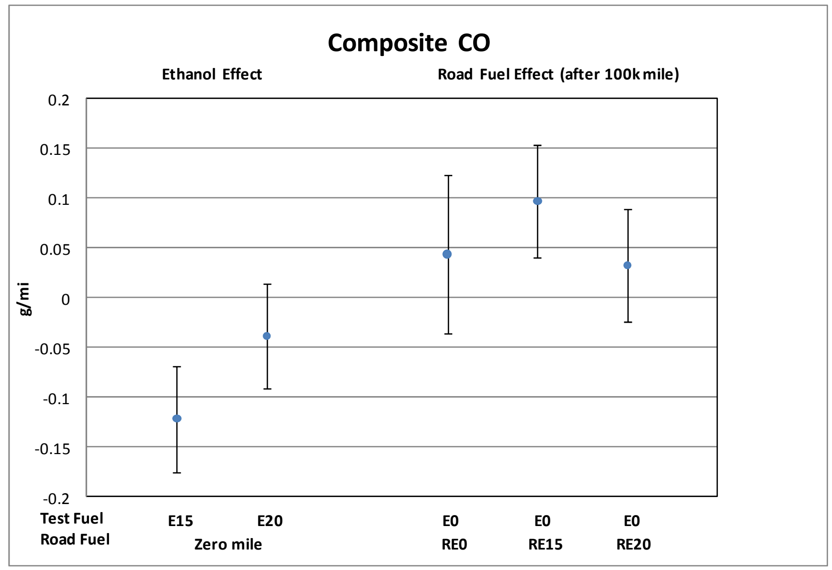
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.24
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.21

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Honda Civic (Composite NOx)

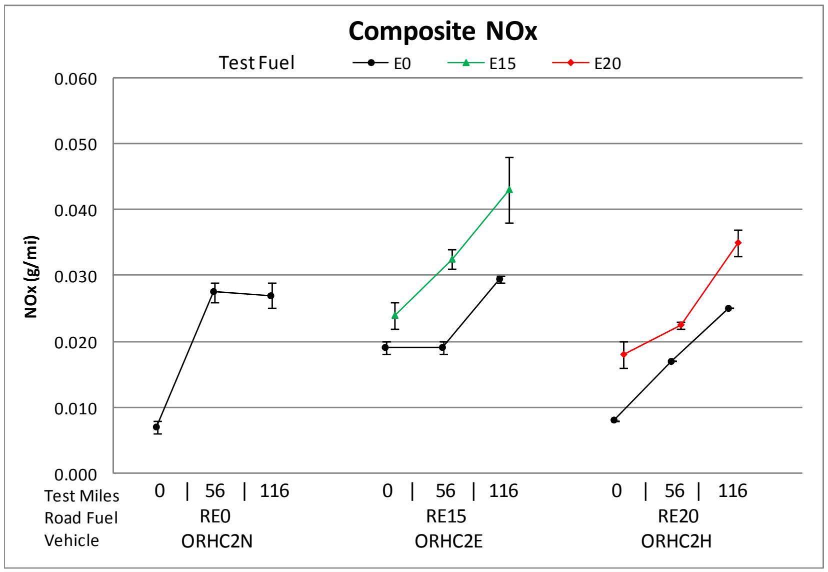
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.011*	0.0026	0.0188
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.008*	0.0004	0.0166
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.017*	0.0050	0.0293
Aging Effect with RE15 (Δg/mi per 100k mi)	0.013*	0.0042	0.0214
Aging Effect with RE20 (Δg/mi per 100k mi)	0.015*	0.0062	0.0234

* Indicates estimate is different from zero at the 95% confidence level.

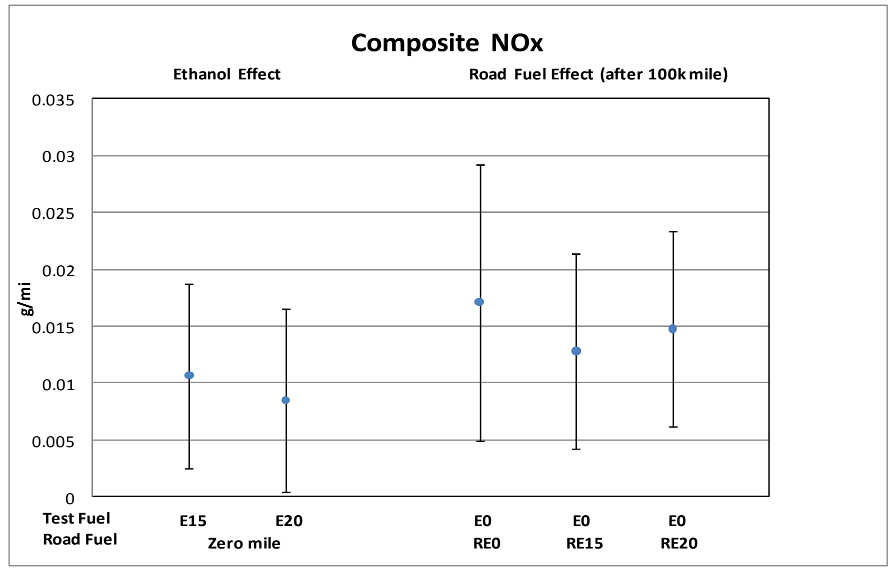
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.02*
No Aging Effect with RE0 (Beta0 = 0)	0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.79

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Honda Civic (Composite Nonmethane Hydrocarbons)

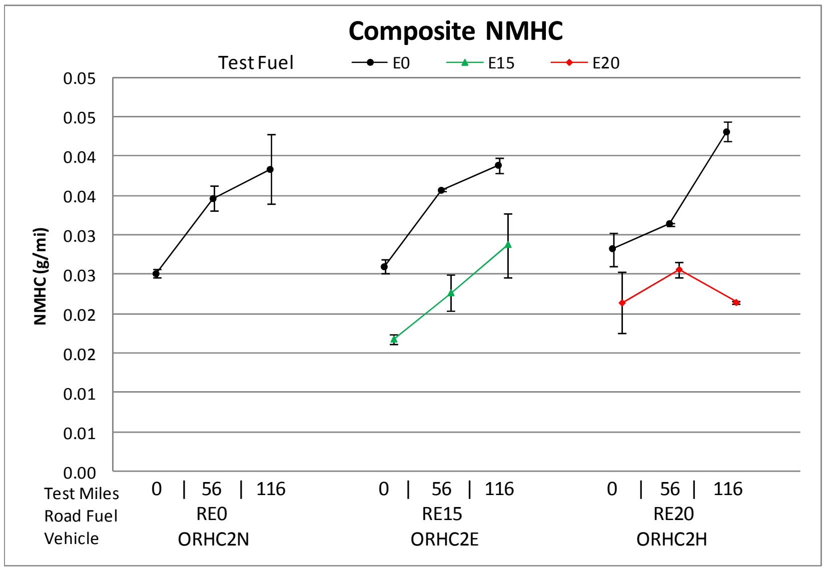
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.011*	-0.0179	-0.0038
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.011*	-0.0185	-0.0043
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.011*	0.0008	0.0220
Aging Effect with RE15 (Δg/mi per 100k mi)	0.011*	0.0032	0.0183
Aging Effect with RE20 (Δg/mi per 100k mi)	0.007	-0.0010	0.0140

* Indicates estimate is different from zero at the 95% confidence level.

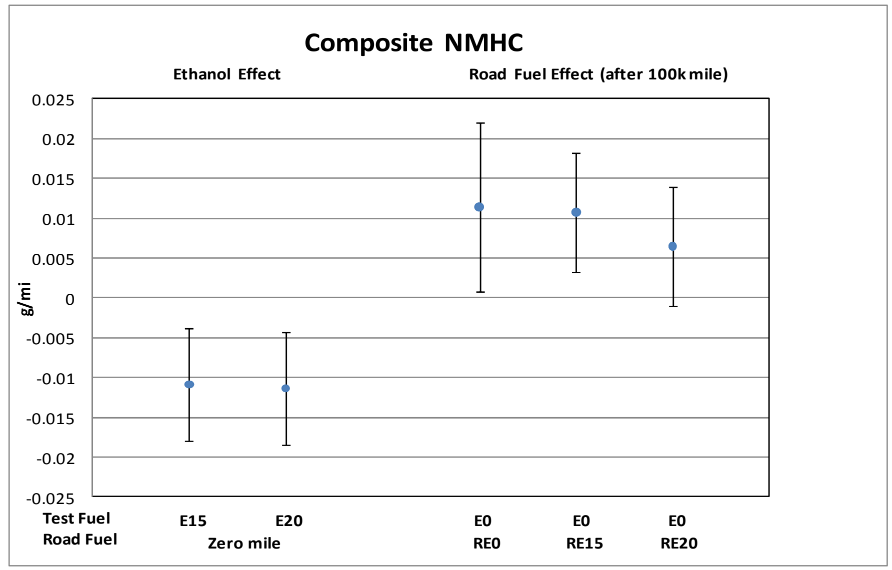
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.04*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.57

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Honda Civic (Composite Nonmethane Organic Gases)

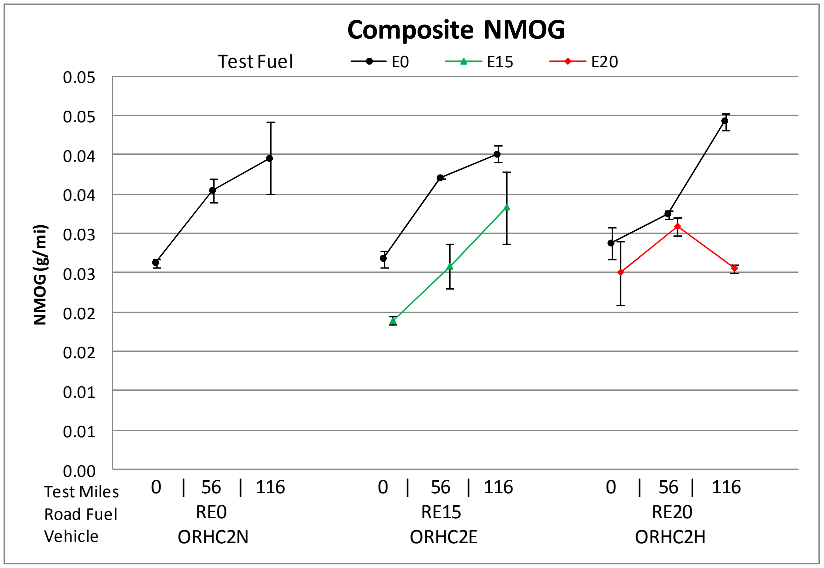
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.009*	-0.0161	-0.0012
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.008*	-0.0154	-0.0006
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.012*	0.0004	0.0227
Aging Effect with RE15 (Δg/mi per 100k mi)	0.012*	0.0041	0.0199
Aging Effect with RE20 (Δg/mi per 100k mi)	0.007	-0.0010	0.0148

* Indicates estimate is different from zero at the 95% confidence level.

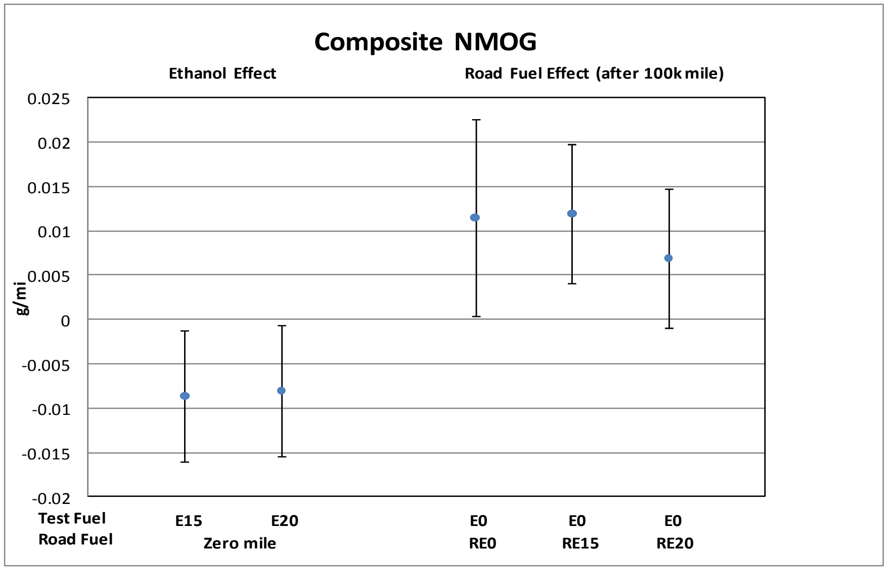
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.02*
No Aging Effect with RE0 (Beta0 = 0)	0.04*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.54

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Honda Civic (Composite Fuel Economy)

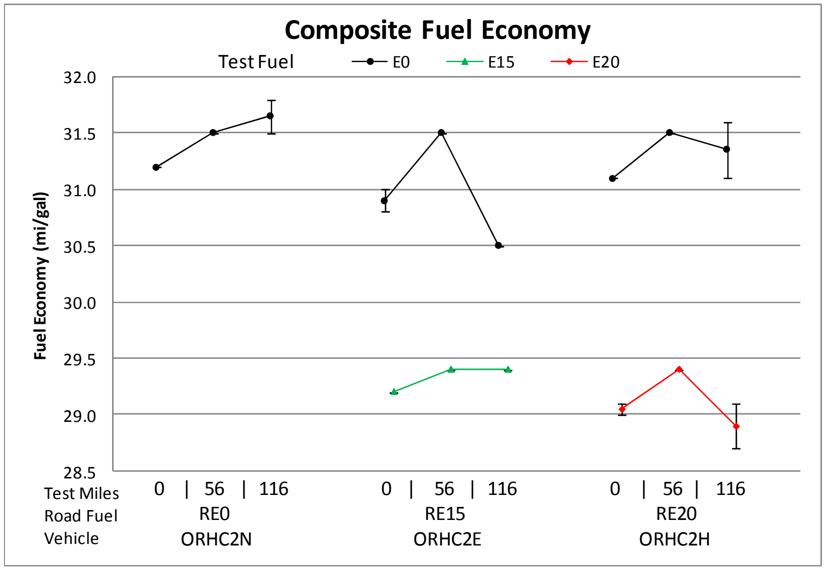
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmi/gal)	-1.633*	-2.260	-1.007
Ethanol Effect (E20 vs. E0) (Δmi/gal)	-2.200*	-2.827	-1.573
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmi/gal per 100k mi)	0.388	-0.552	1.329
Aging Effect with RE15 (Δmi/gal per 100k mi)	-0.095	-0.760	0.570
Aging Effect with RE20 (Δmi/gal per 100k mi)	0.037	-0.628	0.702

* Indicates estimate is different from zero at the 95% confidence level.

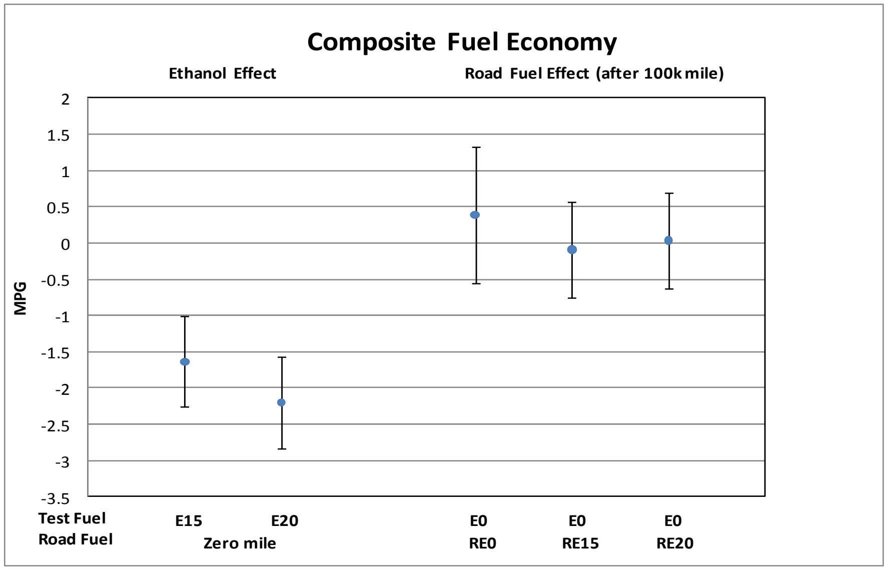
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.36
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.63

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Honda Civic (Composite Acetaldehyde)

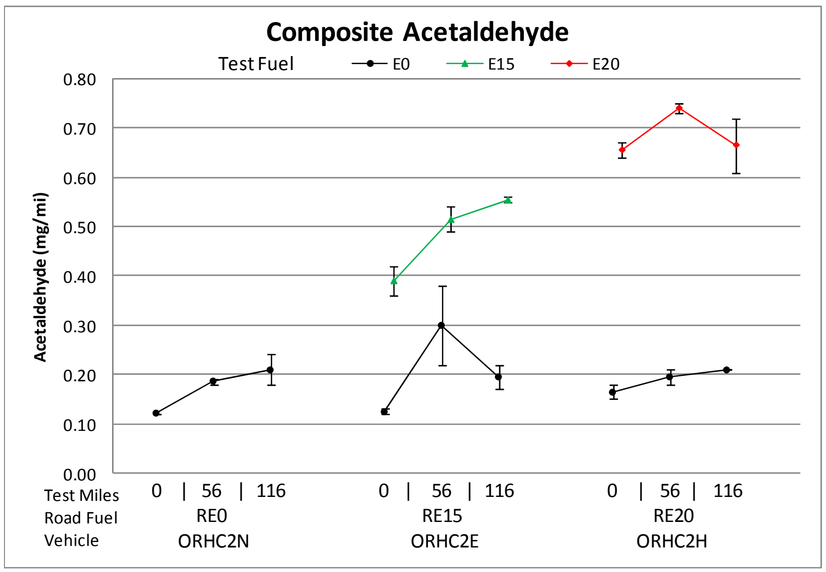
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.239*	0.0753	0.4022
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.468*	0.2091	0.7260
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.077	-0.0222	0.1759
Aging Effect with RE15 (Δmg/mi per 100k mi)	0.063	-0.0341	0.1606
Aging Effect with RE20 (Δmg/mi per 100k mi)	0.020	-0.0791	0.1187

* Indicates estimate is different from zero at the 95% confidence level.

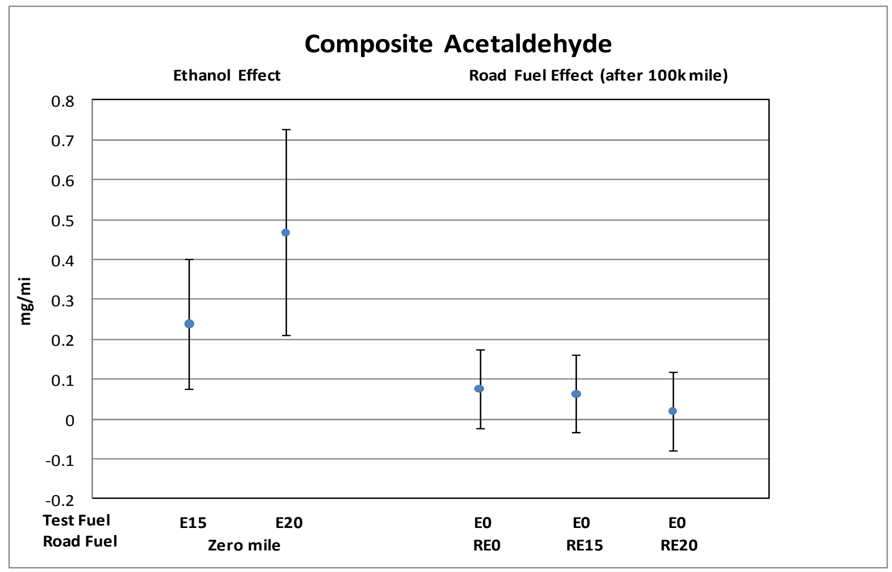
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.12
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.51

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Honda Civic (Composite Formaldehyde)

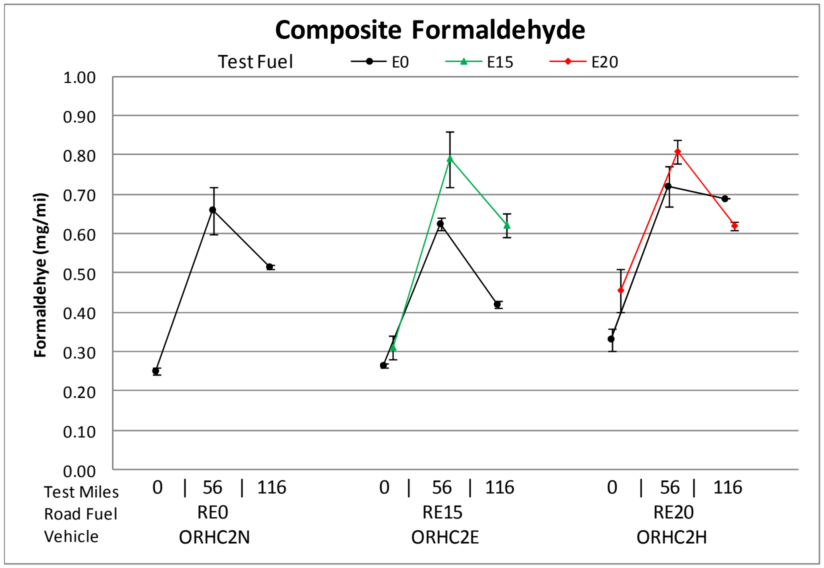
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.091	-0.2651	0.4474
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.049	-0.3949	0.4932
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.263	-0.2234	0.7488
Aging Effect with RE15 (Δmg/mi per 100k mi)	0.197	-0.1914	0.5850
Aging Effect with RE20 (Δmg/mi per 100k mi)	0.241	-0.2755	0.7572

* Indicates estimate is different from zero at the 95% confidence level.

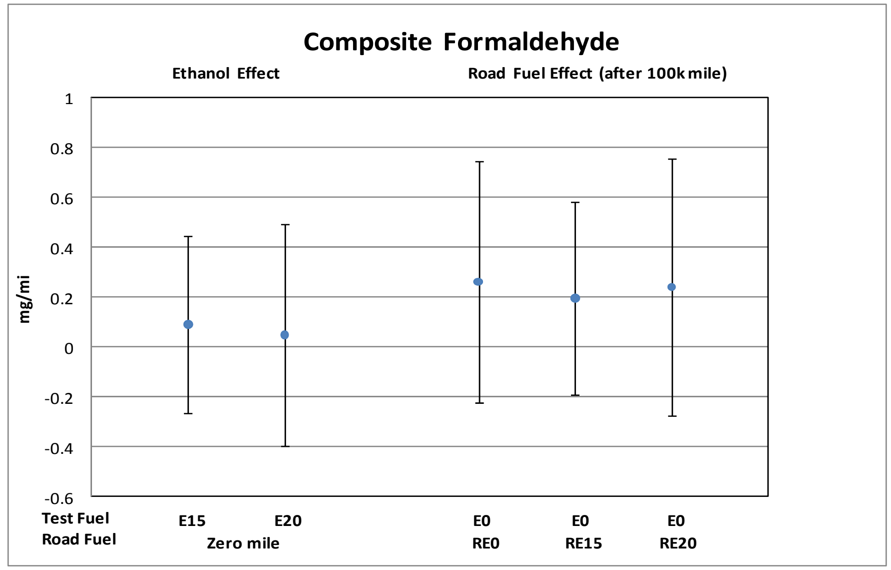
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.69
No Aging Effect with RE0 (Beta0 = 0)	0.24
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.96

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Honda Civic (Composite CH_4)

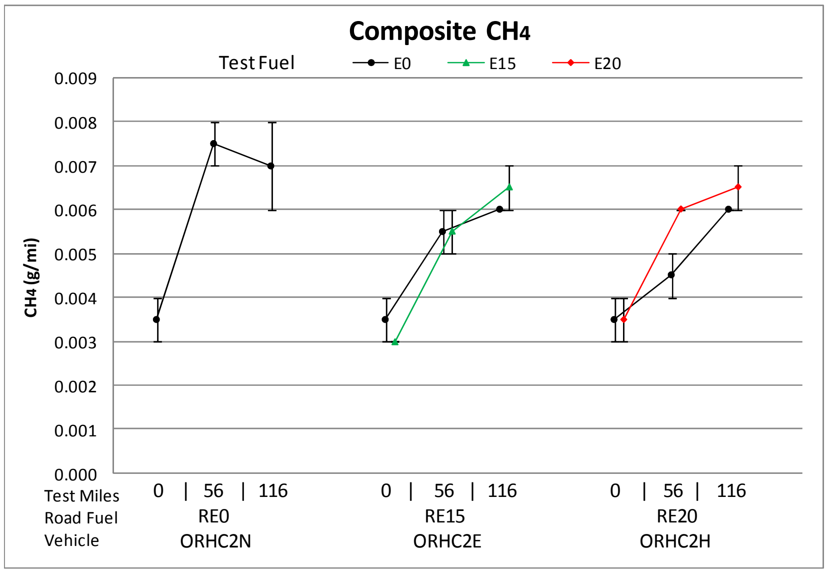
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0000	-0.0017	0.0017
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.0007	-0.0010	0.0024
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0030*	0.0004	0.0055
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0026*	0.0008	0.0044
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0024*	0.0006	0.0042

* Indicates estimate is different from zero at the 95% confidence level.

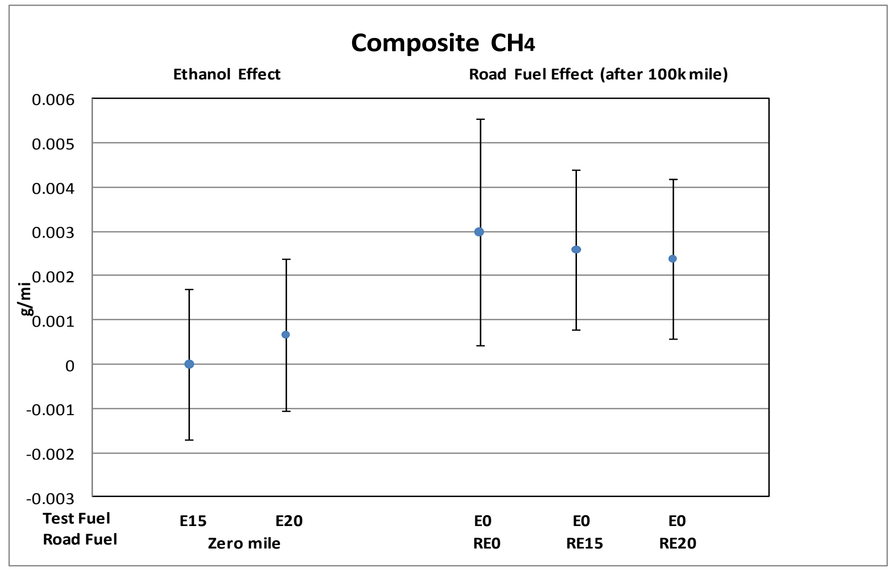
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.67
No Aging Effect with RE0 (Beta0 = 0)	0.03*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.90

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Toyota Corolla - Composite Emissions Summary

Emisssion Parameter (units)	Ethanol Effect				Aging Effect with RE0		RExx Aging Effect on E0 Emissions				RExx Aging Effect on Exx Emissions			Road and Test Fuel Effects are Additive
	Δ units vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value	Δ units per 100K mi			Overall p-value
Fuels	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0		RE10/E10	RE15/E15	RE20/E20	
CO (g/mi)	NA	-0.033	-0.087	0.56	0.106	0.42	NA	0.217*	0.204	0.76	NA	NA	NA	0.85
NOx (g/mi)	NA	-0.003	0.003	0.64	0.034*	<0.01*	NA	0.027*	0.018*	0.17	NA	NA	NA	0.81
NMHC (g/mi)[a]	NA	-0.0018	-0.0057	0.59	0.0115	0.21	NA	0.0153*	0.0137	0.93	NA	NA	NA	0.90
NMOG (g/mi)[a]	NA	0.003	0.000	0.90	0.012	0.24	NA	0.017*	0.015*	0.90	NA	NA	NA	0.95
Fuel Econ (mi/gal)	NA	-1.533*	-2.333*	<0.01*	0.957	0.11	NA	0.948*	1.224*	0.85	NA	NA	NA	0.87
Acetaldehyde (mg/mi)[#]	NA	0.511*	0.556*	<0.01*	0.073	0.34	NA	0.060	0.062	0.97	NA	NA	NA	0.91
Formaldehyde (mg/mi)[#]	NA	0.101	0.094	0.74	0.181	0.56	NA	0.086	0.050	0.94	NA	NA	NA	0.96
CH_4 (g/mi)	NA	0.0008	0.0010	0.34	0.0047*	<0.01*	NA	0.0058*	0.0074*	0.25	NA	NA	NA	0.55

Log-normal model was used. Results are presented as changes in emissions at 0k mile.

Data did not support the assumption of linear effects with mileage.

* Indicates estimate is different from zero at the 95% confidence level.

a test "9474" is identified as an outlier and excluded from the analysis

2009 Toyota Corolla (Composite CO)

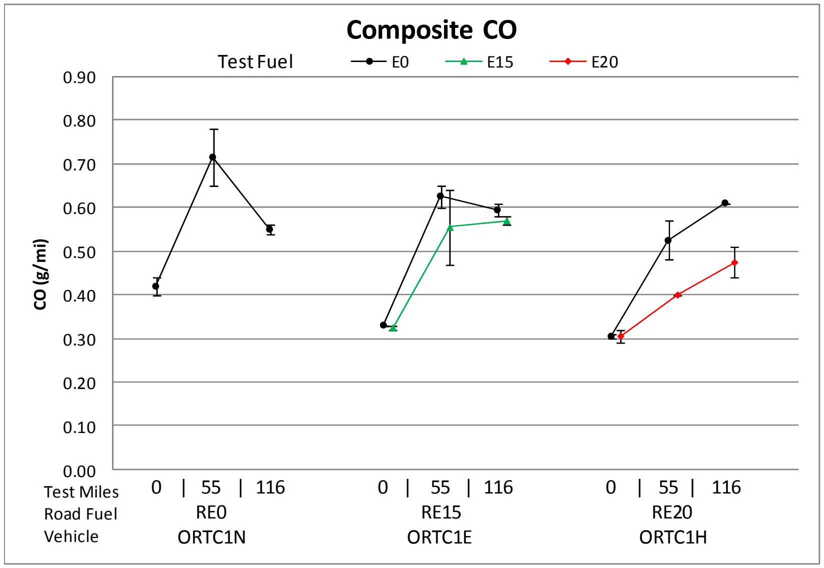
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.033	-0.230	0.163
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.087	-0.283	0.110
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.106	-0.189	0.400
Aging Effect with RE15 (Δg/mi per 100k mi)	0.217*	0.009	0.425
Aging Effect with RE20 (Δg/mi per 100k mi)	0.204	-0.004	0.413

* Indicates estimate is different from zero at the 95% confidence level.

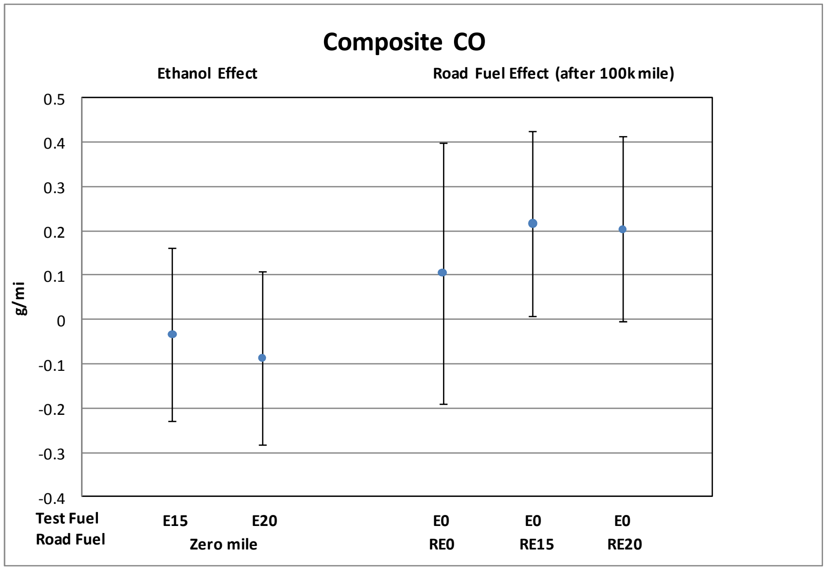
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.56
No Aging Effect with RE0 (Beta0 = 0)	0.42
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.76

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Toyota Corolla (Composite NOx)

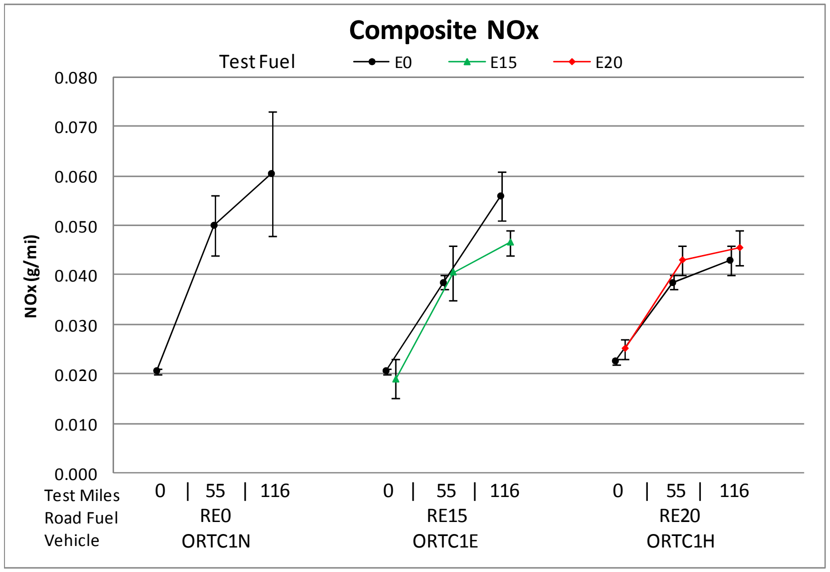
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.003	-0.014	0.008
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.003	-0.007	0.014
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.034*	0.018	0.050
Aging Effect with RE15 (Δg/mi per 100k mi)	0.027*	0.016	0.038
Aging Effect with RE20 (Δg/mi per 100k mi)	0.018*	0.006	0.029

* Indicates estimate is different from zero at the 95% confidence level.

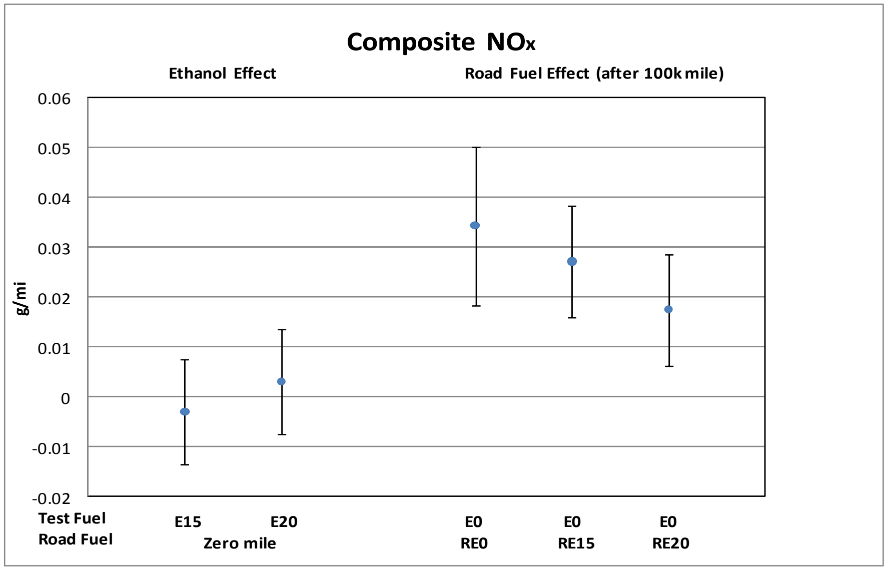
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.64
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.17

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Toyota Corolla (Composite Nonmethane Hydrocarbons)

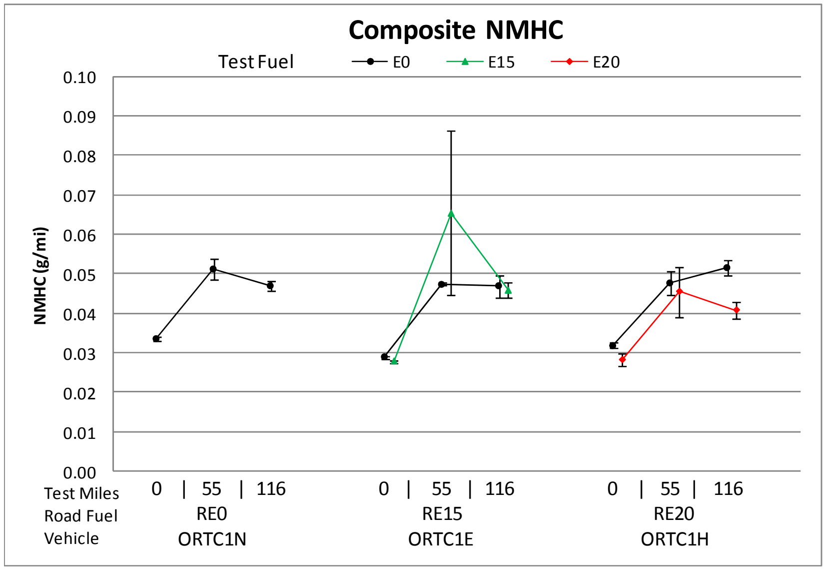
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.0018	-0.0150	0.0114
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.0057	-0.0188	0.0075
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0115	-0.0082	0.0312
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0153*	0.0014	0.0293
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0137	-0.0002	0.0277

* Indicates estimate is different from zero at the 95% confidence level.

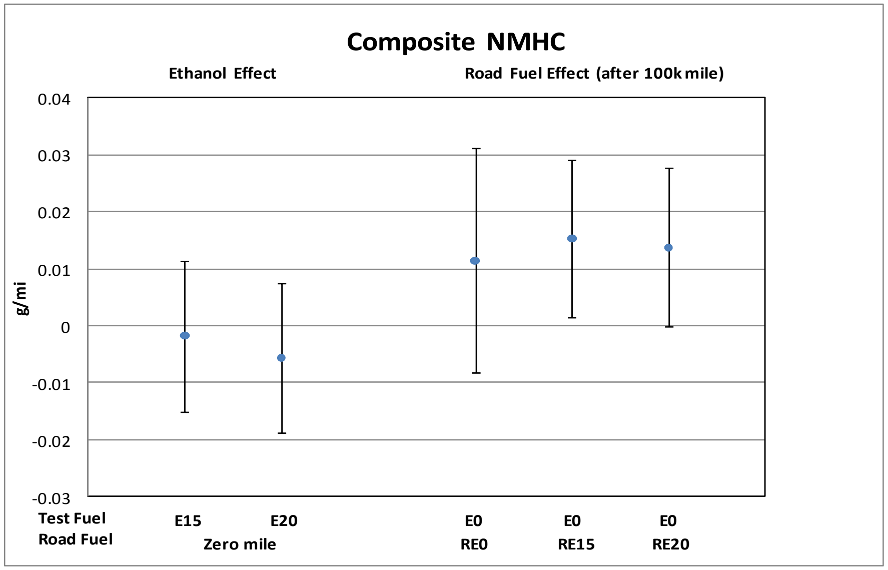
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.59
No Aging Effect with RE0 (Beta0 = 0)	0.21
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.93

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Toyota Corolla (Composite Nonmethane Organic Gases)

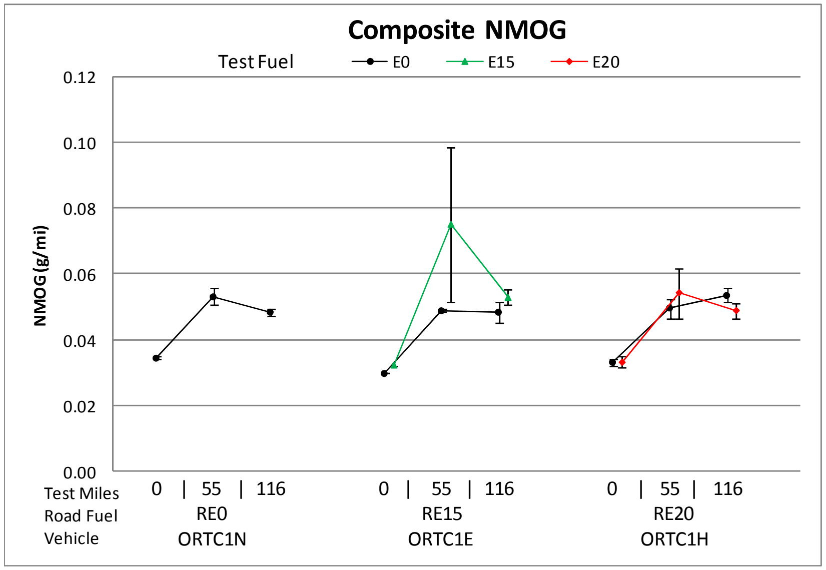
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.003	-0.012	0.017
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.000	-0.014	0.014
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.012	-0.010	0.033
Aging Effect with RE15 (Δg/mi per 100k mi)	0.017*	0.002	0.032
Aging Effect with RE20 (Δg/mi per 100k mi)	0.015*	0.000	0.031

* Indicates estimate is different from zero at the 95% confidence level.

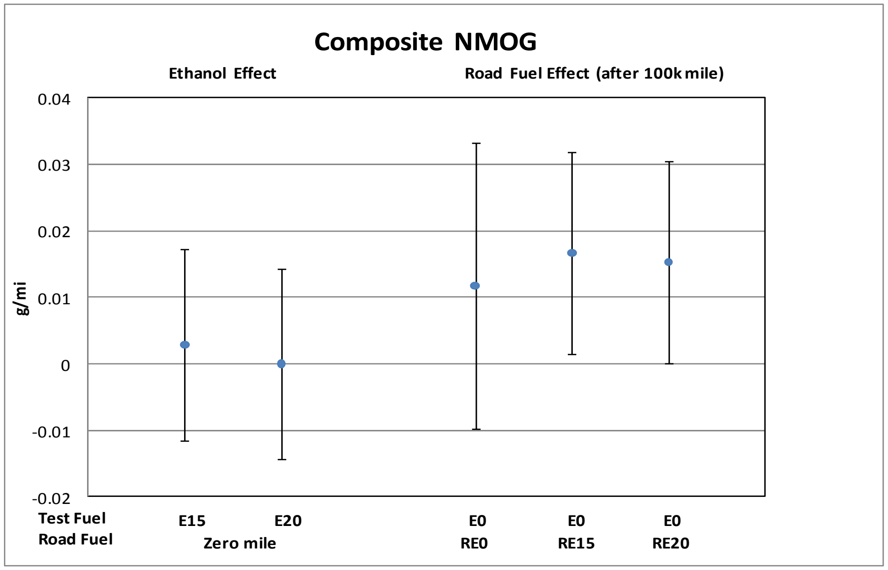
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.90
No Aging Effect with RE0 (Beta0 = 0)	0.24
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.90

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Toyota Corolla (Composite Fuel Economy)

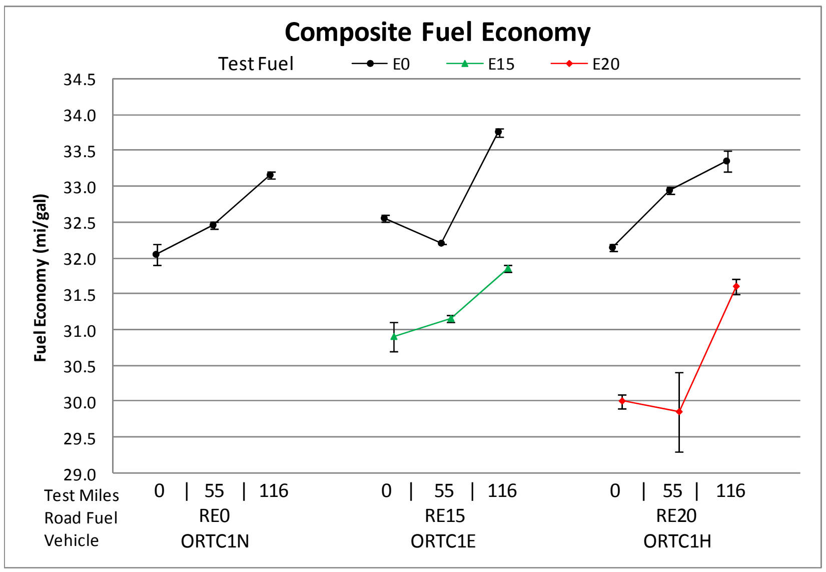
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmi/gal)	-1.533*	-2.351	-0.716
Ethanol Effect (E20 vs. E0) (Δmi/gal)	-2.333*	-3.150	-1.515
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmi/gal per 100k mi)	0.957	-0.270	2.184
Aging Effect with RE15 (Δmi/gal per 100k mi)	0.948*	0.081	1.816
Aging Effect with RE20 (Δmi/gal per 100k mi)	1.224*	0.357	2.090

* Indicates estimate is different from zero at the 95% confidence level.

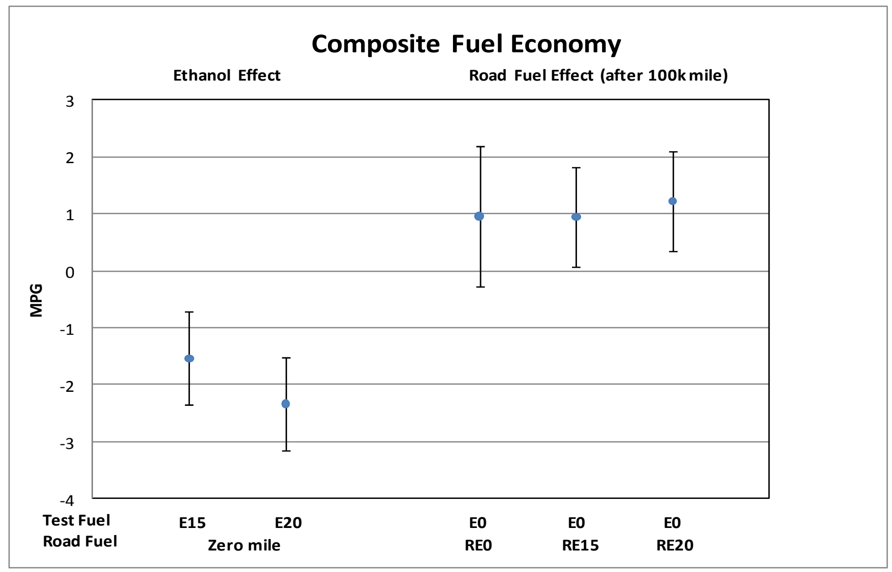
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.11
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.85

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Toyota Corolla (Composite Acetaldehyde)

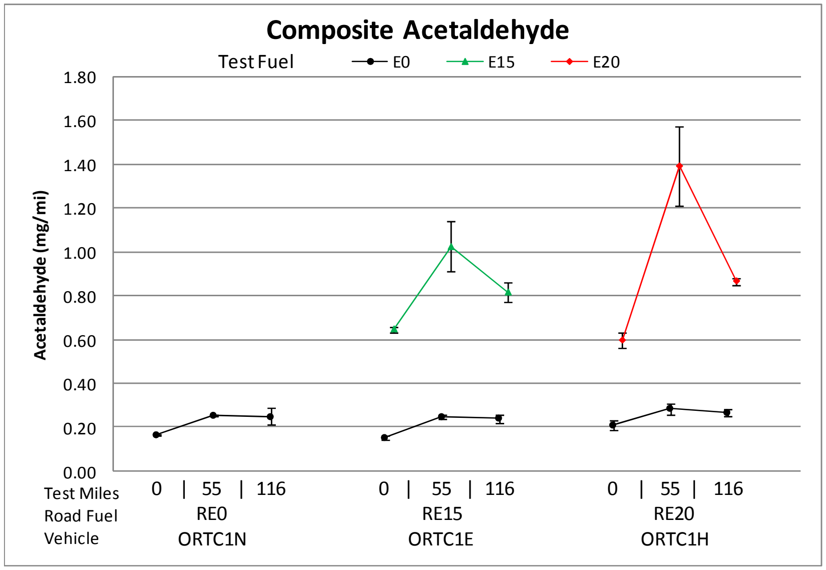
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.511*	0.167	0.854
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.556*	0.167	0.945
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.073	-0.091	0.237
Aging Effect with RE15 (Δmg/mi per 100k mi)	0.060	-0.074	0.195
Aging Effect with RE20 (Δmg/mi per 100k mi)	0.062	-0.100	0.224

* Indicates estimate is different from zero at the 95% confidence level.

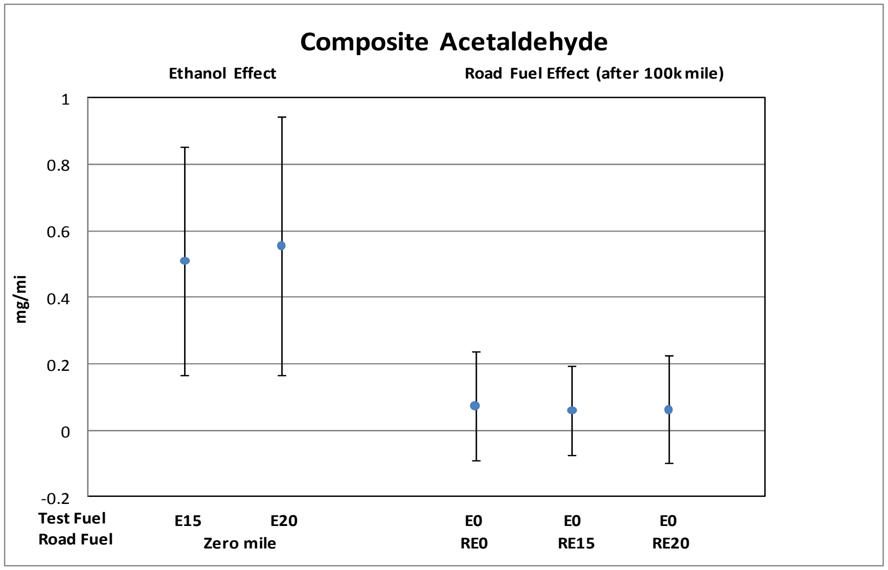
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.34
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.97

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

E-107

2009 Toyota Corolla (Composite Formaldehyde)

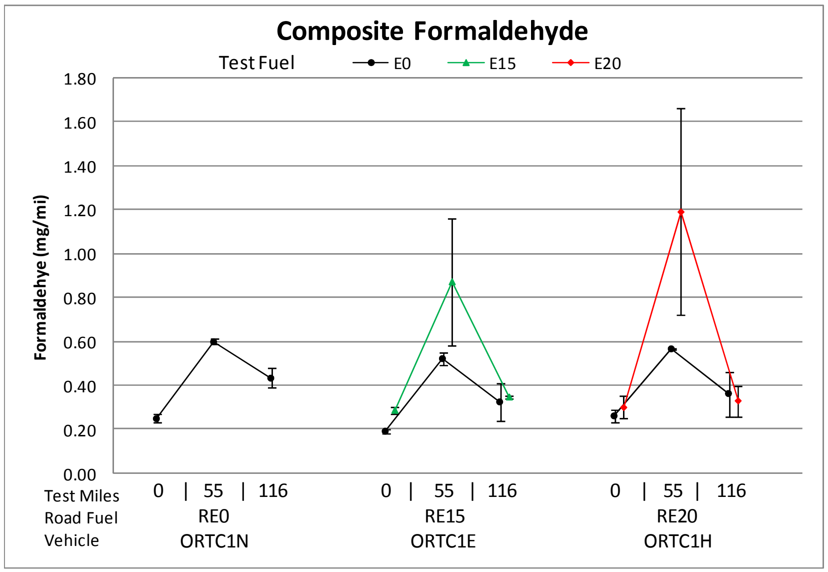
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.101	-0.403	0.605
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.094	-0.518	0.705
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.181	-0.511	0.872
Aging Effect with RE15 (Δmg/mi per 100k mi)	0.086	-0.376	0.547
Aging Effect with RE20 (Δmg/mi per 100k mi)	0.050	-0.495	0.594

* Indicates estimate is different from zero at the 95% confidence level.

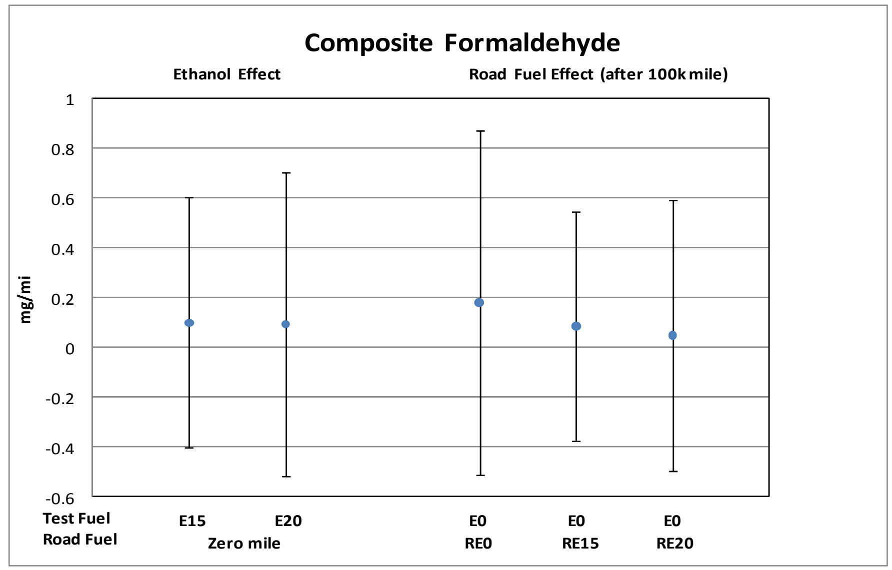
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.74
No Aging Effect with RE0 (Beta0 = 0)	0.56
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.94

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Toyota Corolla (Composite CH_4)

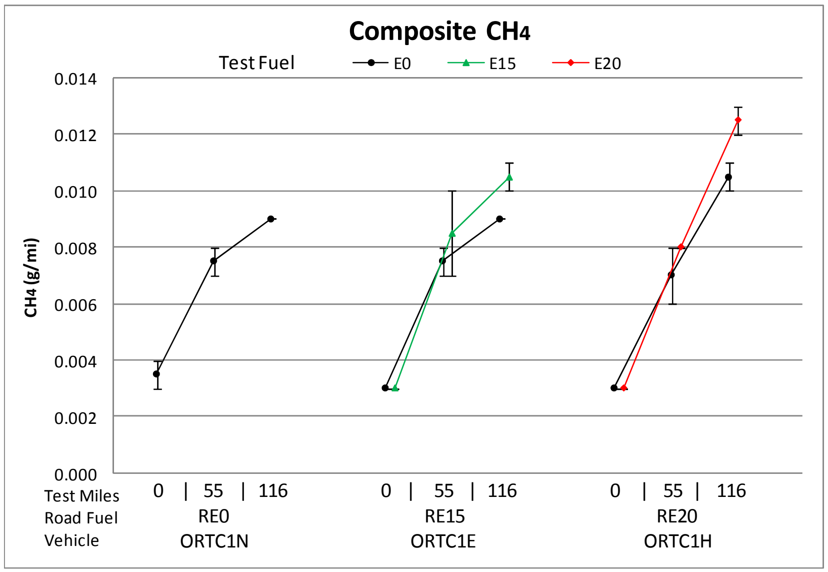
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0008	-0.0012	0.0028
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.0010	-0.0010	0.0030
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0047*	0.0017	0.0077
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0058*	0.0037	0.0079
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0074*	0.0052	0.0095

* Indicates estimate is different from zero at the 95% confidence level.

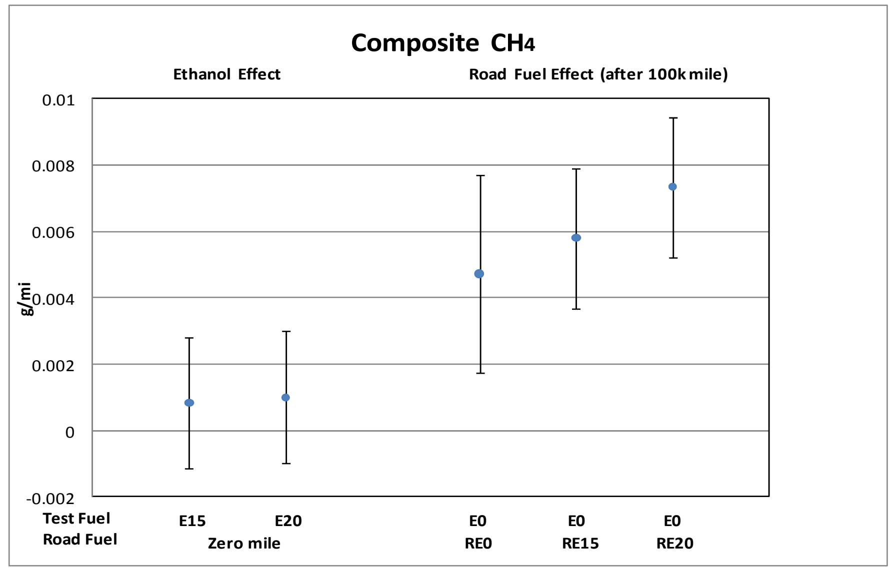
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.34
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.25

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2005 Toyota Tundra - Composite Emissions Summary

Emisssion Parameter (units)	Ethanol Effect				Aging Effect with RE0		RExx Aging Effect on E0 Emissions				RExx Aging Effect on Exx Emissions			Road and Test Fuel Effects are Additive
	Δ units vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value	Δ units per 100K mi			Overall p-value
Fuels	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0		RE10/E10	RE15/E15	RE20/E20	
CO (g/mi)	NA	-0.078	-0.092	0.23	0.167	0.32	NA	0.293*	0.465*	0.34	NA	NA	NA	0.07
NOx (g/mi)	NA	0.000	0.002	0.65	0.037*	<0.01*	NA	0.014*	0.019*	0.04*	NA	NA	NA	0.82
NMHC (g/mi)	NA	-0.007	-0.009	0.21	0.005	0.72	NA	-0.015	0	0.07	NA	NA	NA	0.23
NMOG (g/mi)	NA	-0.001	-0.002	0.96	0.005	0.73	NA	-0.018	0.024	0.06	NA	NA	NA	0.21
Fuel Econ (mi/gal)	NA	-1.077*	-1.281*	<0.01*	-0.077	0.89	NA	-0.275	-0.477	0.83	NA	NA	NA	0.84
Acetaldehyde (mg/mi)#	NA	0.748*	0.984*	<0.01*	-0.053	0.40	NA	-0.105*	-0.044	0.54	NA	NA	NA	0.96
Formaldehyde (mg/mi)##	NA	0.133*	0.144*	<0.01*	0.170*	0.05*	NA	-0.119	0.093	0.01*	NA	NA	NA	NA
CH_4 (g/mi)	NA	0.0001	0.0017	0.42	0.0102*	0.02*	NA	0.0069*	0.0072*	0.69	NA	NA	NA	0.96

Log-normal model was used. Results are presented as changes in emissions at 0k mile.

Data did not support the assumption of linear effects with mileage.

* Indicates estimate is different from zero at the 95% confidence level.

2005 Toyota Tundra (Composite CO)

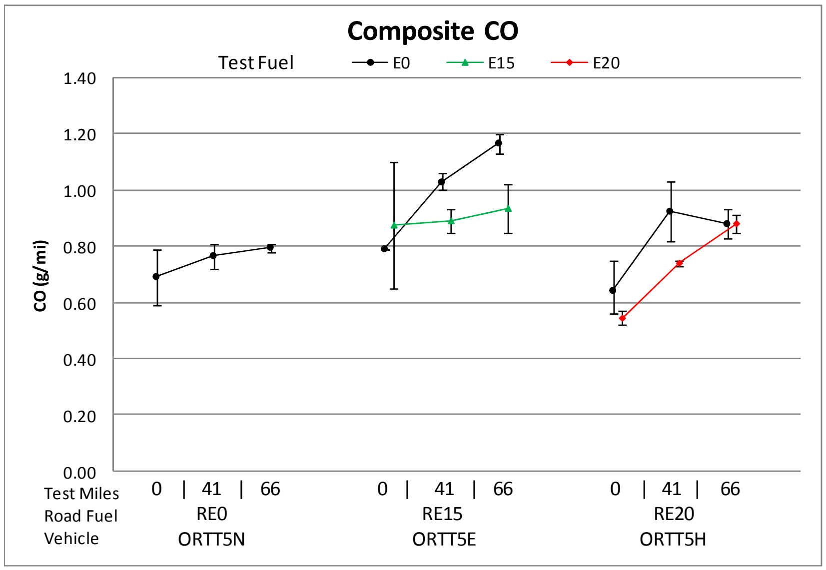
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.078	-0.227	0.072
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.092	-0.241	0.058
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.167	-0.231	0.564
Aging Effect with RE15 (Δg/mi per 100k mi)	0.293*	0.014	0.572
Aging Effect with RE20 (Δg/mi per 100k mi)	0.465*	0.185	0.745

* Indicates estimate is different from zero at the 95% confidence level.

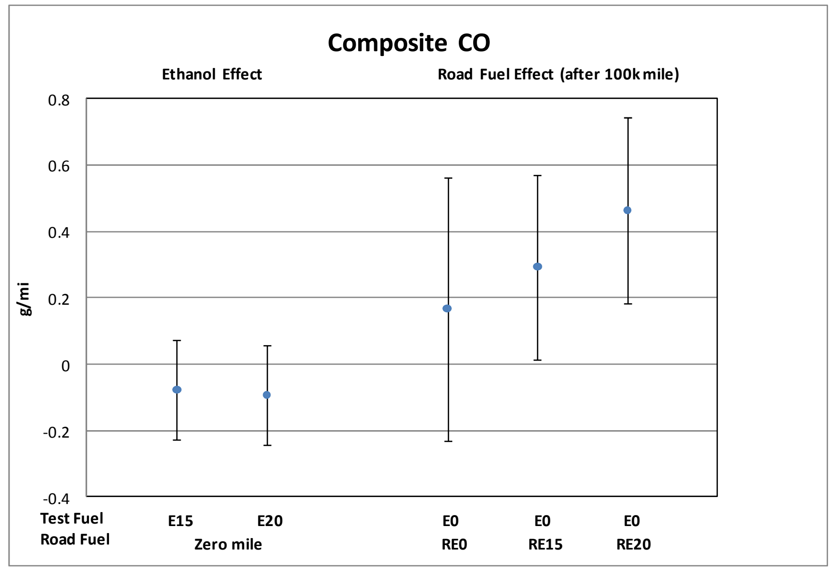
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.23
No Aging Effect with RE0 (Beta0 = 0)	0.32
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.34

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 43k-55k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2005 Toyota Tundra (Composite NOx)

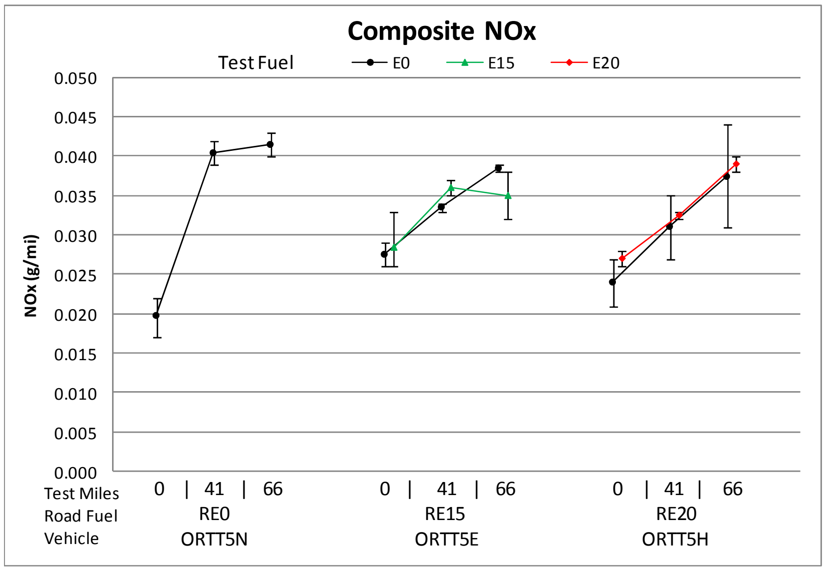
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.000	-0.005	0.005
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.002	-0.003	0.007
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.037*	0.023	0.051
Aging Effect with RE15 (Δg/mi per 100k mi)	0.014*	0.004	0.023
Aging Effect with RE20 (Δg/mi per 100k mi)	0.019*	0.010	0.029

* Indicates estimate is different from zero at the 95% confidence level.

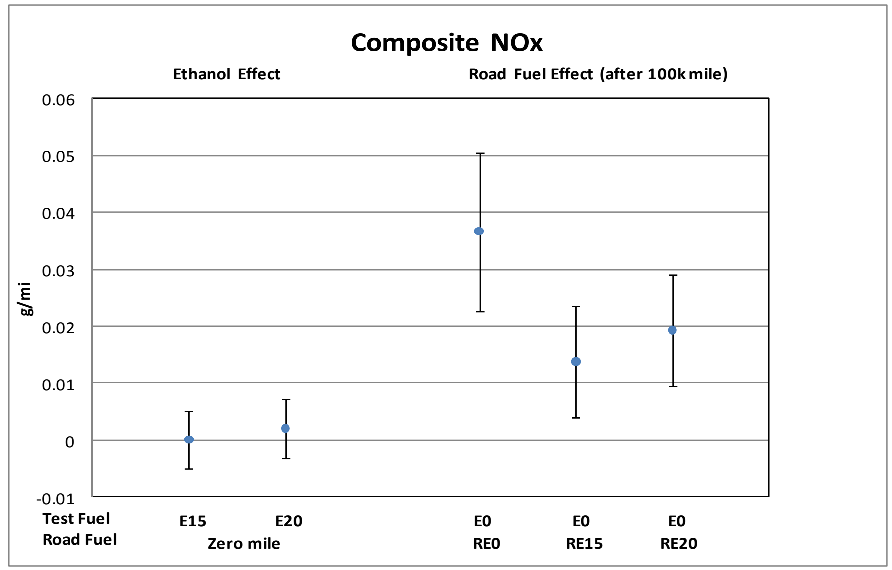
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.65
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.04*

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 43k-55k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2005 Toyota Tundra (Composite Nonmethane Hydrocarbons)

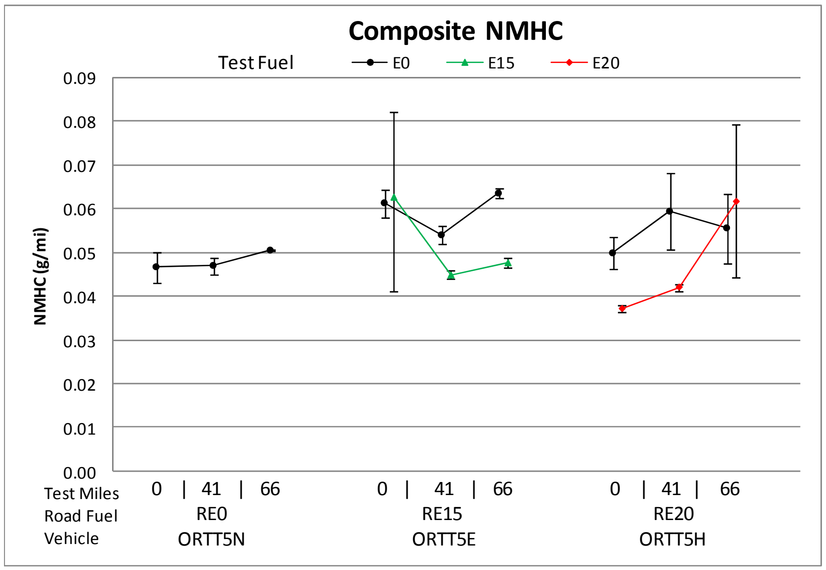
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.007	-0.019	0.006
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.009	-0.021	0.004
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.005	-0.023	0.034
Aging Effect with RE15 (Δg/mi per 100k mi)	-0.015	-0.037	0.006
Aging Effect with RE20 (Δg/mi per 100k mi)	0.021	0.000	0.043

* Indicates estimate is different from zero at the 95% confidence level.

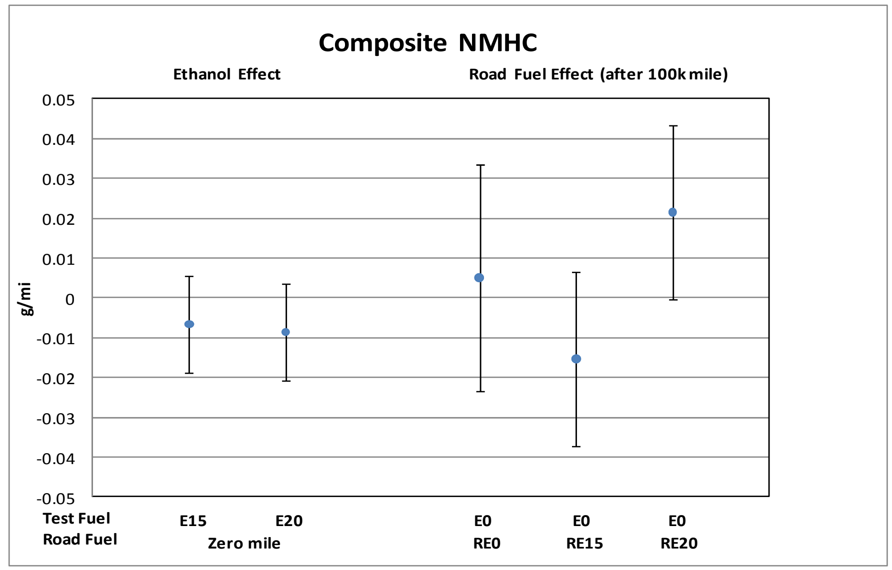
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.21
No Aging Effect with RE0 (Beta0 = 0)	0.72
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.07

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 43k-55k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2005 Toyota Tundra (Composite Nonmethane Organic Gases)

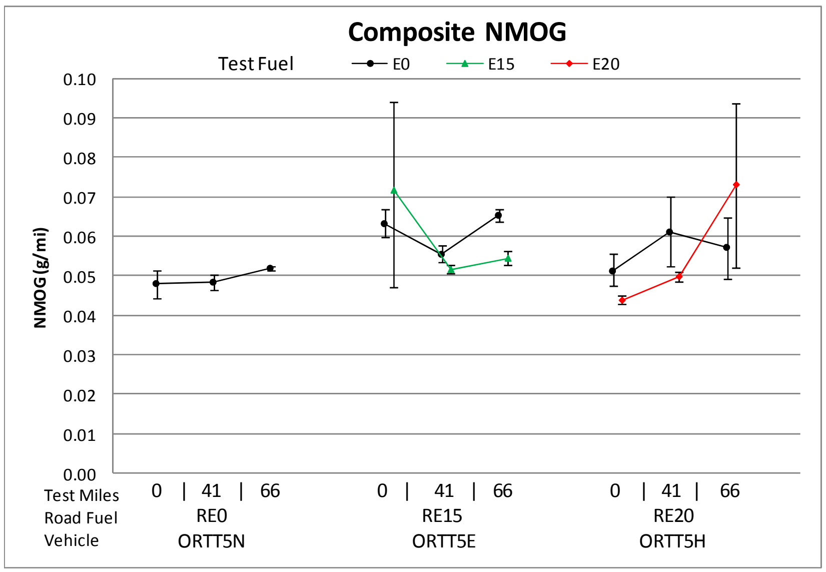
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.001	-0.0144	0.0133
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.002	-0.0155	0.0121
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.005	-0.0270	0.0378
Aging Effect with RE15 (Δg/mi per 100k mi)	-0.018	-0.0427	0.0070
Aging Effect with RE20 (Δg/mi per 100k mi)	0.024	-0.0005	0.0493

* Indicates estimate is different from zero at the 95% confidence level.

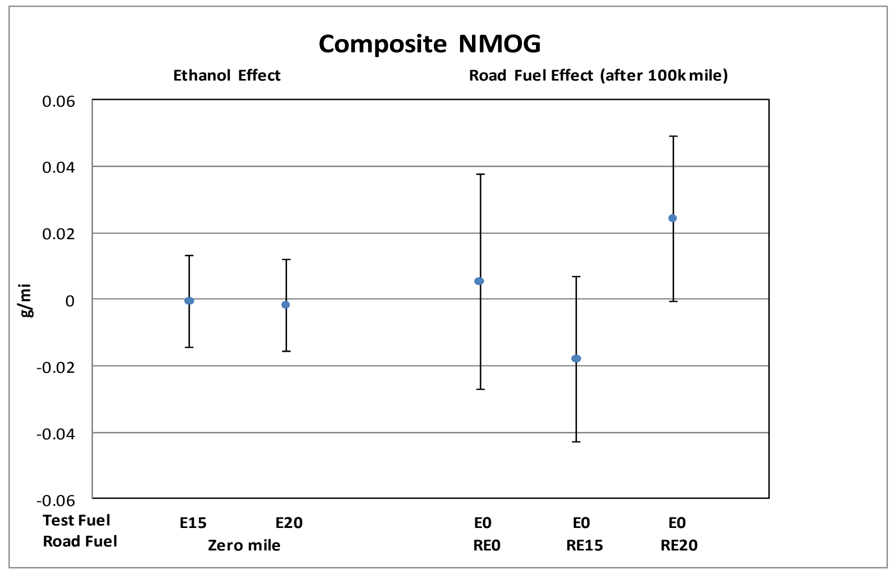
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.96
No Aging Effect with RE0 (Beta0 = 0)	0.73
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.06

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 43k-55k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2005 Toyota Tundra (Composite Fuel Economy)

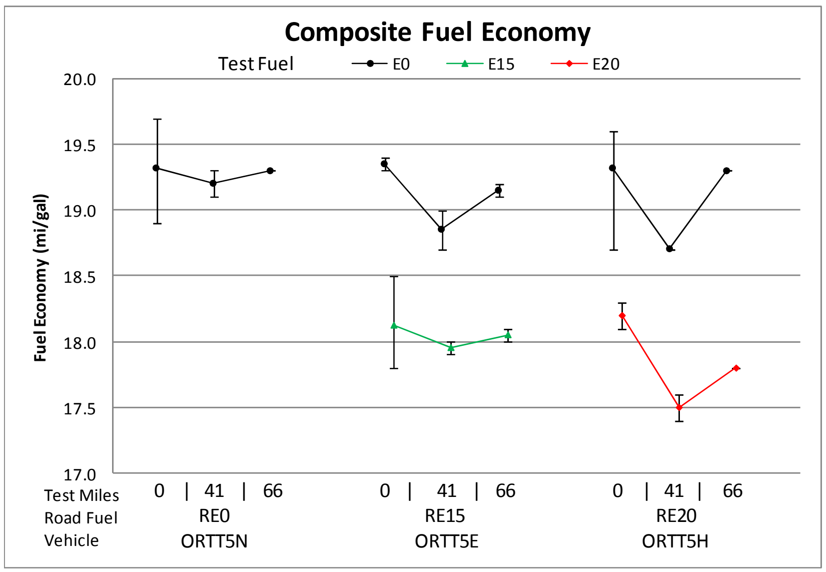
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmi/gal)	-1.077*	-1.597	-0.556
Ethanol Effect (E20 vs. E0) (Δmi/gal)	-1.281*	-1.801	-0.761
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmi/gal per 100k mi)	-0.077	-1.468	1.314
Aging Effect with RE15 (Δmi/gal per 100k mi)	-0.275	-1.256	0.706
Aging Effect with RE20 (Δmi/gal per 100k mi)	-0.477	-1.459	0.505

* Indicates estimate is different from zero at the 95% confidence level.

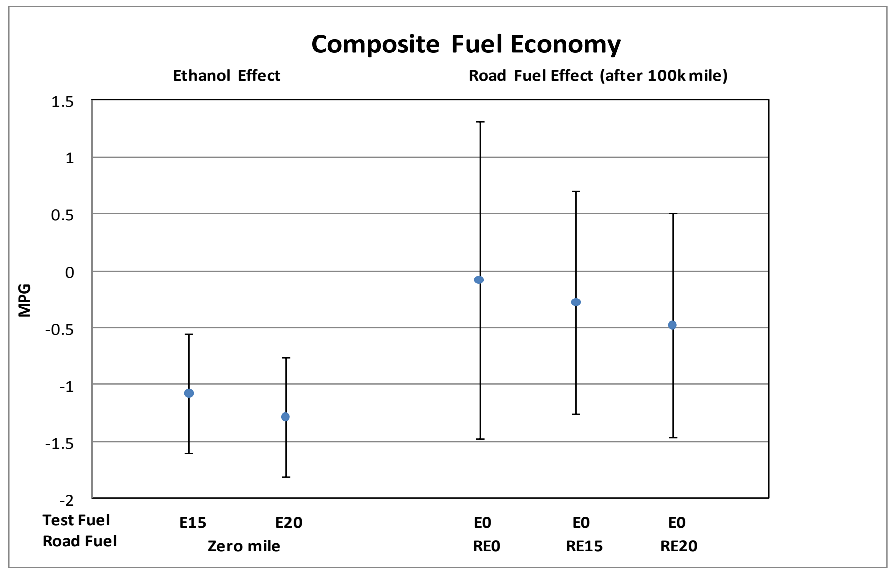
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.89
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.83

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 43k-55k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2005 Toyota Tundra (Composite Acetaldehyde)

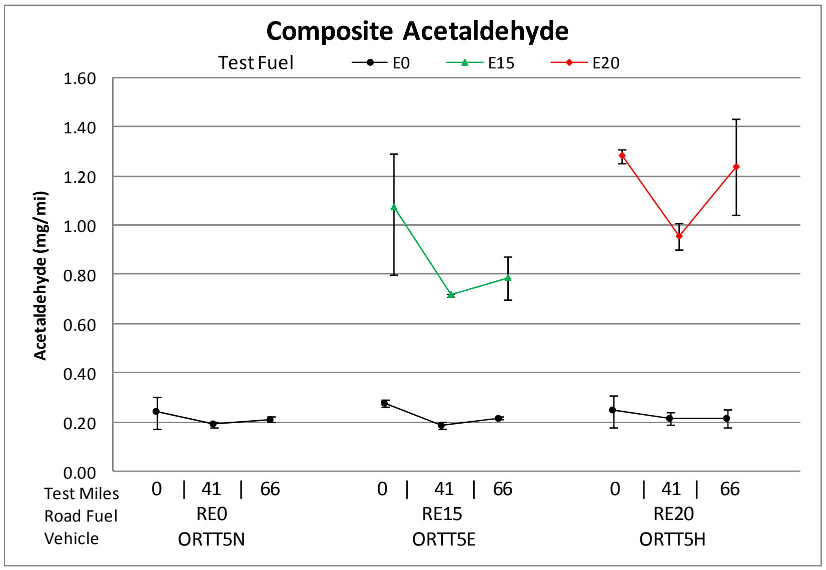
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.748*	0.438	1.057
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.984*	0.553	1.416
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	-0.053	-0.221	0.115
Aging Effect with RE15 (Δmg/mi per 100k mi)	-0.105*	-0.194	-0.016
Aging Effect with RE20 (Δmg/mi per 100k mi)	-0.044	-0.168	0.081

* Indicates estimate is different from zero at the 95% confidence level.

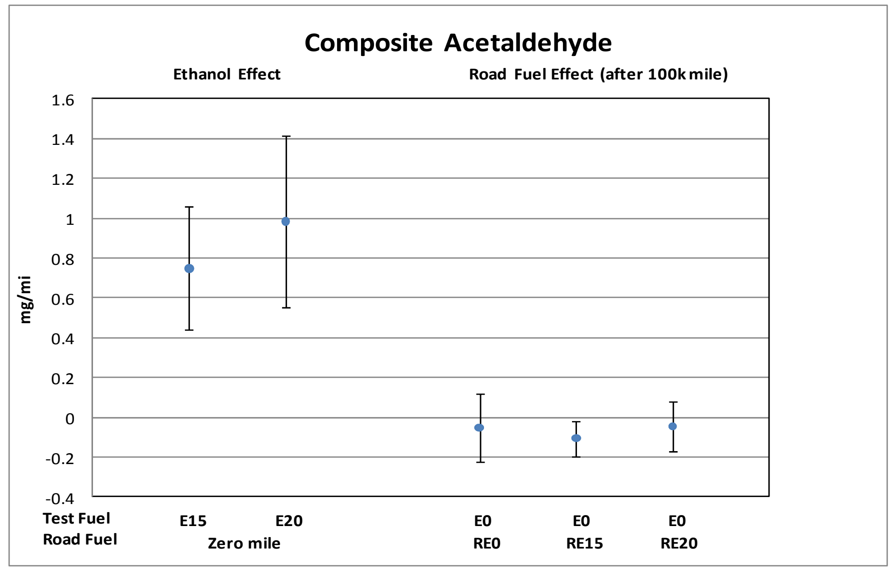
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.40
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.54

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 43k-55k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2005 Toyota Tundra (Composite Formaldehyde)

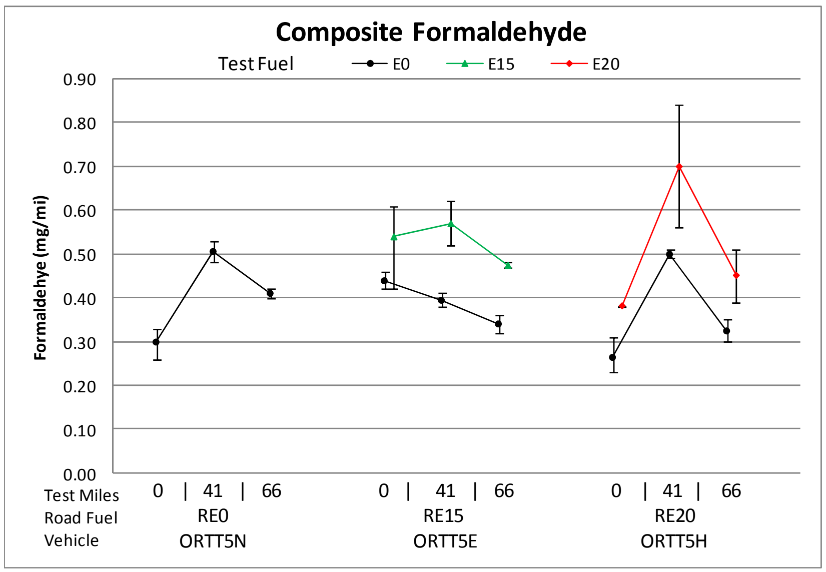
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.133*	0.065	0.201
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.144*	0.075	0.212
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.170*	0.003	0.337
Aging Effect with RE15 (Δmg/mi per 100k mi)	-0.119	-0.245	0.007
Aging Effect with RE20 (Δmg/mi per 100k mi)	0.093	-0.033	0.219

* Indicates estimate is different from zero at the 95% confidence level.

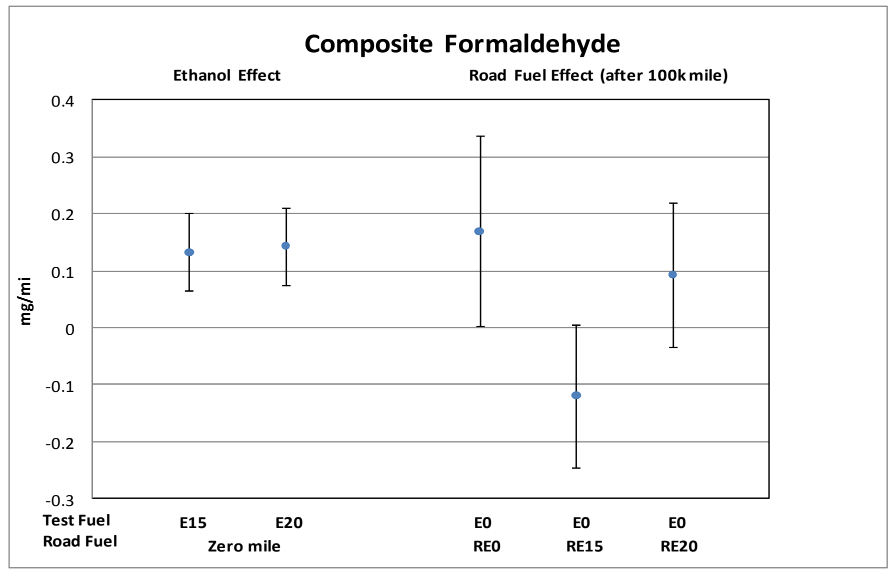
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.05*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.01*

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 43k-55k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2005 Toyota Tundra (Composite CH_4)

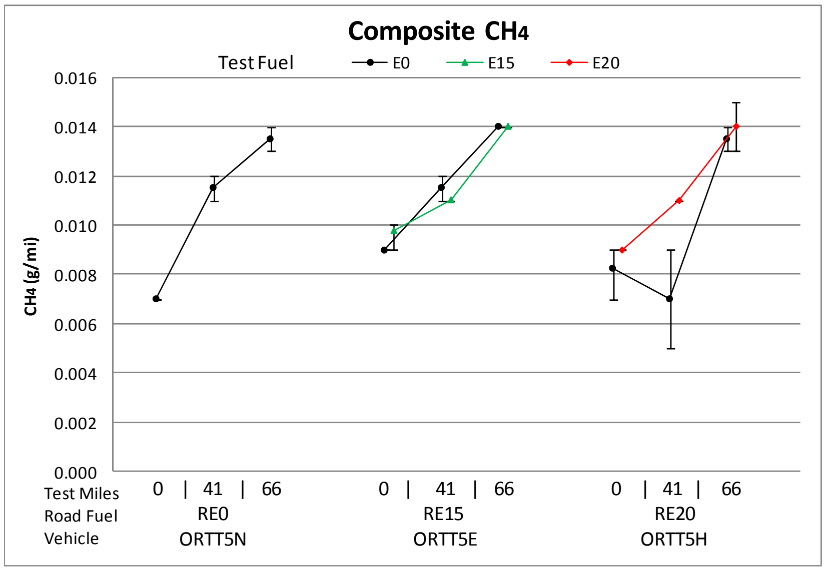
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0001	-0.0028	0.0030
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.0017	-0.0012	0.0047
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0102*	0.0024	0.0180
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0069*	0.0014	0.0124
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0072*	0.0016	0.0127

* Indicates estimate is different from zero at the 95% confidence level.

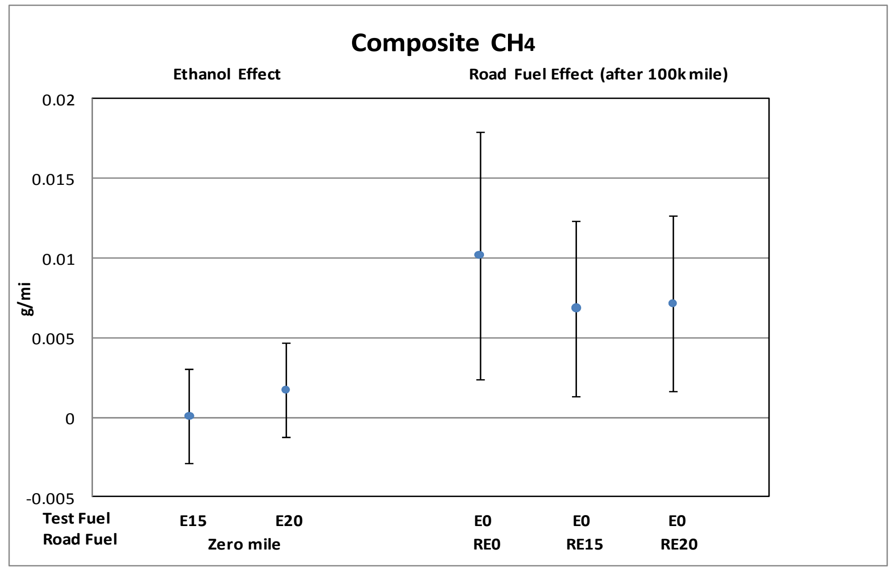
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.42
No Aging Effect with RE0 (Beta0 = 0)	0.02*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.69

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 43k-55k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2006 Chevrolet Impala - Composite Emissions Summary

Emisssion Parameter (units)	Ethanol Effect				Aging Effect with RE0		RExx Aging Effect on E0 Emissions				RExx Aging Effect on Exx Emissions			Road and Test Fuel Effects are Additive
	Δ units vs. E0			Overall	Δ units per 100K mi	Overall	Δ units per 100K mi			Overall	Δ units per 100K mi			Overall p-
Fuels	E10	E15	E20	p-value	RE0/E0	p-value	RE10/E0	RE15/E0	RE20/E0	p-value	RE10/E10	RE15/E15	RE20/E20	value
CO (g/mi)	NA	-0.117	-0.093	0.41	0.097	0.67	NA	0.579*	0.342	0.25	NA	NA	NA	0.52
NOx (g/mi)	NA	0.002	0.046*	0.01*	0.005	0.67	NA	0.022	0.018	0.61	NA	0.020	-0.063*	0.01*
NMHC (g/mi)	NA	-0.003	-0.004	0.10	-0.005	0.35	NA	0.010*	0.002	0.05	NA	NA	NA	0.16
NMOG (g/mi)	NA	0.001	0.003	0.53	-0.005	0.41	NA	0.010*	0.002	0.08	NA	NA	NA	0.18
Fuel Econ (mi/gal)	NA	-1.267*	-1.486*	<0.01*	0.109	0.84	NA	0.439	-0.108	0.60	NA	NA	NA	0.39
Acetaldehyde (mg/mi)[#]	NA	0.453*	0.928*	<0.01*	-0.040	0.60	NA	-0.089	-0.079	0.87	NA	NA	NA	0.10
Formaldehyde (mg/mi)[#]	NA	-0.163	0.201	0.40	-0.165	0.55	NA	-0.316	-0.219	0.95	NA	NA	NA	0.97
CH_4 (g/mi)	NA	0.0010	0.0033*	<0.01*	0.0139*	<0.01*	NA	0.0197*	0.0124*	<0.01*	NA	NA	NA	0.47

Log-normal model was used. Results are presented as changes in emissions at 0k mile.

Data did not support the assumption of linear effects with mileage.

* Indicates estimate is different from zero at the 95% confidence level.

2006 Chevrolet Impala (Composite CO)

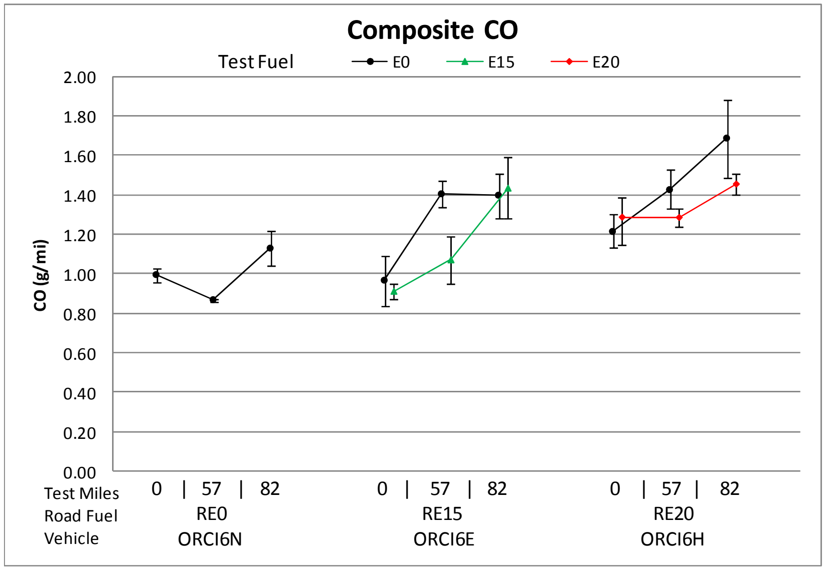
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.117	-0.363	0.130
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.093	-0.340	0.153
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.097	-0.417	0.611
Aging Effect with RE15 (Δg/mi per 100k mi)	0.579*	0.215	0.943
Aging Effect with RE20 (Δg/mi per 100k mi)	0.342	-0.020	0.705

* Indicates estimate is different from zero at the 95% confidence level.

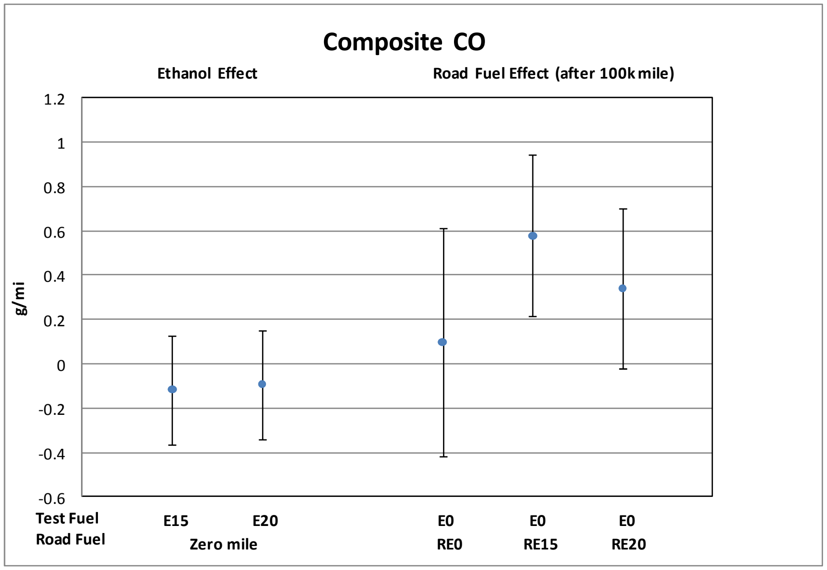
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.41
No Aging Effect with RE0 (Beta0 = 0)	0.67
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.25

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 31k-38k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2006 Chevrolet Impala (Composite NOx)

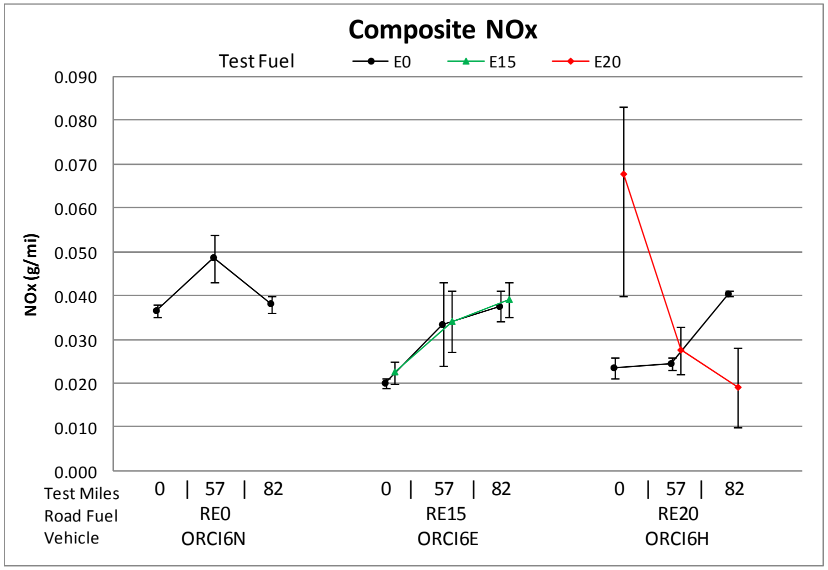
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.002	-0.018	0.023
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.046*	0.027	0.064
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.005	-0.020	0.031
Aging Effect with RE15 (Δg/mi per 100k mi)	0.022	-0.003	0.047
Aging Effect with RE15 (Δg/mi per 100k mi)	0.018	-0.008	0.043

* Indicates estimate is different from zero at the 95% confidence level.

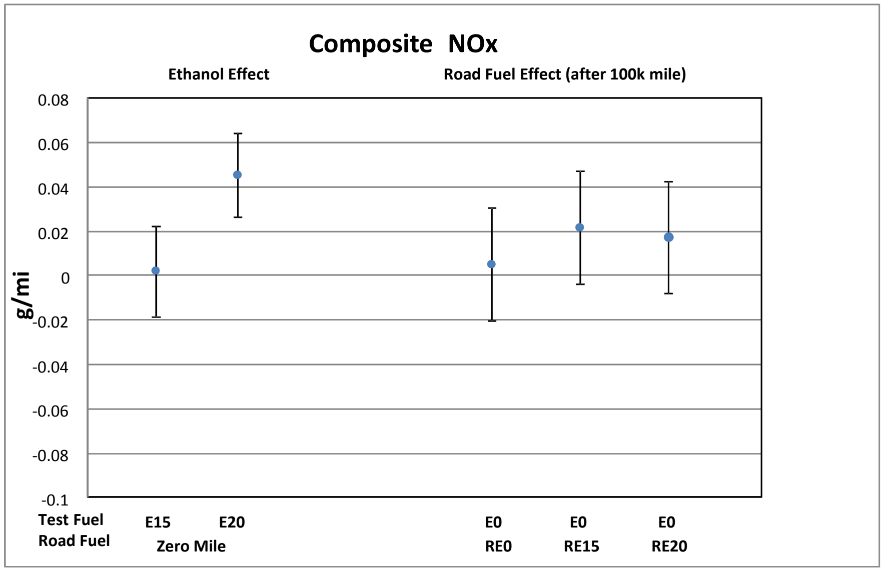
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.67
No Effect of Ethanol on Road Fuel Aging (Beta 1s = 0)	0.61

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 31k-38k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2006 Chevrolet Impala (Composite Nonmethane Hydrocarbons)

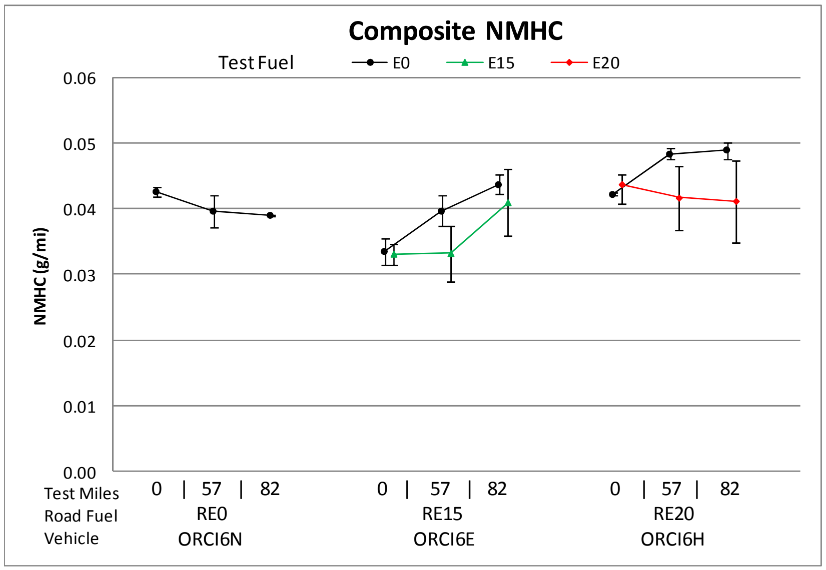
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.003	-0.008	0.002
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.004	-0.009	0.001
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	-0.005	-0.015	0.005
Aging Effect with RE15 (Δg/mi per 100k mi)	0.010*	0.003	0.017
Aging Effect with RE20 (Δg/mi per 100k mi)	0.002	-0.005	0.009

* Indicates estimate is different from zero at the 95% confidence level.

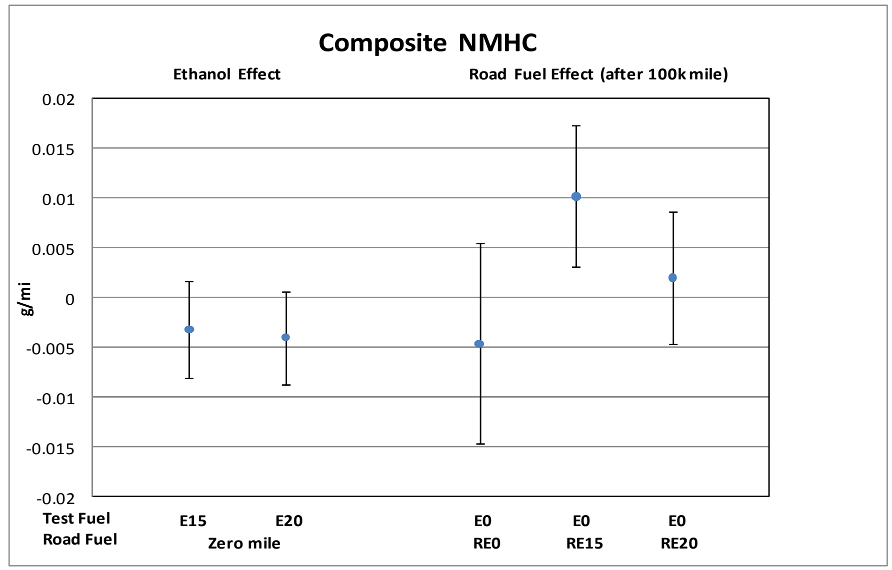
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.10
No Aging Effect with RE0 (Beta0 = 0)	0.35
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.05

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 31k-38k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2006 Chevrolet Impala (Composite Nonmethane Organic Gases)

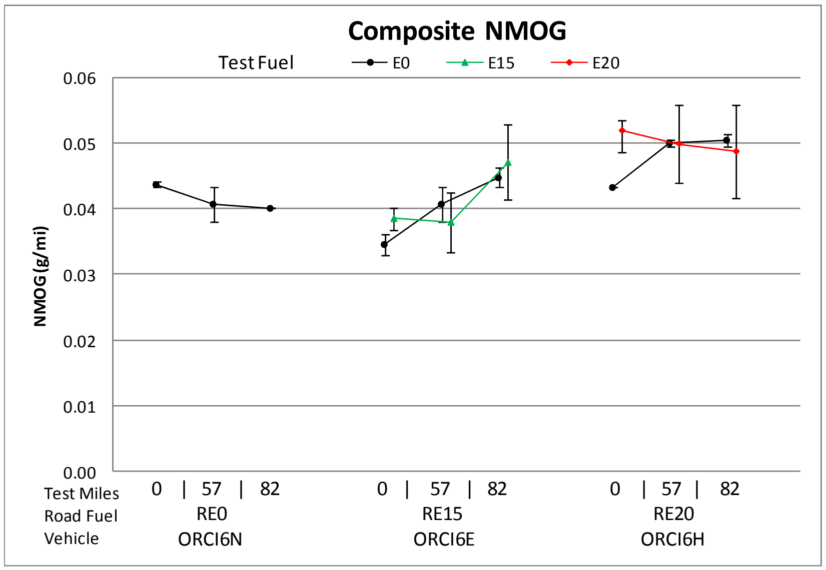
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.001	-0.004	0.007
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.003	-0.003	0.008
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	-0.005	-0.016	0.007
Aging Effect with RE15 (Δg/mi per 100k mi)	0.010*	0.003	0.018
Aging Effect with RE20 (Δg/mi per 100k mi)	0.002	-0.005	0.010

* Indicates estimate is different from zero at the 95% confidence level.

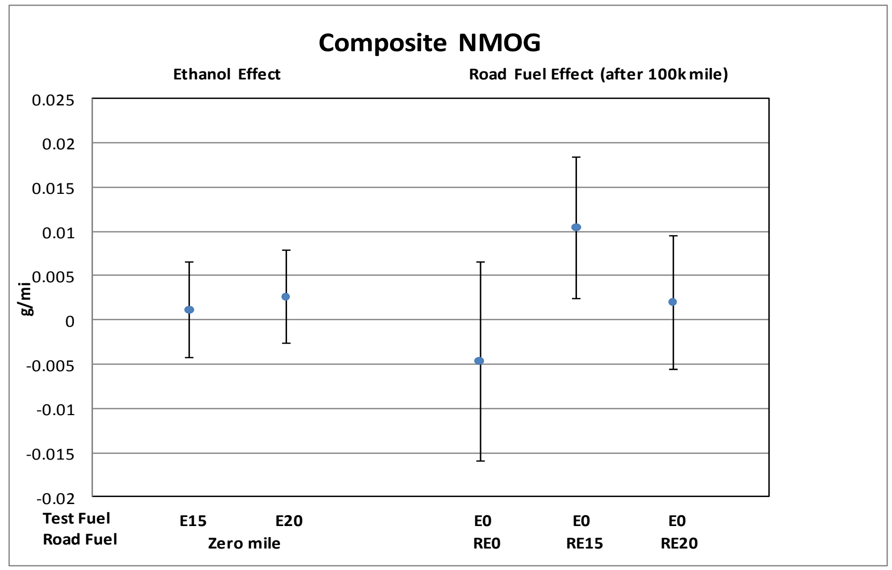
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.53
No Aging Effect with RE0 (Beta0 = 0)	0.41
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.08

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 31k-38k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2006 Chevrolet Impala (Composite Fuel Economy)

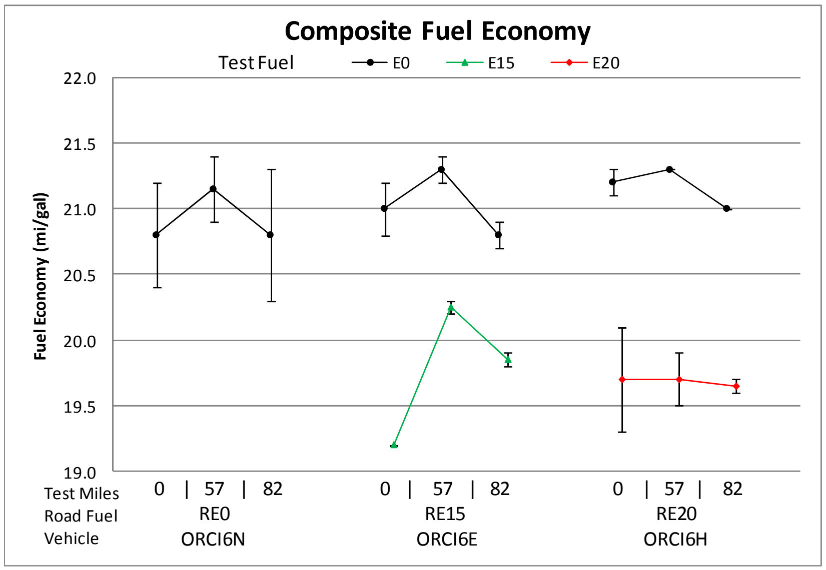
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmi/gal)	-1.267*	-1.863	-0.671
Ethanol Effect (E20 vs. E0) (Δmi/gal)	-1.486*	-2.081	-0.890
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmi/gal per 100k mi)	0.109	-1.133	1.350
Aging Effect with RE15 (Δmi/gal per 100k mi)	0.439	-0.439	1.318
Aging Effect with RE20 (Δmi/gal per 100k mi)	-0.108	-0.984	0.769

* Indicates estimate is different from zero at the 95% confidence level.

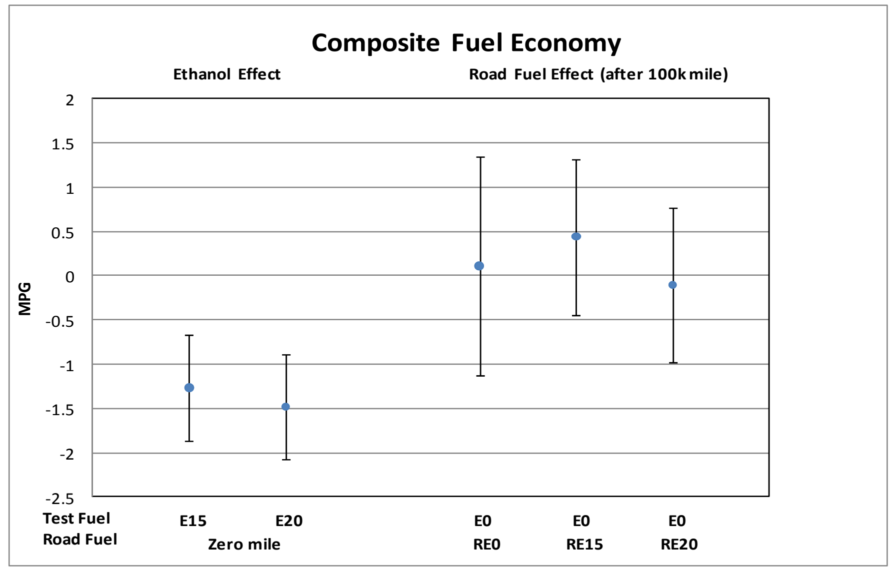
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.84
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.60

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 31k-38k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2006 Chevrolet Impala (Composite Acetaldehyde)

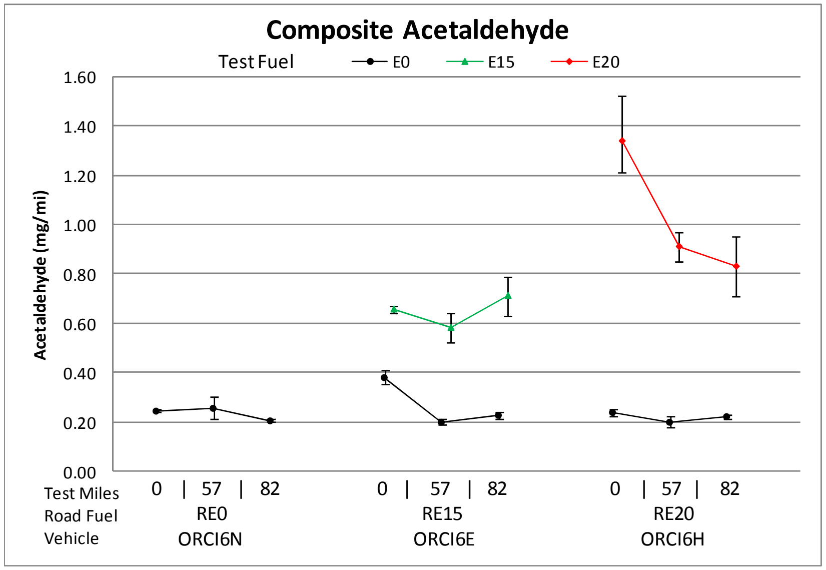
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.453*	0.171	0.735
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.928*	0.508	1.349
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	-0.040	-0.186	0.106
Aging Effect with RE15 (Δmg/mi per 100k mi)	-0.089	-0.221	0.043
Aging Effect with RE20 (Δmg/mi per 100k mi)	-0.079	-0.191	0.032

* Indicates estimate is different from zero at the 95% confidence level.

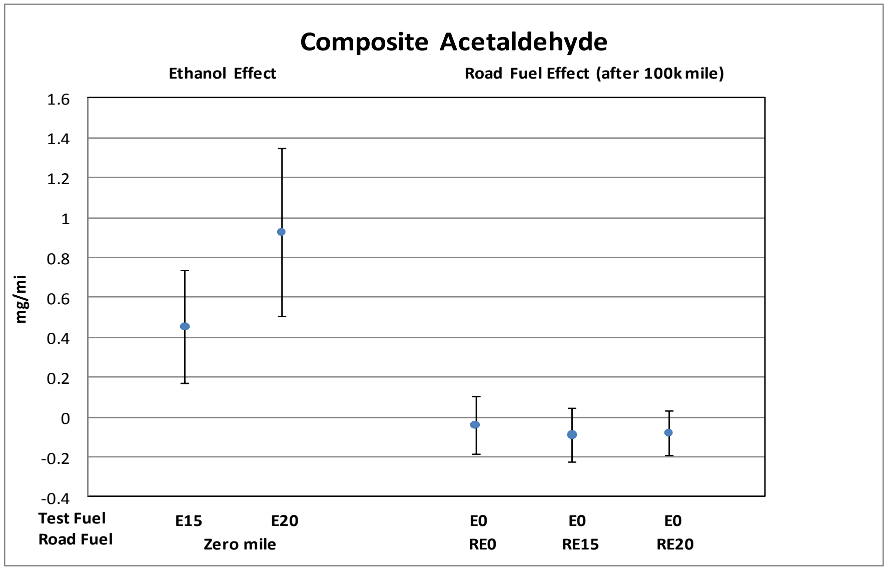
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.60
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.87

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 31k-38k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2006 Chevrolet Impala (Composite Formaldehyde)

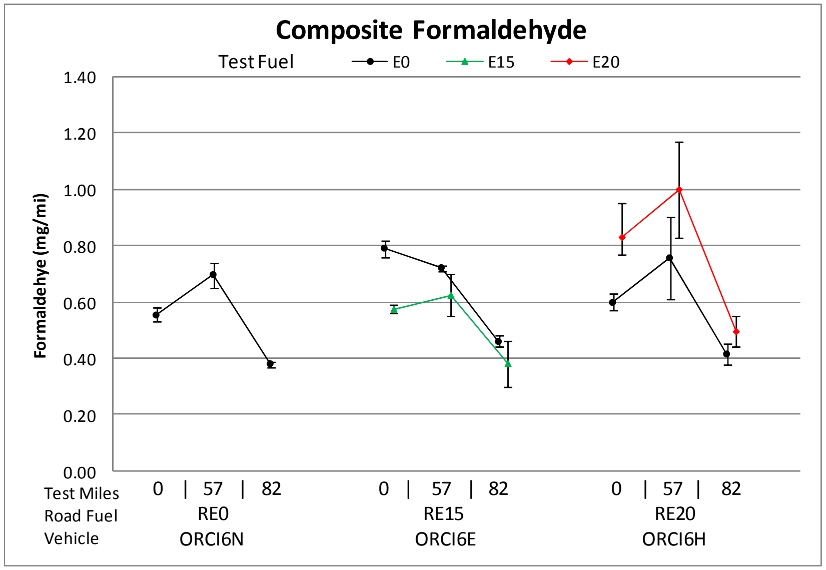
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	-0.163	-0.745	0.419
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.201	-0.430	0.832
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	-0.165	-0.705	0.375
Aging Effect with RE15 (Δmg/mi per 100k mi)	-0.316	-0.862	0.229
Aging Effect with RE20 (Δmg/mi per 100k mi)	-0.219	-0.697	0.259

* Indicates estimate is different from zero at the 95% confidence level.

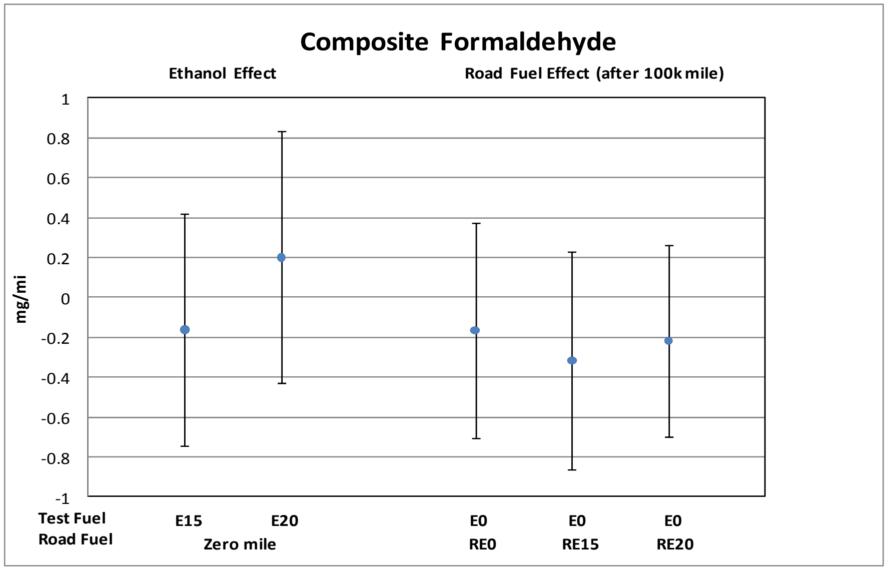
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.40
No Aging Effect with RE0 (Beta0 = 0)	0.55
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.95

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 31k-38k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2006 Chevrolet Impala (Composite CH_4)

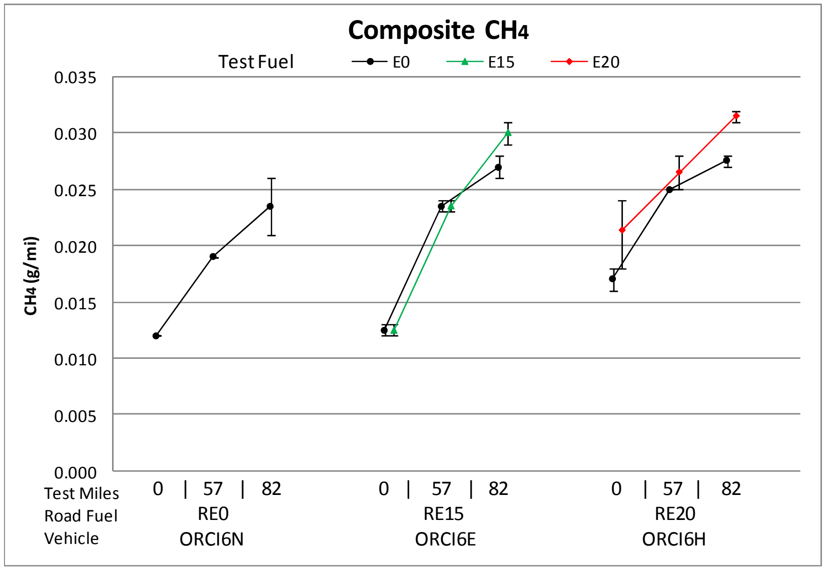
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0010	-0.0009	0.0029
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.0033*	0.0015	0.0052
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0139*	0.0099	0.0178
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0197*	0.0169	0.0225
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0124*	0.0098	0.0150

* Indicates estimate is different from zero at the 95% confidence level.

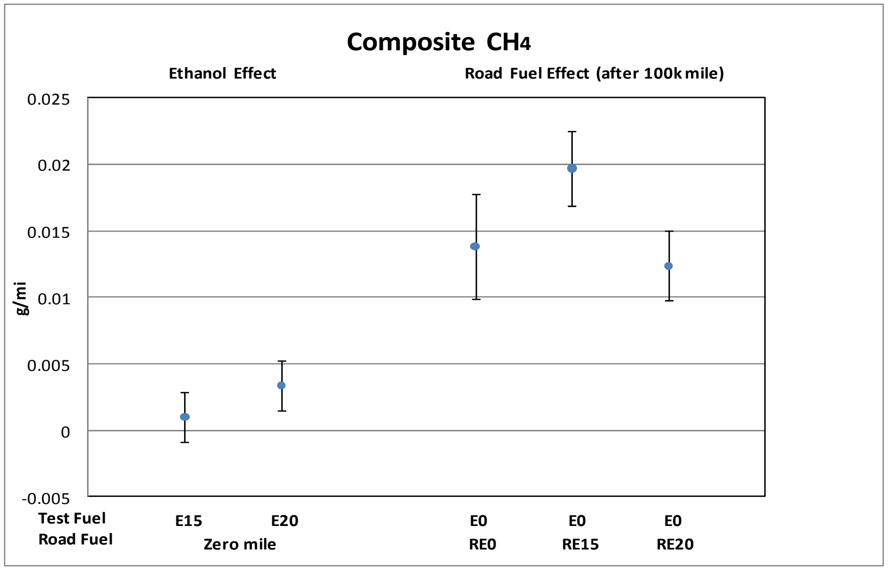
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	<0.01*

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 31k-38k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2005 Ford F150 - Composite Emissions Summary

Emisssion Parameter (units)	Ethanol Effect				Aging Effect with RE0		RExx Aging Effect on E0 Emissions				RExx Aging Effect on Exx Emissions			Road and Test Fuel Effects are Additive
	Δ units vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value	Δ units per 100K mi			Overall p-value
Fuels	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0		RE10/E10	RE15/E15	RE20/E20	
CO (g/mi)	NA	-0.062	-0.389	0.17	2.840*	<0.01*	NA	1.404*	1.257*	0.05*	NA	NA	NA	0.80
NOx (g/mi)	NA	-0.012	-0.007	0.34	0.054*	0.05*	NA	0.062*	0.051*	0.88	NA	NA	NA	0.51
NMHC (g/mi)	NA	-0.015*	-0.014*	<0.01*	0.047*	<0.01*	NA	0.040*	0.020*	0.12	NA	NA	NA	0.52
NMOG (g/mi)	NA	-0.007	-0.008	0.09	0.048*	<0.01*	NA	0.043*	0.022*	0.13	NA	NA	NA	0.61
Fuel Econ (mi/gal)	NA	-0.816*	-0.983*	<0.01*	0.565*	0.02*	NA	1.009*	0.438*	0.04*	NA	NA	NA	0.93
Acetaldehyde (mg/mi)#	NA	0.655*	0.603*	<0.01*	-0.016	0.73	NA	0.037	-0.042	0.30	NA	NA	NA	0.25
Formaldehyde (mg/mi)#	NA	-0.127	0.015	0.65	-0.187	0.39	NA	-0.154	-0.348*	0.46	NA	NA	NA	0.86
CH_4 (g/mi)	NA	0.0030	0.0007	0.68	0.0448*	<0.01*	NA	0.0319*	0.0277*	0.33	NA	NA	NA	0.99

Log-normal model was used. Results are presented as changes in emissions at 0k mile.

Data did not support the assumption of linear effects with mileage.

* Indicates estimate is different from zero at the 95% confidence level.

2005 Ford F150 (Composite CO)

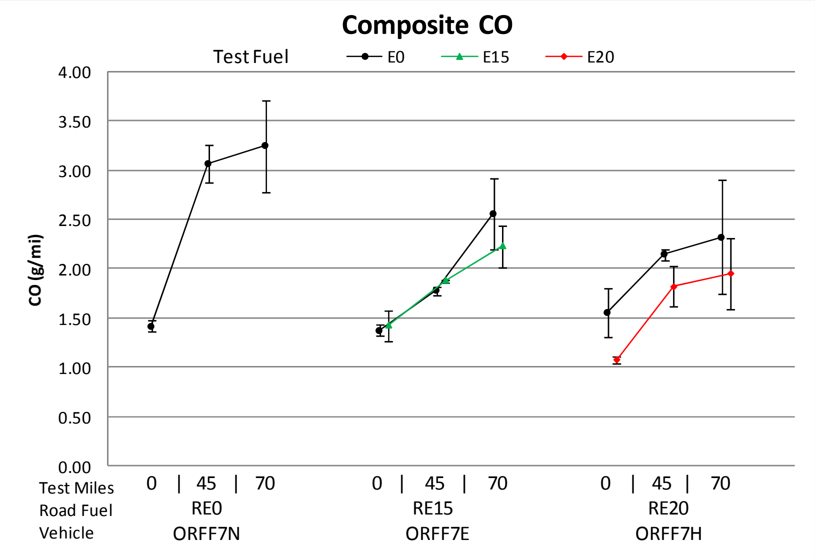
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.062	-0.480	0.355
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.389	-0.806	0.028
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	2.840*	1.780	3.900
Aging Effect with RE15 (Δg/mi per 100k mi)	1.404*	0.658	2.149
Aging Effect with RE20 (Δg/mi per 100k mi)	1.257*	0.512	2.003

* Indicates estimate is different from zero at the 95% confidence level.

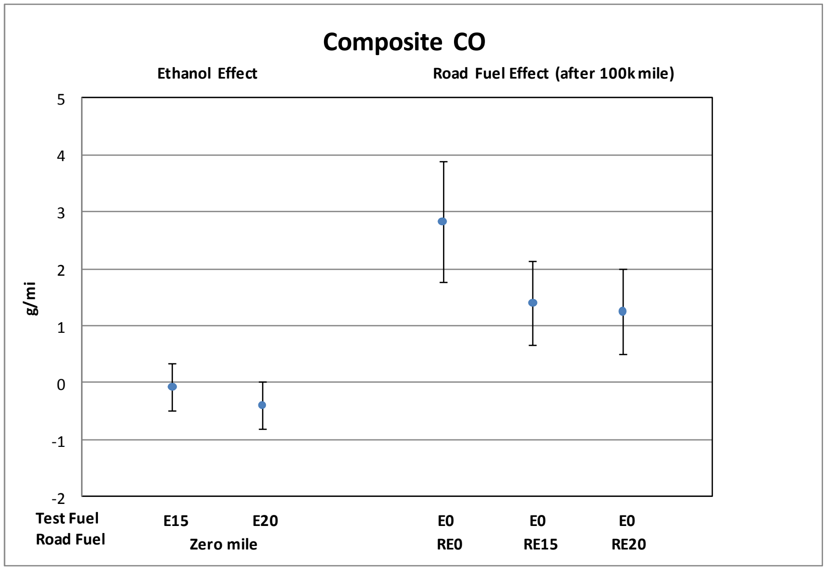
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.17
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.05*

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 31k-38k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2005 Ford F150 (Composite NOx)

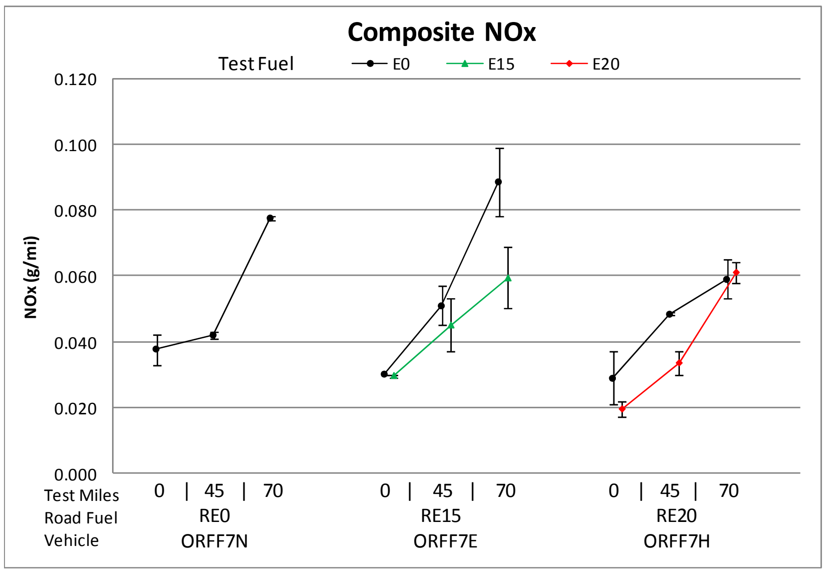
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.012	-0.033	0.009
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.007	-0.028	0.013
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.054*	0.001	0.107
Aging Effect with RE15 (Δg/mi per 100k mi)	0.062*	0.025	0.099
Aging Effect with RE20 (Δg/mi per 100k mi)	0.051*	0.014	0.088

* Indicates estimate is different from zero at the 95% confidence level.

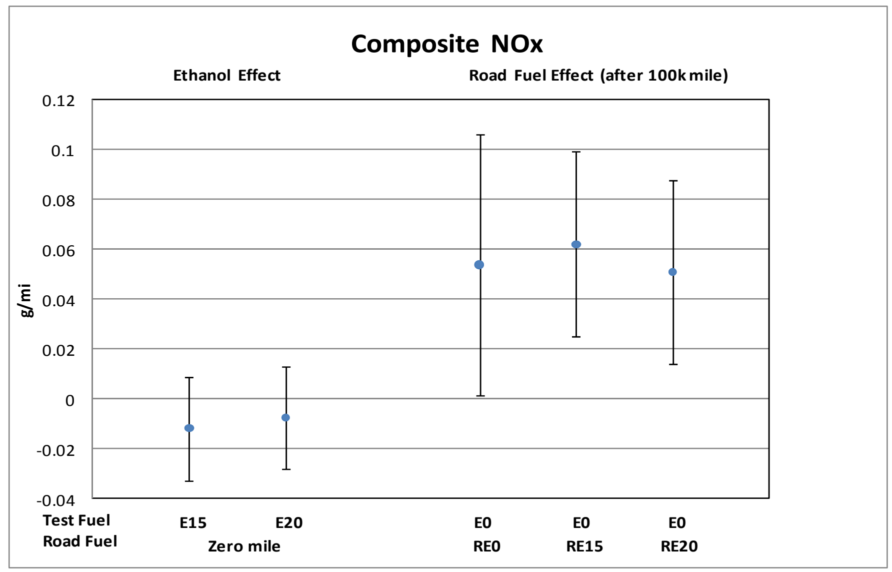
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.34
No Aging Effect with RE0 (Beta0 = 0)	0.05*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.88

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 31k-38k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2005 Ford F150 (Composite Nonmethane Hydrocarbons)

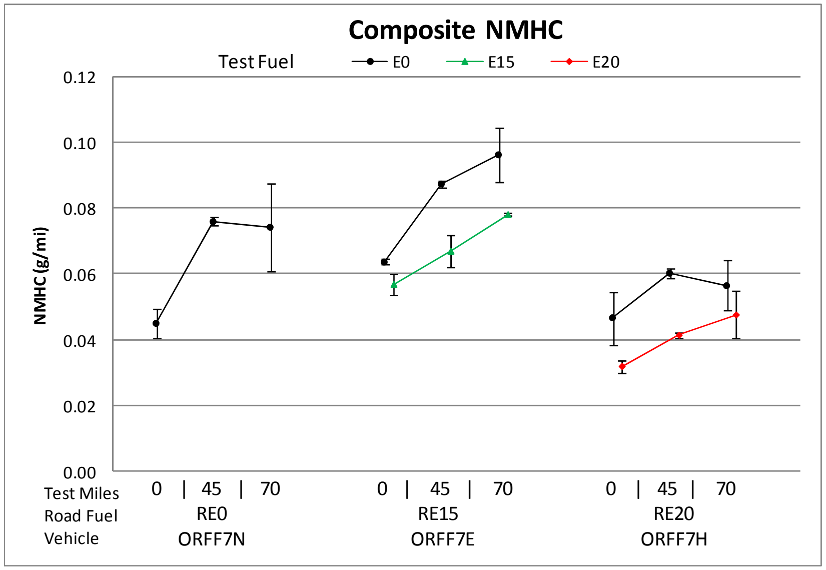
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.015*	-0.025	-0.006
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.014*	-0.023	-0.005
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.047*	0.023	0.070
Aging Effect with RE15 (Δg/mi per 100k mi)	0.040*	0.023	0.056
Aging Effect with RE20 (Δg/mi per 100k mi)	0.020*	0.003	0.037

* Indicates estimate is different from zero at the 95% confidence level.

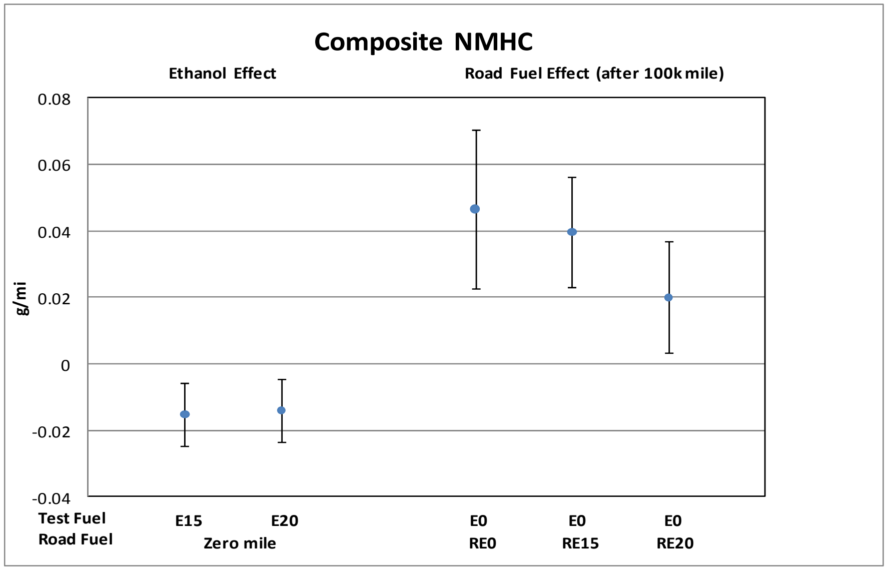
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.12

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 31k-38k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2005 Ford F150 (Composite Nonmethane Organic Gases)

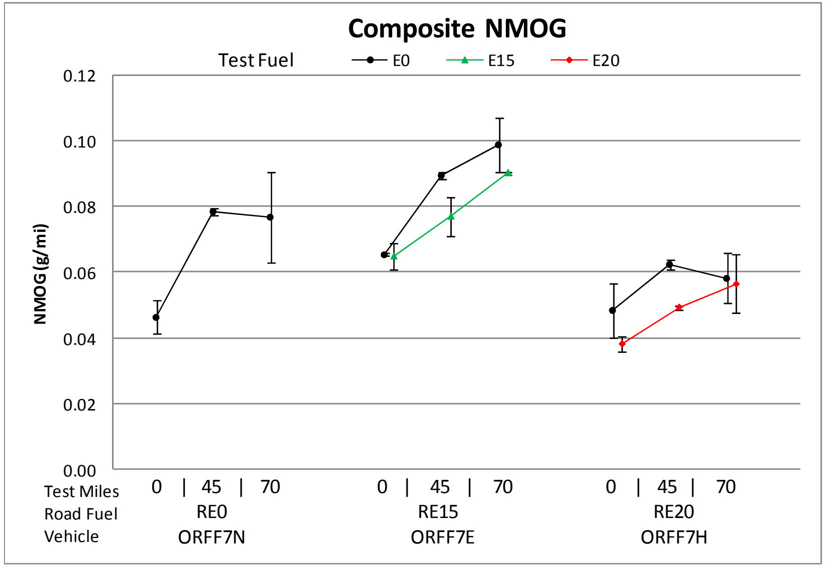
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.007	-0.017	0.003
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.008	-0.018	0.002
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.048*	0.023	0.073
Aging Effect with RE15 (Δg/mi per 100k mi)	0.043*	0.026	0.061
Aging Effect with RE20 (Δg/mi per 100k mi)	0.022*	0.004	0.040

* Indicates estimate is different from zero at the 95% confidence level.

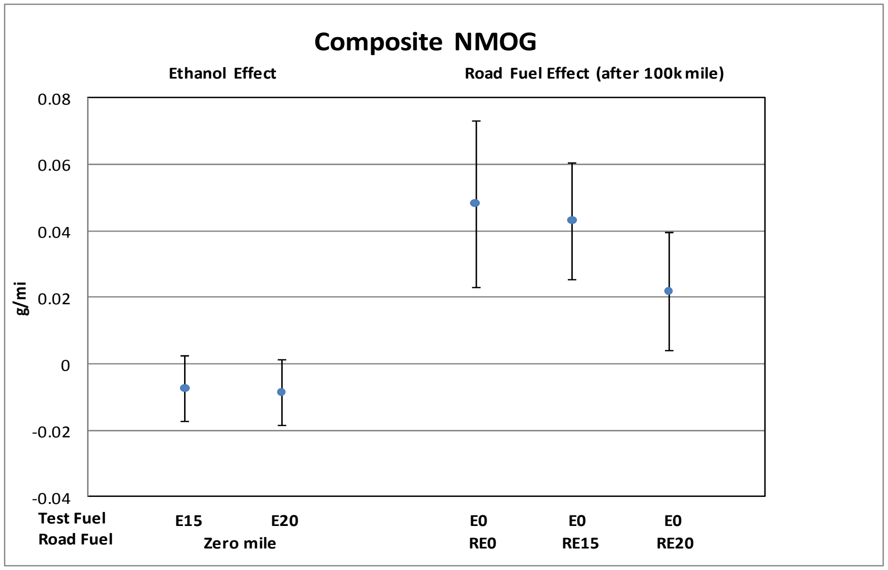
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.09
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.13

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 31k-38k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2005 Ford F150 (Composite Fuel Economy)

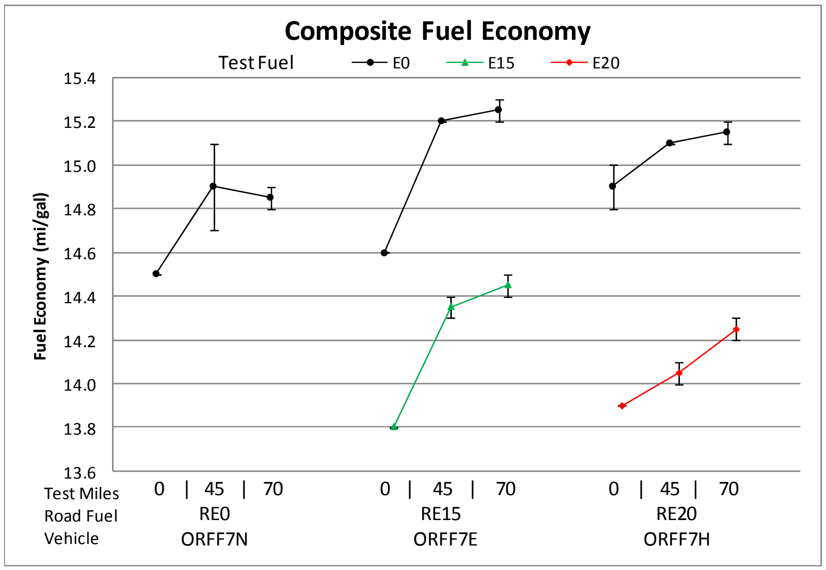
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmi/gal)	-0.816*	-0.987	-0.645
Ethanol Effect (E20 vs. E0) (Δmi/gal)	-0.983*	-1.154	-0.812
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmi/gal per 100k mi)	0.565*	0.132	0.999
Aging Effect with RE15 (Δmi/gal per 100k mi)	1.009*	0.704	1.314
Aging Effect with RE20 (Δmi/gal per 100k mi)	0.438*	0.133	0.743

* Indicates estimate is different from zero at the 95% confidence level.

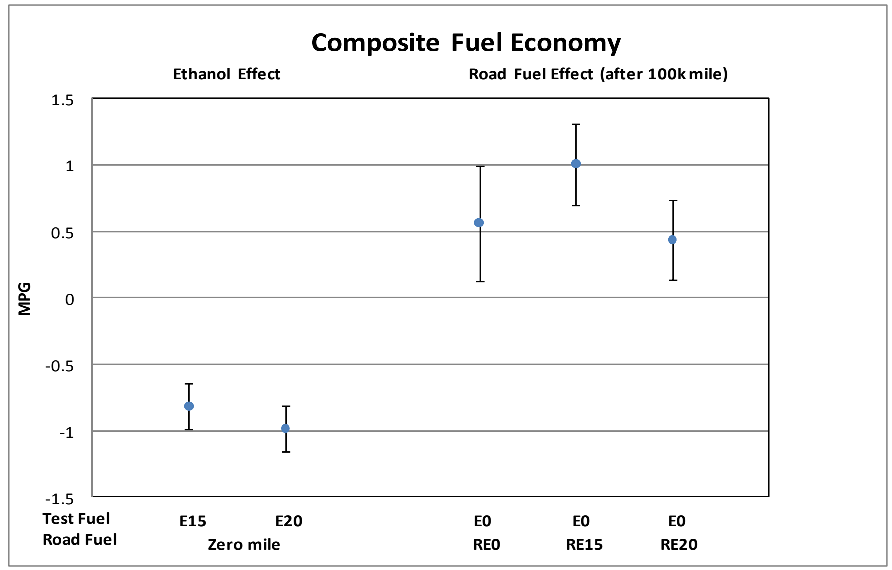
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.02*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.04*

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 31k-38k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2005 Ford F150 (Composite Acetaldehyde)

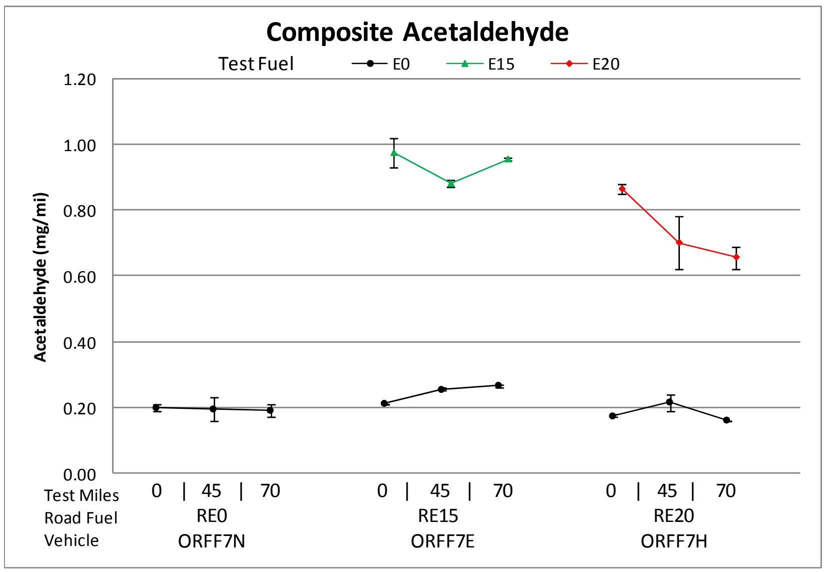
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.655*	0.465	0.846
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.603*	0.431	0.774
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	-0.016	-0.101	0.069
Aging Effect with RE15 (Δmg/mi per 100k mi)	0.037	-0.052	0.126
Aging Effect with RE20 (Δmg/mi per 100k mi)	-0.042	-0.103	0.018

* Indicates estimate is different from zero at the 95% confidence level.

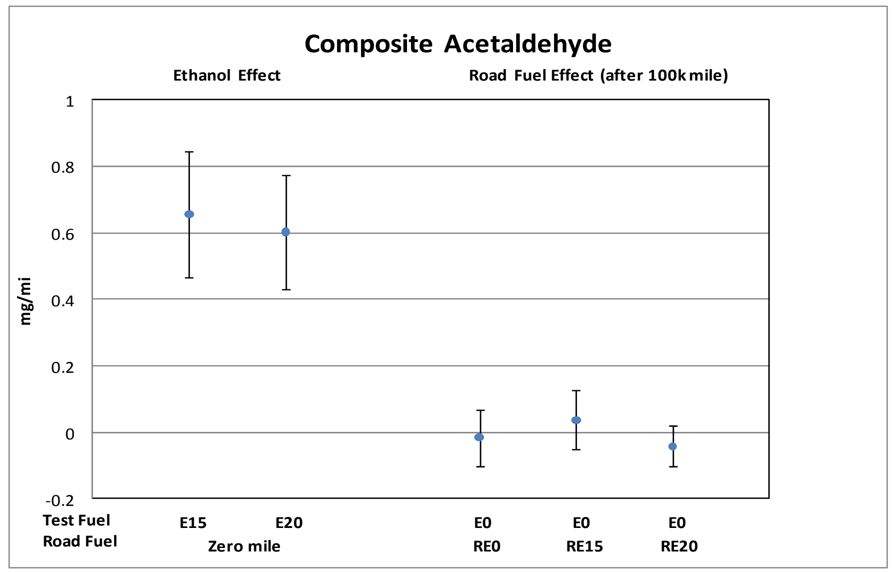
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.73
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.30

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 31k-38k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2005 Ford F150 (Composite Formaldehyde)

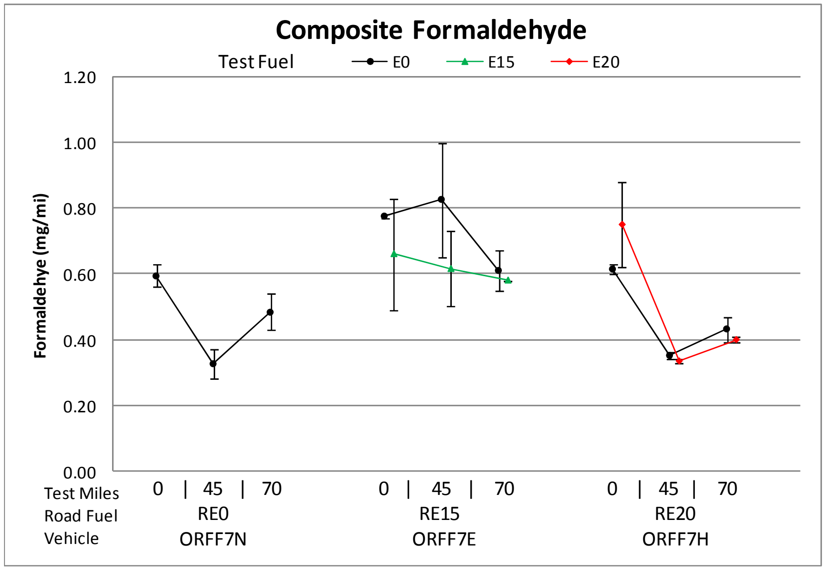
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	-0.127	-0.564	0.310
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.015	-0.362	0.391
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	-0.187	-0.566	0.192
Aging Effect with RE15 (Δmg/mi per 100k mi)	-0.154	-0.650	0.342
Aging Effect with RE20 (Δmg/mi per 100k mi)	-0.348*	-0.654	-0.043

* Indicates estimate is different from zero at the 95% confidence level.

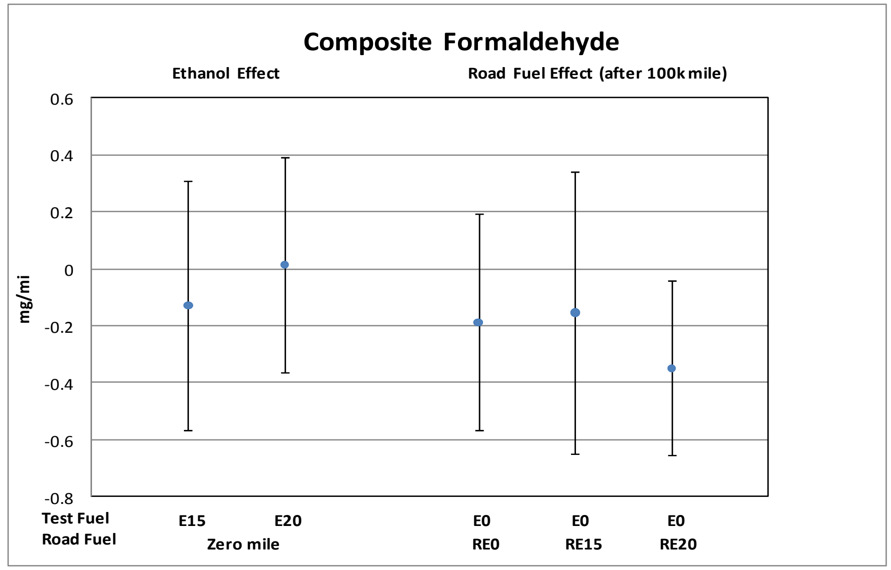
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.65
No Aging Effect with RE0 (Beta0 = 0)	0.39
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.46

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 31k-38k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2005 Ford F150 (Composite CH_4)

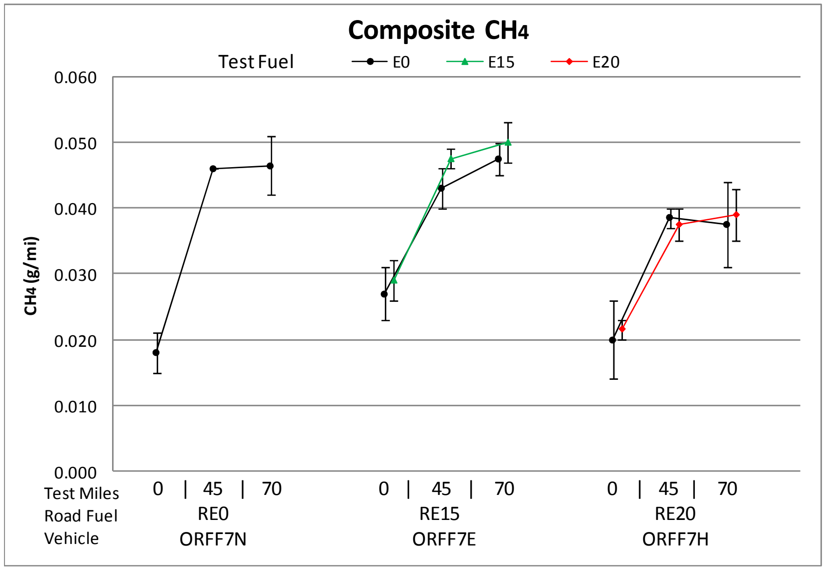
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0030	-0.0051	0.0112
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.0007	-0.0075	0.0089
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0448*	0.0241	0.0656
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0319*	0.0173	0.0465
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0277*	0.0131	0.0423

* Indicates estimate is different from zero at the 95% confidence level.

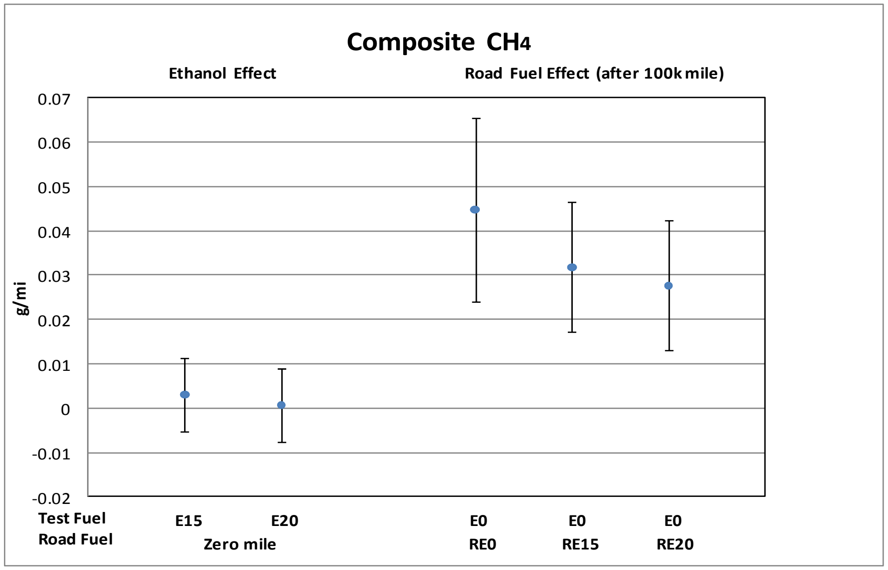
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.68
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.33

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 31k-38k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Saturn Outlook - Composite Emissions Summary

Emisssion Parameter (units)	Ethanol Effect				Aging Effect with RE0		RExx Aging Effect on E0 Emissions				RExx Aging Effect on Exx Emissions			Road and Test Fuel Effects are Additive
	Δ units vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value	Δ units per 100K mi			Overall p-value
Fuels	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0		RE10/E10	RE15/E15	RE20/E20	
CO (g/mi)	NA	-0.104	NA	0.05	0.936*	<0.01*	NA	0.246*	NA	<0.01*	NA	NA	NA	0.10
NOx (g/mi)	NA	-0.003	NA	0.41	0.032*	<0.01*	NA	0.007*	NA	<0.01*	NA	NA	NA	0.77
NMHC (g/mi)	NA	0.000	NA	0.95	0.018*	<0.01*	NA	0.004	NA	0.04*	NA	NA	NA	0.85
NMOG (g/mi)	NA	0.004	NA	0.23	0.019*	<0.01*	NA	0.004	NA	0.04*	NA	NA	NA	0.92
Fuel Econ (mi/gal)	NA	-0.916*	NA	<0.01*	0.279	0.14	NA	0.628*	NA	0.13	NA	NA	NA	0.97
CH_4 (g/mi)	NA	0.0003	NA	0.73	0.0100*	<0.01*	NA	0.0057*	NA	0.04*	NA	NA	NA	0.84

Log-normal model was used. Results are presented as changes in emissions at 0k mile.

Data did not support the assumption of linear effects with mileage.

* Indicates estimate is different from zero at the 95% confidence level.

2009 Saturn Outlook (Composite CO)

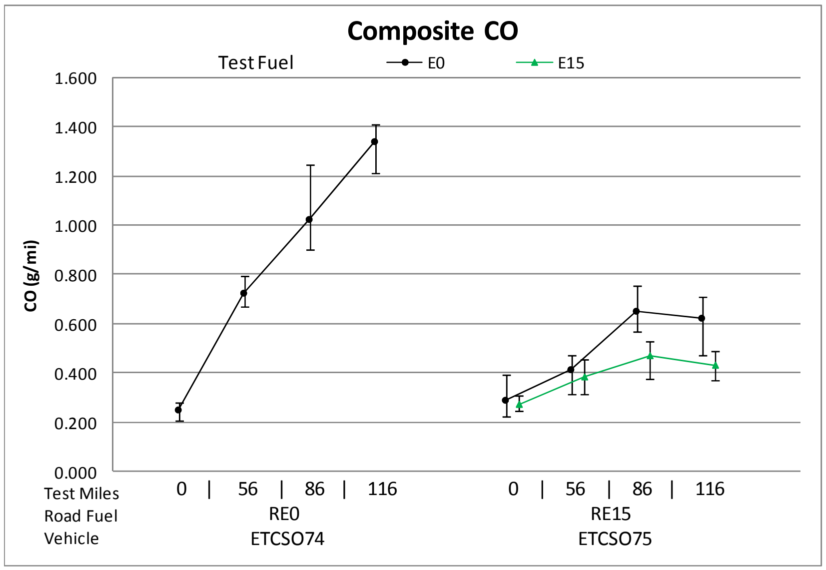
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.104	-0.208	0.001
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.936*	0.764	1.109
Aging Effect with RE15 (Δg/mi per 100k mi)	0.246*	0.124	0.369

* Indicates estimate is different from zero at the 95% confidence level.

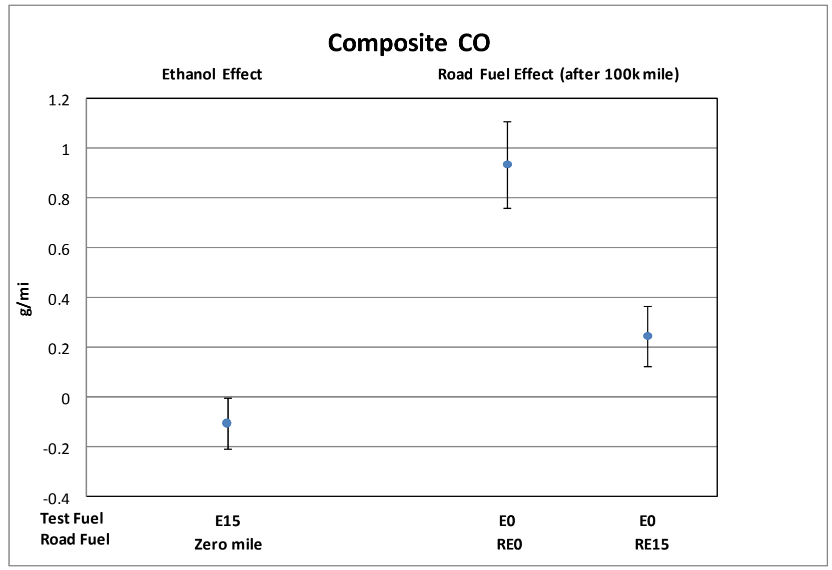
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.05
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	<0.01*

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Saturn Outlook (Composite NOx)

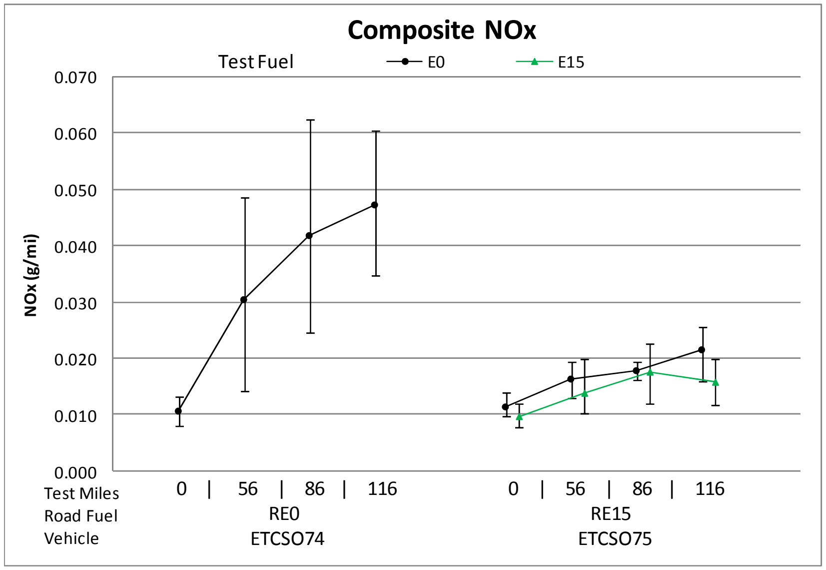
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.003	-0.0086	0.0036
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.032*	0.0231	0.0413
Aging Effect with RE15 (Δg/mi per 100k mi)	0.007*	0.0002	0.0144

* Indicates estimate is different from zero at the 95% confidence level.

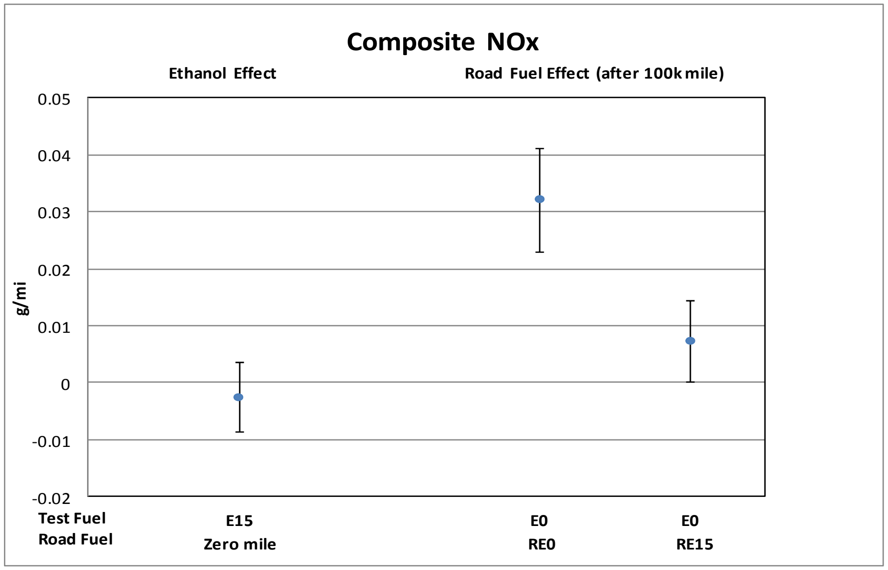
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.41
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	<0.01*

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Saturn Outlook (Composite Nonmethane Hydrocarbons)

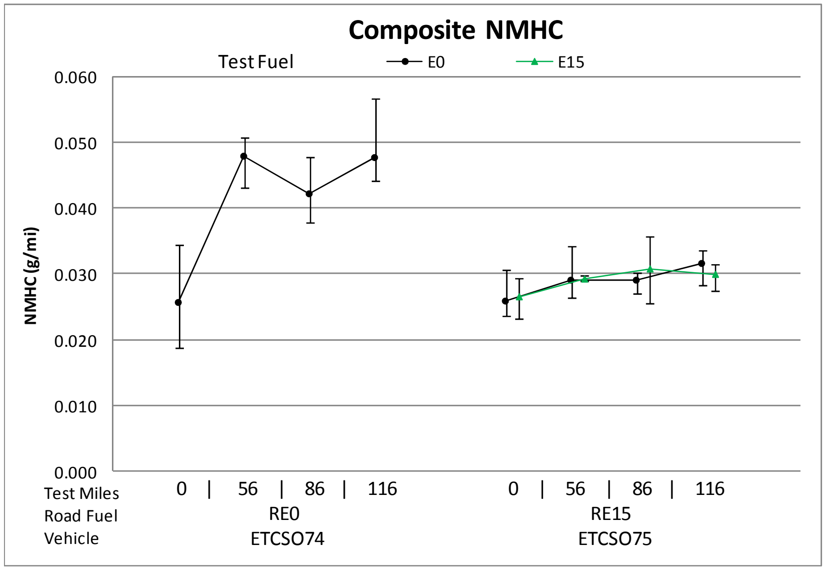
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.000	-0.006	0.006
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.018*	0.008	0.028
Aging Effect with RE15 (Δg/mi per 100k mi)	0.004	-0.003	0.011

* Indicates estimate is different from zero at the 95% confidence level.

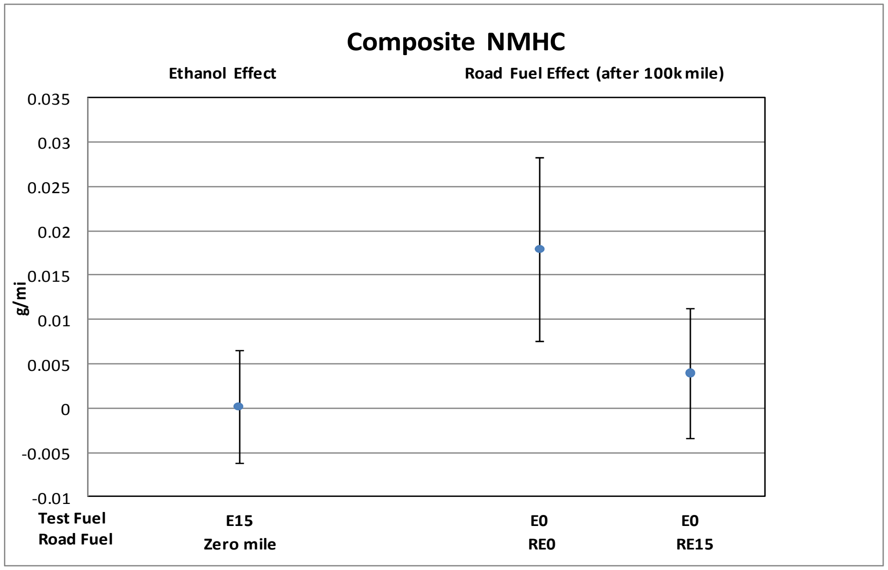
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.95
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.04*

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Saturn Outlook (Composite Nonmethane Organic Gases)

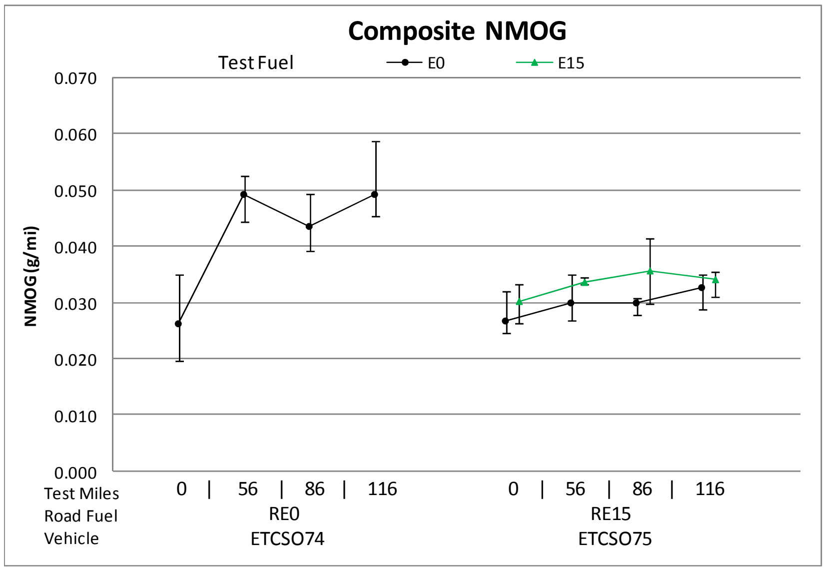
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.004	-0.003	0.010
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.019*	0.008	0.029
Aging Effect with RE15 (Δg/mi per 100k mi)	0.004	-0.003	0.012

* Indicates estimate is different from zero at the 95% confidence level.

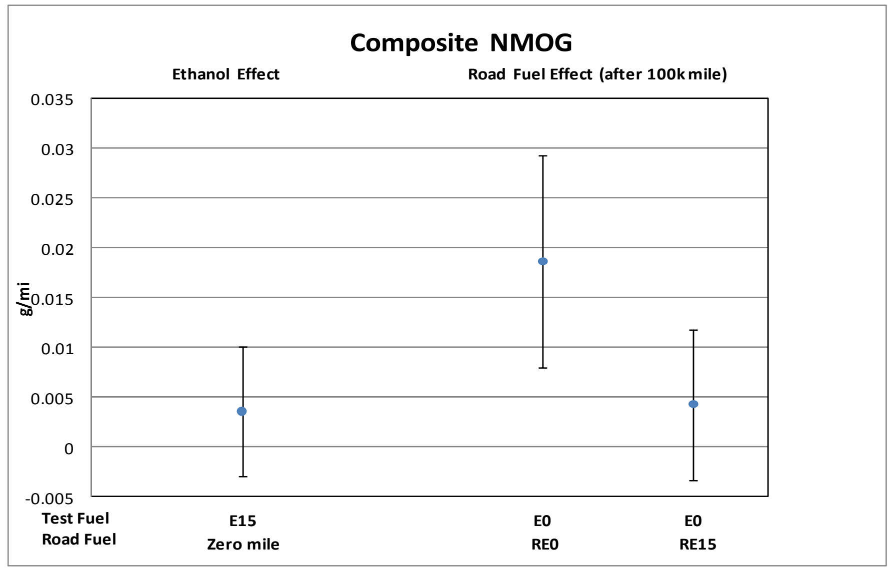
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.23
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.04*

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Saturn Outlook (Composite Fuel Economy)

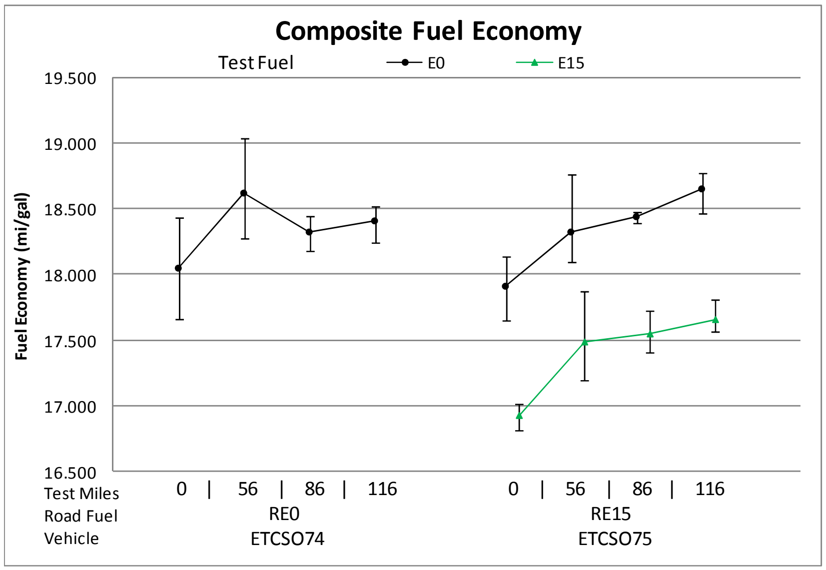
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmi/gal)	-0.916*	-1.163	-0.669
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmi/gal per 100k mi)	0.279	-0.126	0.684
Aging Effect with RE15 (Δmi/gal per 100k mi)	0.628*	0.339	0.917

* Indicates estimate is different from zero at the 95% confidence level.

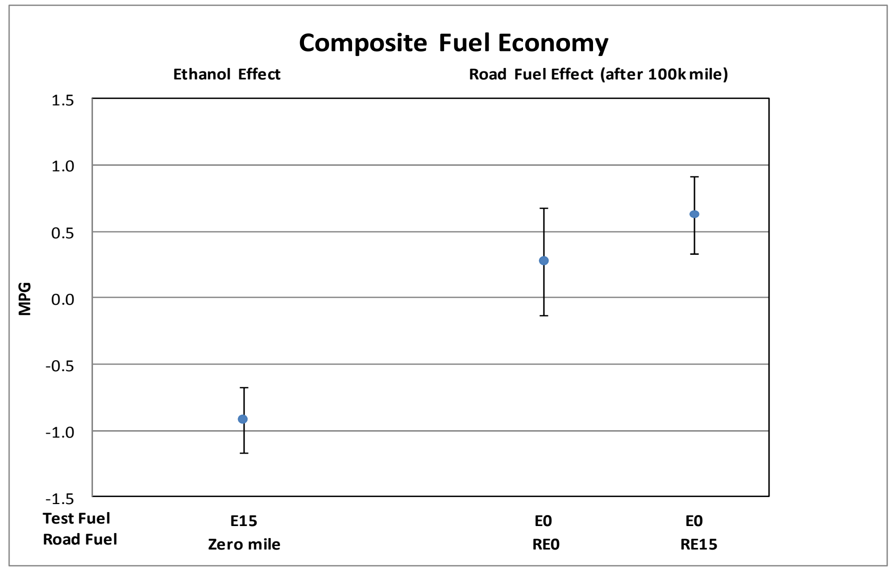
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.14
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.13

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Saturn Outlook (Composite CH_4)

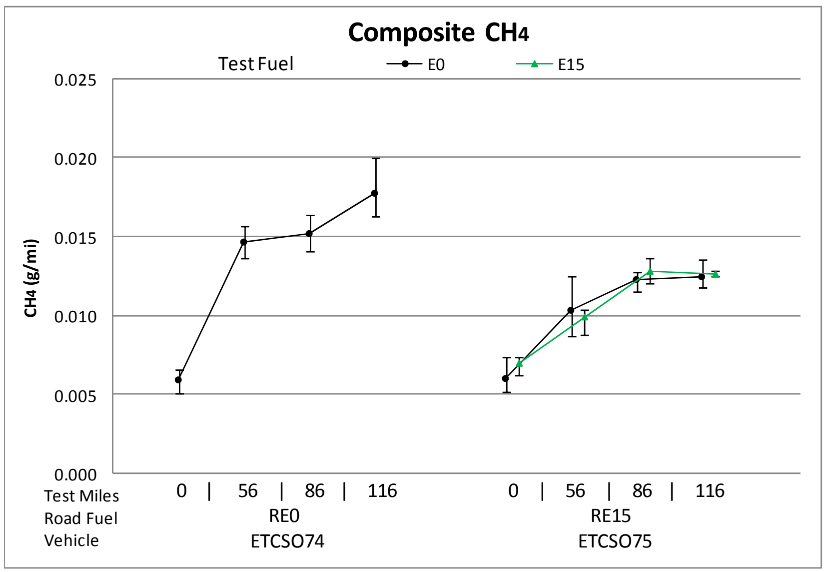
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0003	-0.0017	0.0023
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0100*	0.0068	0.0132
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0057*	0.0034	0.0080

* Indicates estimate is different from zero at the 95% confidence level.

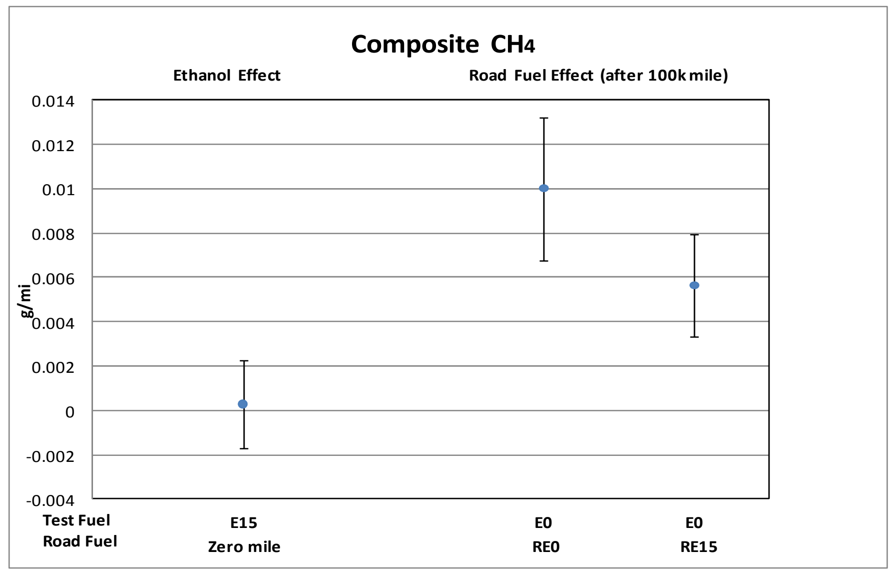
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.73
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.04*

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Toyota Camry - Composite Emissions Summary

Emisssion Parameter (units)	Ethanol Effect				Aging Effect with RE0		RExx Aging Effect on E0 Emissions				RExx Aging Effect on Exx Emissions			Road and Test Fuel Effects are Additive
	Δ units vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value	Δ units per 100K mi			Overall p-value
Fuels	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0		RE10/E10	RE15/E15	RE20/E20	
CO (g/mi)	NA	0.006	NA	0.75	0.120*	<0.01*	NA	0.051	NA	0.12	NA	NA	NA	0.62
NOx (g/mi)	NA	0.006	NA	0.12	0.031*	<0.01*	NA	0.016*	NA	0.07	NA	NA	NA	0.19
NMHC (g/mi)	NA	0.0003	NA	0.89	0.0122*	0.01*	NA	0.0045	NA	0.13	NA	NA	NA	0.13
NMOG (g/mi)	NA	0.0037	NA	0.16	0.0123*	0.01*	NA	0.0047	NA	0.15	NA	NA	NA	0.18
Fuel Econ (mi/gal)	NA	-1.497*	NA	<0.01*	0.113	0.80	NA	-0.020	NA	0.81	NA	NA	NA	0.85
CH_4 (g/mi)	NA	0.0001	NA	0.92	0.0078*	<0.01*	NA	0.0055*	NA	0.17	NA	NA	NA	0.50

Log-normal model was used. Results are presented as changes in emissions at 0k mile.

Data did not support the assumption of linear effects with mileage.

* Indicates estimate is different from zero at the 95% confidence level.

a test "115937" is identified as an outlier and excluded from the analysis

2009 Toyota Camry (Composite CO)

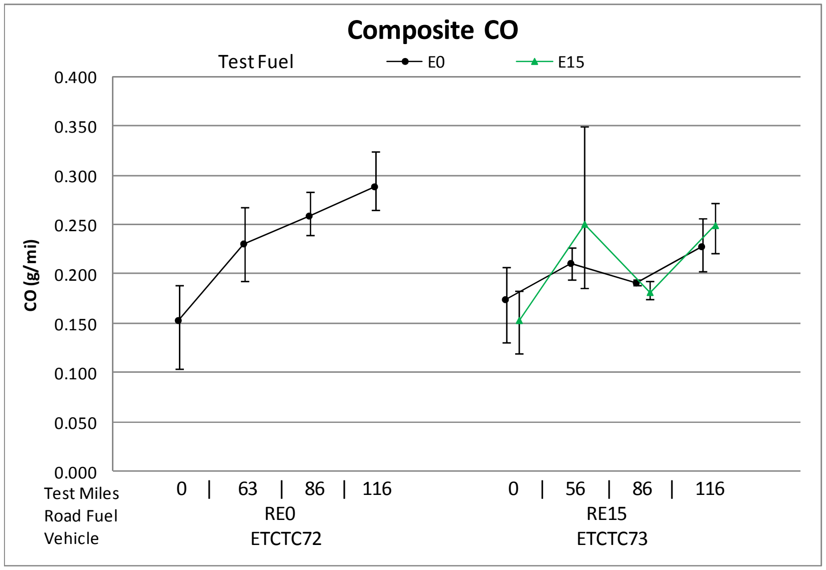
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.006	-0.039	0.052
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.120*	0.046	0.194
Aging Effect with RE15 (Δg/mi per 100k mi)	0.051	-0.003	0.104

* Indicates estimate is different from zero at the 95% confidence level.

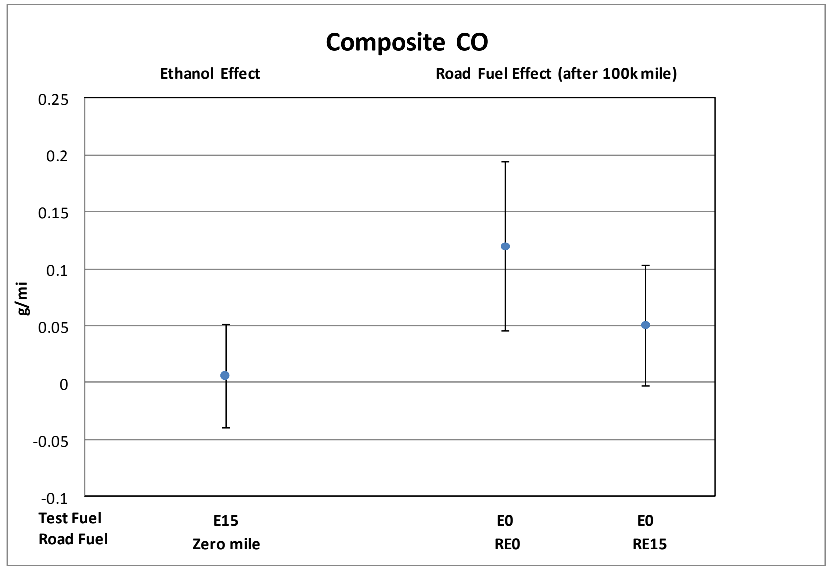
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.75
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.12

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Toyota Camry (Composite NOx)

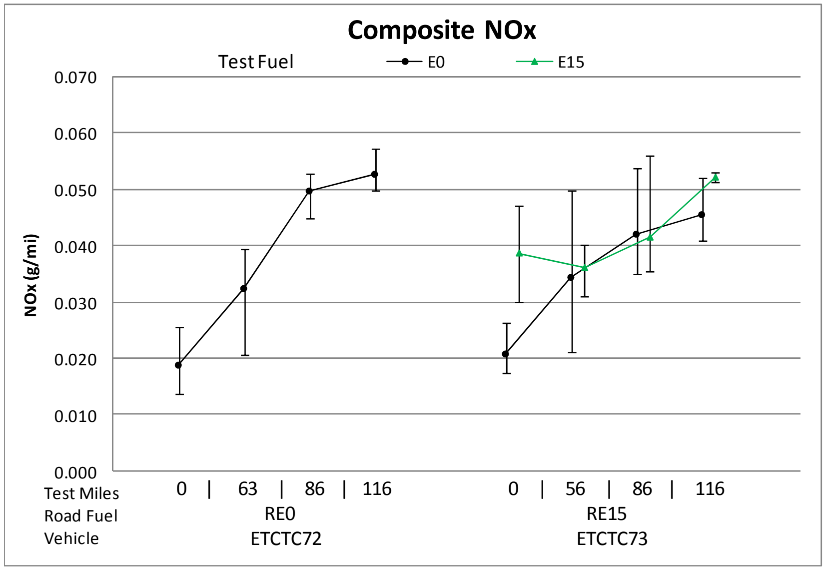
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.006	-0.002	0.015
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.031*	0.018	0.045
Aging Effect with RE15 (Δg/mi per 100k mi)	0.016*	0.006	0.026

* Indicates estimate is different from zero at the 95% confidence level.

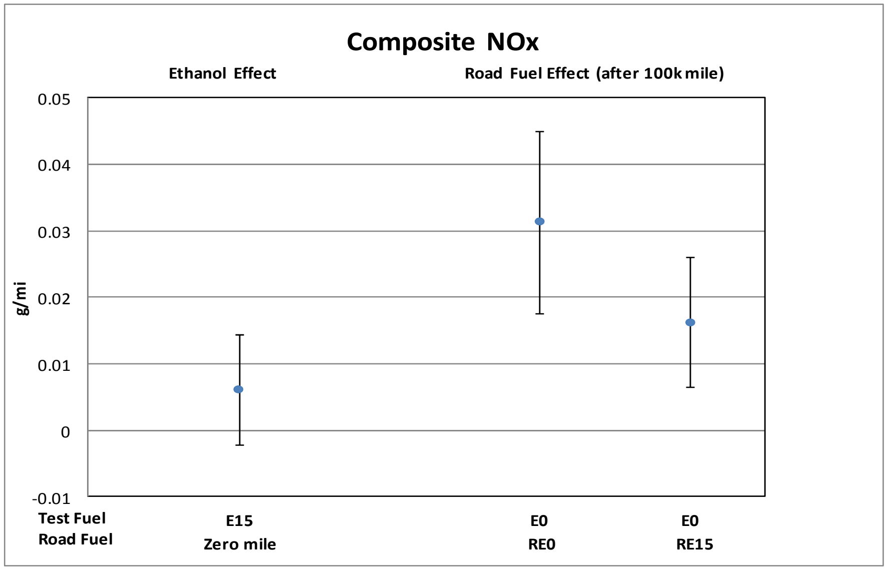
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.12
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.07

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Toyota Camry (Composite Nonmethane Hydrocarbons)

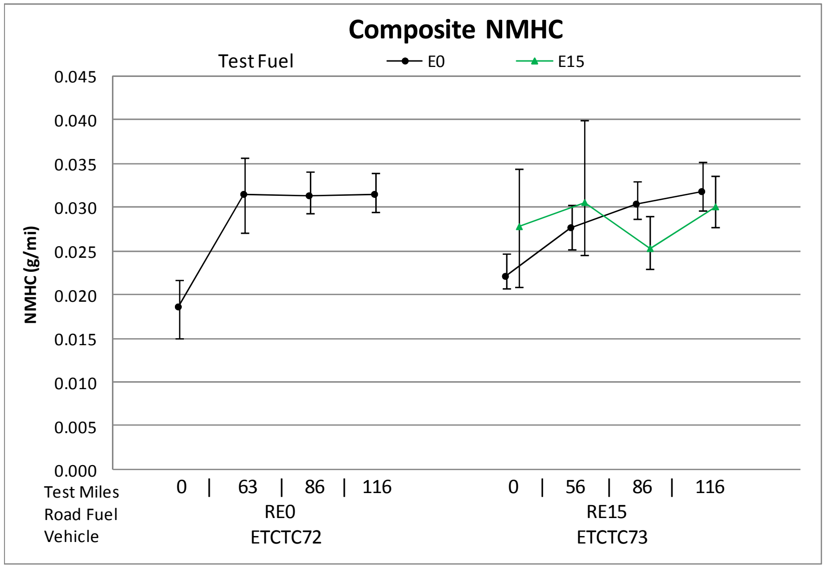
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0003	-0.0049	0.0056
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0122*	0.0035	0.0208
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0045	-0.0017	0.0107

* Indicates estimate is different from zero at the 95% confidence level.

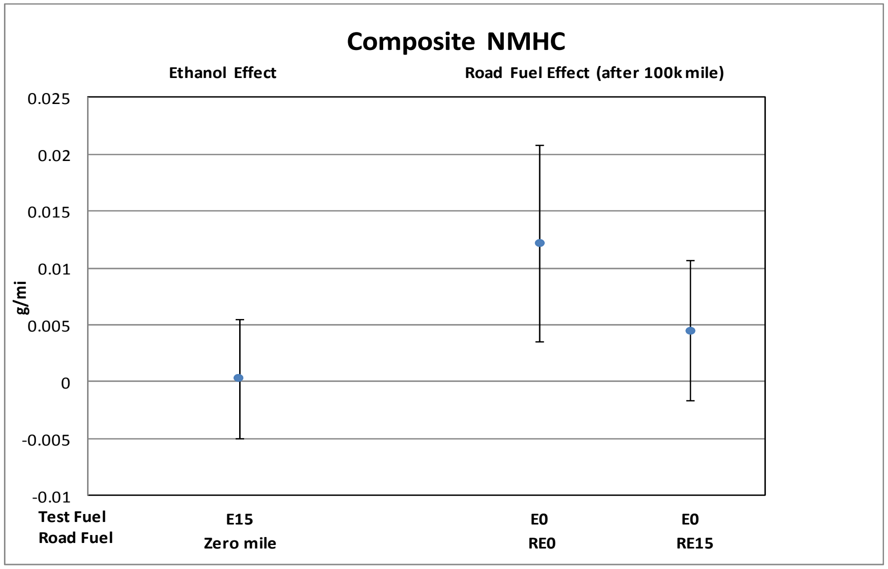
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.89
No Aging Effect with RE0 (Beta0 = 0)	0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.13

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Toyota Camry (Composite Nonmethane Organic Gases)

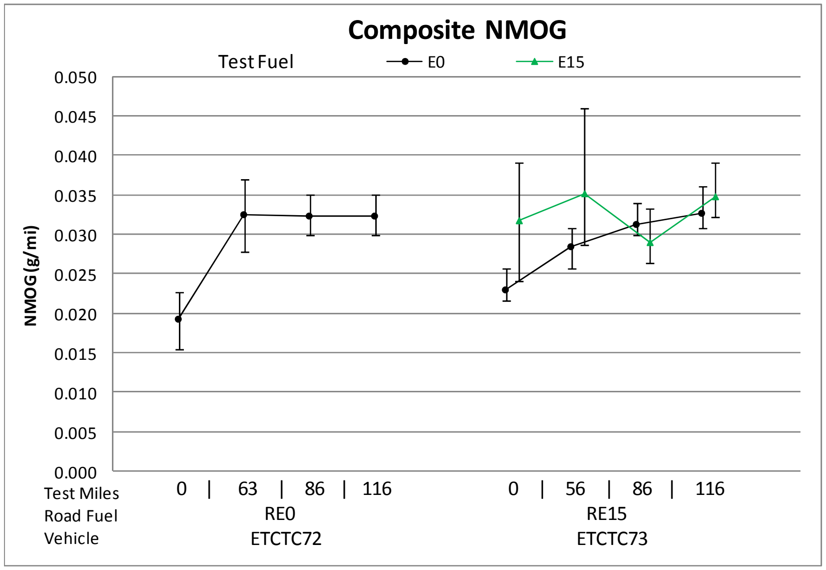
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0037	-0.0018	0.0092
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0123*	0.0033	0.0214
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0047	-0.0018	0.0112

* Indicates estimate is different from zero at the 95% confidence level.

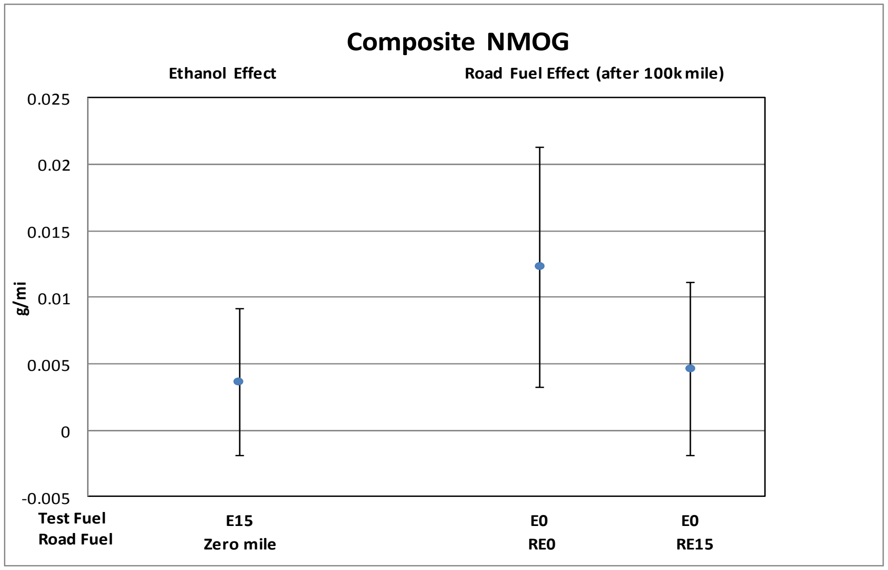
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.16
No Aging Effect with RE0 (Beta0 = 0)	0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.15

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Toyota Camry (Composite Fuel Economy)

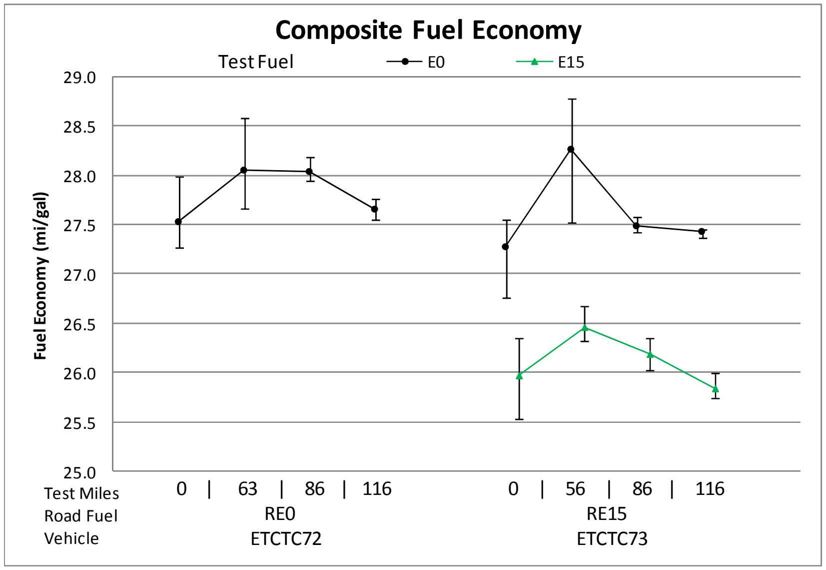
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmi/gal)	-1.497*	-2.127	-0.867
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmi/gal per 100k mi)	0.113	-0.919	1.145
Aging Effect with RE15 (Δmi/gal per 100k mi)	-0.020	-0.759	0.719

* Indicates estimate is different from zero at the 95% confidence level.

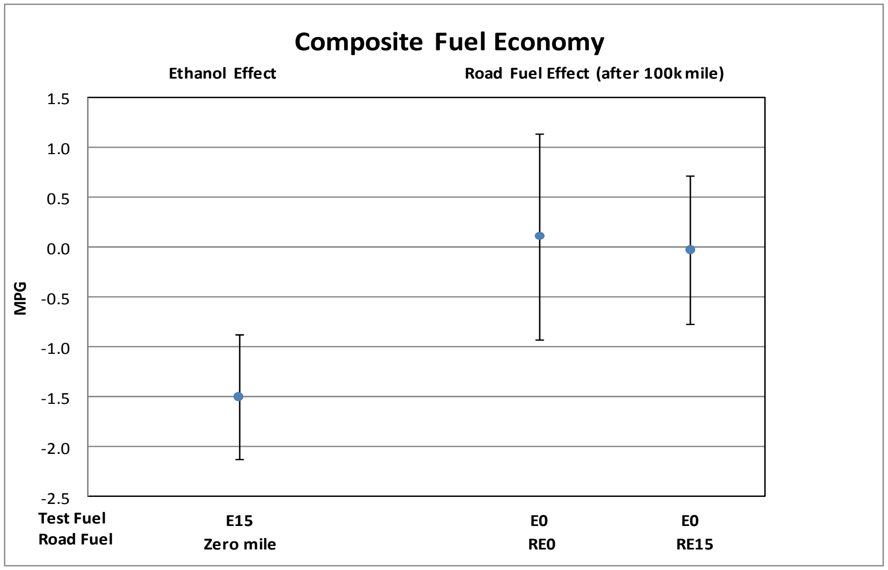
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.80
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.81

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Toyota Camry (Composite CH_4)

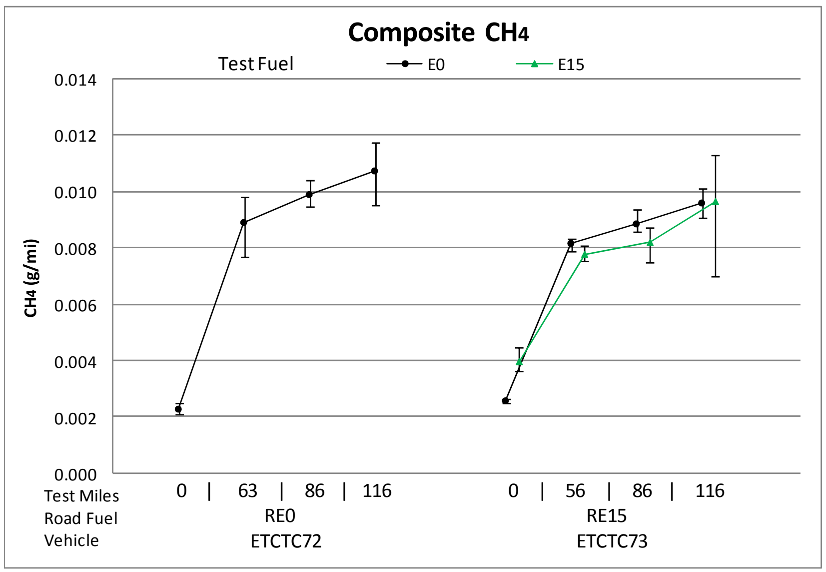
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0001	-0.0017	0.0018
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0078*	0.0049	0.0106
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0055*	0.0034	0.0075

* Indicates estimate is different from zero at the 95% confidence level.

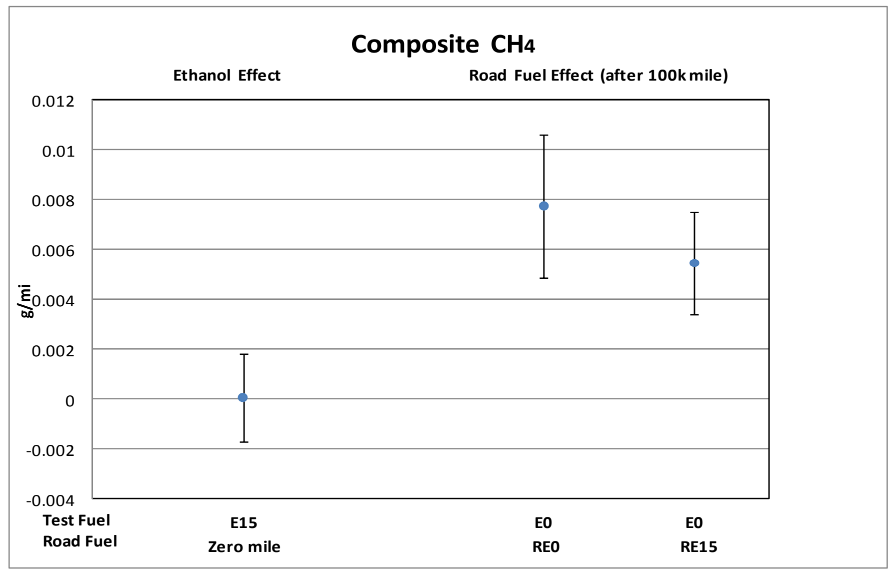
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.92
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.17

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Ford Focus - Composite Emissions Summary

Emisssion Parameter (units)	Ethanol Effect				Aging Effect with RE0		RExx Aging Effect on E0 Emissions				RExx Aging Effect on Exx Emissions			Road and Test Fuel Effects are Additive
	Δ units vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value	Δ units per 100K mi			Overall p-value
Fuels	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0		RE10/E10	RE15/E15	RE20/E20	
CO (g/mi)	NA	-0.039	NA	0.70	0.366	0.05	NA	0.224	NA	0.49	NA	NA	NA	0.93
NOx (g/mi)	NA	0.005	NA	0.65	0.084*	<0.01*	NA	0.042*	NA	0.08	NA	NA	NA	0.33
NMHC (g/mi)	NA	-0.009	NA	0.07	-0.012	0.13	NA	-0.001	NA	0.23	NA	NA	NA	0.68
NMOG (g/mi)	NA	-0.006	NA	0.21	-0.012	0.13	NA	-0.001	NA	0.23	NA	NA	NA	0.67
Fuel Econ (mi/gal)	NA	-1.350*	NA	<0.01*	1.127	0.10	NA	0.263	NA	0.27	NA	NA	NA	0.60
CH4 (g/mi)	NA	-0.0006	NA	0.48	0.0022	0.13	NA	0.0041*	NA	0.25	NA	NA	NA	0.46

Log-normal model was used. Results are presented as changes in emissions at 0k mile.

Data did not support the assumption of linear effects with mileage.

* Indicates estimate is different from zero at the 95% confidence level.

2009 Ford Focus (Composite CO)

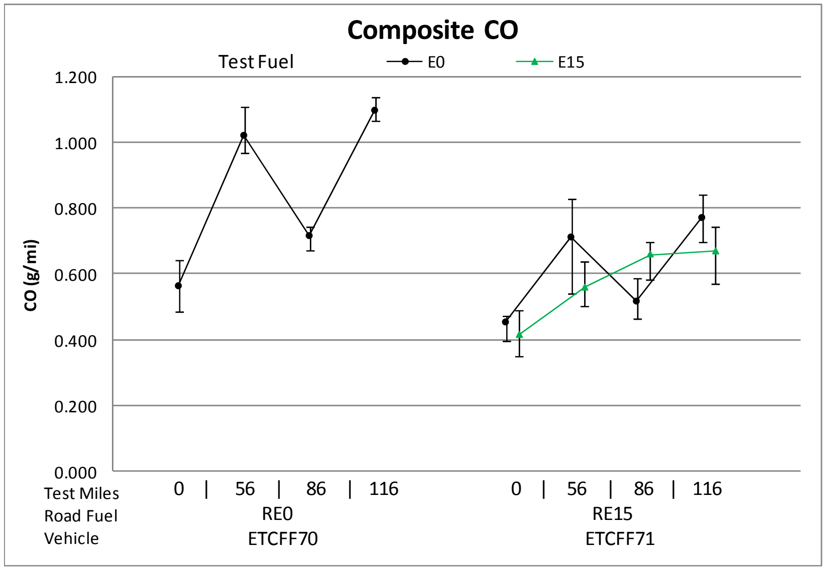
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.039	-0.267	0.189
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.366	-0.010	0.742
Aging Effect with RE15 (Δg/mi per 100k mi)	0.224	-0.043	0.491

* Indicates estimate is different from zero at the 95% confidence level.

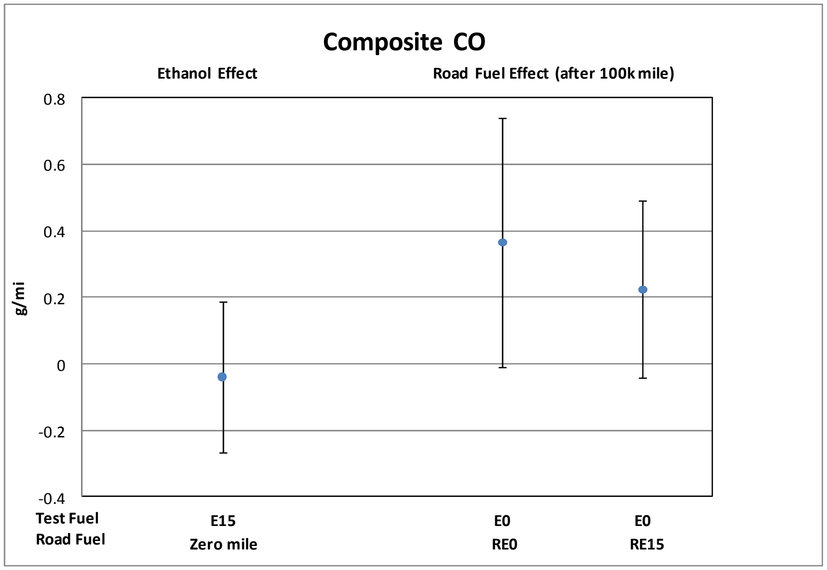
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.70
No Aging Effect with RE0 (Beta0 = 0)	0.05
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.49

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Ford Focus (Composite NO_x)

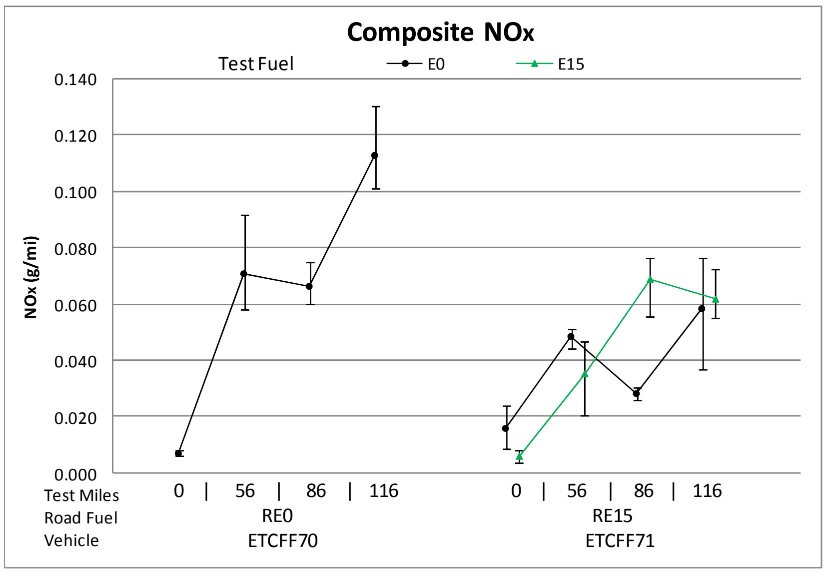
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.005	-0.019	0.029
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.084*	0.044	0.124
Aging Effect with RE15 (Δg/mi per 100k mi)	0.042*	0.014	0.070

* Indicates estimate is different from zero at the 95% confidence level.

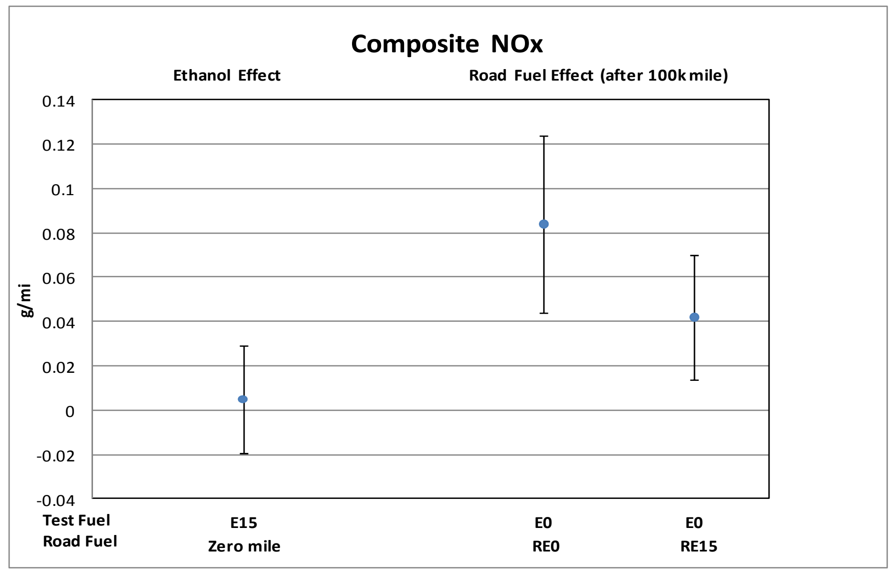
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.65
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.08

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Ford Focus (Composite Nonmethane Hydrocarbons)

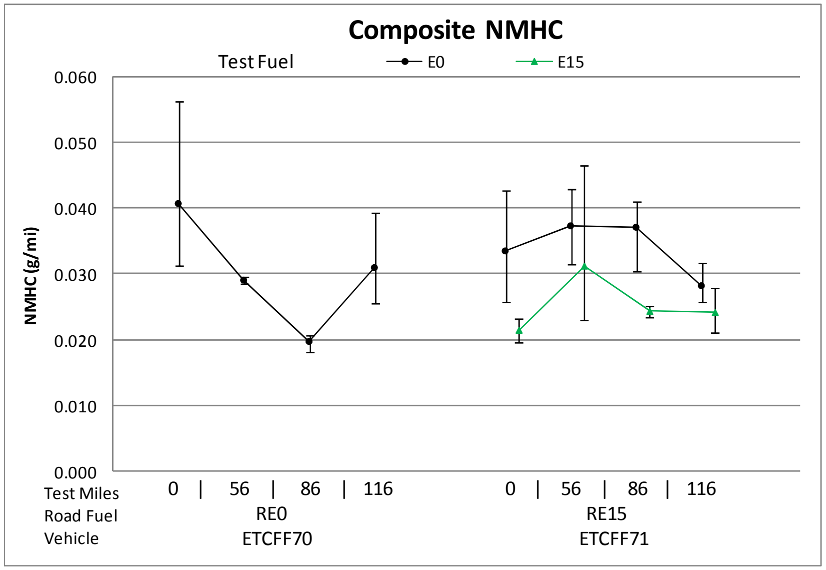
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.009	-0.018	0.001
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	-0.012	-0.027	0.004
Aging Effect with RE15 (Δg/mi per 100k mi)	-0.001	-0.012	0.010

* Indicates estimate is different from zero at the 95% confidence level.

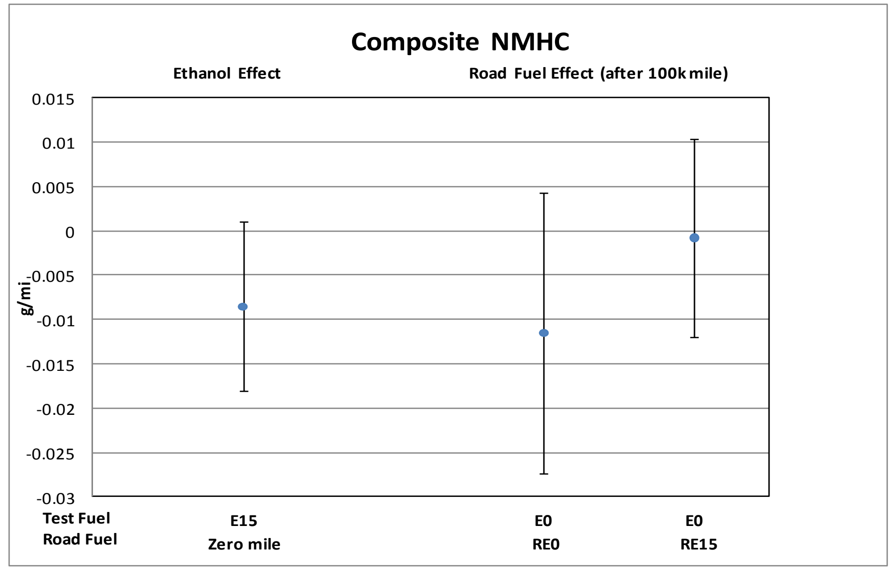
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.07
No Aging Effect with RE0 (Beta0 = 0)	0.13
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.23

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Ford Focus (Composite Nonmethane Organic Gases)

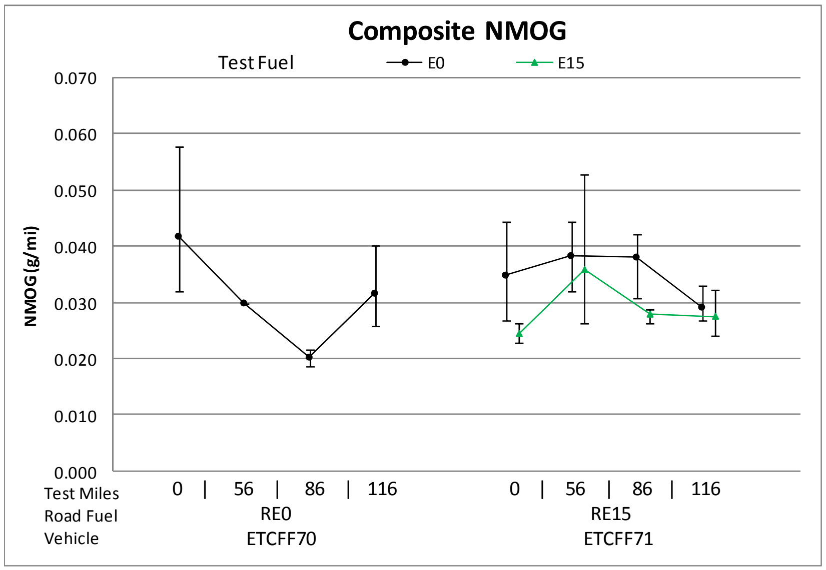
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.006	-0.016	0.004
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	-0.012	-0.029	0.004
Aging Effect with RE15 (Δg/mi per 100k mi)	-0.001	-0.013	0.011

* Indicates estimate is different from zero at the 95% confidence level.

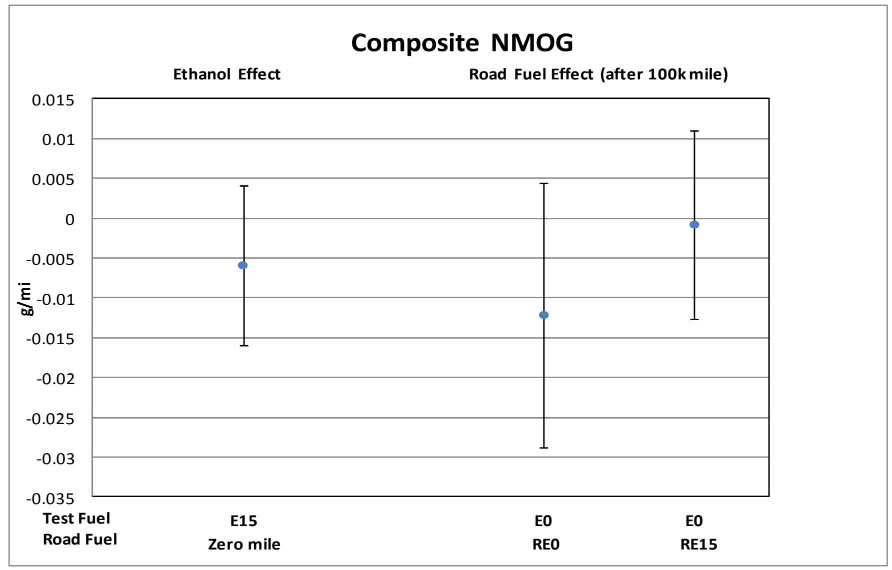
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.21
No Aging Effect with RE0 (Beta0 = 0)	0.13
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.23

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Ford Focus (Composite Fuel Economy)

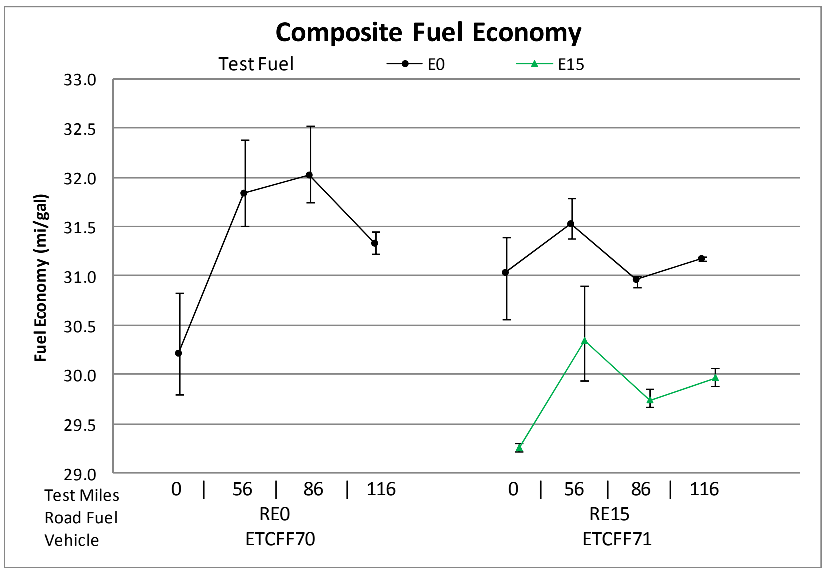
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmi/gal)	-1.350*	-2.188	-0.513
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmi/gal per 100k mi)	1.127	-0.255	2.508
Aging Effect with RE15 (Δmi/gal per 100k mi)	0.263	-0.718	1.245

* Indicates estimate is different from zero at the 95% confidence level.

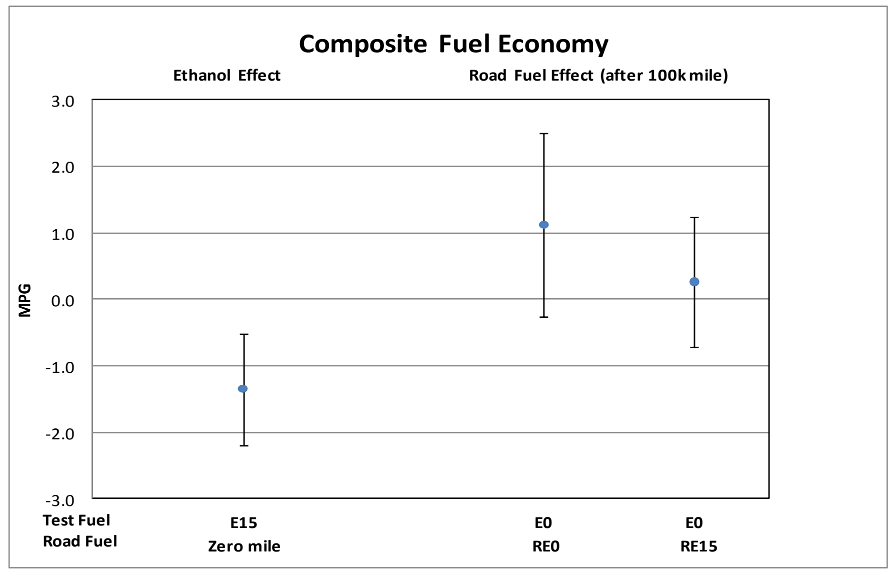
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.10
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.27

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Ford Focus (Composite CH_4)

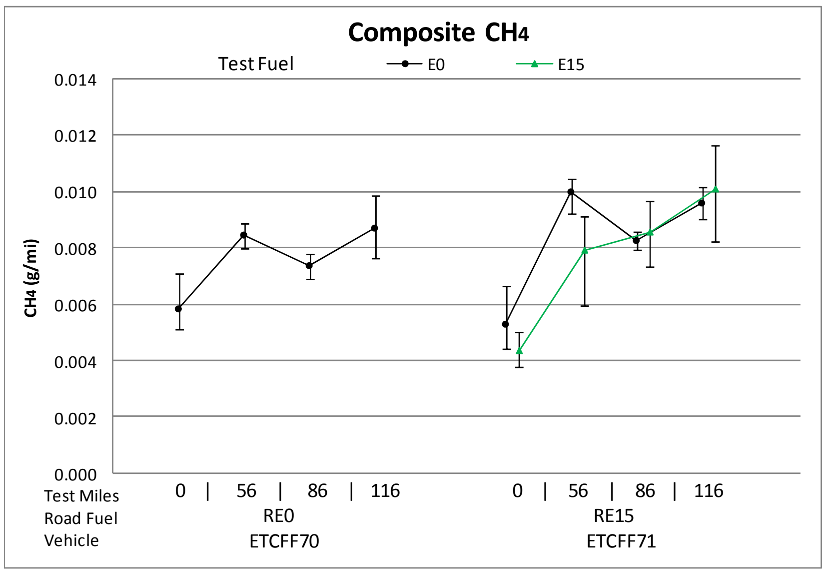
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.0006	-0.0024	0.0013
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0022	-0.0009	0.0052
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0041*	0.0020	0.0063

* Indicates estimate is different from zero at the 95% confidence level.

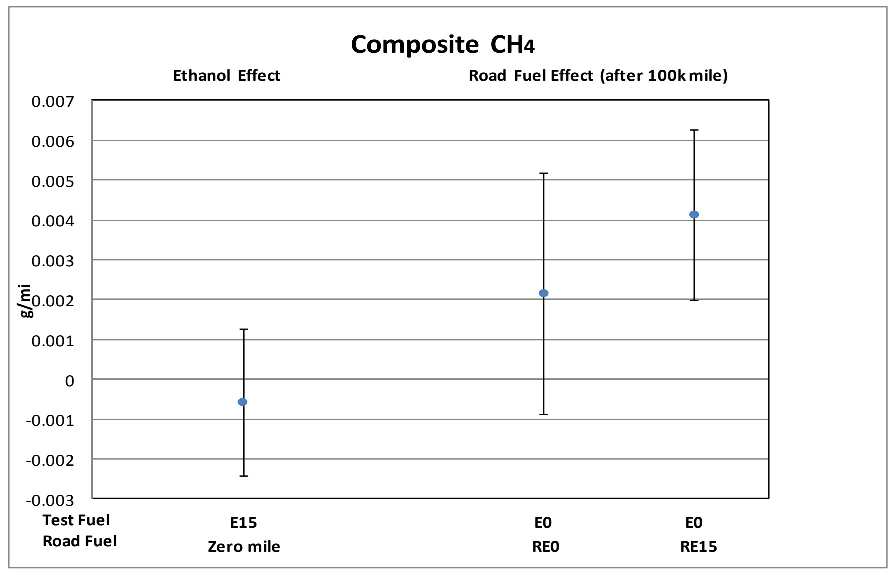
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.48
No Aging Effect with RE0 (Beta0 = 0)	0.13
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.25

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Honda Odyssey - Composite Emissions Summary

Emisssion Parameter (units)	Ethanol Effect				Aging Effect with RE0		RExx Aging Effect on E0 Emissions				RExx Aging Effect on Exx Emissions			Road and Test Fuel Effects are Additive
	Δ units vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value	Δ units per 100K mi			Overall p-value
Fuels	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0		RE10/E10	RE15/E15	RE20/E20	
CO (g/mi)	NA	-0.010	NA	0.76	0.354*	<0.01*	NA	-0.001	NA	0.01*	NA	NA	NA	0.85
NOx (g/mi)	NA	0.001	NA	0.76	0.058*	<0.01*	NA	0.029*	NA	0.01*	NA	NA	NA	0.82
NMHC (g/mi)	NA	-0.000	NA	0.97	0.023*	<0.01*	NA	0.001	NA	<0.01*	NA	NA	NA	0.91
NMOG (g/mi)	NA	0.003	NA	0.17	0.024*	<0.01*	NA	0.002	NA	<0.01*	NA	NA	NA	0.91
Fuel Econ (mi/gal)	NA	-0.839*	NA	0.03*	0.518	0.33	NA	0.617	NA	0.88	NA	NA	NA	0.97
CH4 (g/mi)	NA	0.0007	NA	0.41	0.0085*	<0.01*	NA	0.0025*	NA	<0.01*	NA	NA	NA	0.83

Log-normal model was used. Results are presented as changes in emissions at 0k mile.

Data did not support the assumption of linear effects with mileage.

* Indicates estimate is different from zero at the 95% confidence level.

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2009 Honda Odyssey (Composite CO)

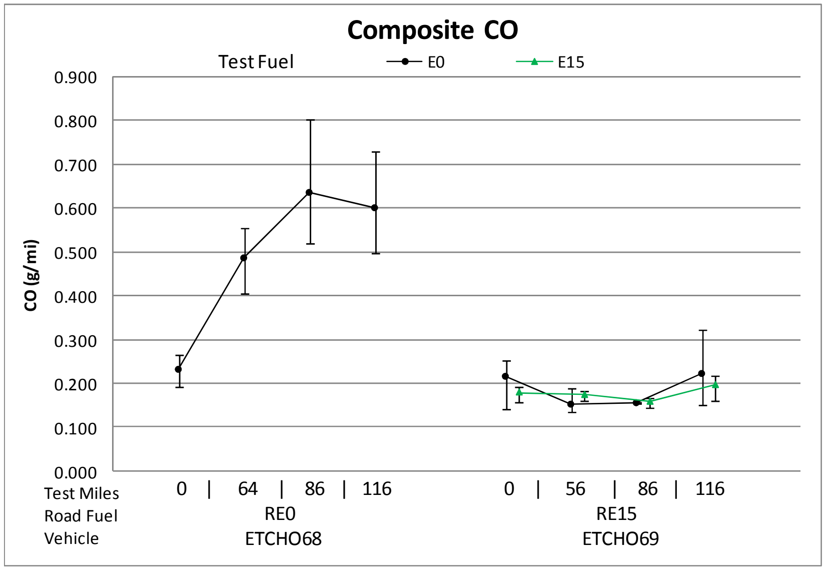
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.010	-0.088	0.067
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.354*	0.225	0.482
Aging Effect with RE15 (Δg/mi per 100k mi)	-0.001	-0.092	0.090

* Indicates estimate is different from zero at the 95% confidence level.

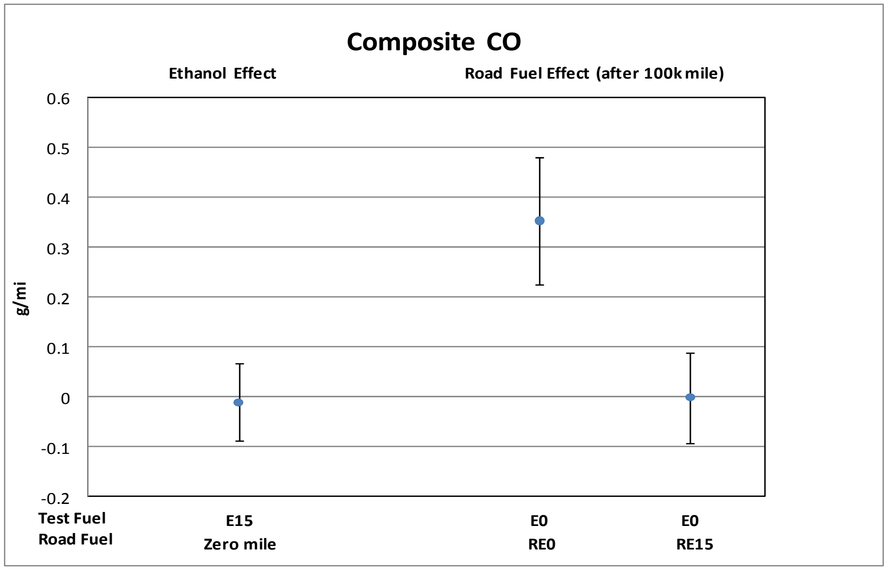
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.76
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.01*

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Honda Odyssey (Composite NO_x)

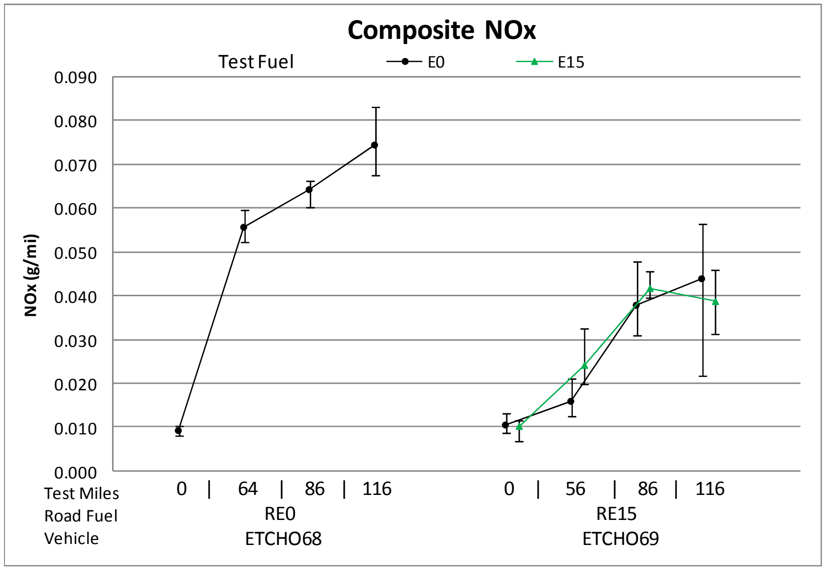
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.001	-0.009	0.011
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.058*	0.041	0.075
Aging Effect with RE15 (Δg/mi per 100k mi)	0.029*	0.017	0.041

* Indicates estimate is different from zero at the 95% confidence level.

Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.76
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.01*

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 4k



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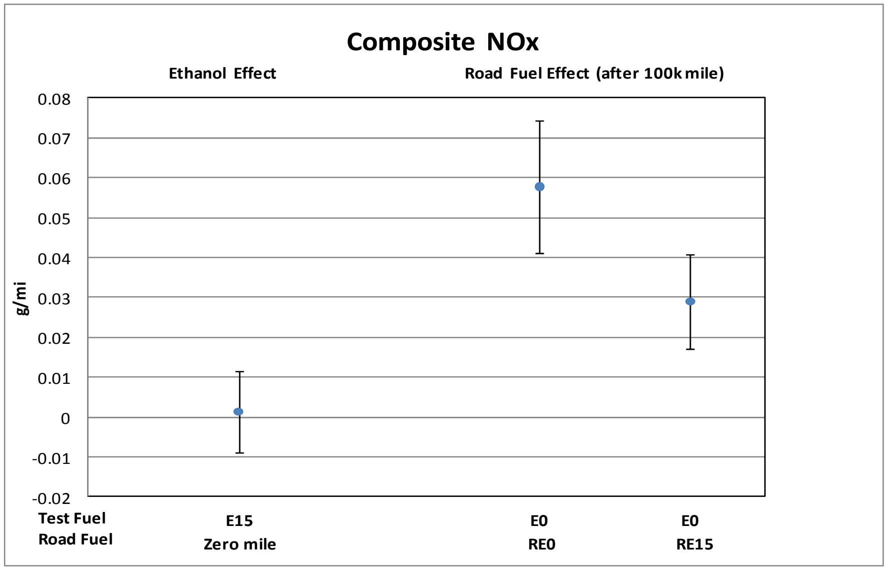


Error bars represent 95% confidence intervals on the estimated effects

2009 Honda Odyssey (Composite Nonmethane Hydrocarbons)

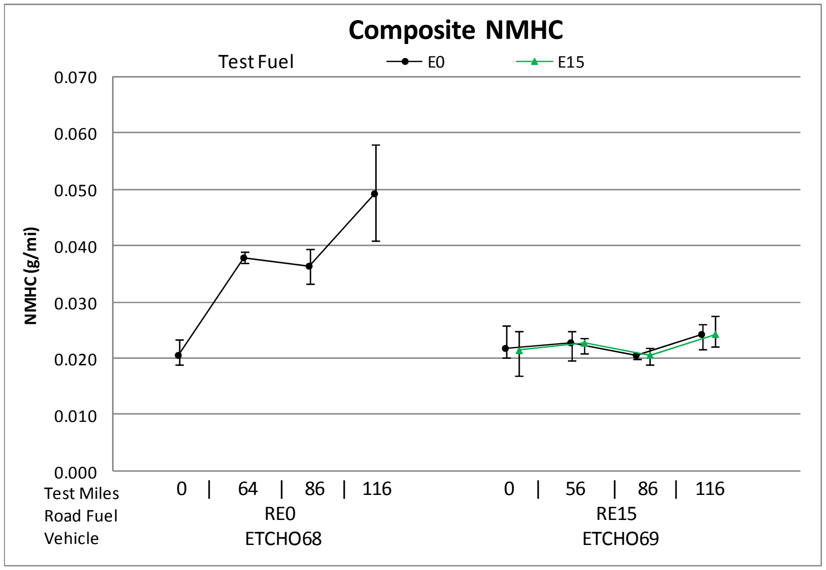
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.000	-0.004	0.004
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.023*	0.017	0.030
Aging Effect with RE15 (Δg/mi per 100k mi)	0.001	-0.003	0.006

* Indicates estimate is different from zero at the 95% confidence level.

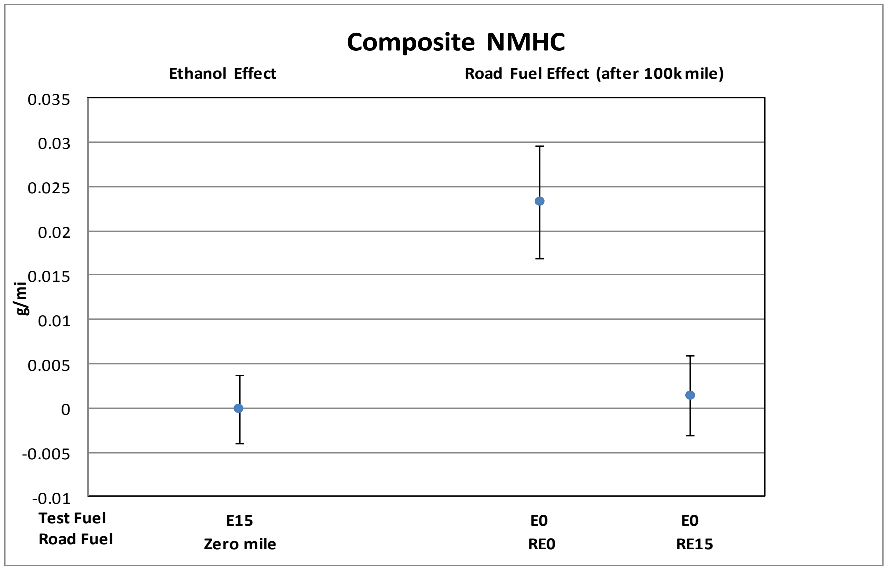
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.97
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	<0.01*

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Honda Odyssey (Composite Nonmethane Organic Gases)

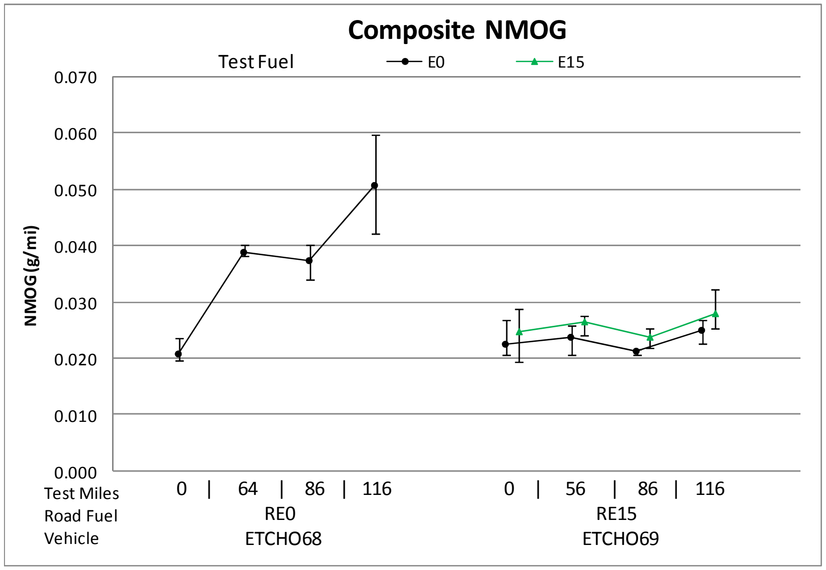
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.003	-0.001	0.007
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.024*	0.018	0.031
Aging Effect with RE15 (Δg/mi per 100k mi)	0.002	-0.003	0.006

* Indicates estimate is different from zero at the 95% confidence level.

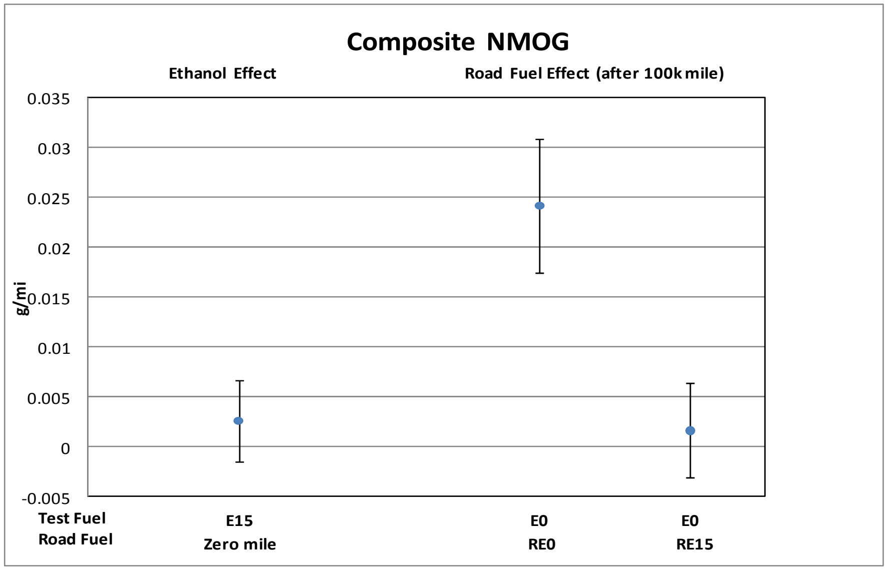
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.17
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	<0.01*

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Honda Odyssey (Composite Fuel Economy)

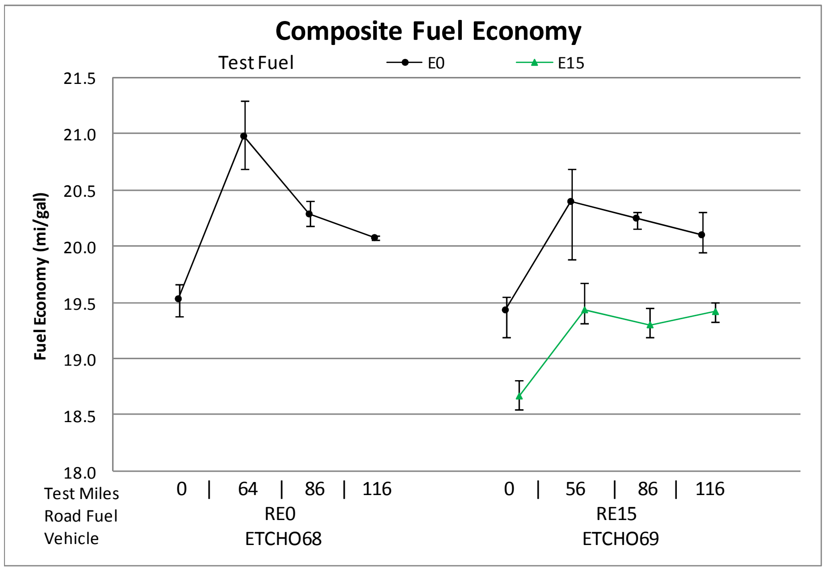
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmi/gal)	-0.839*	-1.552	-0.125
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmi/gal per 100k mi)	0.518	-0.665	1.701
Aging Effect with RE15 (Δmi/gal per 100k mi)	0.617	-0.219	1.453

* Indicates estimate is different from zero at the 95% confidence level.

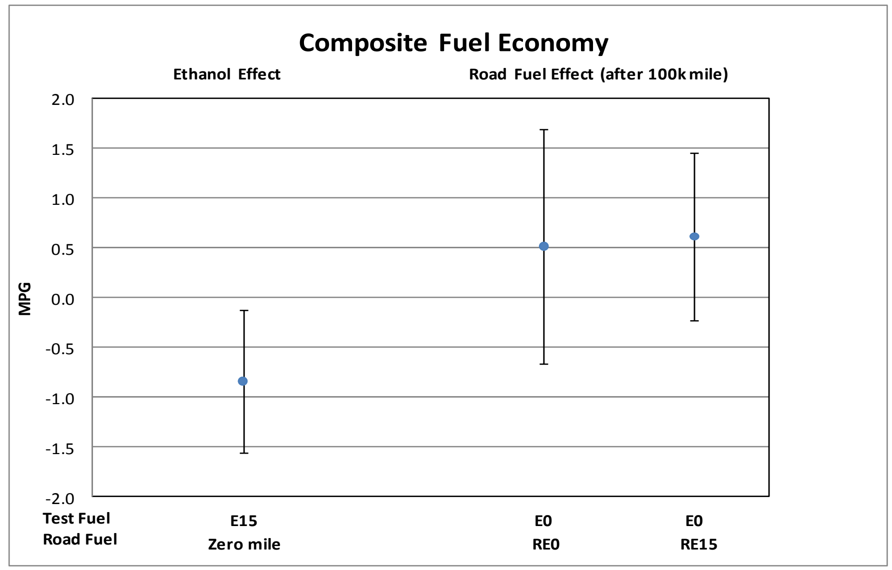
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.03*
No Aging Effect with RE0 (Beta0 = 0)	0.33
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.88

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2009 Honda Odyssey (Composite CH_4)

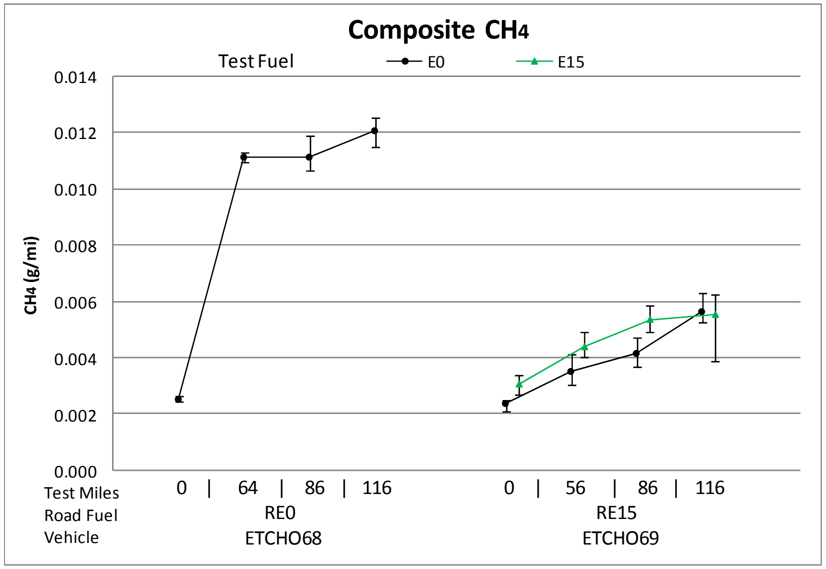
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0007	-0.0011	0.0025
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0085*	0.0055	0.0115
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0025*	0.0004	0.0046

* Indicates estimate is different from zero at the 95% confidence level.

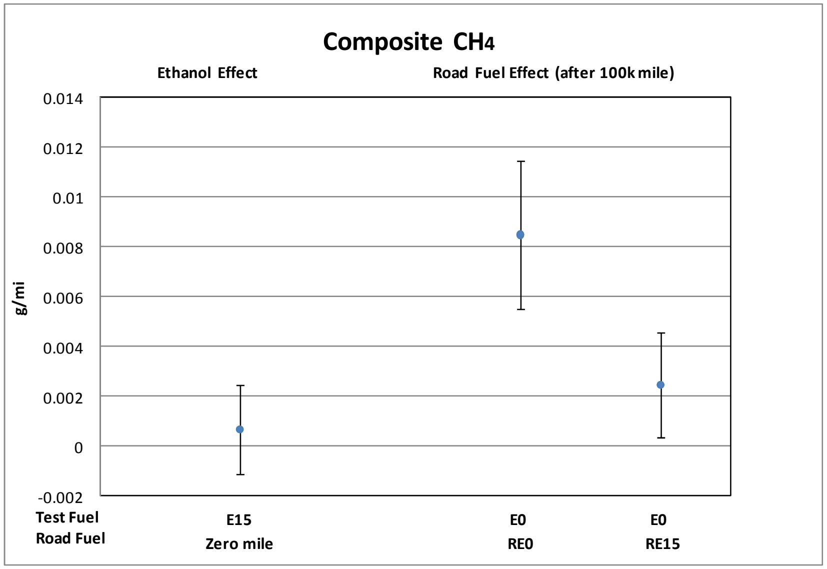
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.41
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	<0.01*

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 4k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2000 Chevrolet Silverado - Composite Emissions Summary

Emisssion Parameter (units)	Ethanol Effect				Aging Effect with RE0		RExx Aging Effect on E0 Emissions				RExx Aging Effect on Exx Emissions			Road and Test Fuel Effects are Additive
	Δ units vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value	Δ units per 100K mi			Overall p-value
Fuels	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0		RE10/E10	RE15/E15	RE20/E20	
CO (g/mi)	NA	-0.457*	-0.230	0.03*	0.703	0.21	NA	-0.089	0.789	0.23	NA	NA	NA	0.74
NOx (g/mi)	NA	-0.002	0.025	0.76	0.479*	<0.01*	NA	0.204*	0.345*	0.21	NA	NA	NA	0.90
NMHC (g/mi)	NA	-0.026	-0.022	0.12	0.069	0.21	NA	-0.049	0.037	0.15	NA	NA	NA	0.82
NMOG (g/mi)	NA	-0.0085	-0.0000	0.84	0.0715	0.21	NA	-0.0518	0.0426	0.14	NA	NA	NA	0.81
Fuel Econ (mi/gal)	NA	-0.727*	-0.829*	<0.01*	0.594	0.35	NA	1.201*	0.230	0.29	NA	NA	NA	0.74
Ethanol (mg/mi)[##]	NA	10.453*	14.629*	<0.01*	-0.000	1.00	NA	2.003	4.930	0.76	NA	NA	NA	NA
Acetaldehyde (mg/mi)[#]	NA	2.967*	3.356*	<0.01*	1.489	0.27	NA	-0.013	-0.058	0.55	NA	NA	NA	0.97
Formaldehyde (mg/mi)[##]	NA	0.324	0.566	0.18	4.363*	<0.01*	NA	0.414	-0.391	0.02*	NA	NA	NA	NA
CH_4 (g/mi)	NA	0.0016	0.0044*	<0.01*	0.0130*	<0.01*	NA	0.0049	0.0119*	0.15	NA	NA	NA	0.78

Log-normal model was used. Results are presented as changes in emissions at 0k mile.

Data did not support the assumption of linear effects with mileage.

* Indicates estimate is different from zero at the 95% confidence level.

2000 Chevrolet Silverado (Composite CO)

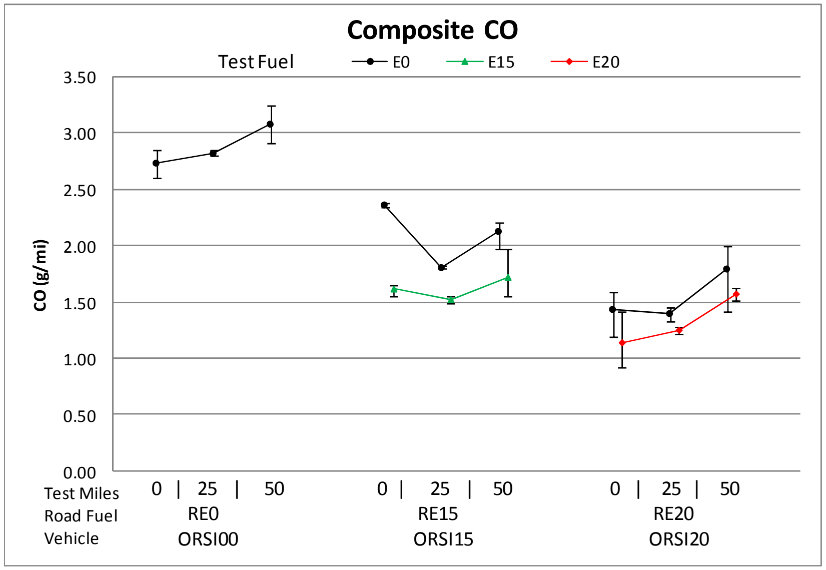
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.457*	-0.798	-0.115
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.230	-0.570	0.111
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.703	-0.489	1.895
Aging Effect with RE15 (Δg/mi per 100k mi)	-0.089	-0.917	0.739
Aging Effect with RE20 (Δg/mi per 100k mi)	0.789	-0.046	1.624

* Indicates estimate is different from zero at the 95% confidence level.

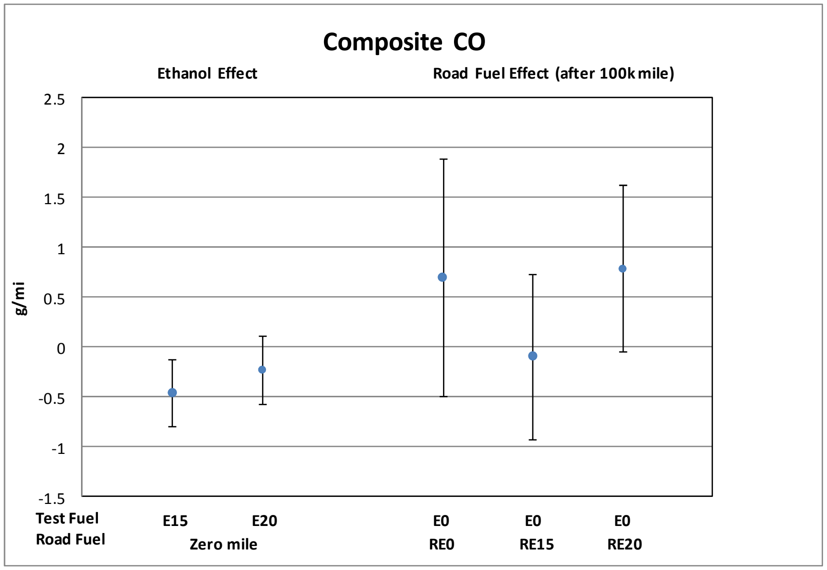
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.03*
No Aging Effect with RE0 (Beta0 = 0)	0.21
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.23

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 111k-115k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2000 Chevrolet Silverado (Composite NOx)

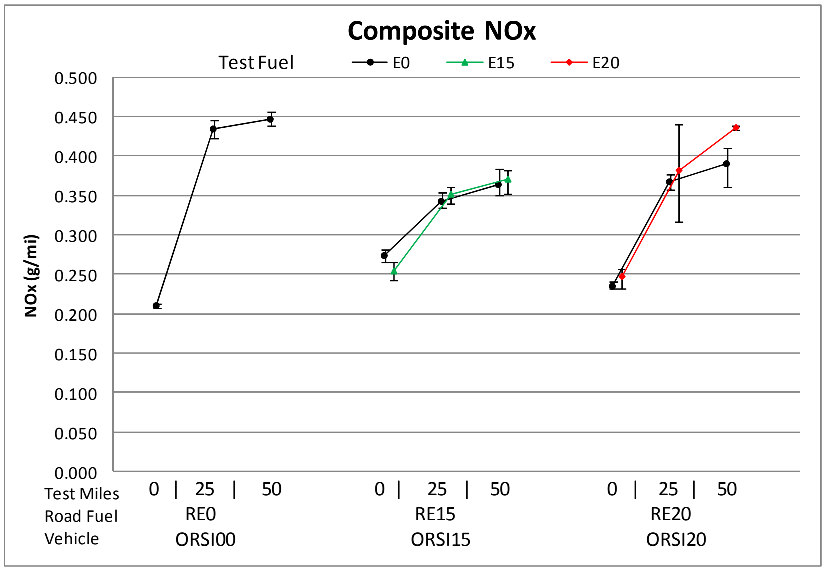
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.002	-0.082	0.078
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.025	-0.055	0.105
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.479*	0.199	0.758
Aging Effect with RE15 (Δg/mi per 100k mi)	0.204*	0.008	0.399
Aging Effect with RE20 (Δg/mi per 100k mi)	0.345*	0.148	0.542

* Indicates estimate is different from zero at the 95% confidence level.

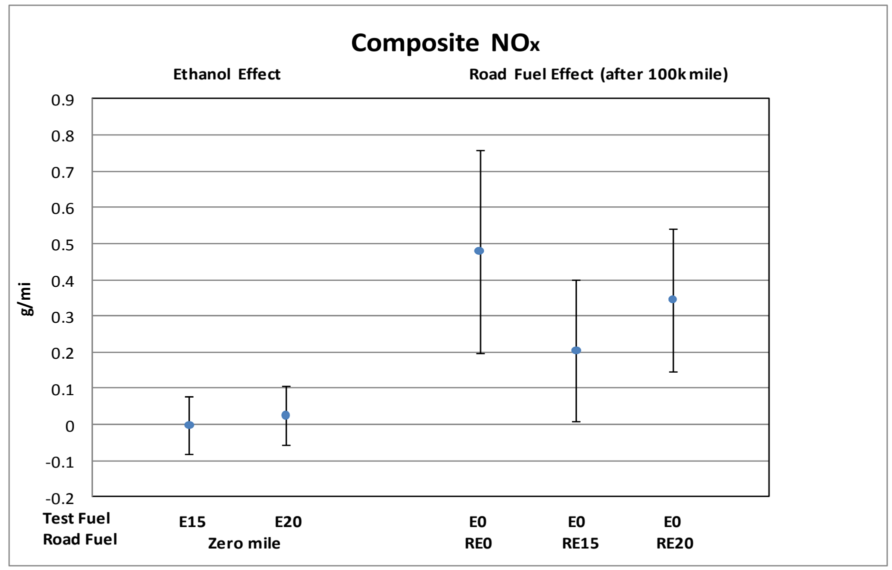
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.76
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.21

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 111k-115k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2000 Chevrolet Silverado (Composite Nonmethane Hydrocarbons)

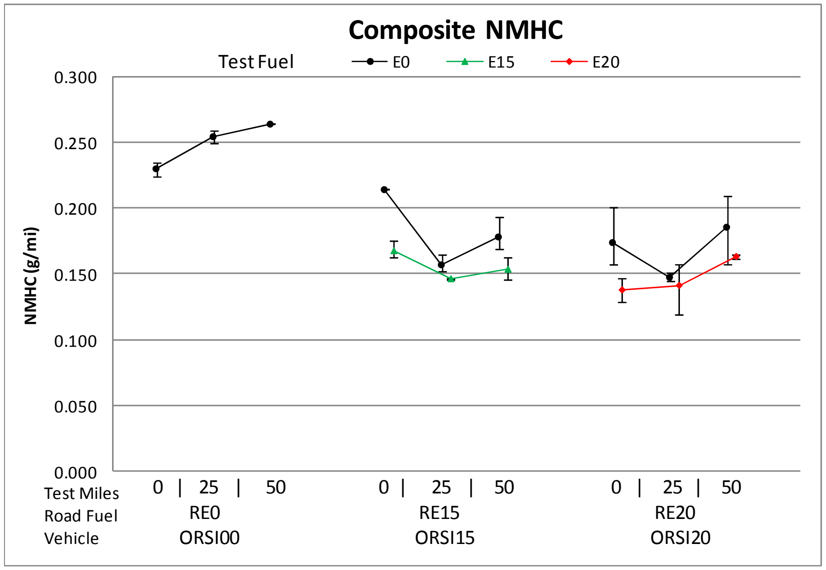
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.026	-0.060	0.007
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.022	-0.056	0.011
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.069	-0.048	0.186
Aging Effect with RE15 (Δg/mi per 100k mi)	-0.049	-0.131	0.032
Aging Effect with RE20 (Δg/mi per 100k mi)	0.037	-0.045	0.119

* Indicates estimate is different from zero at the 95% confidence level.

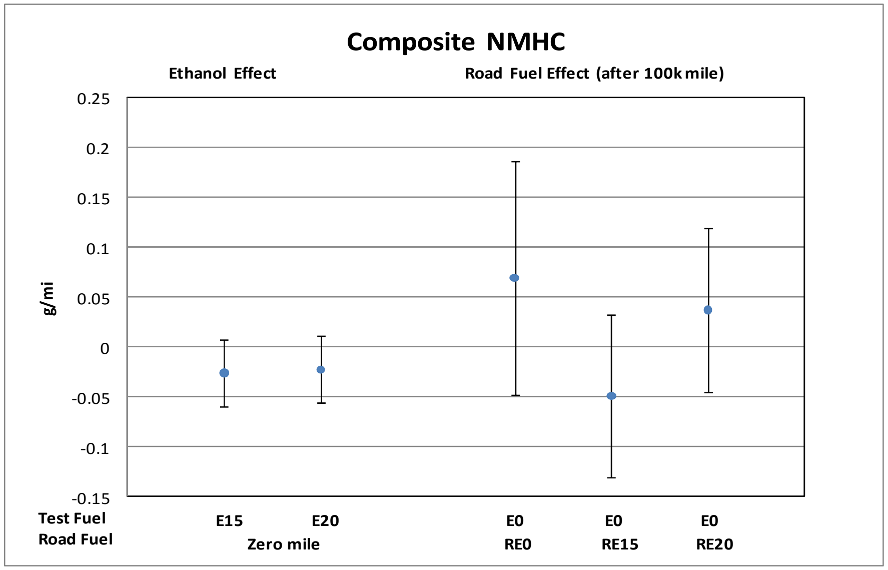
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.12
No Aging Effect with RE0 (Beta0 = 0)	0.21
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.15

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 111k-115k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2000 Chevrolet Silverado (Composite Nonmethane Organic Gases)

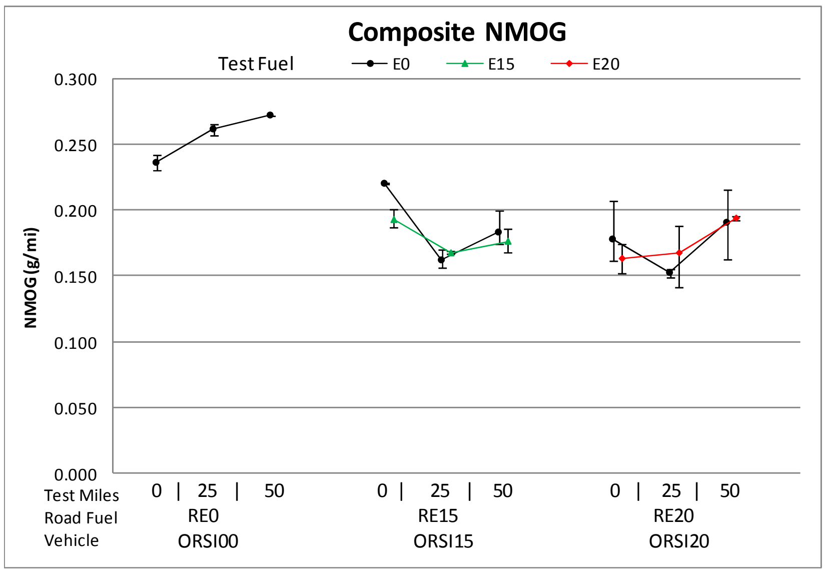
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.0085	-0.0434	0.0263
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.0000	-0.0348	0.0348
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0715	-0.0506	0.1935
Aging Effect with RE15 (Δg/mi per 100k mi)	-0.0518	-0.1366	0.0331
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0426	-0.0431	0.1282

* Indicates estimate is different from zero at the 95% confidence level.

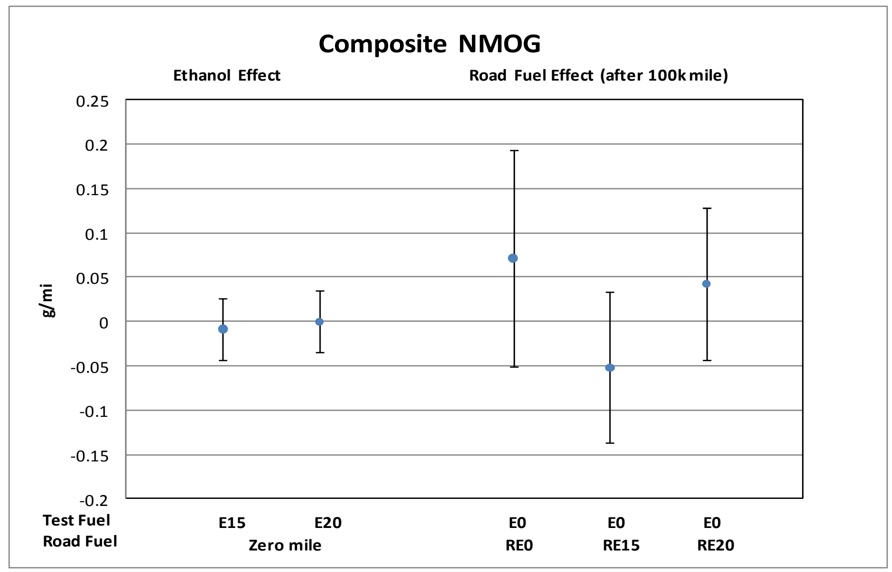
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.84
No Aging Effect with RE0 (Beta0 = 0)	0.21
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.14

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 111k-115k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2000 Chevrolet Silverado (Composite Fuel Economy)

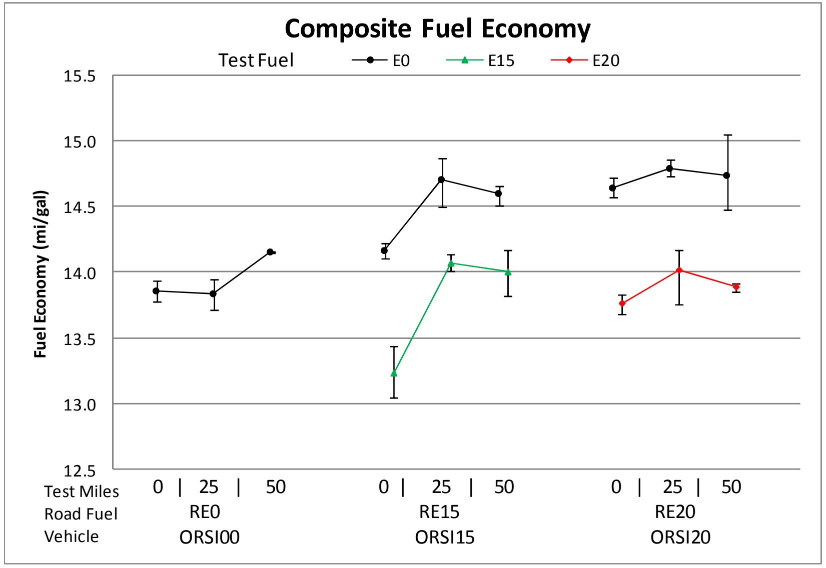
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmi/gal)	-0.727*	-1.122	-0.332
Ethanol Effect (E20 vs. E0) (Δmi/gal)	-0.829*	-1.224	-0.434
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmi/gal per 100k mi)	0.594	-0.788	1.977
Aging Effect with RE15 (Δmi/gal per 100k mi)	1.201*	0.239	2.163
Aging Effect with RE20 (Δmi/gal per 100k mi)	0.230	-0.742	1.201

* Indicates estimate is different from zero at the 95% confidence level.

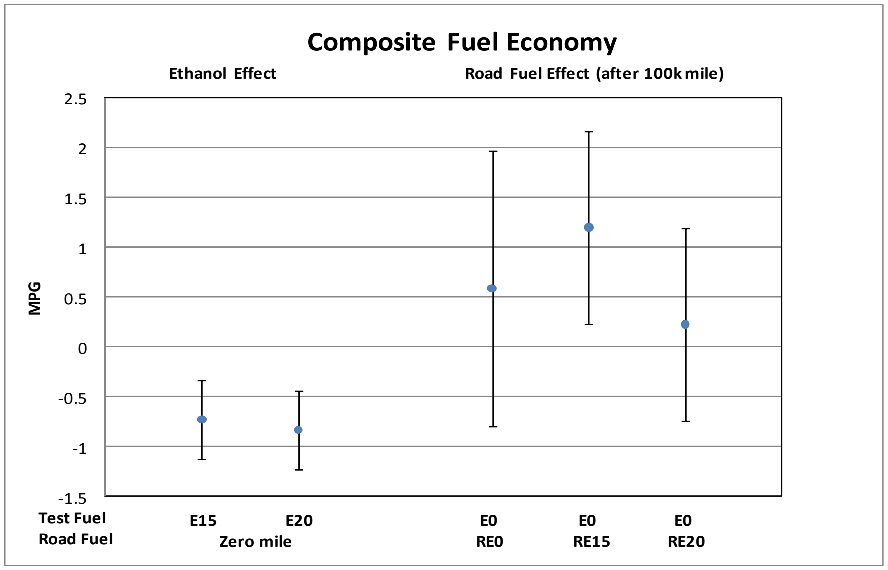
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.35
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.29

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 111k-115k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2000 Chevrolet Silverado (Composite Ethanol)

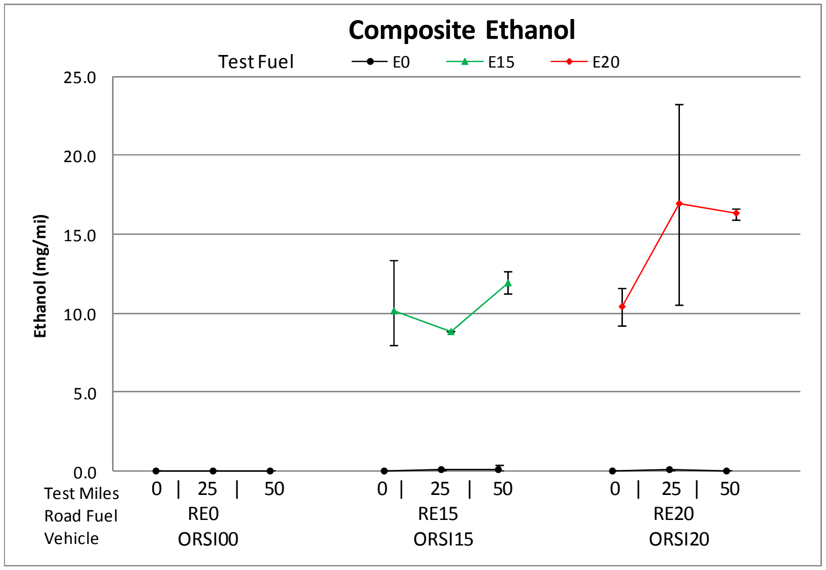
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	10.453*	5.867	15.039
Ethanol Effect (E20 vs. E0) (Δmg/mi)	14.629*	10.326	18.933
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	-0.000	-14.672	14.672
Aging Effect with RE15 (Δmg/mi per 100k mi)	2.003	-9.262	13.267
Aging Effect with RE20 (Δmg/mi per 100k mi)	4.930	-5.935	15.795

* Indicates estimate is different from zero at the 95% confidence level.

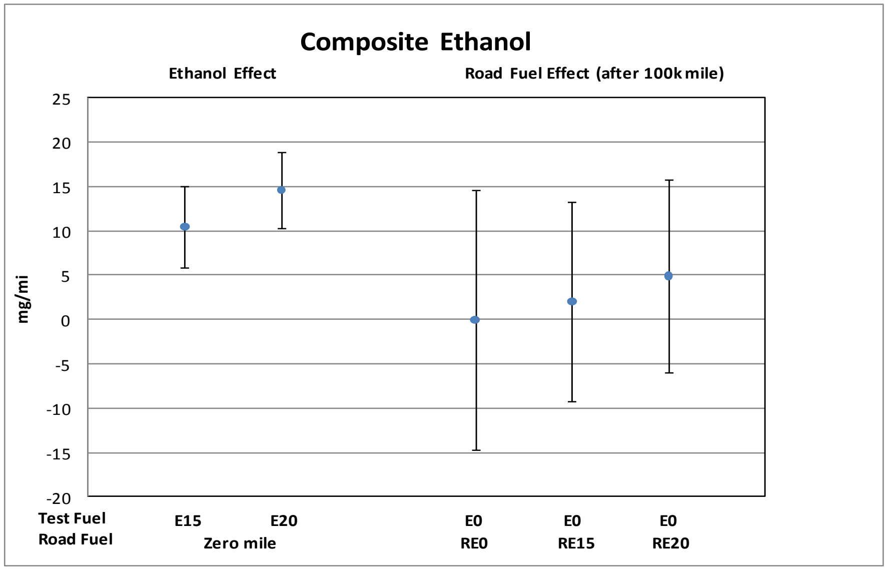
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	1.00
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.76

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 111k-115k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2000 Chevrolet Silverado (Composite Acetaldehyde)

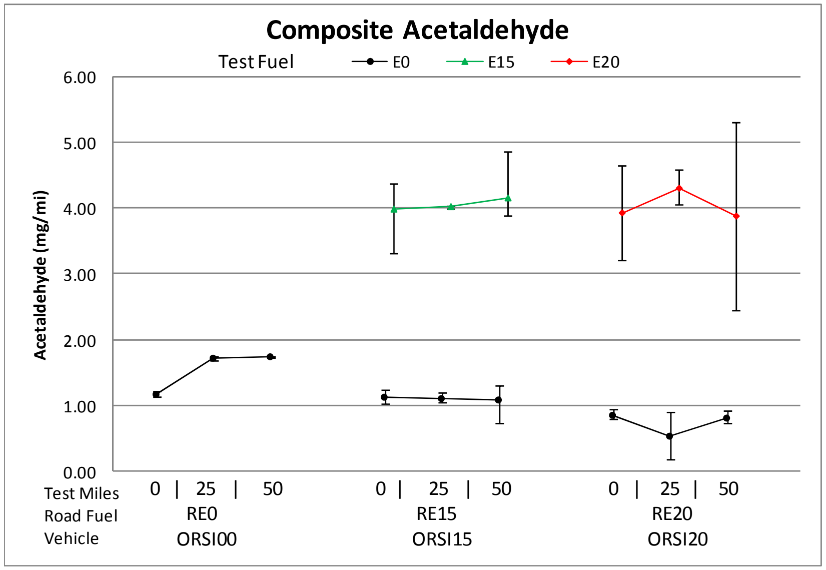
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	2.967*	1.258	4.676
Ethanol Effect (E20 vs. E0) (Δmg/mi)	3.356*	1.655	5.057
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	1.489	-1.800	4.778
Aging Effect with RE15 (Δmg/mi per 100k mi)	-0.013	-1.086	1.060
Aging Effect with RE20 (Δmg/mi per 100k mi)	-0.058	-0.692	0.576

* Indicates estimate is different from zero at the 95% confidence level.

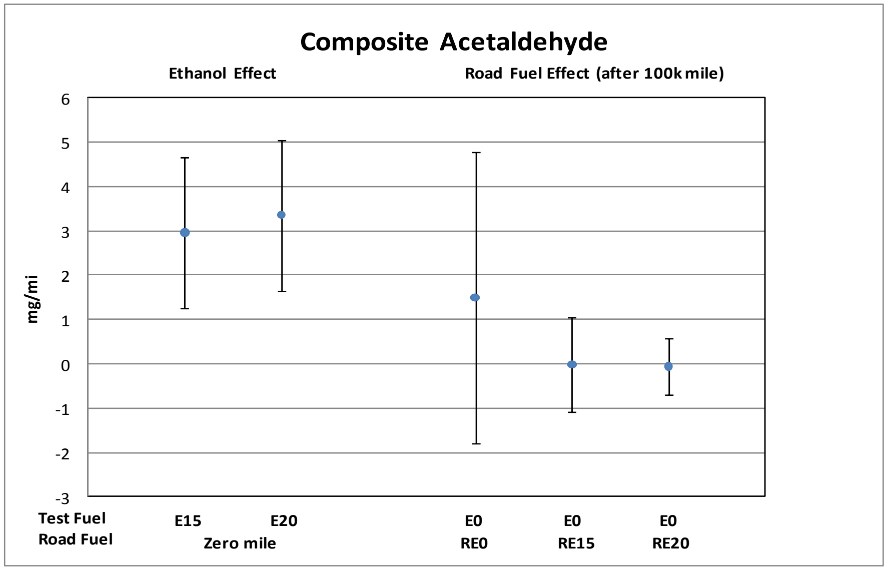
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.27
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.55

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 111k-115k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2000 Chevrolet Silverado(Composite Formaldehyde)

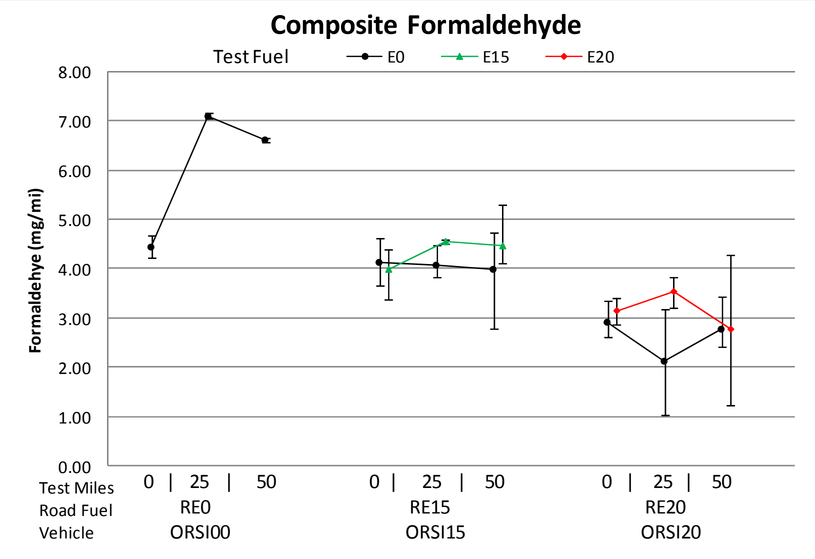
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.324	-0.332	0.981
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.566	-0.152	1.284
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	4.363*	1.525	7.202
Aging Effect with RE15 (Δmg/mi per 100k mi)	0.414	-1.156	1.985
Aging Effect with RE20 (Δmg/mi per 100k mi)	-0.391	-2.110	1.328

* Indicates estimate is different from zero at the 95% confidence level.

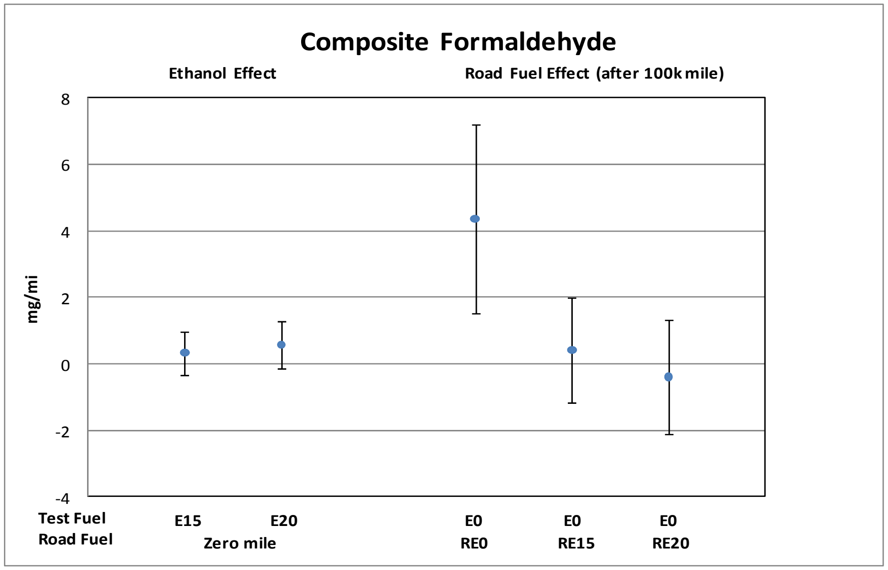
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.18
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.02*

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 111k-115k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2000 Chevrolet Silverado (Composite CH_4)

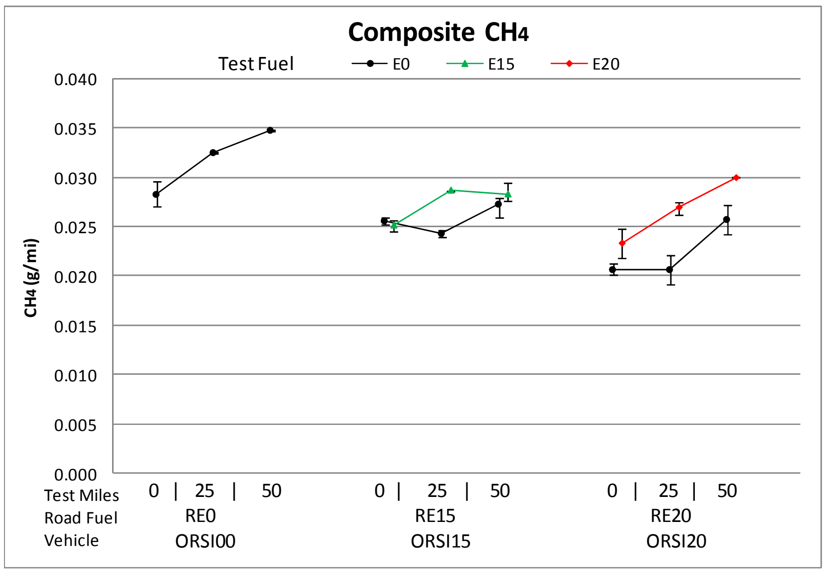
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0016	-0.0009	0.0041
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.0044*	0.0019	0.0069
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0130*	0.0043	0.0217
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0049	-0.0011	0.0110
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0119*	0.0058	0.0180

* Indicates estimate is different from zero at the 95% confidence level.

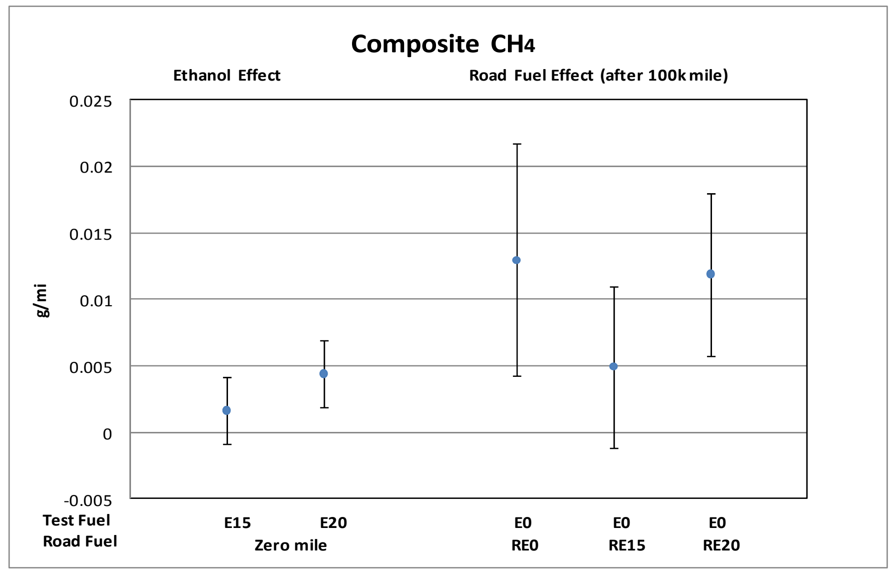
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.15

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 111k-115k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2002 Nissan Frontier - Composite Emissions Summary

Emisssion Parameter (units)	Ethanol Effect				Aging Effect with RE0		RExx Aging Effect on E0 Emissions				RExx Aging Effect on Exx Emissions			Road and Test Fuel Effects are Additive
	Δ units vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value	Δ units per 100K mi			Overall p-value
Fuels	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0		RE10/E10	RE15/E15	RE20/E20	
CO (g/mi)	NA	0.131	0.168	0.90	4.491*	0.01*	NA	4.958*	5.305*	0.93	NA	NA	NA	0.87
NOx (g/mi)	NA	-0.061	0.005	0.15	0.119	0.33	NA	0.210*	0.055	0.38	NA	NA	NA	0.23
NMHC (g/mi)	NA	-0.019*	-0.027*	<0.01*	-0.022	0.15	NA	0.042*	0.005	<0.01*	NA	0.049*	0.059*	0.05*
NMOG (g/mi)	NA	-0.013	-0.018*	0.03*	-0.023	0.17	NA	0.043*	0.004	<0.01*	NA	0.056*	0.071*	0.02*
Fuel Econ (mi/gal)	NA	-0.074*	-1.569*	<0.01*	0.953*	0.02*	NA	-0.119	0.990*	0.01*	NA	NA	NA	0.57
Ethanol (mg/mi)##	NA	5.237*	6.422*	<0.01*	-0.220	0.89	NA	0.528	0.155	0.92	NA	NA	NA	NA
Acetaldehyde (mg/mi)#	NA	0.638*	1.108*	<0.01*	0.000	1.00	NA	0.152	0.156	0.70	NA	NA	NA	0.87
Formaldehyde (mg/mi)#	NA	0.035	0.166	0.43	0.236	0.51	NA	0.455	0.361	0.96	NA	NA	NA	0.92
CH_4 (g/mi)	NA	0.0026	0.0040	0.09	0.0479*	<0.01*	NA	0.0256*	0.0280*	0.05	NA	NA	NA	0.27

Log-normal model was used. Results are presented as changes in emissions at 0k mile.

Data did not support the assumption of linear effects with mileage.

* Indicates estimate is different from zero at the 95% confidence level.

2002 Nissan Frontier (Composite CO)

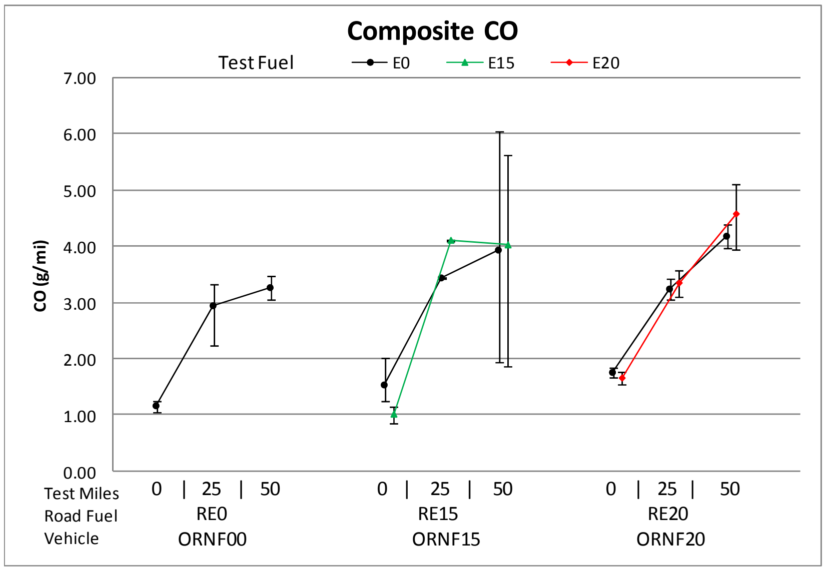
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.131	-0.755	1.016
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.168	-0.850	1.186
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	4.491*	1.013	7.970
Aging Effect with RE15 (Δg/mi per 100k mi)	4.958*	2.888	7.028
Aging Effect with RE20 (Δg/mi per 100k mi)	5.305*	2.848	7.761

* Indicates estimate is different from zero at the 95% confidence level.

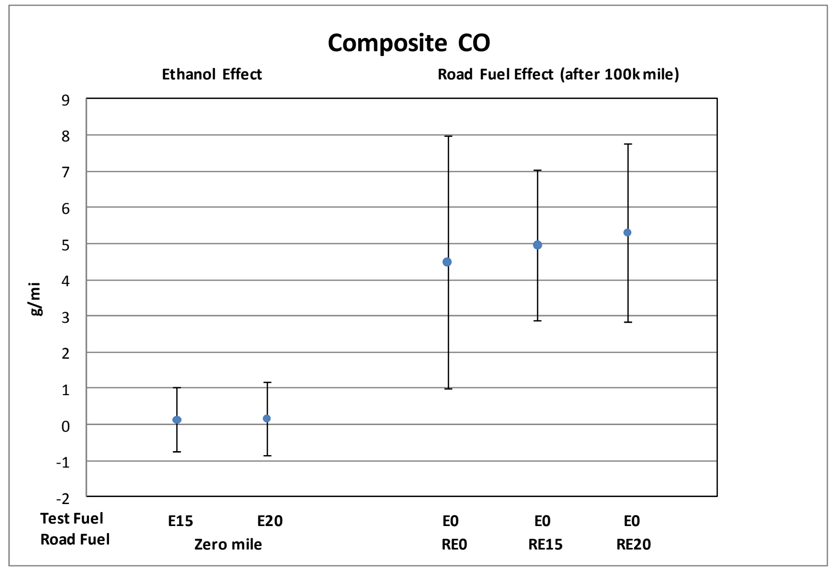
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.90
No Aging Effect with RE0 (Beta0 = 0)	0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.93

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 91k-96k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2002 Nissan Frontier (Composite NOx)

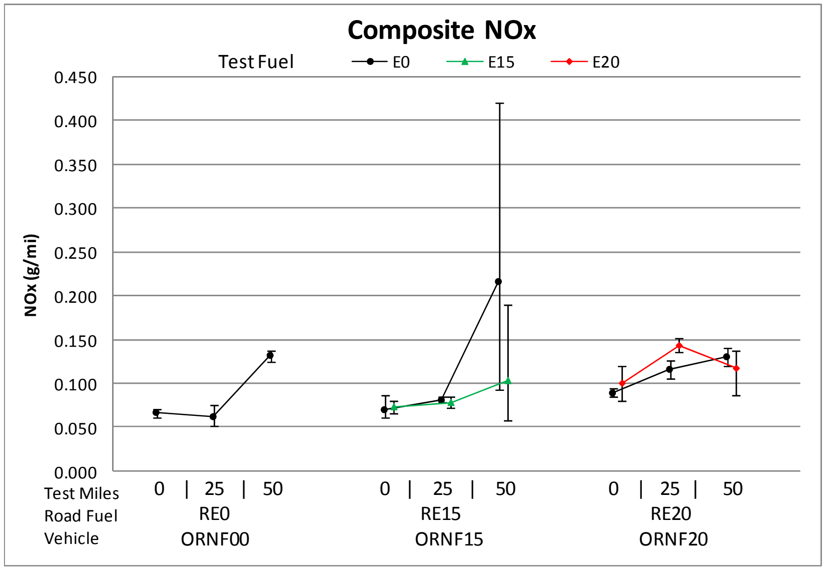
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.061	-0.123	0.001
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.005	-0.066	0.076
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.119	-0.125	0.363
Aging Effect with RE15 (Δg/mi per 100k mi)	0.210*	0.065	0.356
Aging Effect with RE20 (Δg/mi per 100k mi)	0.055	-0.118	0.227

* Indicates estimate is different from zero at the 95% confidence level.

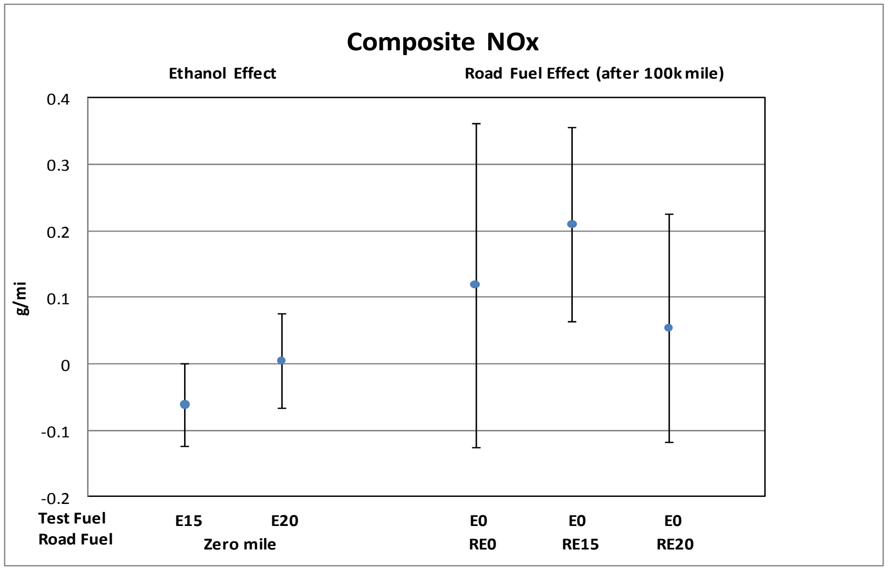
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.15
No Aging Effect with RE0 (Beta0 = 0)	0.33
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.38

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 91k-96k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2002 Nissan Frontier (Composite Nonmethane Hydrocarbons)

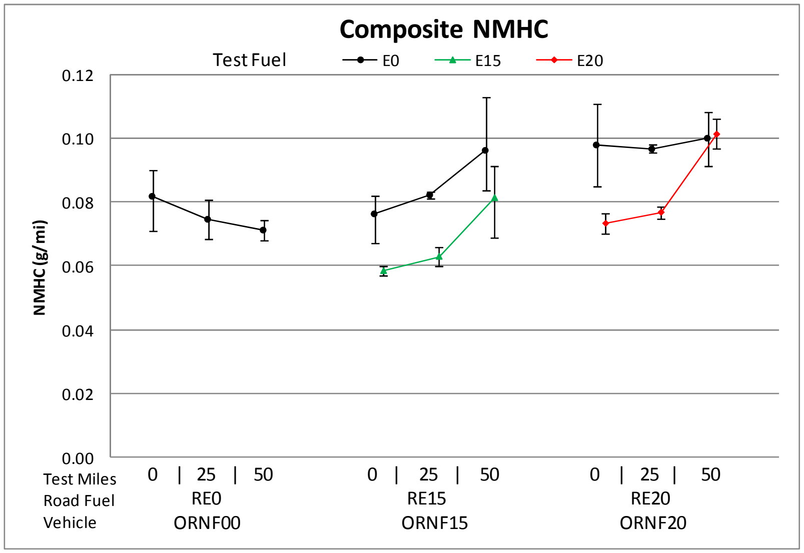
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.019*	-0.033	-0.005
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.027*	-0.043	-0.012
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	-0.022	-0.052	0.009
Aging Effect with RE15 (Δg/mi per 100k mi)	0.042*	0.018	0.065
Aging Effect with RE20 (Δg/mi per 100k mi)	0.005	-0.025	0.035

* Indicates estimate is different from zero at the 95% confidence level.

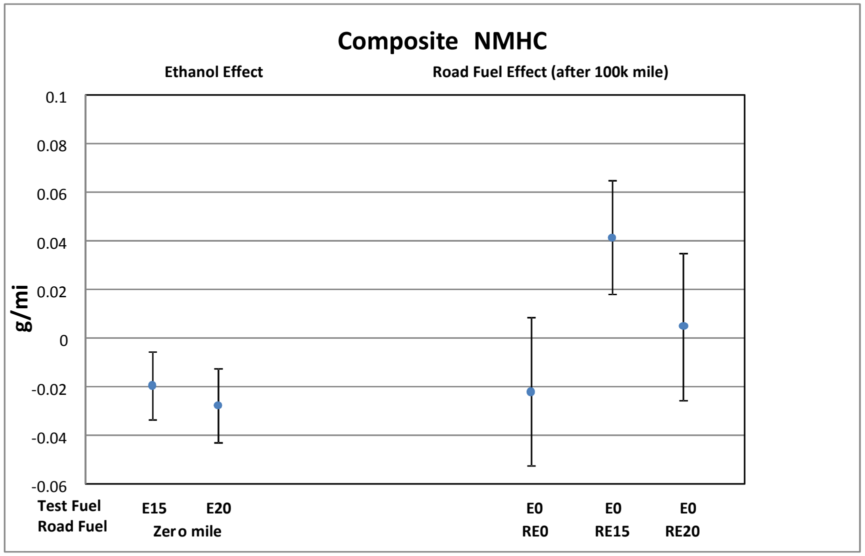
Hypothesis	
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.15
No Effect of Ethanol on Road Fuel Aging (Beta 1s = 0)	<0.01*

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 91k-96k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2002 Nissan Frontier (Composite Nonmethane Organic Gases)

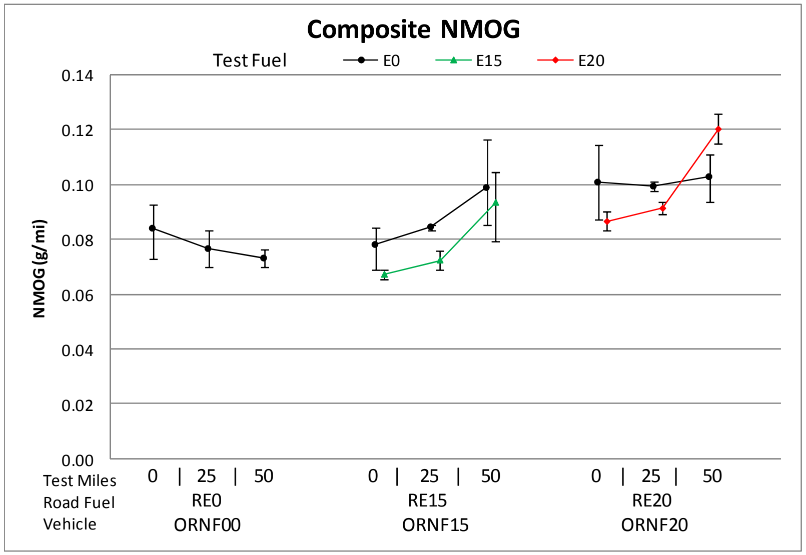
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.013	-0.028	0.002
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.018*	-0.034	-0.001
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	-0.023	-0.055	0.010
Aging Effect with RE15 (Δg/mi per 100k mi)	0.043*	0.018	0.068
Aging Effect with RE20 (Δg/mi per 100k mi)	0.004	-0.029	0.037

* Indicates estimate is different from zero at the 95% confidence level.

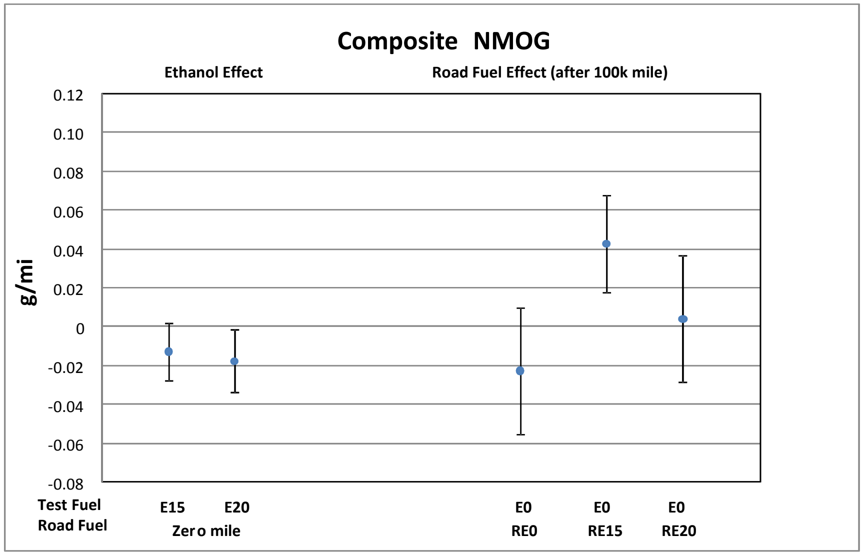
Hypothesis	
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.03*
No Aging Effect with RE0 (Beta0 = 0)	0.17
No Effect of Ethanol on Road Fuel Aging (Beta 1s = 0)	<0.01*

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 91k-96k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2002 Nissan Frontier (Composite Fuel Economy)

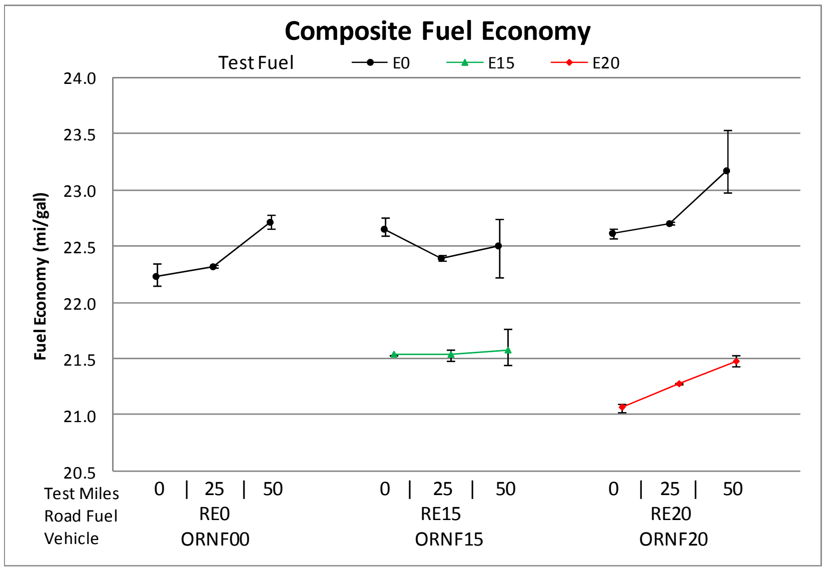
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmi/gal)	-0.074*	-1.183	-0.765
Ethanol Effect (E20 vs. E0) (Δmi/gal)	-1.569*	-1.773	-1.365
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmi/gal per 100k mi)	0.953*	0.247	1.659
Aging Effect with RE15 (Δmi/gal per 100k mi)	-0.119	-0.627	0.388
Aging Effect with RE20 (Δmi/gal per 100k mi)	0.990*	0.493	1.487

* Indicates estimate is different from zero at the 95% confidence level.

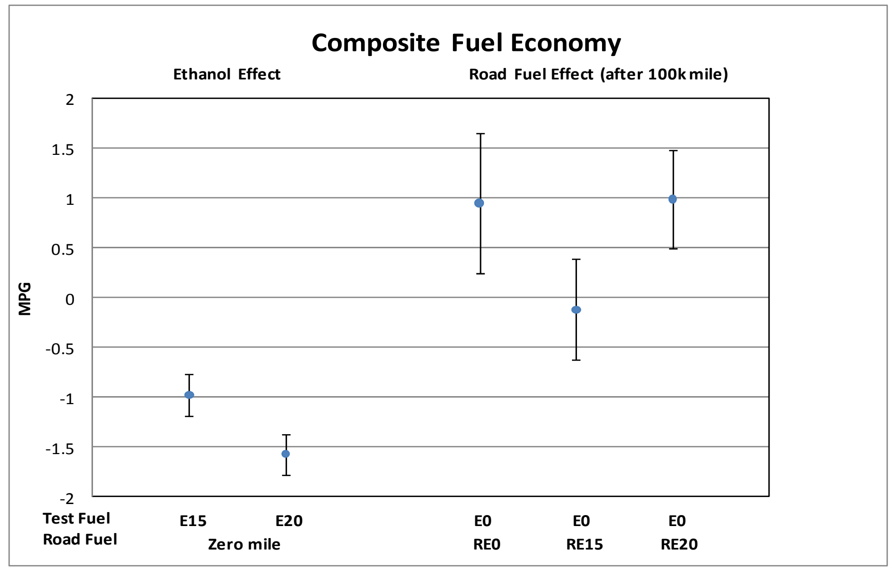
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.02*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.01*

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 91k-96k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2002 Nissan Frontier (Composite Ethanol)

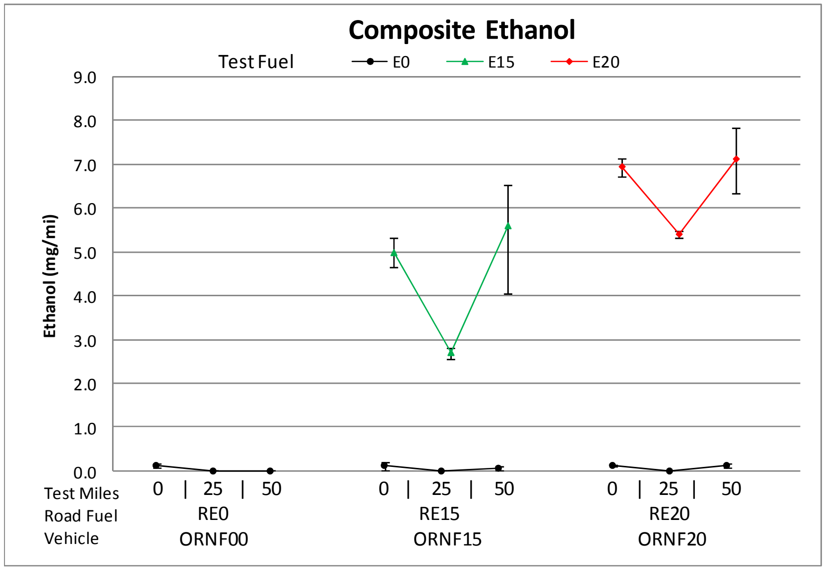
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	5.237*	3.339	7.135
Ethanol Effect (E20 vs. E0) (Δmg/mi)	6.422*	5.025	7.820
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	-0.220	-5.084	4.645
Aging Effect with RE15 (Δmg/mi per 100k mi)	0.528	-3.172	4.228
Aging Effect with RE20 (Δmg/mi per 100k mi)	0.155	-3.272	3.581

* Indicates estimate is different from zero at the 95% confidence level.

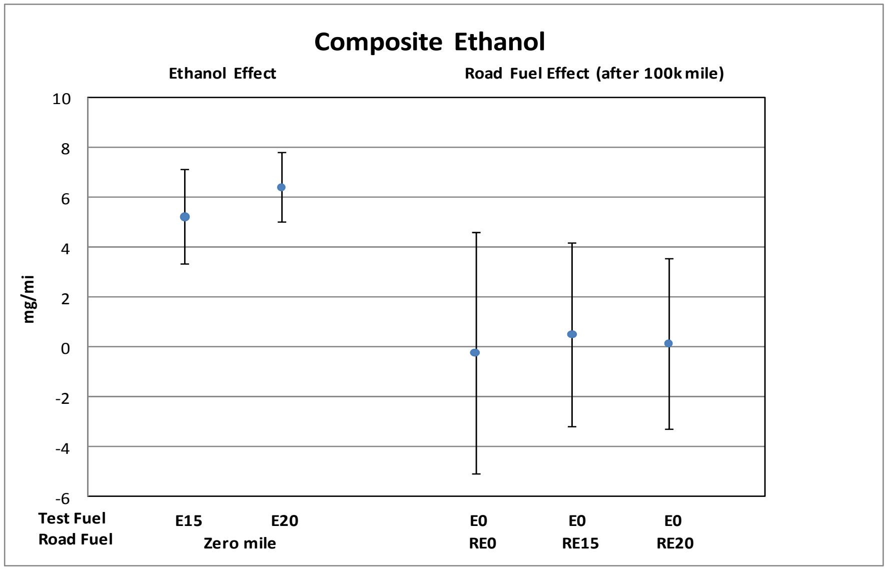
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.89
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.92

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 91k-96k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2002 Nissan Frontier (Composite Acetaldehyde)

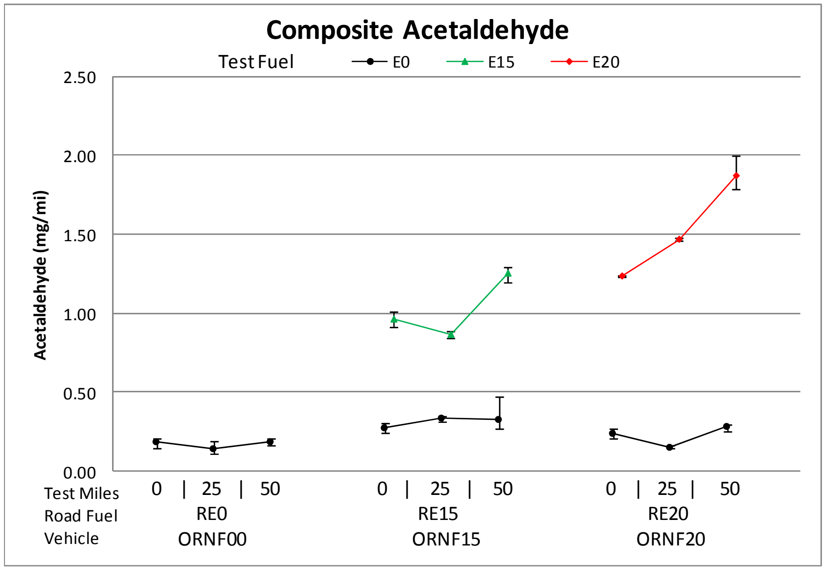
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.638*	0.281	0.996
Ethanol Effect (E20 vs. E0) (Δmg/mi)	1.108*	0.626	1.591
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.000	-0.193	0.194
Aging Effect with RE15 (Δmg/mi per 100k mi)	0.152	-0.197	0.501
Aging Effect with RE20 (Δmg/mi per 100k mi)	0.156	-0.119	0.430

* Indicates estimate is different from zero at the 95% confidence level.

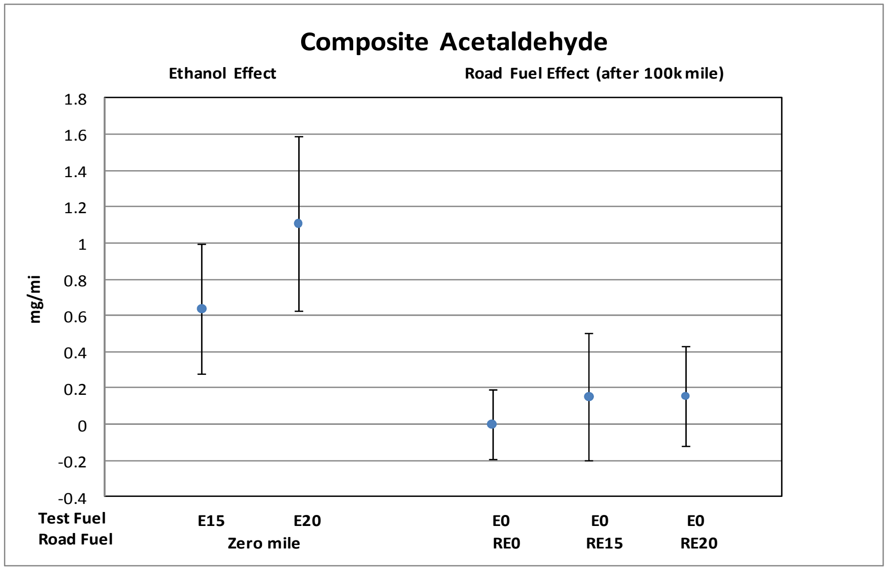
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	1.00
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.70

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 91k-96k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2002 Nissan Frontier (Composite Formaldehyde)

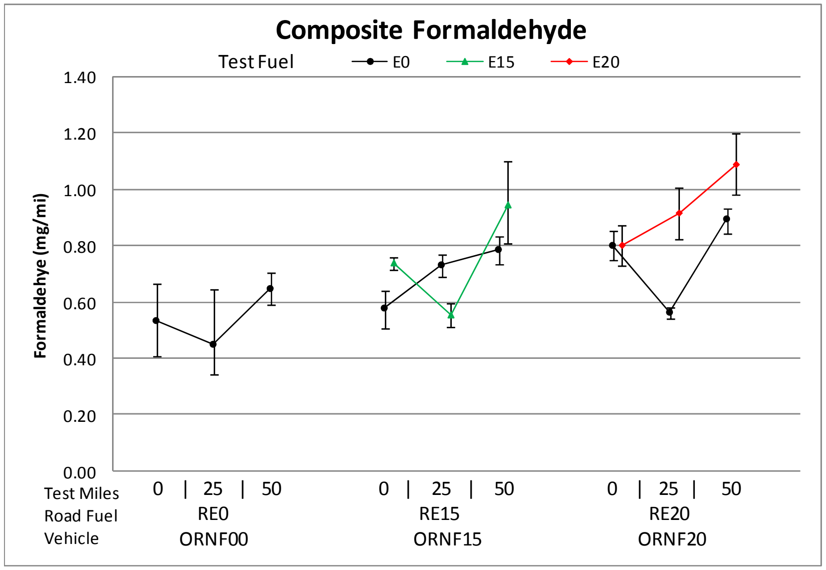
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.035	-0.289	0.360
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.166	-0.226	0.559
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.236	-0.573	1.044
Aging Effect with RE15 (Δmg/mi per 100k mi)	0.455	-0.397	1.307
Aging Effect with RE20 (Δmg/mi per 100k mi)	0.361	-0.473	1.196

* Indicates estimate is different from zero at the 95% confidence level.

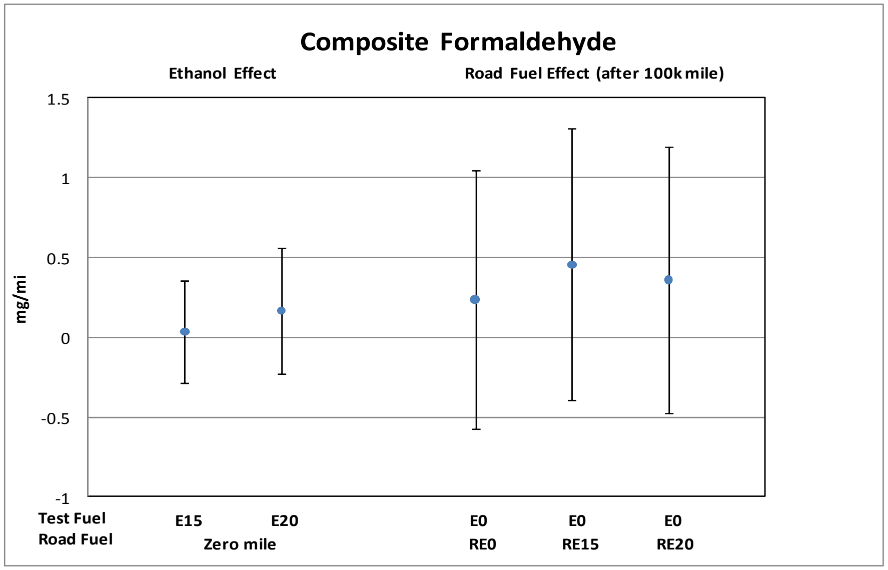
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.43
No Aging Effect with RE0 (Beta0 = 0)	0.51
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.96

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 91k-96k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2002 Nissan Frontier (Composite CH_4)

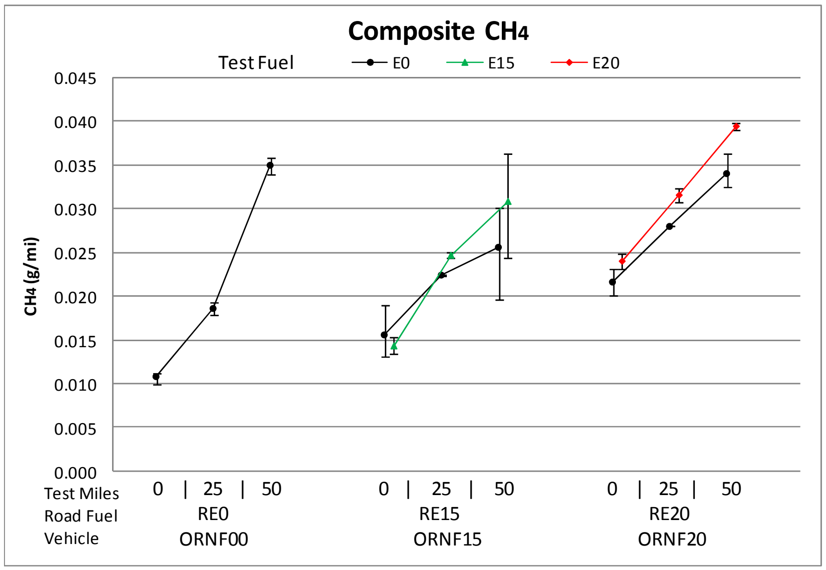
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0026	-0.0016	0.0068
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.0040	-0.0003	0.0082
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0479*	0.0332	0.0625
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0256*	0.0154	0.0359
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0280*	0.0177	0.0384

* Indicates estimate is different from zero at the 95% confidence level.

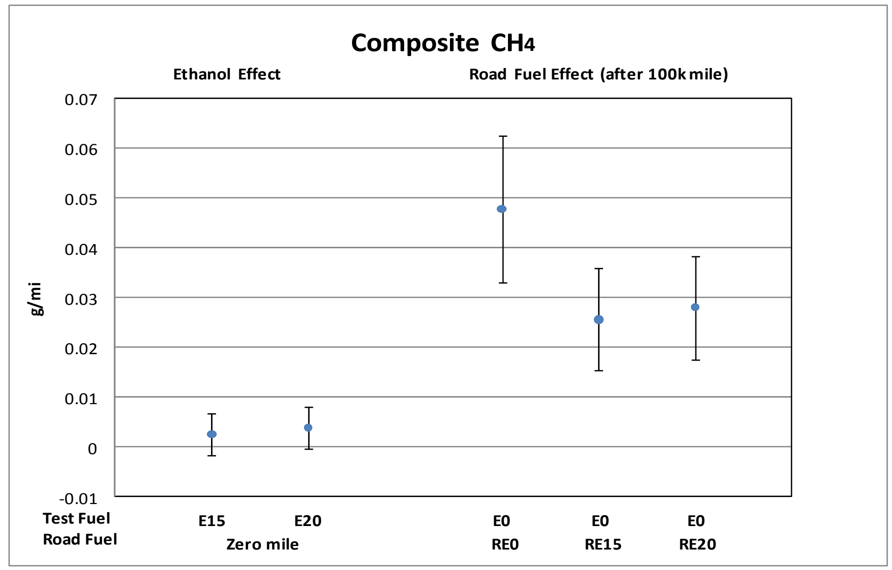
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.09
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.05

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 91k-96k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2002 Dodge Durango - Composite Emissions Summary

Emisssion Parameter (units)	Ethanol Effect				Aging Effect with RE0		RExx Aging Effect on E0 Emissions				RExx Aging Effect on Exx Emissions			Road and Test Fuel Effects are Additive
	Δ units vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value	Δ units per 100K mi			Overall p-value
Fuels	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0		RE10/E10	RE15/E15	RE20/E20	
CO (g/mi)[a]	NA	0.425	0.356	0.07	-0.345	0.49	NA	0.935	0.537	0.20	NA	-0.455	-1.018	0.02*
NOx (g/mi)	NA	0.053	0.070	0.41	0.153	0.49	NA	0.308	0.482*	0.46	NA	NA	NA	0.96
NMHC (g/mi)[a]	NA	-0.011	-0.012	0.13	-0.068*	0.02*	NA	0.011	-0.020	0.07	NA	NA	NA	0.10
NMOG (g/mi)[a]	NA	0.0047	0.0092	0.46	-0.0693*	0.02*	NA	0.0115	-0.0243	0.08	NA	NA	NA	0.07
Fuel Econ (mi/gal)	NA	-0.809*	-0.872*	<0.01*	0.673	0.06	NA	0.485	0.739*	0.71	NA	NA	NA	0.30
Ethanol (mg/mi)[##]	NA	9.733*	11.046*	<0.01*	-0.299	0.88	NA	1.100	0.142	0.77	NA	NA	NA	NA
Acetaldehyde (mg/mi)[#]	NA	1.895*	2.334*	<0.01*	-0.096	0.32	NA	0.200*	0.198*	0.11	NA	NA	NA	0.85
Formaldehyde (mg/mi)[#]	NA	0.071	0.322	0.03*	0.961*	<0.01*	NA	1.811*	1.641*	0.45	NA	NA	NA	0.83
CH_4 (g/mi)[b]	NA	0.0033*	0.0062*	<0.01*	0.0068	0.09	NA	0.0078*	0.0176*	0.05*	NA	NA	NA	0.85

Log-normal model was used. Results are presented as changes in emissions at 0k mile.

Data did not support the assumption of linear effects with mileage.

* Indicates estimate is different from zero at the 95% confidence level.

a test "SW025516" is identified as an outlier and excluded from the analysis

b test "SW024800" is identified as an outlier and excluded from the analysis

2002 Dodge Durango (Composite CO)

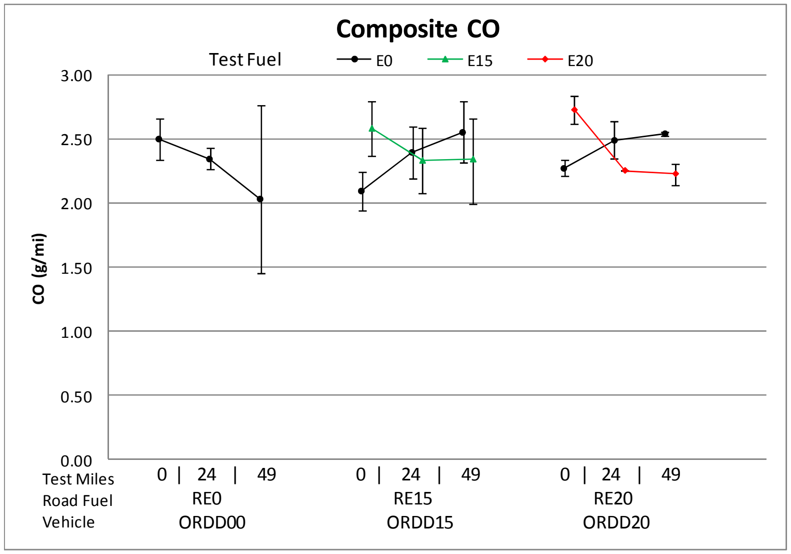
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.425	-0.042	0.891
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.356	-0.112	0.825
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	-0.345	-1.375	0.685
Aging Effect with RE15 (Δg/mi per 100k mi)	0.935	-0.100	1.970
Aging Effect with RE20 (Δg/mi per 100k mi)	0.537	-0.492	1.566

* Indicates estimate is different from zero at the 95% confidence level.

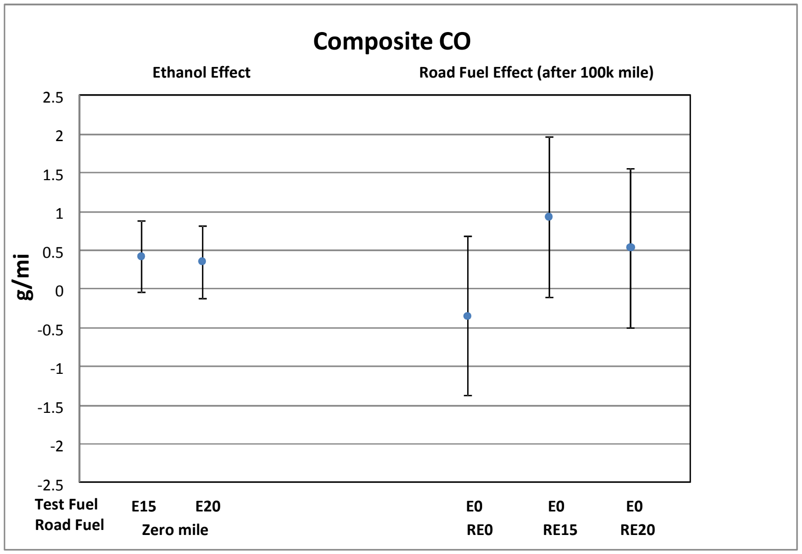
Hypothesis	
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.07
No Aging Effect with RE0 (Beta0 = 0)	0.49
No Effect of Ethanol on Road Fuel Aging (Beta 1s = 0)	0.20

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 60k-71k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2002 Dodge Durango (Composite NOx)

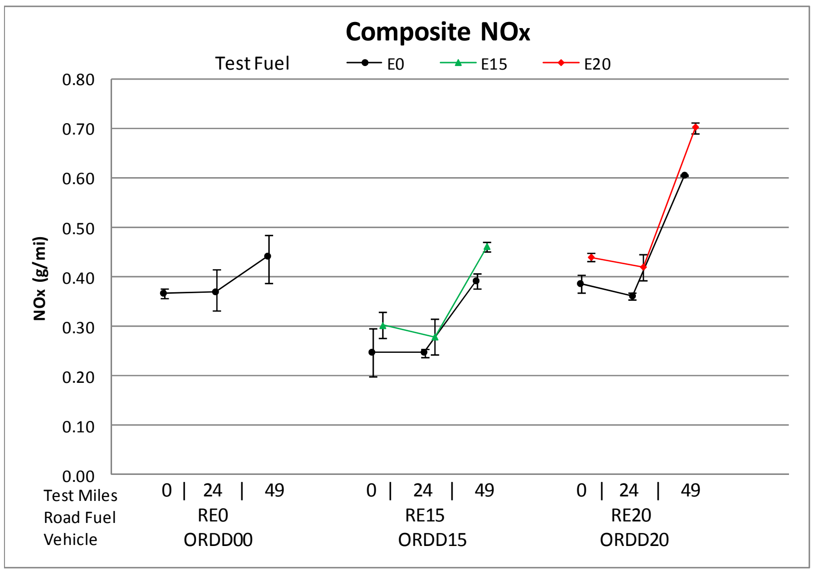
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.053	-0.091	0.197
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.070	-0.074	0.214
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.153	-0.348	0.653
Aging Effect with RE15 (Δg/mi per 100k mi)	0.308	-0.048	0.664
Aging Effect with RE20 (Δg/mi per 100k mi)	0.482*	0.127	0.837

* Indicates estimate is different from zero at the 95% confidence level.

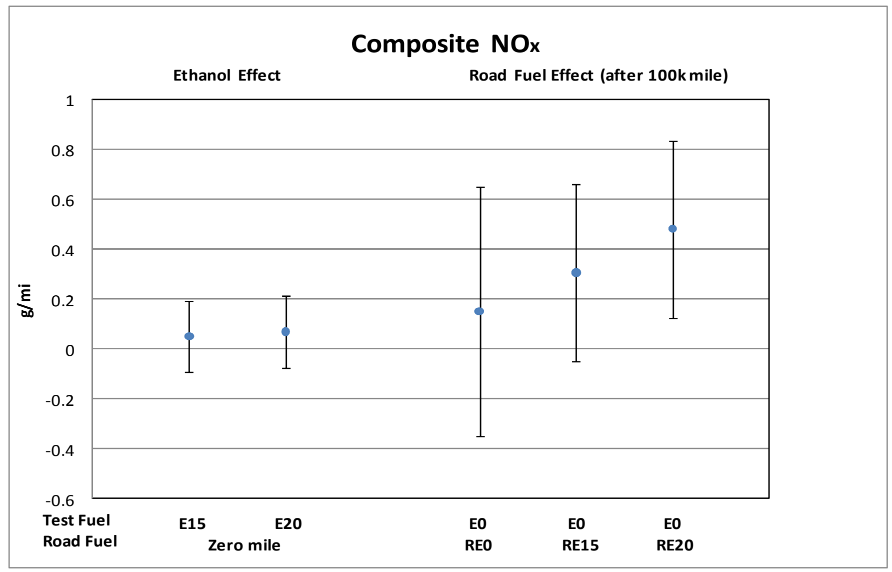
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.41
No Aging Effect with RE0 (Beta0 = 0)	0.49
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.46

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 60k-71k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2002 Dodge Durango (Composite Nonmethane Hydrocarbons)

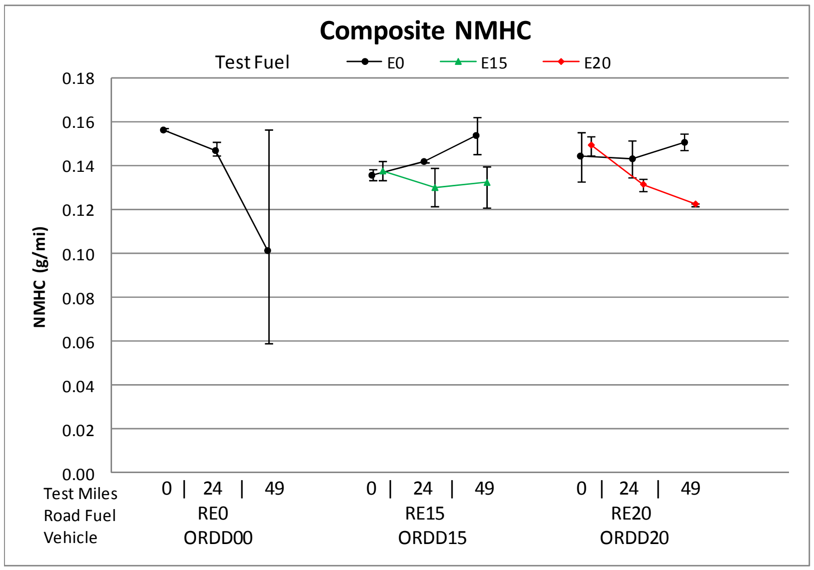
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.011	-0.026	0.005
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.012	-0.028	0.004
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	-0.068*	-0.124	-0.012
Aging Effect with RE15 (Δg/mi per 100k mi)	0.011	-0.027	0.049
Aging Effect with RE20 (Δg/mi per 100k mi)	-0.020	-0.060	0.019

* Indicates estimate is different from zero at the 95% confidence level.

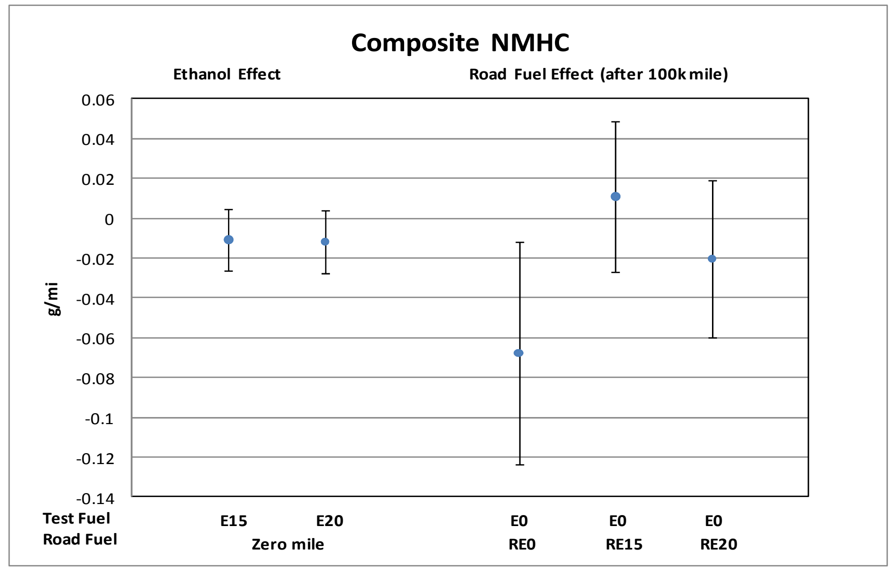
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.13
No Aging Effect with RE0 (Beta0 = 0)	0.02*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.07

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 60k-71k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2002 Dodge Durango (Composite Nonmethane Organic Gases)

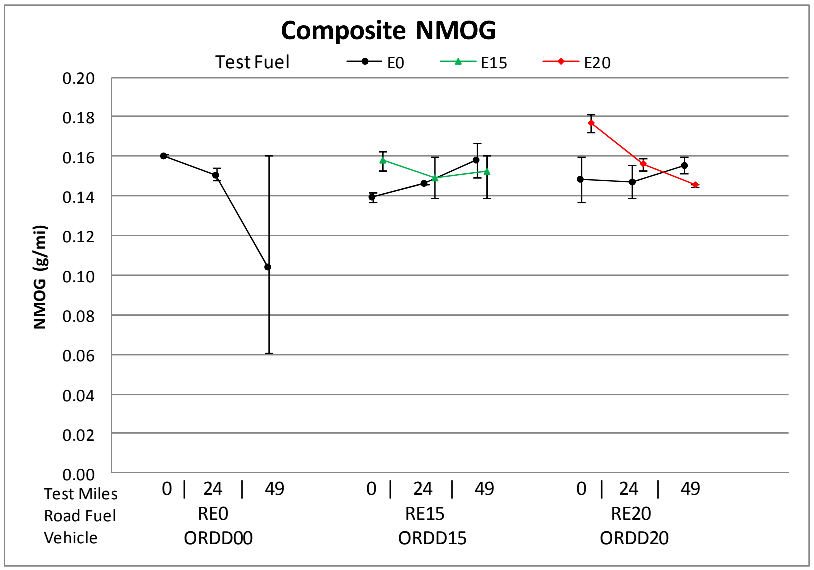
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0047	-0.0117	0.02109
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.0092	-0.0077	0.02615
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	-0.0693*	-0.1283	-0.0103
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0115	-0.0283	0.05135
Aging Effect with RE20 (Δg/mi per 100k mi)	-0.0243	-0.0661	0.01741

* Indicates estimate is different from zero at the 95% confidence level.

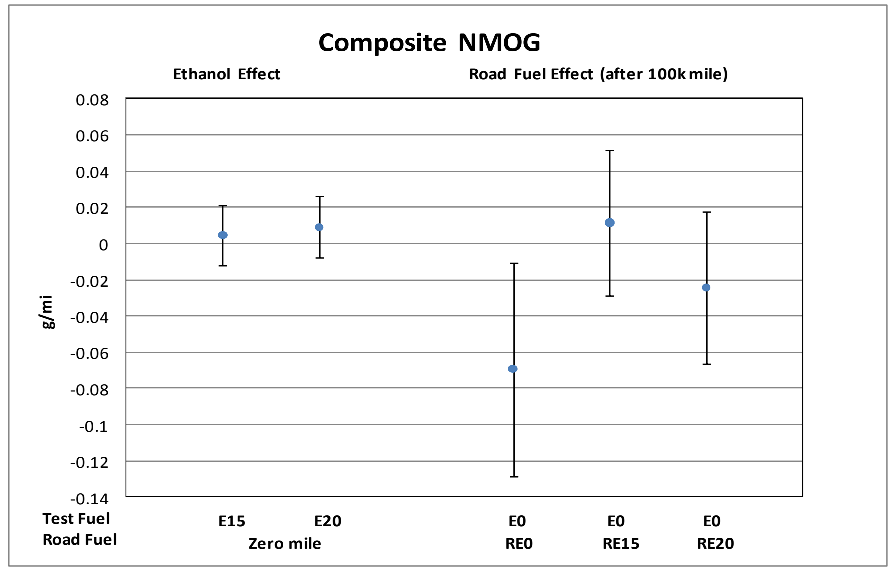
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.46
No Aging Effect with RE0 (Beta0 = 0)	0.02*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.08

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 60k-71k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2002 Dodge Durango (Composite Fuel Economy)

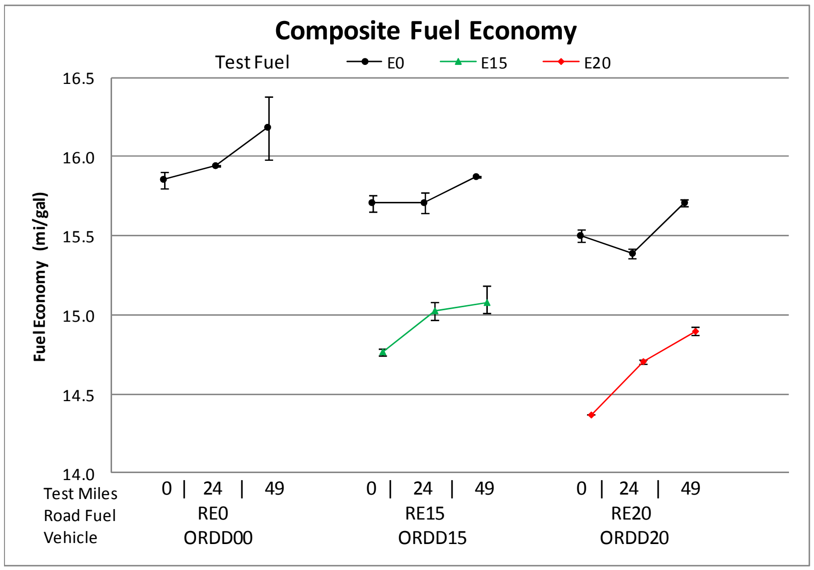
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmi/gal)	-0.809*	-1.017	-0.600
Ethanol Effect (E20 vs. E0) (Δmi/gal)	-0.872*	-1.081	-0.664
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmi/gal per 100k mi)	0.673	-0.051	1.397
Aging Effect with RE15 (Δmi/gal per 100k mi)	0.485	-0.031	1.000
Aging Effect with RE20 (Δmi/gal per 100k mi)	0.739*	0.225	1.252

* Indicates estimate is different from zero at the 95% confidence level.

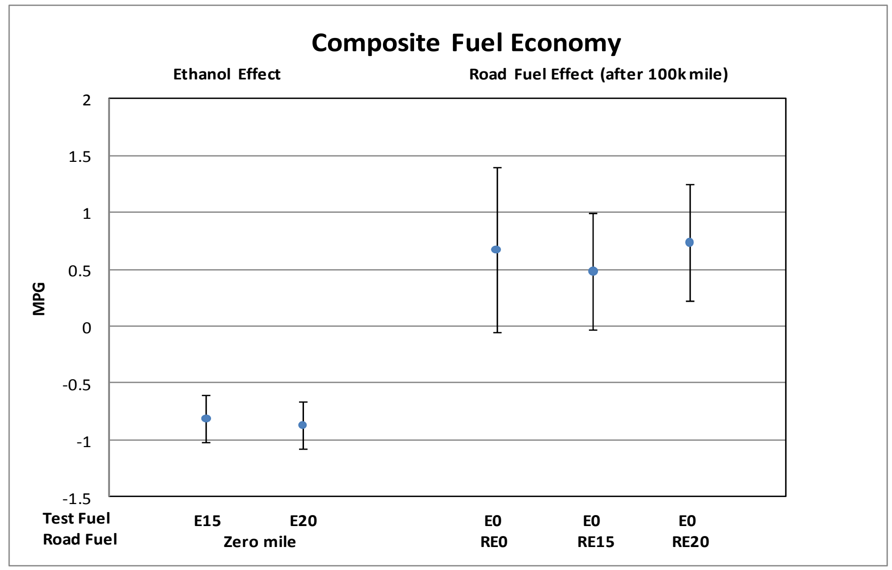
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.06
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.71

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 60k-71k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2002 Dodge Durango (Composite Ethanol)

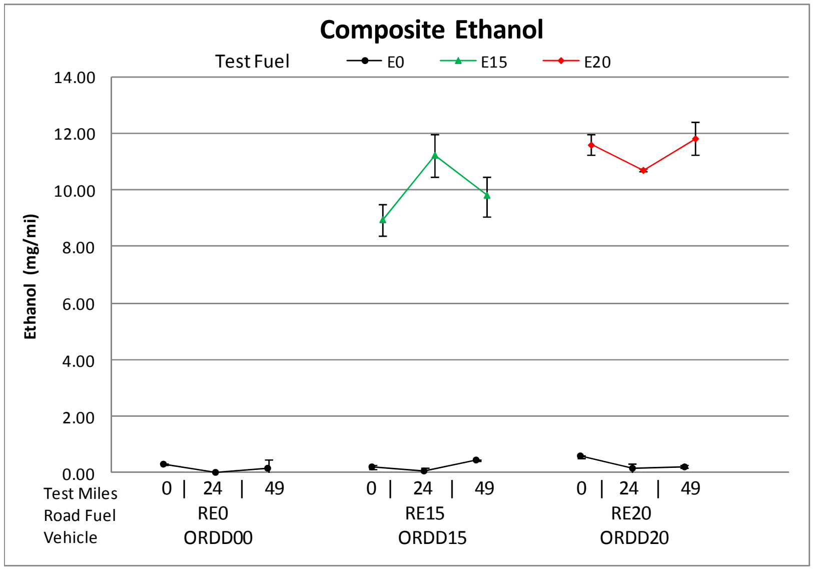
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	9.733*	8.196	11.271
Ethanol Effect (E20 vs. E0) (Δmg/mi)	11.046*	9.518	12.575
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	-0.299	-5.690	5.093
Aging Effect with RE15 (Δmg/mi per 100k mi)	1.100	-2.710	4.911
Aging Effect with RE20 (Δmg/mi per 100k mi)	0.142	-3.905	3.622

* Indicates estimate is different from zero at the 95% confidence level.

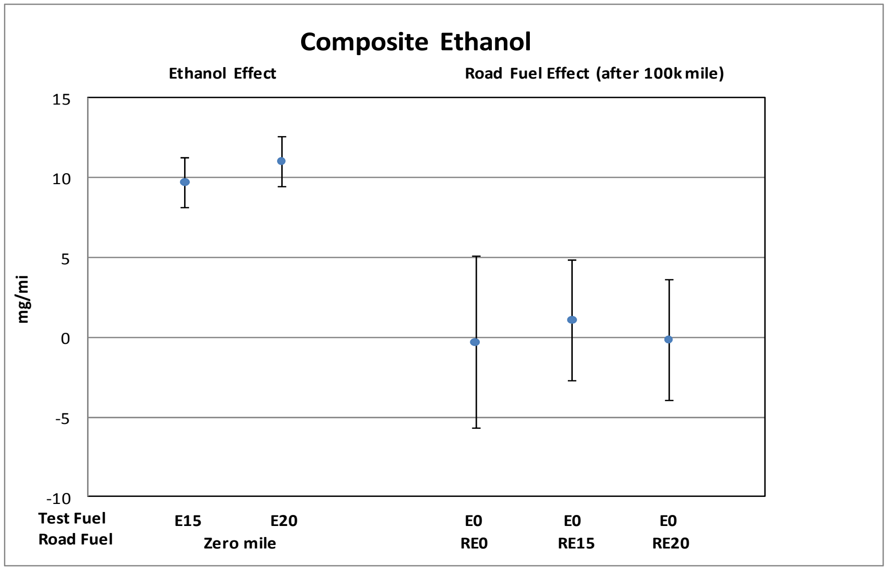
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.88
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.77

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 60k-71k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2002 Dodge Durango (Composite Acetaldehyde)

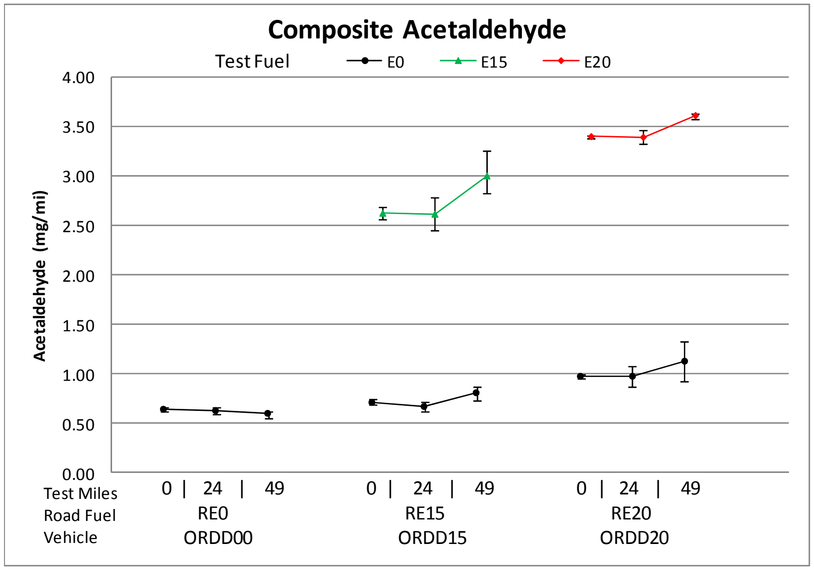
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	1.895*	1.637	2.152
Ethanol Effect (E20 vs. E0) (Δmg/mi)	2.334*	2.000	2.668
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	-0.096	-0.248	0.055
Aging Effect with RE15 (Δmg/mi per 100k mi)	0.200*	0.015	0.386
Aging Effect with RE20 (Δmg/mi per 100k mi)	0.198*	-0.060	0.455

* Indicates estimate is different from zero at the 95% confidence level.

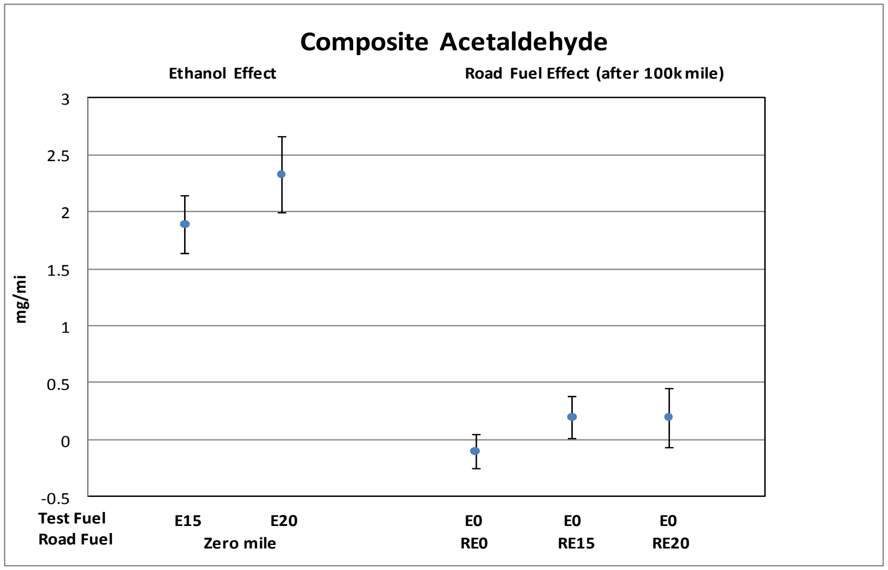
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.32
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.11

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 60k-71k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

E-192

2002 Dodge Durango (Composite Formaldehyde)

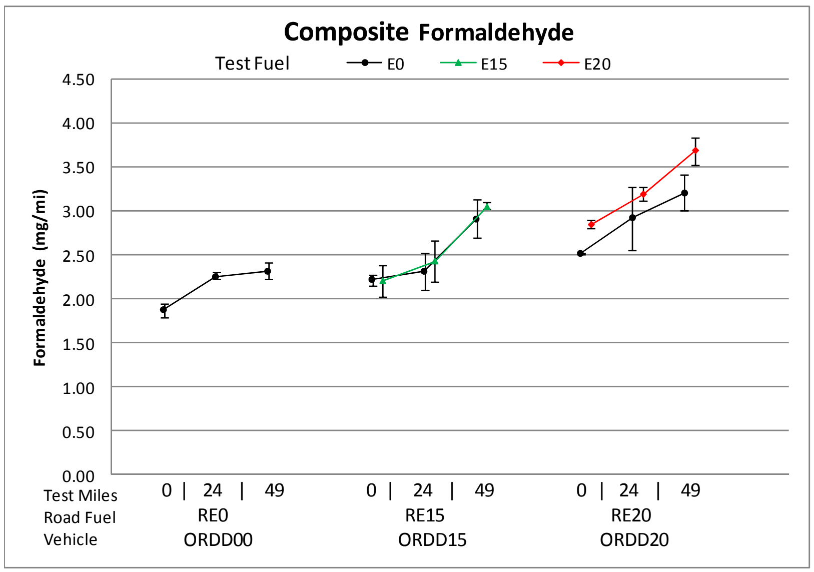
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.071	-0.184	0.326
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.322	-0.001	0.645
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.961*	0.313	1.608
Aging Effect with RE15 (Δmg/mi per 100k mi)	1.811*	1.111	2.511
Aging Effect with RE20 (Δmg/mi per 100k mi)	1.641*	0.862	2.419

* Indicates estimate is different from zero at the 95% confidence level.

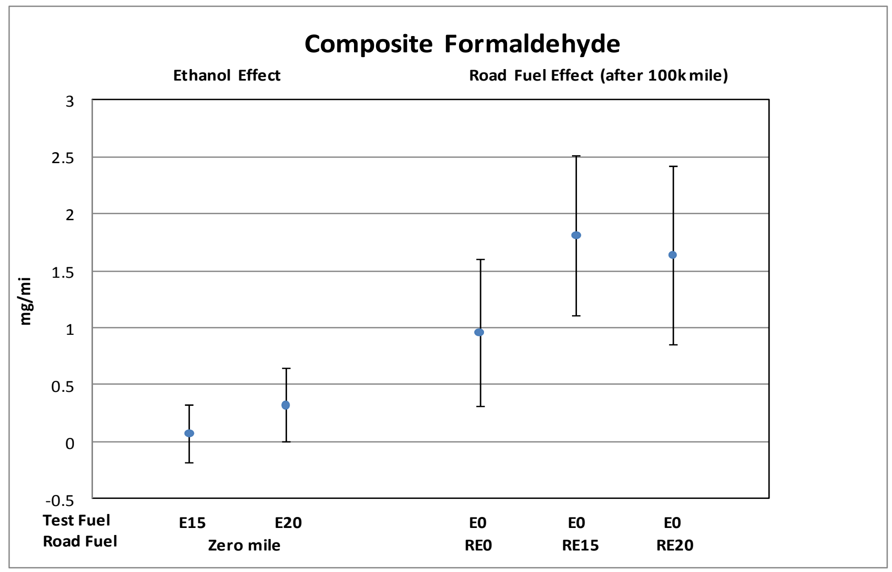
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.03*
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.45

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 60k-71k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2002 Dodge Durango (Composite CH_4)

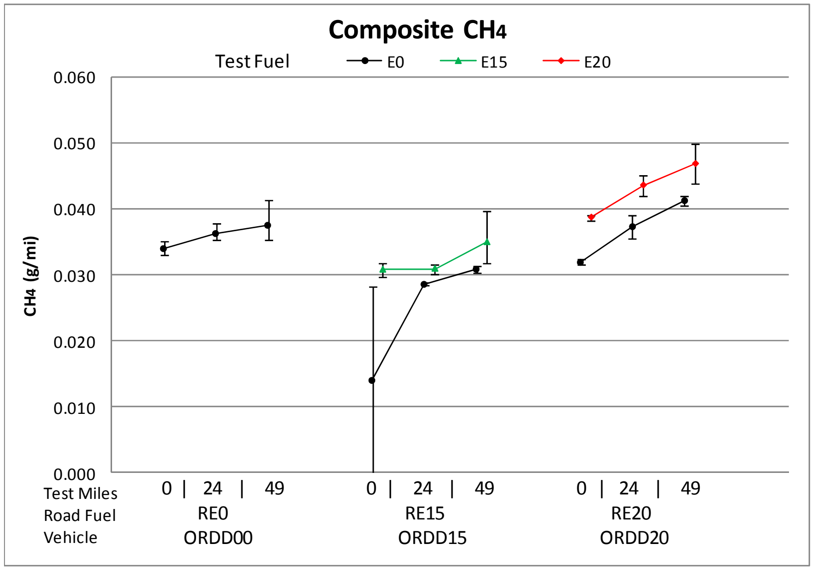
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0033*	0.0007	0.0058
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.0062*	0.0037	0.0087
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0068	-0.0011	0.0148
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0078*	0.0014	0.0142
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0176*	0.0113	0.0238

* Indicates estimate is different from zero at the 95% confidence level.

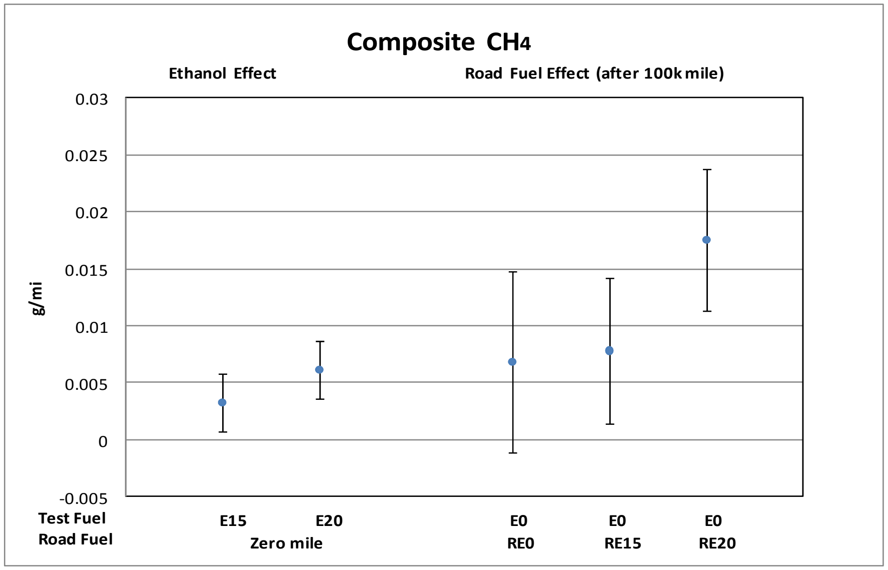
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.09
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.05*

* Indicates effect is statistically significant at the 95% confidence level.

Initial odometers 60k-71k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2003 Toyota Camry - Composite Emissions Summary

Emisssion Parameter (units)	Ethanol Effect				Aging Effect with RE0		RExx Aging Effect on E0 Emissions				RExx Aging Effect on Exx Emissions			Road and Test Fuel Effects are Additive
	Δ units vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value	Δ units per 100K mi			Overall p-value
Fuels	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0		RE10/E10	RE15/E15	RE20/E20	
CO (g/mi)[a]	NA	0.007	-0.045	0.95	0.450	0.29	NA	0.466	0.096	0.82	NA	NA	NA	0.85
NOx (g/mi)[a]	NA	-0.000	0.019	0.80	0.083	0.34	NA	0.074	0.155	0.81	NA	NA	NA	0.53
NMHC (g/mi)[a]	NA	-0.001	-0.003	0.84	0.030	0.11	NA	0.012	-0.018	0.28	NA	NA	NA	0.81
NMOG (g/mi)[a]	NA	0.003	0.003	0.77	0.031	0.13	NA	0.014	-0.020	0.30	NA	NA	NA	0.79
Fuel Econ (mi/gal)[a]	NA	-1.350*	-1.650*	<0.01*	0.699	0.55	NA	1.376	4.029*	0.27	NA	NA	NA	0.87
Acetaldehyde (mg/mi)[#a]	NA	0.428*	0.096*	<0.01*	-0.054	0.73	NA	-0.001	-0.237	0.56	NA	NA	NA	0.72
Formaldehyde (mg/mi)[#a]	NA	0.125	0.193	0.56	-0.305	0.54	NA	-0.105	-0.815*	0.33	NA	NA	NA	0.83
CH_4 (g/mi)[a]	NA	0.0003	-0.0003	0.93	0.0126*	0.01*	NA	0.0073*	0.0029	0.30	NA	NA	NA	0.97

Log-normal model was used. Results are presented as changes in emissions at 0k mile.

Data did not support the assumption of linear effects with mileage.

* Indicates estimate is different from zero at the 95% confidence level.

a RE20 vehicle had a P0420 catalyst failure MIL during mileage accumulation and TRC was instructed to complete the test program with the known problem. All emissions results at the 50k data point for this vehicle are excluded from the analysis.

2003 Toyota Camry (Composite CO)

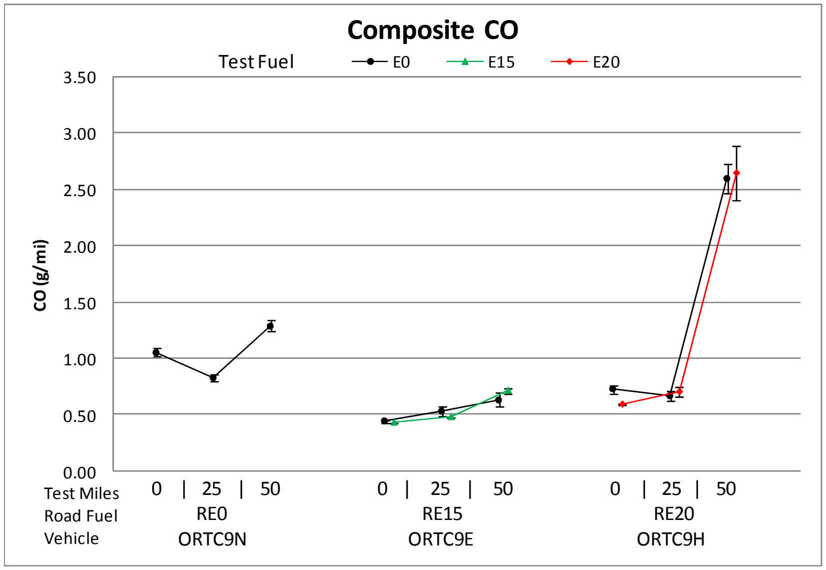
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.007	-0.282	0.295
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.045	-0.398	0.308
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.450	-0.526	1.427
Aging Effect with RE15 (Δg/mi per 100k mi)	0.466	-0.223	1.155
Aging Effect with RE20 (Δg/mi per 100k mi)	0.096	-1.260	1.453

* Indicates estimate is different from zero at the 95% confidence level.

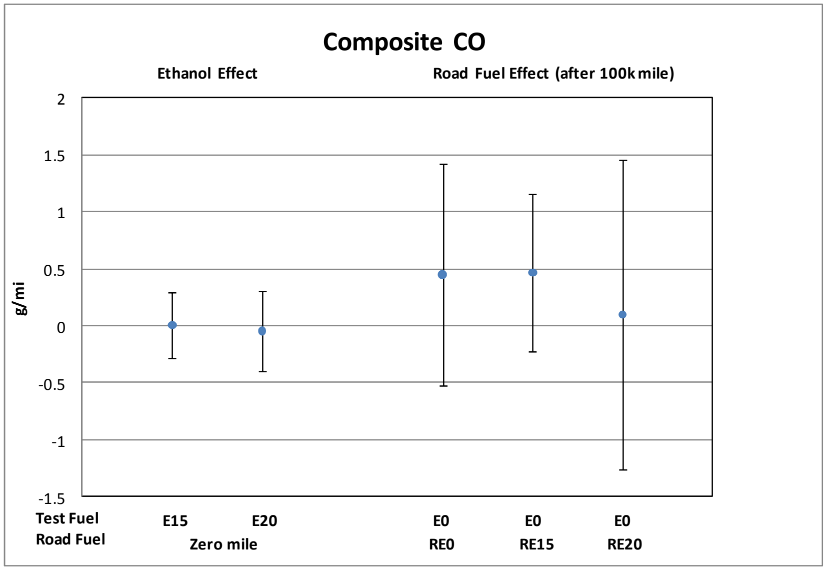
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.95
No Aging Effect with RE0 (Beta0 = 0)	0.29
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.82

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 77k-81k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2003 Toyota Camry (Composite NOx)

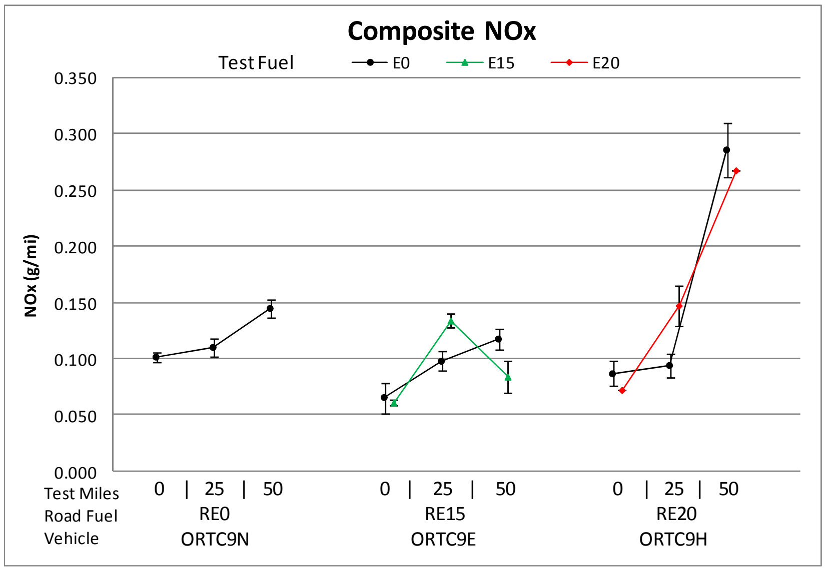
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.000	-0.060	0.059
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.019	-0.054	0.092
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.083	-0.119	0.284
Aging Effect with RE15 (Δg/mi per 100k mi)	0.074	-0.068	0.217
Aging Effect with RE20 (Δg/mi per 100k mi)	0.155	-0.125	0.436

* Indicates estimate is different from zero at the 95% confidence level.

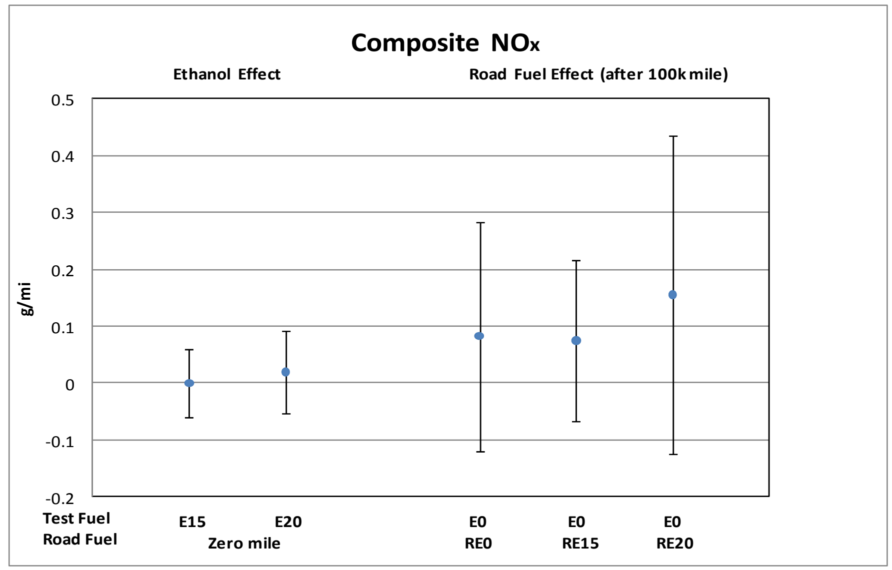
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.80
No Aging Effect with RE0 (Beta0 = 0)	0.34
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.81

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 77k-81k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2003 Toyota Camry (Composite Nonmethane Hydrocarbons)

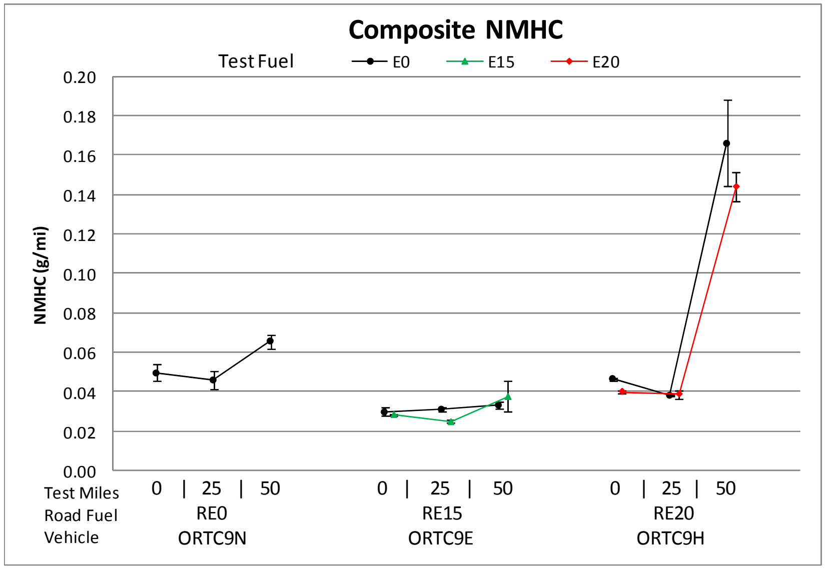
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.001	-0.013	0.011
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.003	-0.018	0.011
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.030	-0.010	0.071
Aging Effect with RE15 (Δg/mi per 100k mi)	0.012	-0.016	0.041
Aging Effect with RE20 (Δg/mi per 100k mi)	-0.018	-0.074	0.037

* Indicates estimate is different from zero at the 95% confidence level.

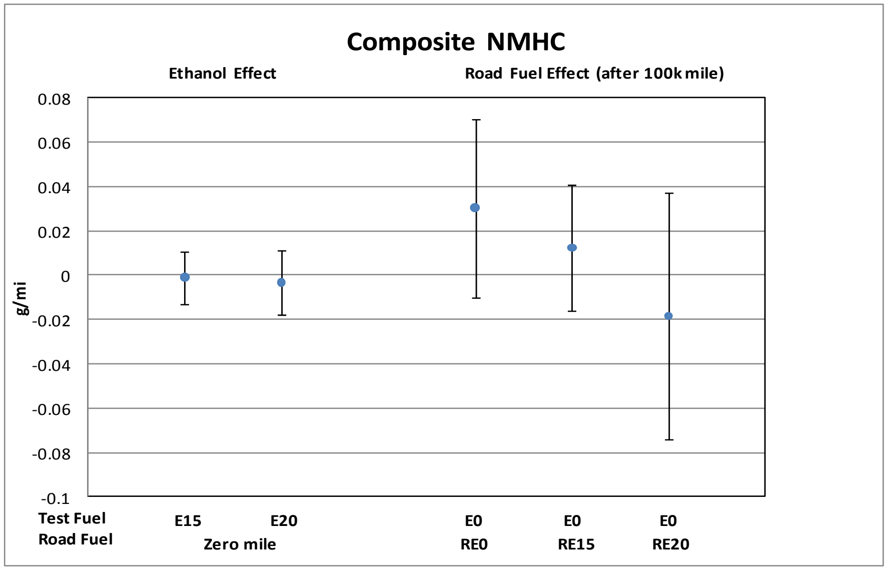
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.84
No Aging Effect with RE0 (Beta0 = 0)	0.11
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.28

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 77k-81k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2003 Toyota Camry (Composite Nonmethane Organic Gases)

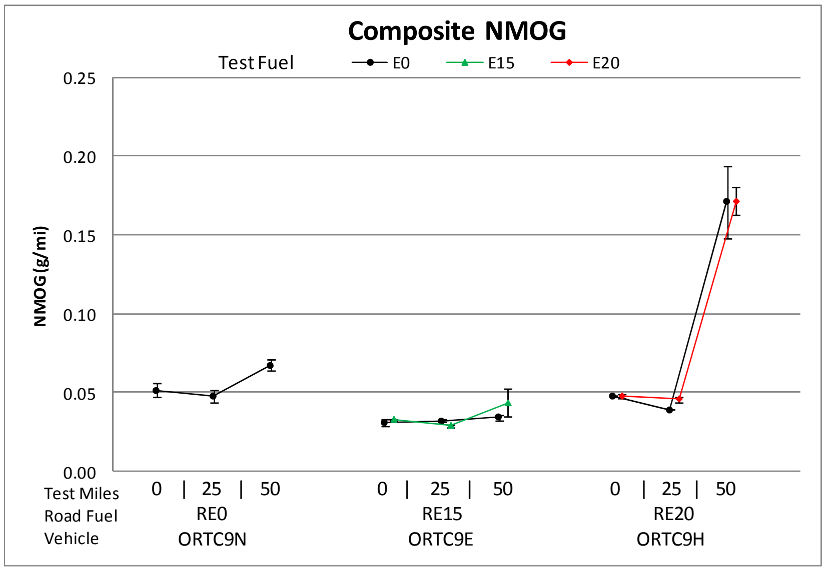
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.003	-0.010	0.016
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.003	-0.013	0.019
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.031	-0.013	0.074
Aging Effect with RE15 (Δg/mi per 100k mi)	0.014	-0.017	0.044
Aging Effect with RE20 (Δg/mi per 100k mi)	-0.020	-0.081	0.040

* Indicates estimate is different from zero at the 95% confidence level.

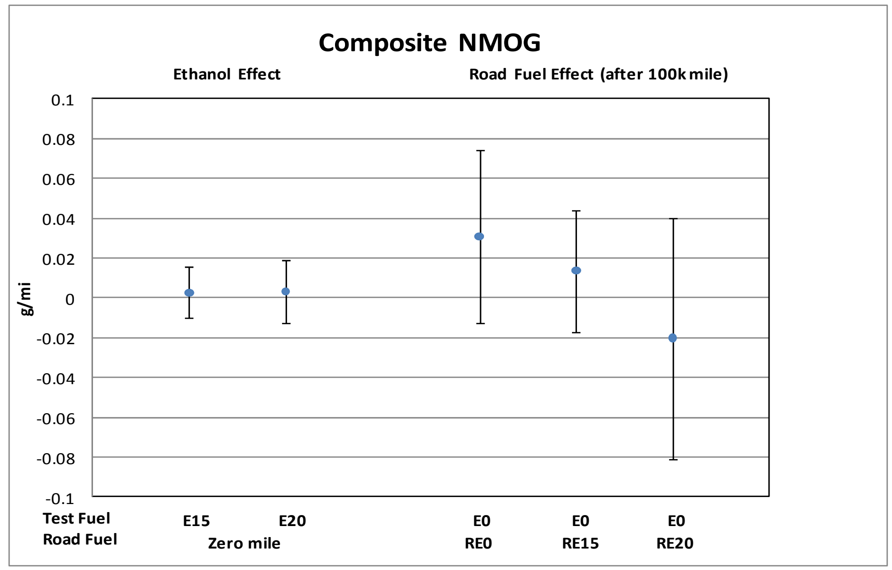
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.77
No Aging Effect with RE0 (Beta0 = 0)	0.13
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.30

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 77k-81k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2003 Toyota Camry (Composite Fuel Economy)

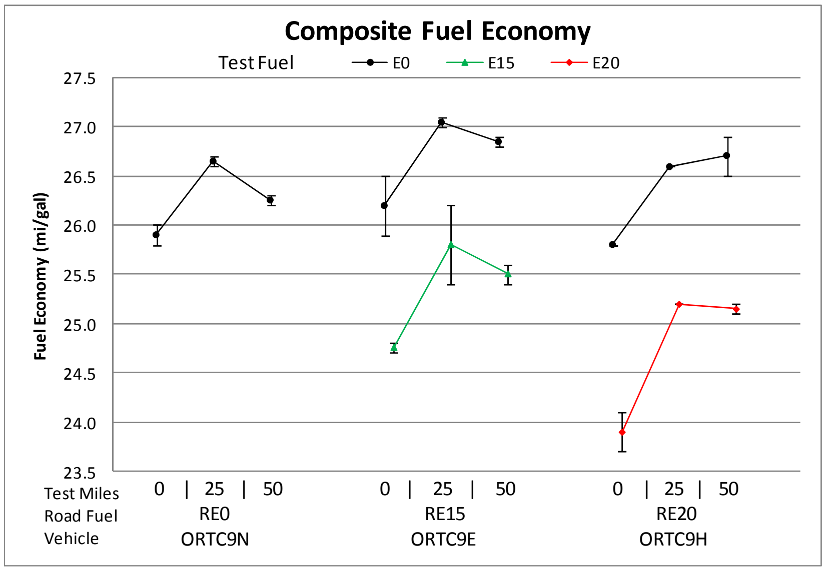
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmi/gal)	-1.350*	-2.169	-0.530
Ethanol Effect (E20 vs. E0) (Δmi/gal)	-1.650*	-2.653	-0.647
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmi/gal per 100k mi)	0.699	-2.075	3.472
Aging Effect with RE15 (Δmi/gal per 100k mi)	1.376	-0.580	3.333
Aging Effect with RE20 (Δmi/gal per 100k mi)	4.029*	0.179	7.880

* Indicates estimate is different from zero at the 95% confidence level.

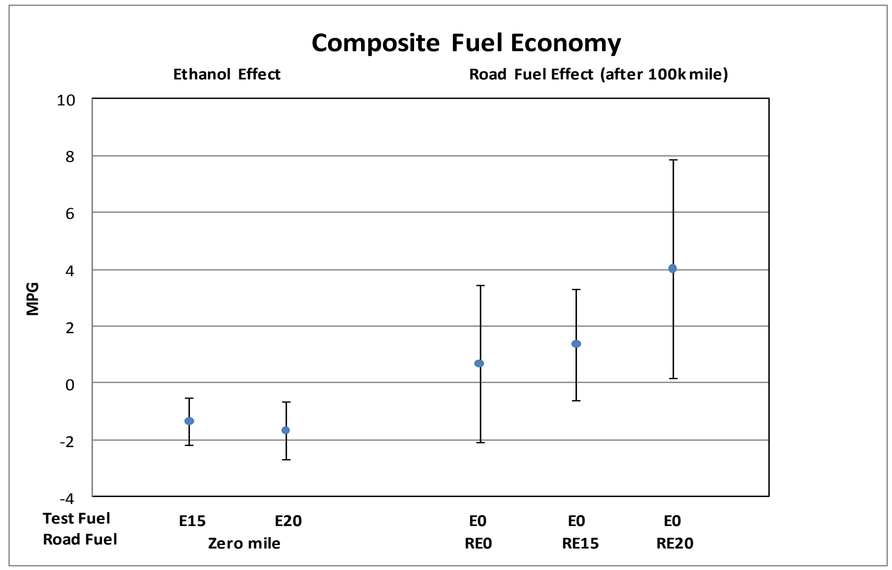
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.55
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.27

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 77k-81k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2003 Toyota Camry (Composite Acetaldehyde)

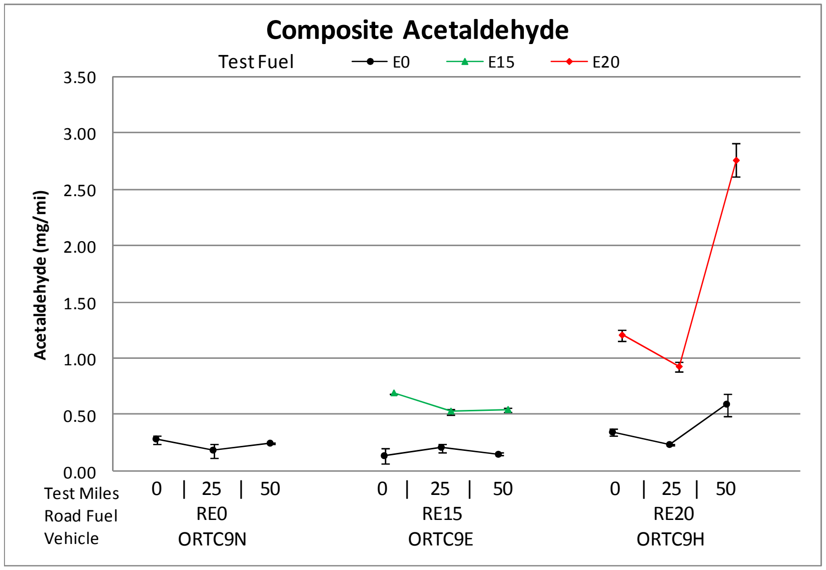
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.428*	0.131	0.725
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.096*	0.189	1.623
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	-0.054	-0.348	0.241
Aging Effect with RE15 (Δmg/mi per 100k mi)	-0.001	-0.171	0.169
Aging Effect with RE20 (Δmg/mi per 100k mi)	-0.237	-0.520	0.046

* Indicates estimate is different from zero at the 95% confidence level.

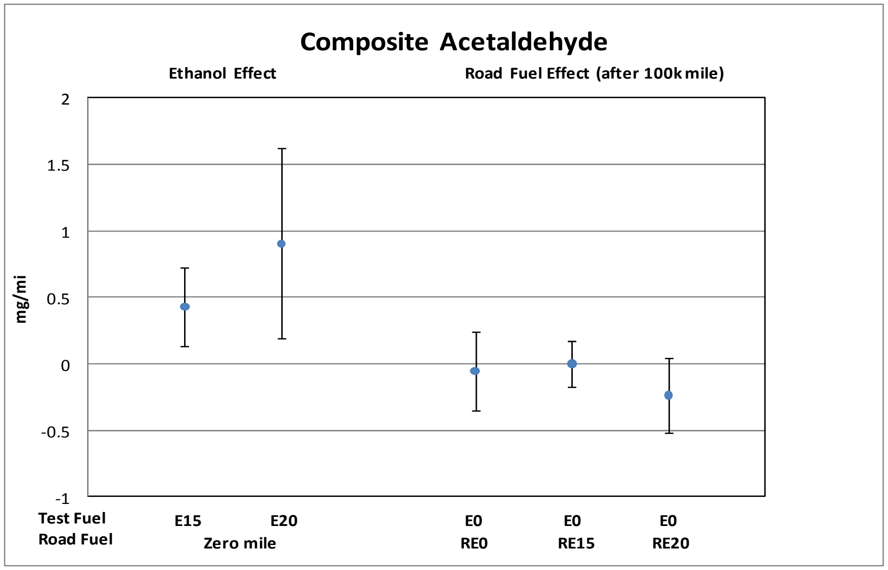
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.73
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.56

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 77k-81k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2003 Toyota Camry (Composite Formaldehyde)

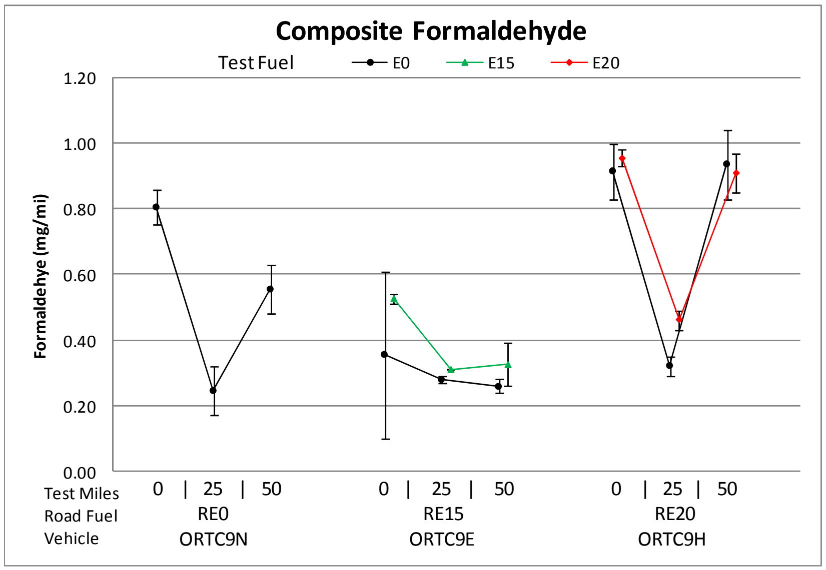
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.125	-0.298	0.548
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.193	-1.057	1.443
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	-0.305	-1.138	0.528
Aging Effect with RE15 (Δmg/mi per 100k mi)	-0.105	-0.504	0.294
Aging Effect with RE20 (Δmg/mi per 100k mi)	-0.815*	-1.611	-0.019

* Indicates estimate is different from zero at the 95% confidence level.

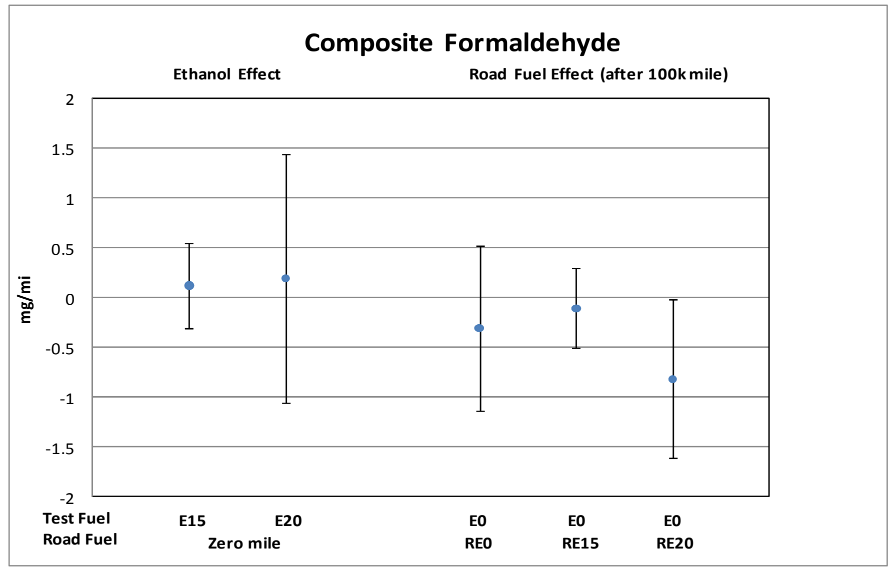
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.56
No Aging Effect with RE0 (Beta0 = 0)	0.54
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.33

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 77k-81k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2003 Toyota Camry (Composite CH_4)

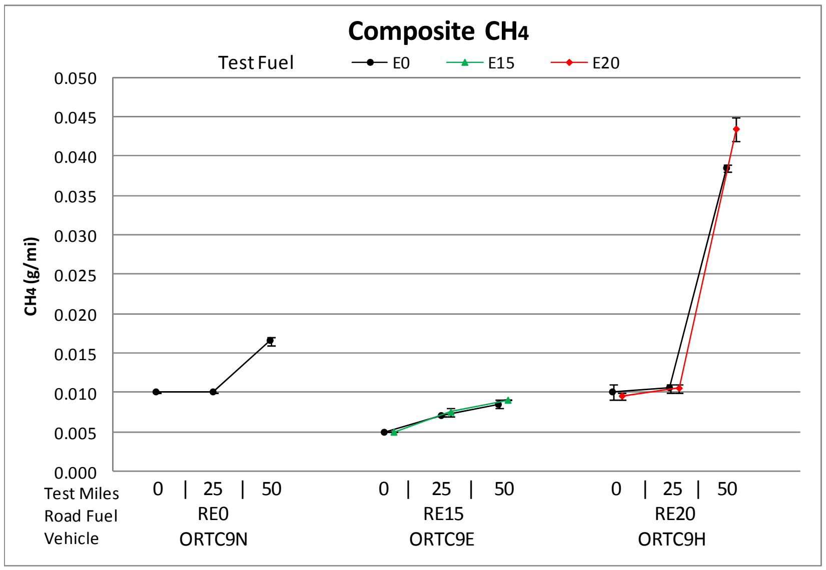
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0003	-0.0023	0.0029
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.0003	-0.0034	0.0029
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0126*	0.0039	0.0214
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0073*	0.0011	0.0135
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0029	-0.0093	0.0150

* Indicates estimate is different from zero at the 95% confidence level.

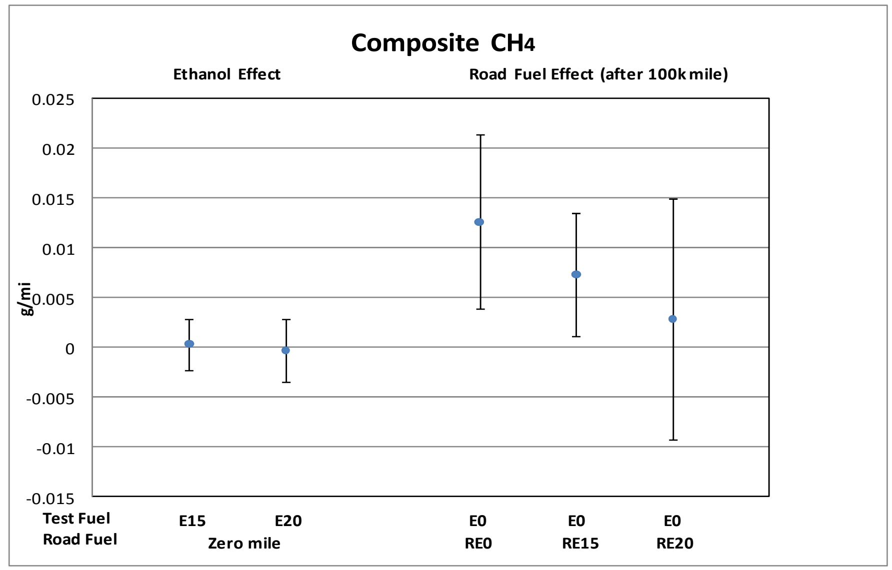
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.93
No Aging Effect with RE0 (Beta0 = 0)	0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.30

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 77k-81k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2003 Ford Taurus - Composite Emissions Summary

Emisssion Parameter (units)	Ethanol Effect				Aging Effect with RE0		RExx Aging Effect on E0 Emissions				Exx Aging Effect on Exx Emission			Road and Test Fuel Effects are Additive
	Δ units vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value	Δ units per 100K mi			Overall p-value
Fuels	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0		RE10/E10	RE15/E15	RE20/E20	
CO (g/mi)	NA	-0.197*	-0.337*	<0.01*	-0.258	0.12	NA	0.055	-0.139	0.25	NA	NA	NA	0.54
NOx (g/mi)	NA	0.010	0.054*	<0.01*	0.014	0.73	NA	0.176*	0.022	<0.01*	NA	NA	NA	0.98
NMHC (g/mi)	NA	-0.016	-0.024	0.12	-0.028	0.50	NA	-0.020	-0.030	0.97	NA	NA	NA	0.95
NMOG (g/mi)	NA	-0.009	-0.017	0.35	-0.030	0.50	NA	-0.022	-0.034	0.96	NA	NA	NA	0.92
Fuel Econ (mi/gal)	NA	-1.116*	-1.349*	<0.01*	1.385*	<0.01*	NA	0.646*	1.491*	0.06	NA	NA	NA	0.91
Acetaldehyde (mg/mi)[#]	NA	0.680*	1.114*	<0.01*	0.051	0.63	NA	0.041	-0.104*	0.20	NA	NA	NA	0.19
Formaldehyde (mg/mi)[#]	NA	0.236	0.166	0.15	-0.252	0.51	NA	-0.299	-0.498*	0.61	NA	NA	NA	0.88
CH_4 (g/mi)	NA	-0.0003	-0.0008*	0.07	0.0020	0.12	NA	0.0030*	0.0040*	0.41	NA	NA	NA	NA[1]

Log-normal model was used. Results are presented as changes in emissions at 0k mile.

Data did not support the assumption of linear effects with mileage.

* Indicates estimate is different from zero at the 95% confidence level.

1 Model fail to converge

2003 Ford Taurus (Composite CO)

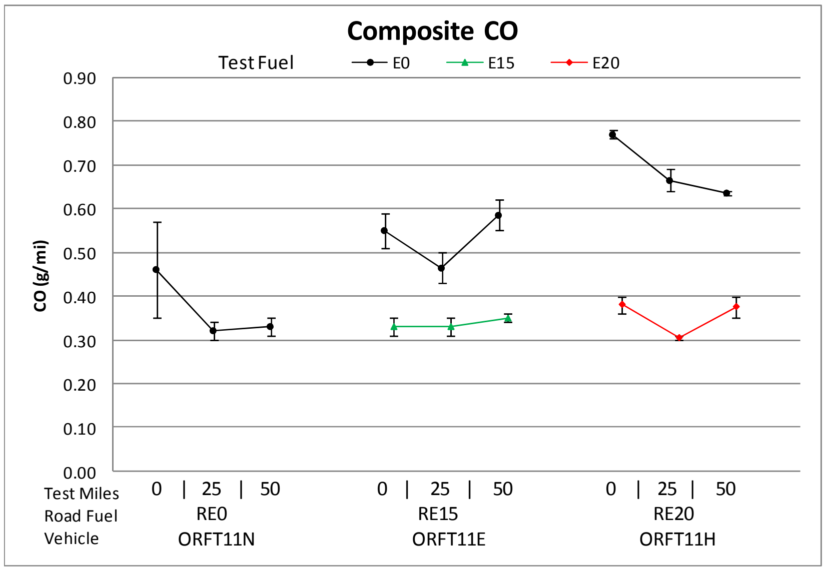
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.197*	-0.299	-0.095
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.337*	-0.439	-0.235
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	-0.258	-0.607	0.091
Aging Effect with RE15 (Δg/mi per 100k mi)	0.055	-0.193	0.303
Aging Effect with RE20 (Δg/mi per 100k mi)	-0.139	-0.387	0.109

* Indicates estimate is different from zero at the 95% confidence level.

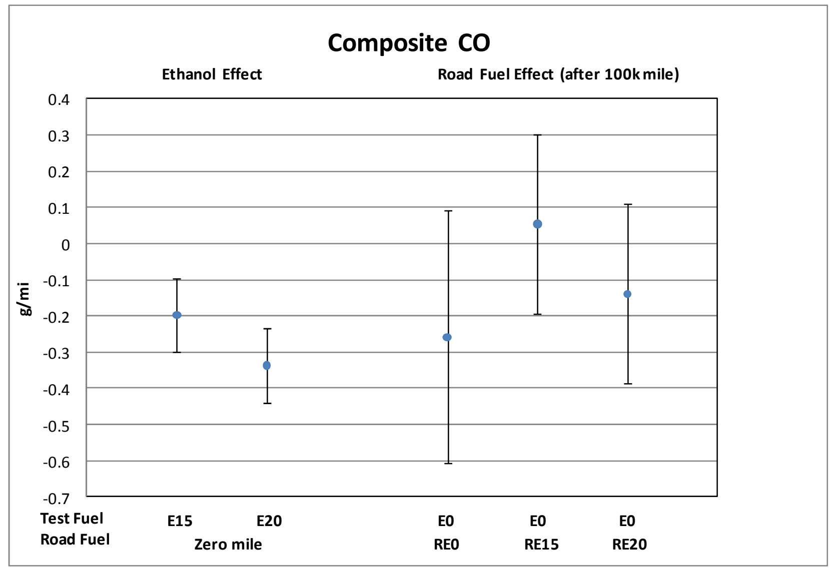
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.12
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.25

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 84k-93k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2003 Ford Taurus (Composite NOx)

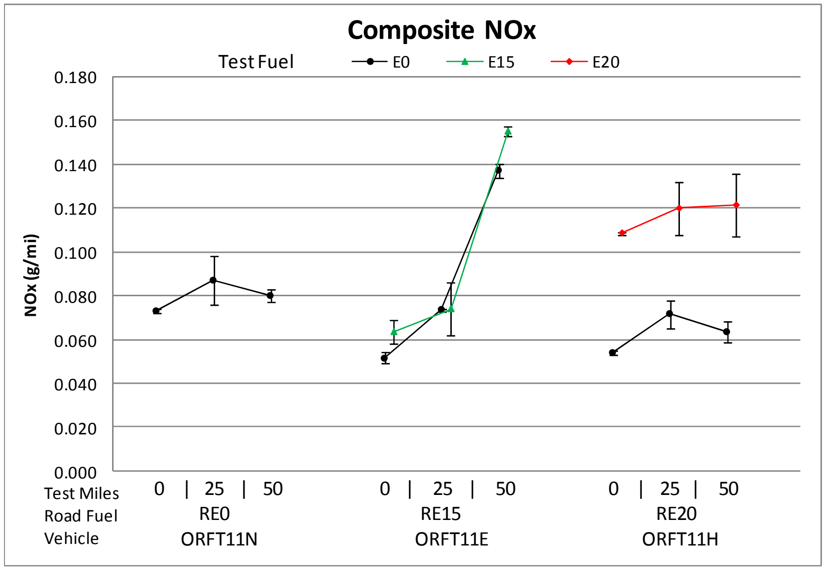
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.010	-0.016	0.037
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.054*	0.027	0.080
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.014	-0.077	0.105
Aging Effect with RE15 (Δg/mi per 100k mi)	0.176*	0.111	0.241
Aging Effect with RE20 (Δg/mi per 100k mi)	0.022	-0.042	0.087

* Indicates estimate is different from zero at the 95% confidence level.

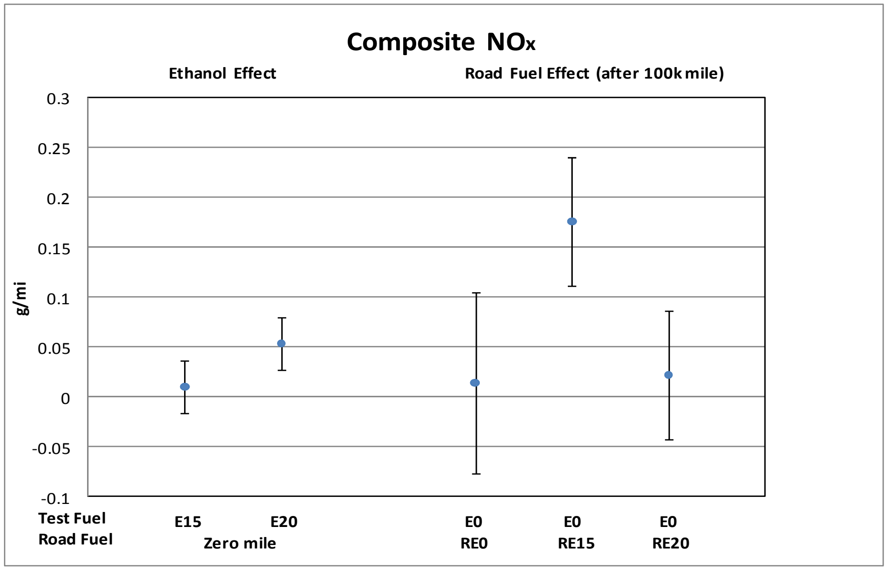
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.73
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	<0.01*

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 84k-93k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

E-207

2003 Ford Taurus (Composite Nonmethane Hydrocarbons)

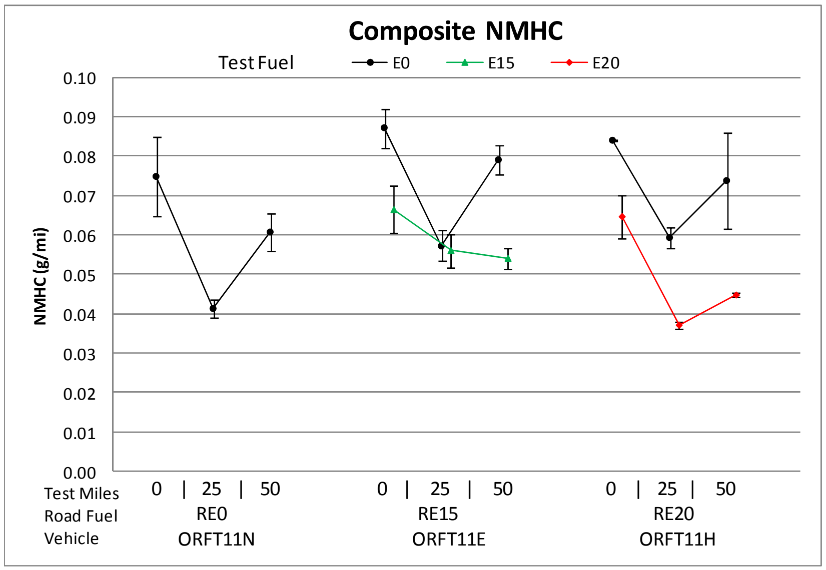
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.016	-0.043	0.012
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.024	-0.051	0.004
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	-0.028	-0.122	0.065
Aging Effect with RE15 (Δg/mi per 100k mi)	-0.020	-0.087	0.046
Aging Effect with RE20 (Δg/mi per 100k mi)	-0.030	-0.097	0.037

* Indicates estimate is different from zero at the 95% confidence level.

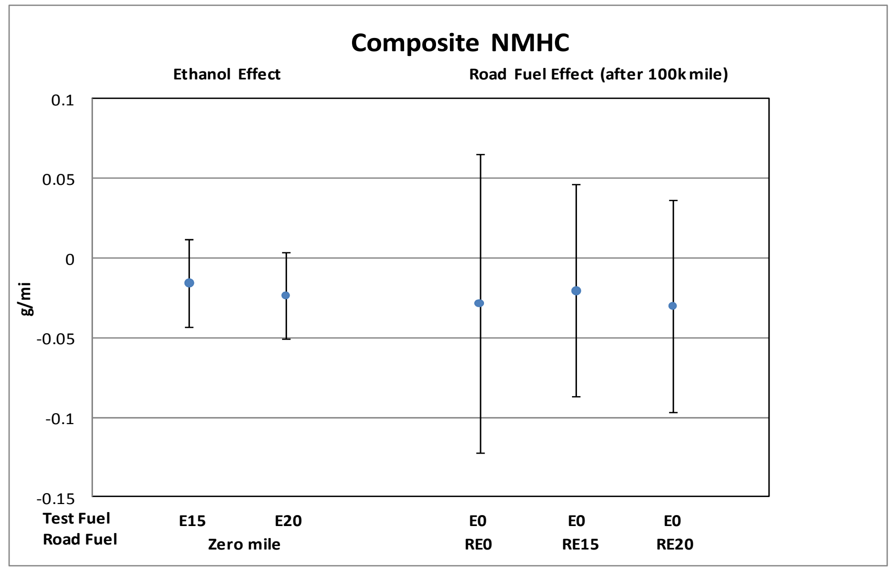
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.12
No Aging Effect with RE0 (Beta0 = 0)	0.50
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.97

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 84k-93k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2003 Ford Taurus (Composite Nonmethane Organic Gases)

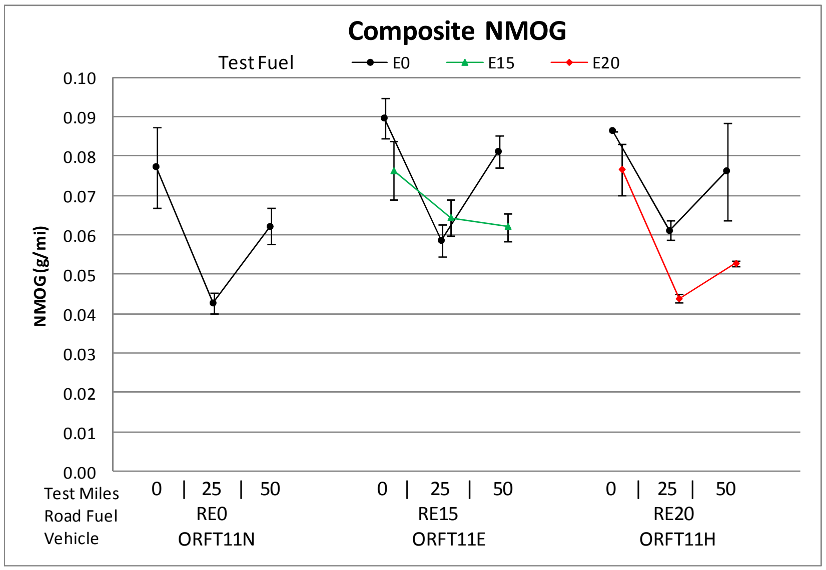
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.009	-0.038	0.020
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.017	-0.046	0.012
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	-0.030	-0.129	0.070
Aging Effect with RE15 (Δg/mi per 100k mi)	-0.022	-0.093	0.048
Aging Effect with RE20 (Δg/mi per 100k mi)	-0.034	-0.105	0.037

* Indicates estimate is different from zero at the 95% confidence level.

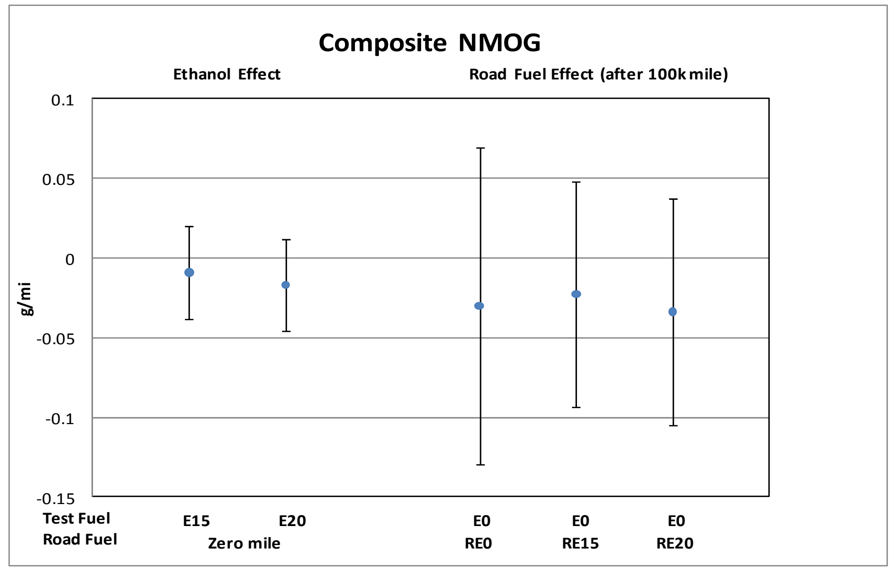
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.35
No Aging Effect with RE0 (Beta0 = 0)	0.50
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.96

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 84k-93k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2003 Ford Taurus (Composite Fuel Economy)

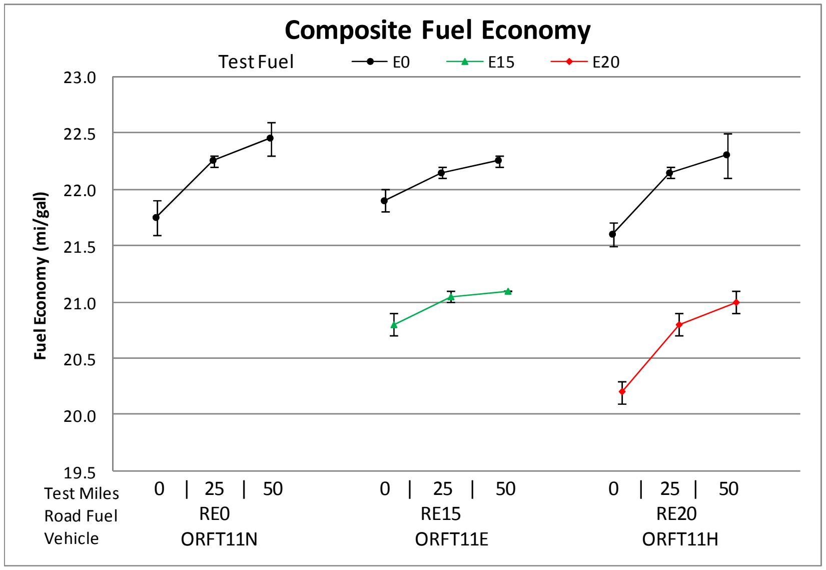
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmi/gal)	-1.116*	-1.324	-0.908
Ethanol Effect (E20 vs. E0) (Δmi/gal)	-1.349*	-1.557	-1.141
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmi/gal per 100k mi)	1.385*	0.673	2.097
Aging Effect with RE15 (Δmi/gal per 100k mi)	0.646*	0.139	1.152
Aging Effect with RE20 (Δmi/gal per 100k mi)	1.491*	0.984	1.998

* Indicates estimate is different from zero at the 95% confidence level.

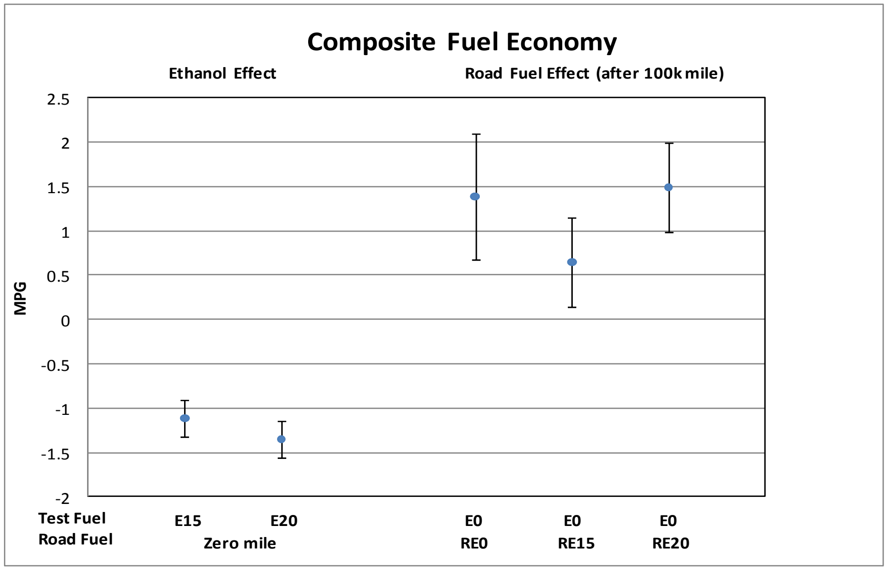
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.06

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 84k-93k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2003 Ford Taurus (Composite Acetaldehyde)

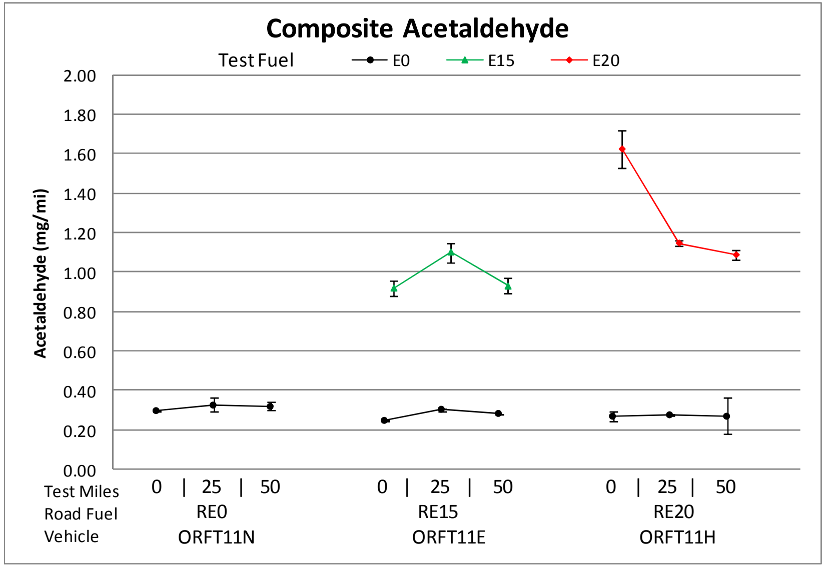
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.680*	0.481	0.879
Ethanol Effect (E20 vs. E0) (Δmg/mi)	1.114*	0.822	1.406
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.051	-0.163	0.266
Aging Effect with RE15 (Δmg/mi per 100k mi)	0.041	-0.099	0.181
Aging Effect with RE20 (Δmg/mi per 100k mi)	-0.104*	-0.205	-0.004

* Indicates estimate is different from zero at the 95% confidence level.

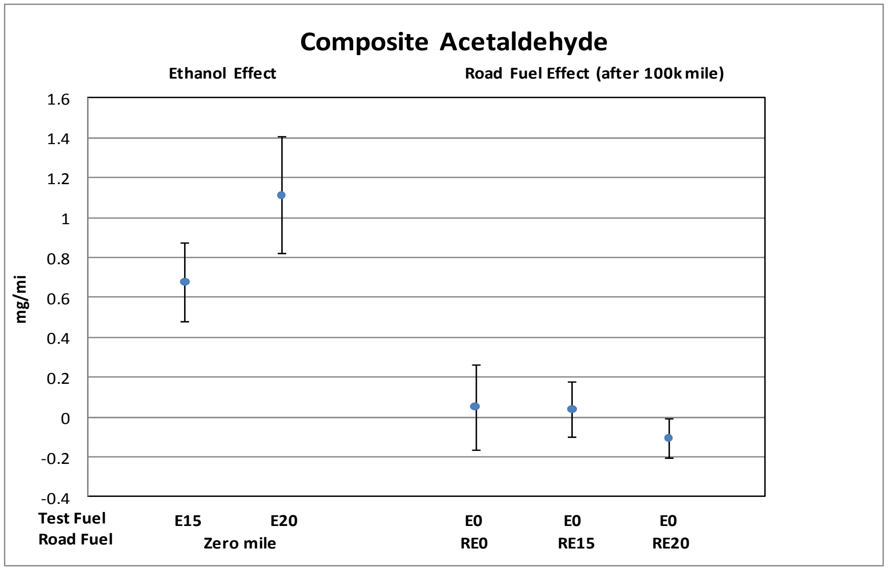
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.63
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.20

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 84k-93k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2003 Ford Taurus (Composite Formaldehyde)

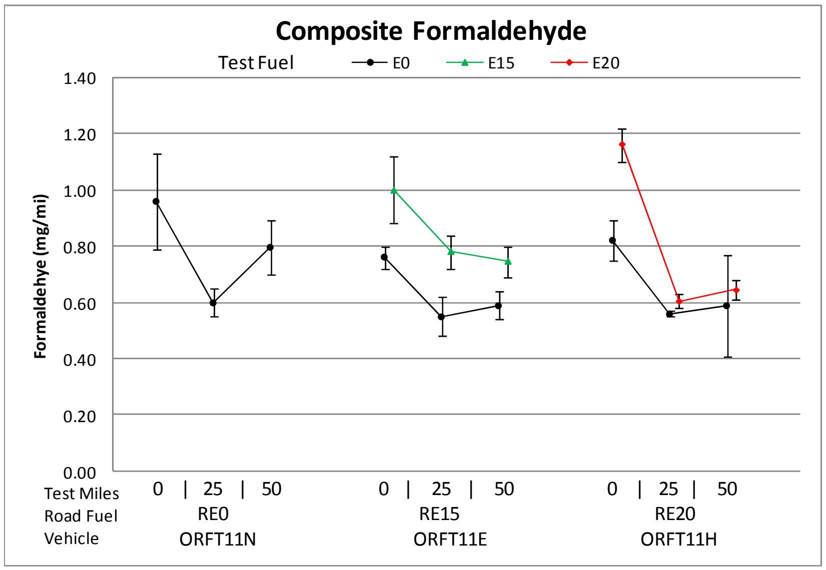
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.236	-0.166	0.639
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.166	-0.262	0.594
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	-0.252	-0.905	0.401
Aging Effect with RE15 (Δmg/mi per 100k mi)	-0.299	-0.680	0.081
Aging Effect with RE20 (Δmg/mi per 100k mi)	-0.498*	-0.848	-0.147

* Indicates estimate is different from zero at the 95% confidence level.

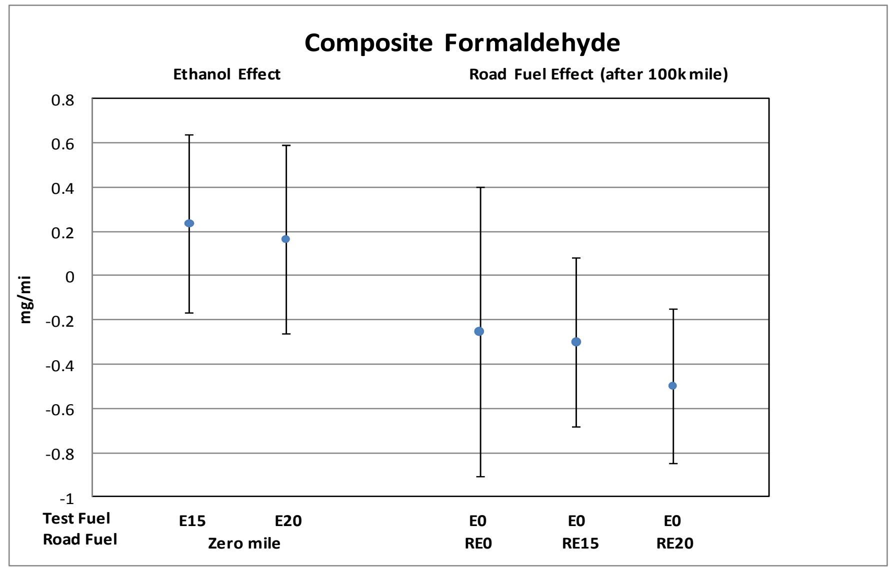
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.15
No Aging Effect with RE0 (Beta0 = 0)	0.51
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.61

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 84k-93k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2003 Ford Taurus (Composite CH_4)

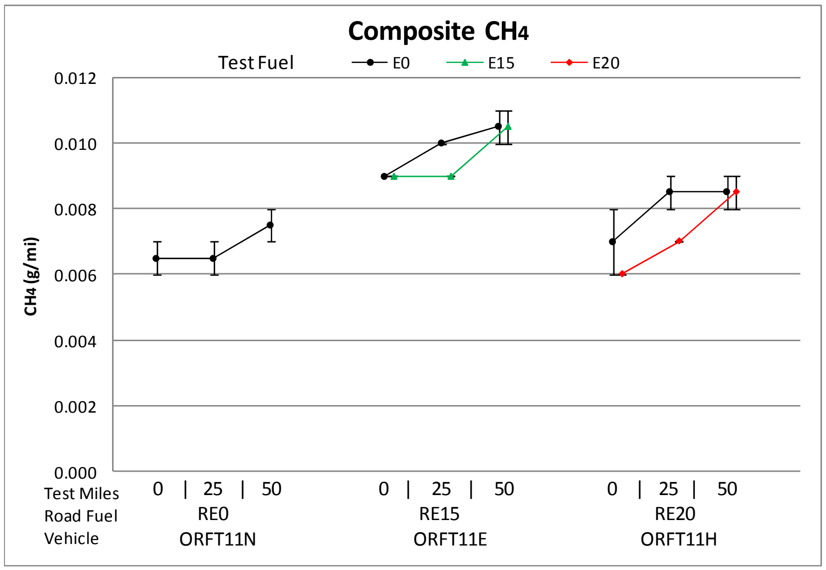
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.0003	-0.0011	0.0004
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.0008*	-0.0016	-0.0001
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0020	-0.0006	0.0045
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0030*	0.0012	0.0048
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0040*	0.0022	0.0058

* Indicates estimate is different from zero at the 95% confidence level.

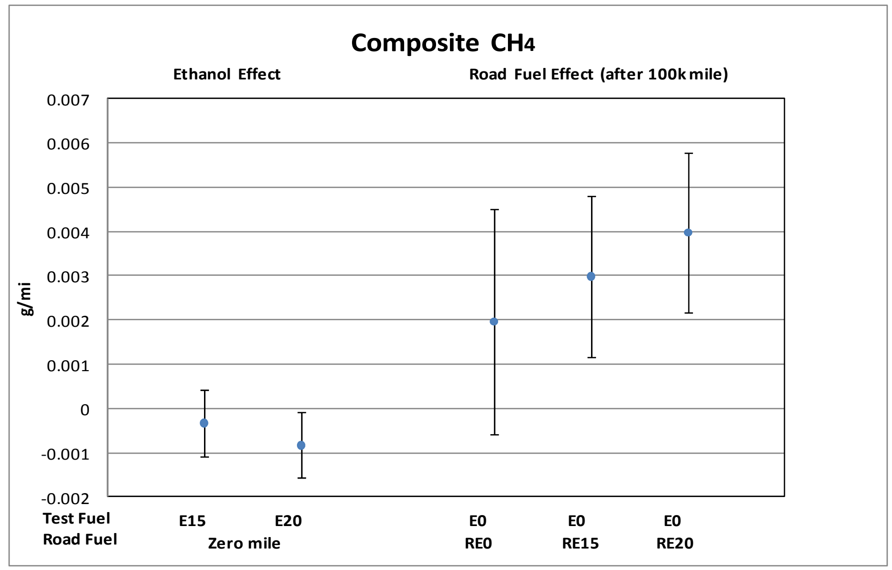
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.07
No Aging Effect with RE0 (Beta0 = 0)	0.12
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.41

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 84k-93k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2003 Chevrolet Cavalier - Composite Emissions Summary

Emisssion Parameter (units)	Ethanol Effect				Aging Effect with RE0		RExx Aging Effect on E0 Emissions				RExx Aging Effect on Exx Emissions			Road and Test Fuel Effects are Additive
	Δ units vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value	Δ units per 100K mi			Overall p-value
Fuels	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0		RE10/E10	RE15/E15	RE20/E20	
CO (g/mi)	NA	-0.130	-0.415*	<0.01*	1.611*	<0.01*	NA	0.120	0.358	<0.01*	NA	NA	NA	0.87
NOx (g/mi)	NA	-0.005	0.018	0.80	0.408*	<0.01*	NA	-0.185*	-0.098	<0.01*	NA	NA	NA	0.50
NMHC (g/mi)	NA	-0.0058	0.0000	0.67	0.0854*	<0.01*	NA	0.0012	0.0491*	0.04*	NA	NA	NA	0.98
NMOG (g/mi)	NA	-0.0001	0.0128	0.28	0.0872*	0.01*	NA	0.0018	0.0540*	0.06	NA	NA	NA	0.95
Fuel Econ (mi/gal)	NA	-1.476*	-1.466*	<0.01*	-2.320*	<0.01*	NA	1.613*	0.694	<0.01*	NA	NA	NA	0.28
Acetaldehyde (mg/mi)[#]	NA	0.414*	0.592*	<0.01*	0.257	0.15	NA	-0.066	0.376*	0.04*	NA	NA	NA	0.26
Formaldehyde (mg/mi)[#]	NA	0.034	0.191	0.15	0.619	0.26	NA	-0.546*	0.161	0.04*	NA	NA	NA	0.64
CH_4 (g/mi)	NA	-0.0008	-0.0013	0.56	0.0271*	<0.01*	NA	0.0028	0.0055	0.01*	NA	NA	NA	0.99

Log-normal model was used. Results are presented as changes in emissions at 0k mile.

Data did not support the assumption of linear effects with mileage.

* Indicates estimate is different from zero at the 95% confidence level.

2003 Chevrolet Cavalier (Composite CO)

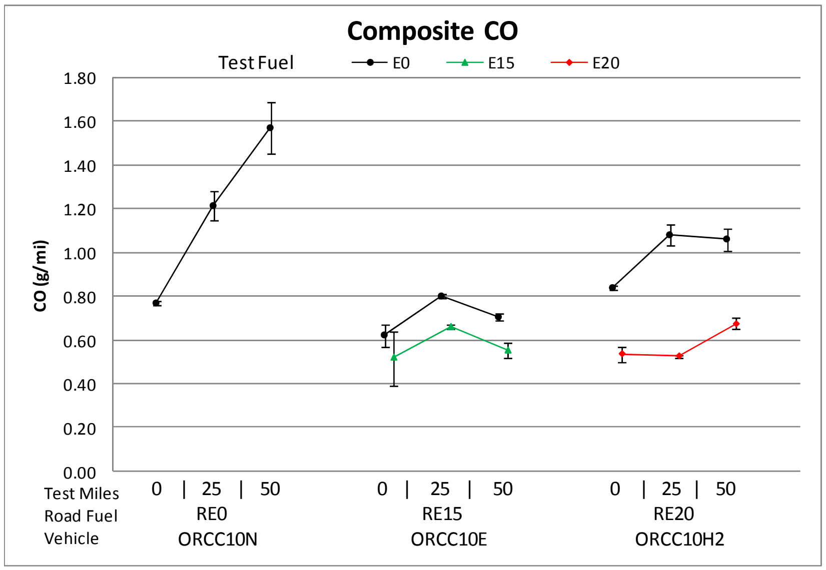
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.130	-0.279	0.018
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.415*	-0.563	-0.266
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	1.611*	1.092	2.130
Aging Effect with RE15 (Δg/mi per 100k mi)	0.120	-0.241	0.481
Aging Effect with RE20 (Δg/mi per 100k mi)	0.358	-0.004	0.719

* Indicates estimate is different from zero at the 95% confidence level.

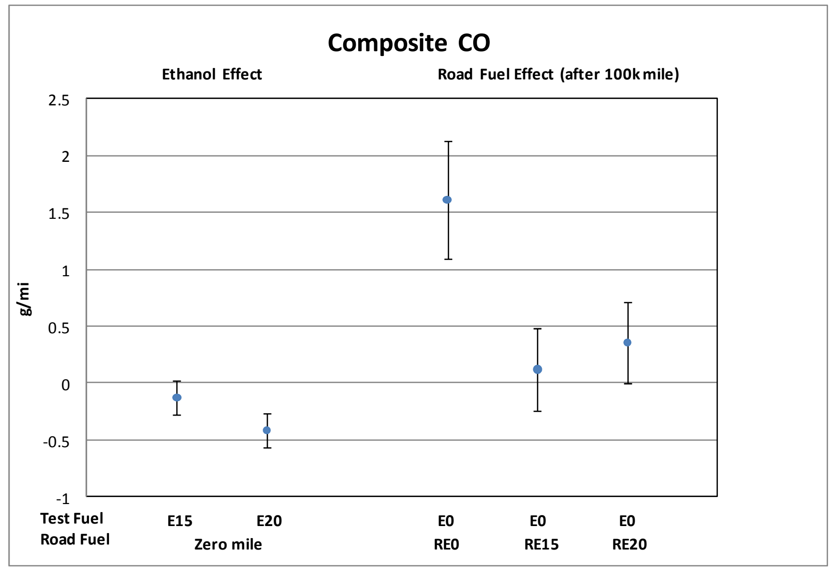
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	<0.01*

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 81k-89k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2003 Chevrolet Cavalier (Composite NOx)

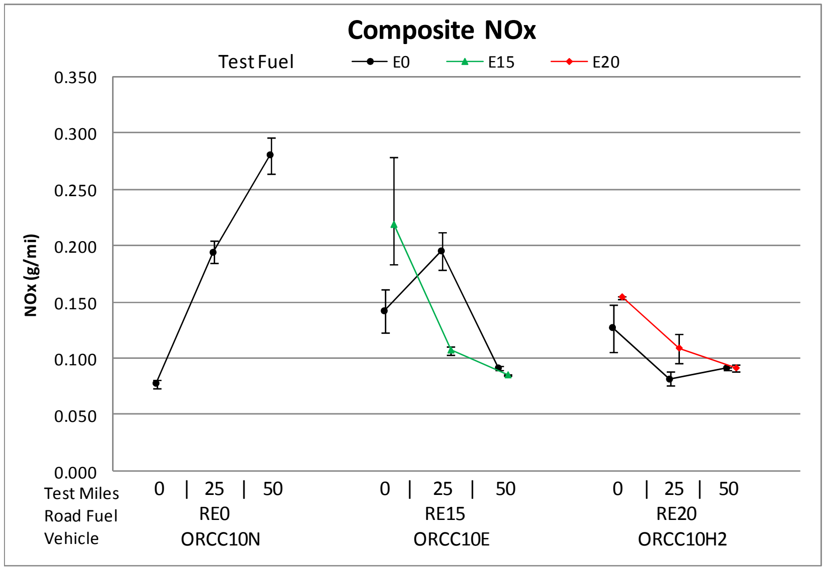
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.005	-0.071	0.061
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.018	-0.048	0.084
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.408*	0.177	0.639
Aging Effect with RE15 (Δg/mi per 100k mi)	-0.185*	-0.345	-0.025
Aging Effect with RE20 (Δg/mi per 100k mi)	-0.098	-0.259	0.063

* Indicates estimate is different from zero at the 95% confidence level.

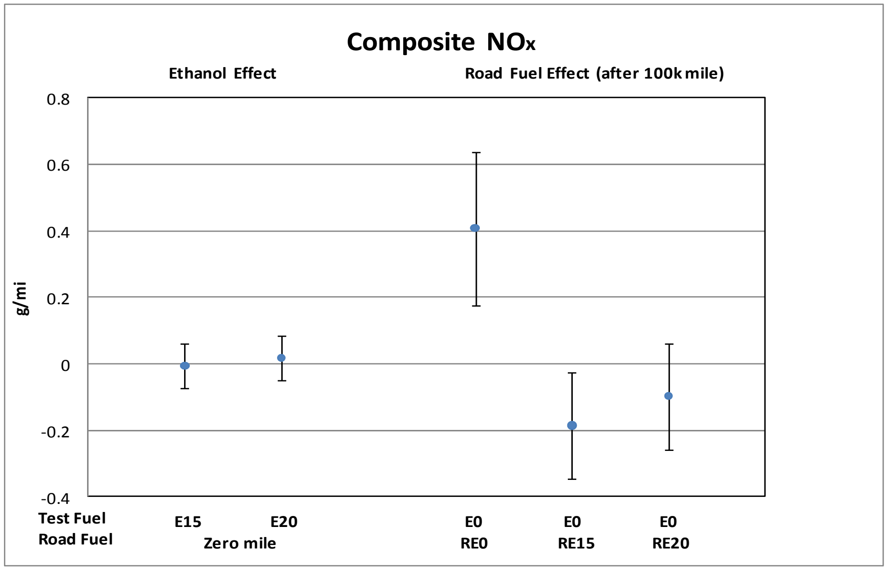
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.80
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	<0.01*

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 81k-89k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2003 Chevrolet Cavalier (Composite Nonmethane Hydrocarbons)

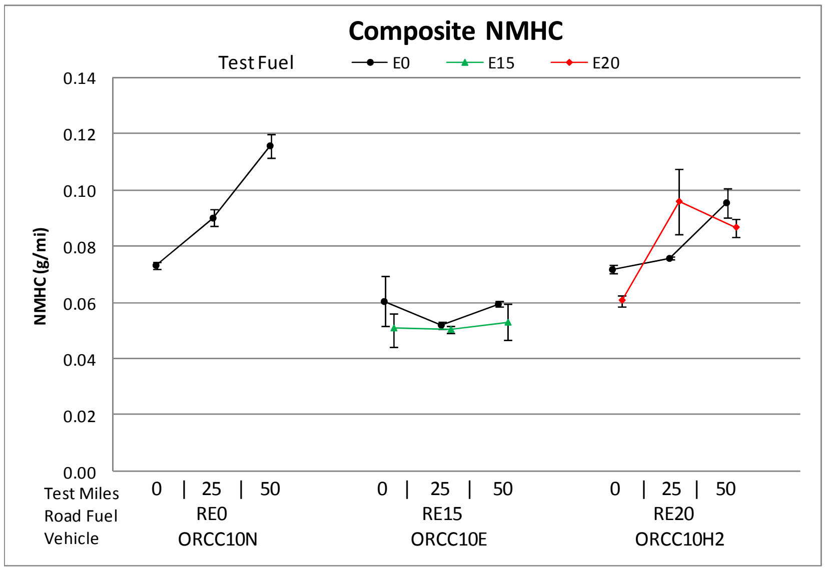
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.0058	-0.0208	0.0092
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.0000	-0.0150	0.0151
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0854*	0.0329	0.1379
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0012	-0.0354	0.0377
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0491*	0.0125	0.0857

* Indicates estimate is different from zero at the 95% confidence level.

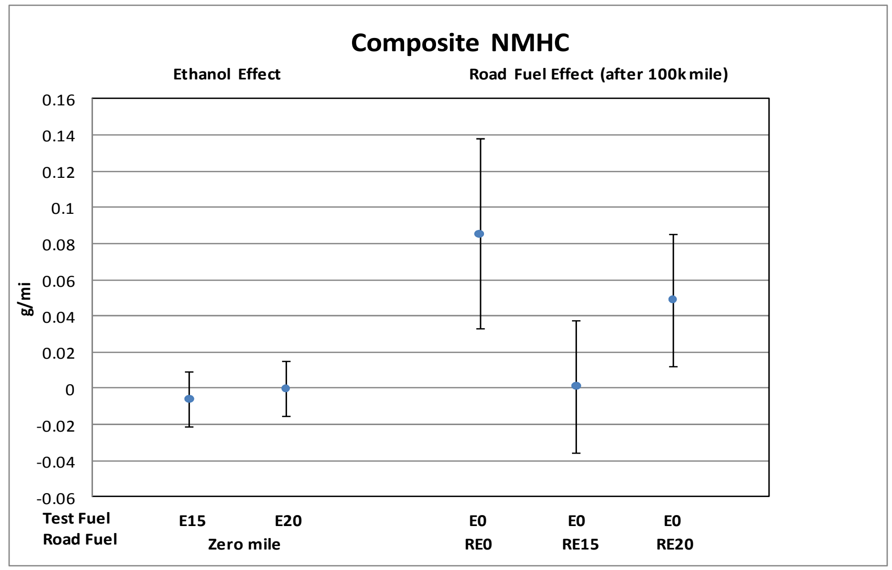
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.67
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.04*

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 81k-89k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2003 Chevrolet Cavalier (Composite Nonmethane Organic Gases)

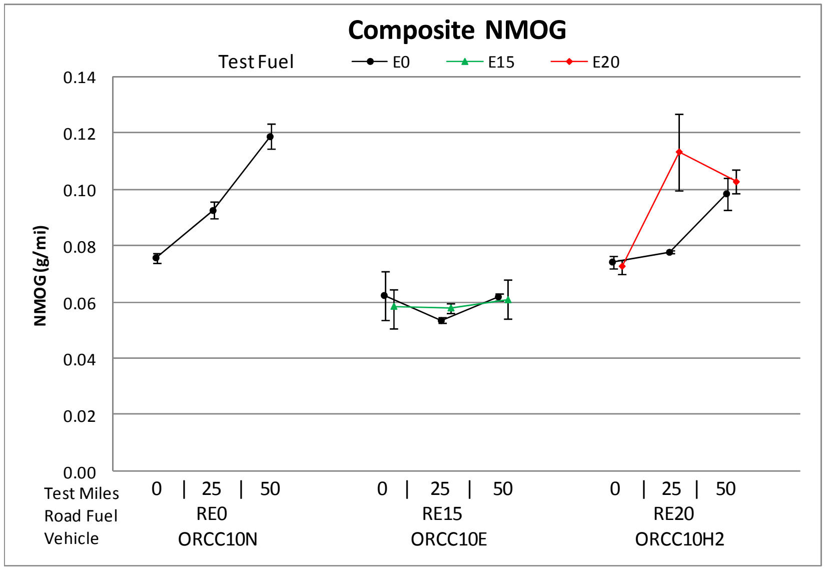
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.0001	-0.0174	0.0172
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.0128	-0.0045	0.0302
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0872*	0.0267	0.1476
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0018	-0.0403	0.0439
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0540*	0.0119	0.0962

* Indicates estimate is different from zero at the 95% confidence level.

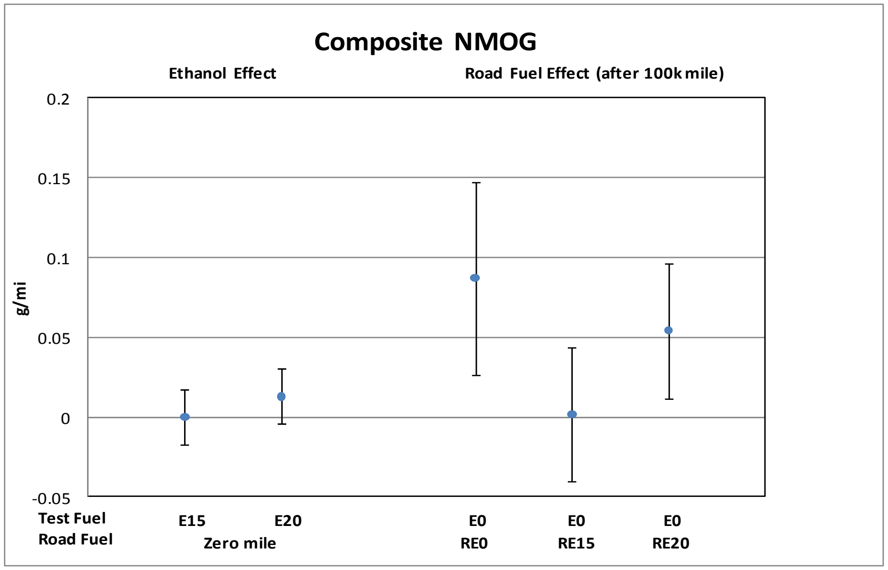
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.28
No Aging Effect with RE0 (Beta0 = 0)	0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.06

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 81k-89k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2003 Chevrolet Cavalier (Composite Fuel Economy)

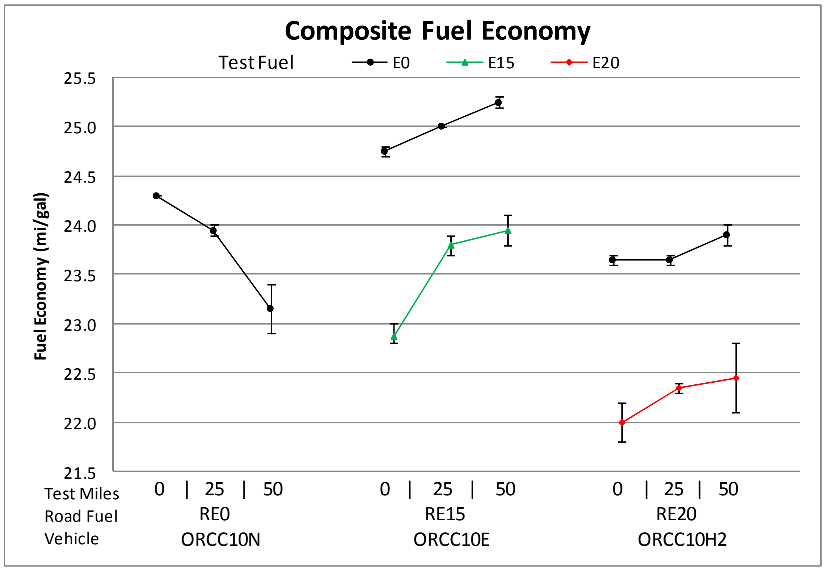
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmi/gal)	-1.476*	-1.851	-1.101
Ethanol Effect (E20 vs. E0) (Δmi/gal)	-1.466*	-1.842	-1.090
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmi/gal per 100k mi)	-2.320*	-3.633	-1.007
Aging Effect with RE15 (Δmi/gal per 100k mi)	1.613*	0.703	2.523
Aging Effect with RE20 (Δmi/gal per 100k mi)	0.694	-0.220	1.609

* Indicates estimate is different from zero at the 95% confidence level.

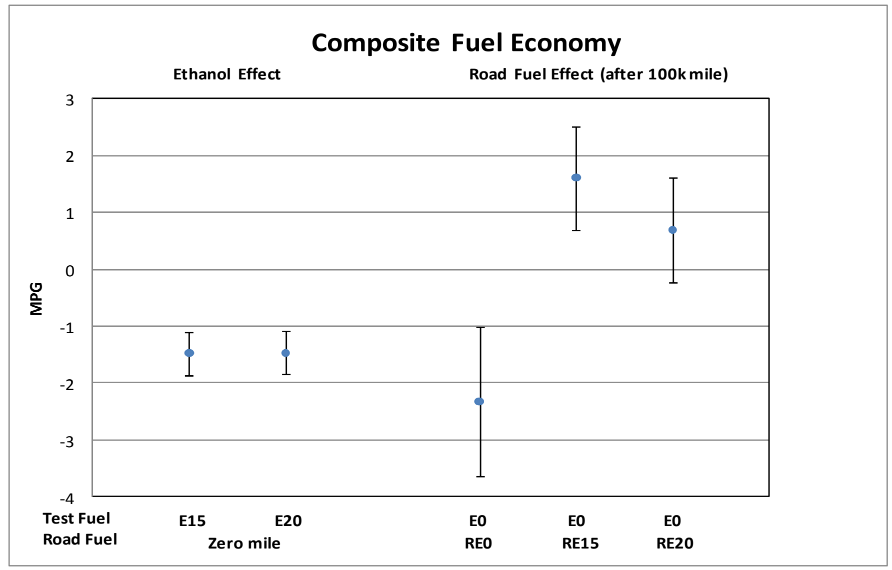
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	<0.01*

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 81k-89k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2003 Chevrolet Cavalier (Composite Acetaldehyde)

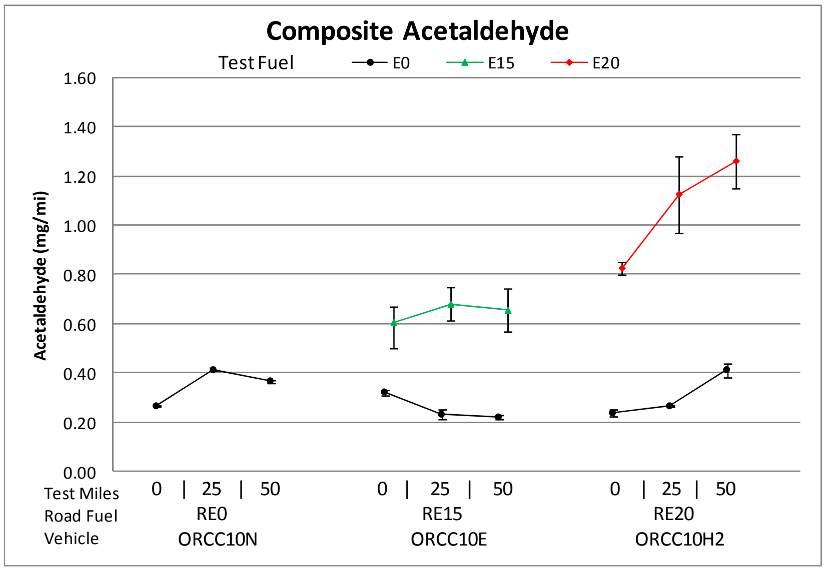
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.414*	0.223	0.604
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.592*	0.373	0.810
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.257	-0.157	0.672
Aging Effect with RE15 (Δmg/mi per 100k mi)	-0.066	-0.196	0.064
Aging Effect with RE20 (Δmg/mi per 100k mi)	0.376*	0.047	0.706

* Indicates estimate is different from zero at the 95% confidence level.

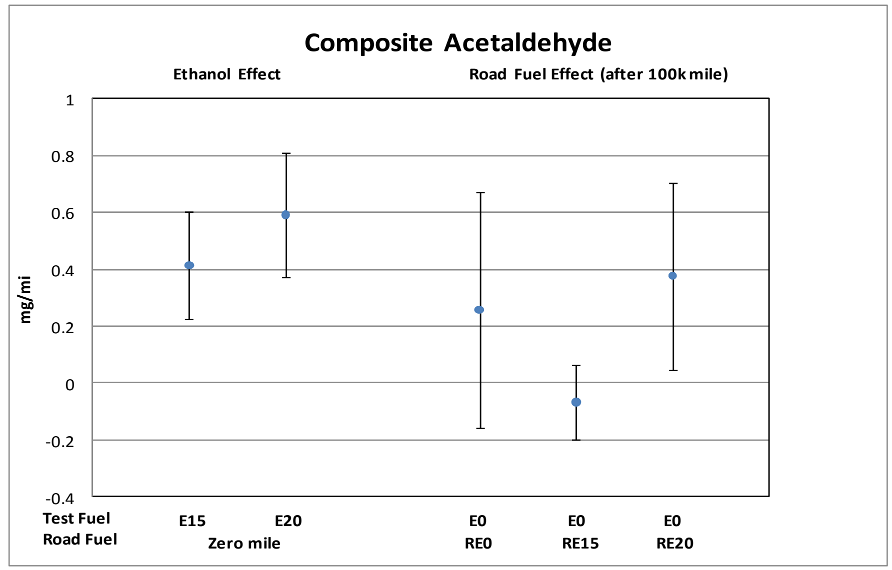
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.15
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.04*

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 81k-89k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2003 Chevrolet Cavalier (Composite Formaldehyde)

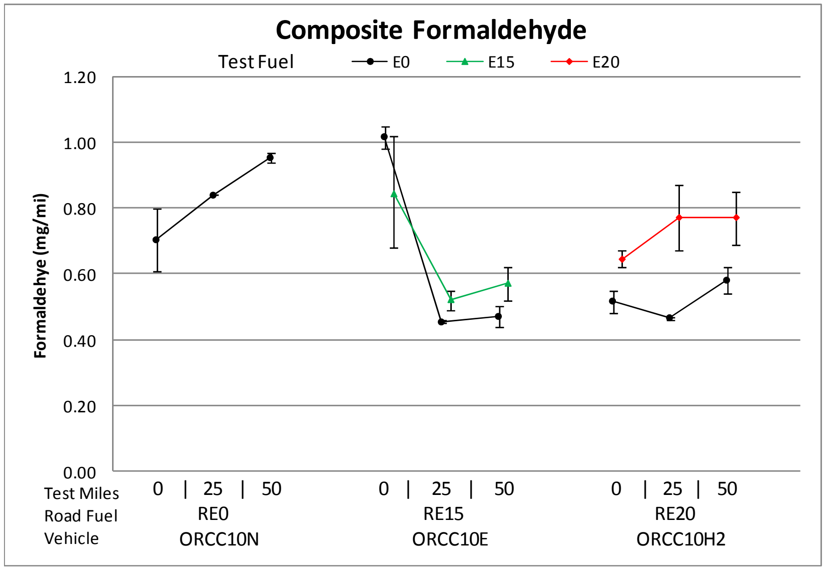
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmg/mi)	0.034	-0.351	0.419
Ethanol Effect (E20 vs. E0) (Δmg/mi)	0.191	-0.081	0.463
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmg/mi per 100k mi)	0.619	-0.680	1.919
Aging Effect with RE15 (Δmg/mi per 100k mi)	-0.546*	-0.864	-0.228
Aging Effect with RE20 (Δmg/mi per 100k mi)	0.161	-0.307	0.630

* Indicates estimate is different from zero at the 95% confidence level.

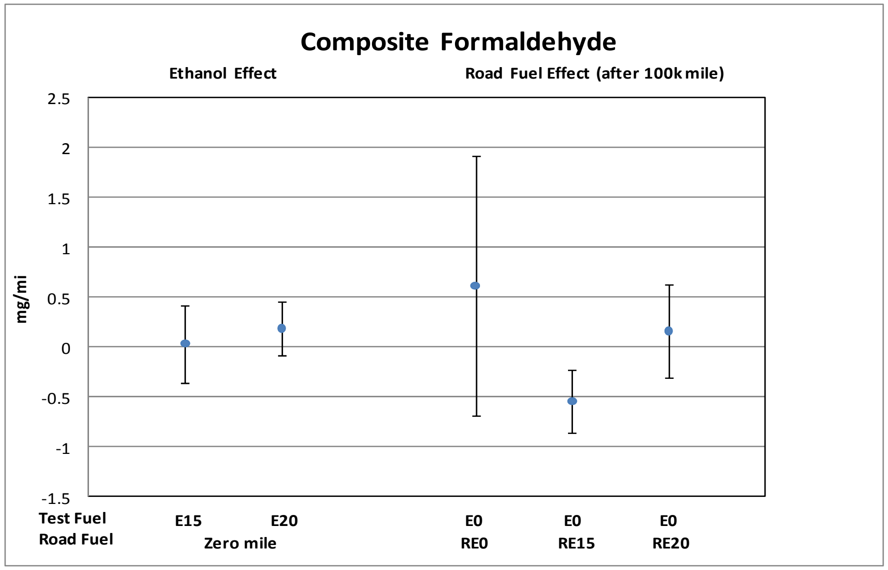
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.15
No Aging Effect with RE0 (Beta0 = 0)	0.26
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.04*

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 81k-89k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2003 Chevrolet Cavalier (Composite CH_4)

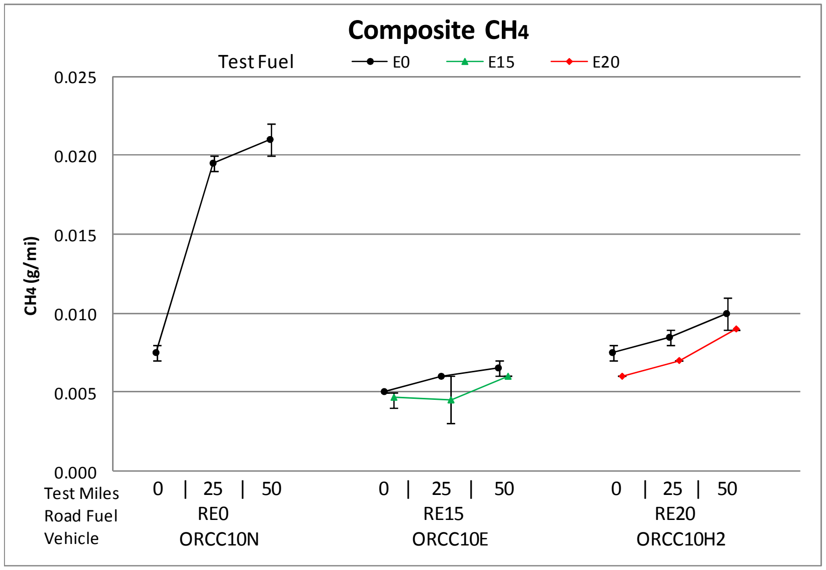
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.0008	-0.0040	0.0025
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.0013	-0.0046	0.0019
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0271*	0.0158	0.0384
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0028	-0.0051	0.0107
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0055	-0.0024	0.0133

* Indicates estimate is different from zero at the 95% confidence level.

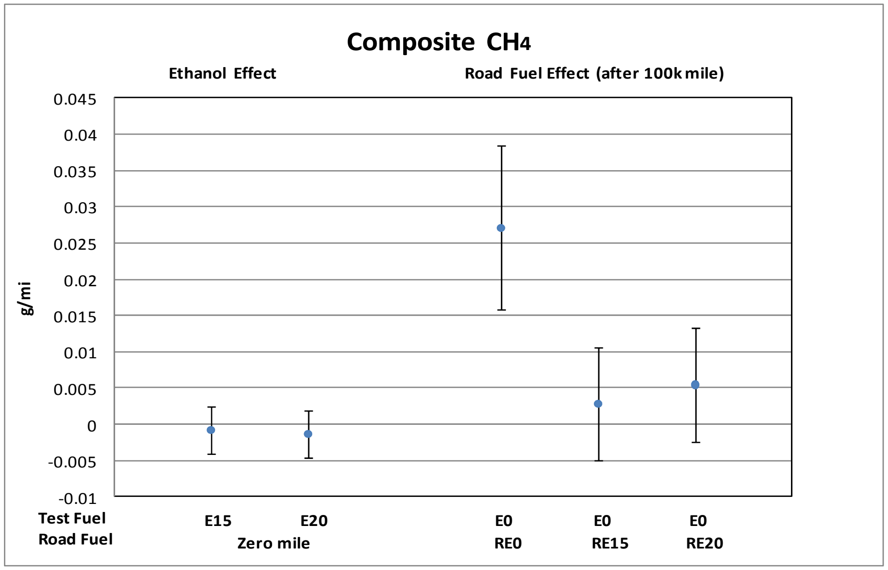
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.56
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.01*

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 81k-89k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2000 Honda Accord - Composite Emissions Summary

Emisssion Parameter (units)	Ethanol Effect				Aging Effect with RE0		RExx Aging Effect on E0 Emissions				RExx Aging Effect on Exx Emissions			Road and Test Fuel Effects are Additive
	Δ units vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value	Δ units per 100K mi			Overall p-value
Fuels	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0		RE10/E10	RE15/E15	RE20/E20	
CO (g/mi)	NA	-1.251	-0.124	0.24	7.933*	0.01*	NA	2.760	0.482	0.09	NA	NA	NA	0.99
NOx (g/mi)	NA	-0.004	0.015	0.71	0.104	0.14	NA	0.175*	0.036	0.15	NA	NA	NA	0.69
NMHC (g/mi)	NA	-0.011	-0.001	0.80	0.159*	0.03*	NA	0.073	0.036	0.28	NA	NA	NA	0.95
NMOG (g/mi)	NA	-0.003	0.007	0.91	0.165*	0.03*	NA	0.080	0.040	0.30	NA	NA	NA	0.92
Fuel Econ (mi/gal)	NA	-1.201*	-1.740*	<0.01*	0.043	0.96	NA	-0.208	0.105	0.91	NA	NA	NA	0.64
CH_4 (g/mi)	NA	-0.0040	-0.0000	0.60	0.0500*	<0.01*	NA	0.0372*	0.0051	0.05*	NA	NA	NA	0.93

Log-normal model was used. Results are presented as changes in emissions at 0k mile.

Data did not support the assumption of linear effects with mileage.

* Indicates estimate is different from zero at the 95% confidence level.

2000 Honda Accord (Composite CO)

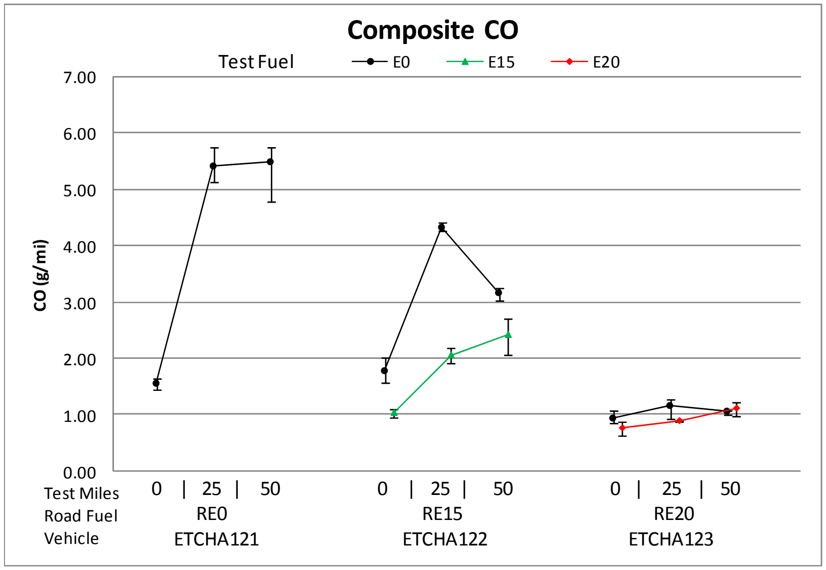
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-1.251	-2.834	0.331
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.124	-1.707	1.459
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	7.933*	2.457	13.410
Aging Effect with RE15 (Δg/mi per 100k mi)	2.760	-1.077	6.597
Aging Effect with RE20 (Δg/mi per 100k mi)	0.482	-3.379	4.344

* Indicates estimate is different from zero at the 95% confidence level.

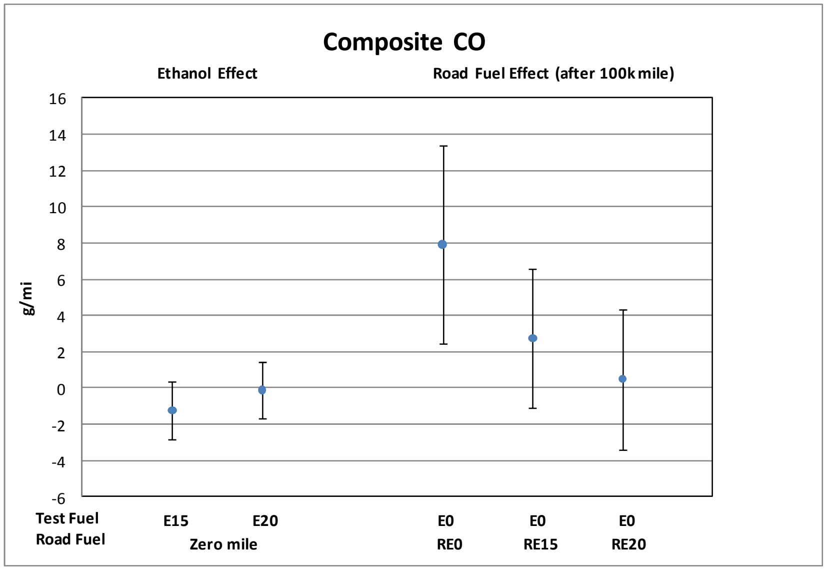
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.24
No Aging Effect with RE0 (Beta0 = 0)	0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.09

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 89k-106k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2000 Honda Accord (Composite NOx)

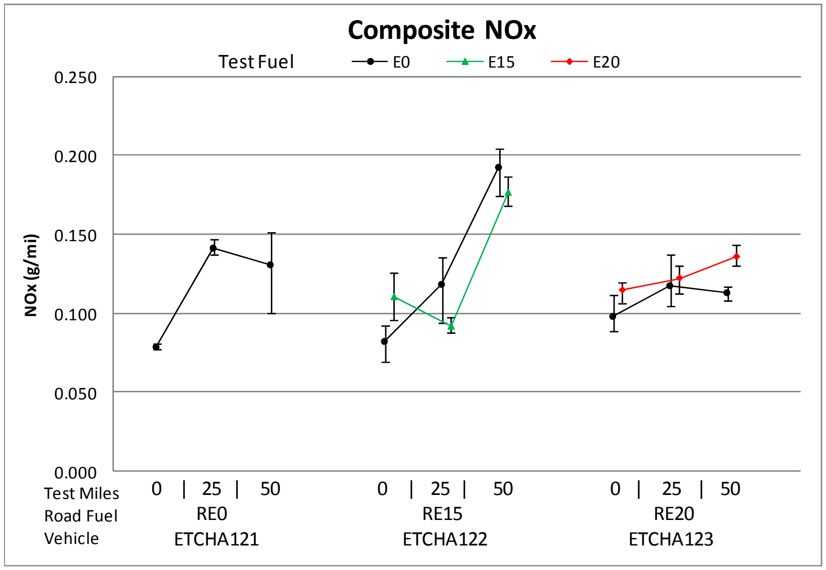
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.004	-0.047	0.038
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.015	-0.028	0.057
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.104	-0.043	0.252
Aging Effect with RE15 (Δg/mi per 100k mi)	0.175*	0.072	0.279
Aging Effect with RE20 (Δg/mi per 100k mi)	0.036	-0.068	0.140

* Indicates estimate is different from zero at the 95% confidence level.

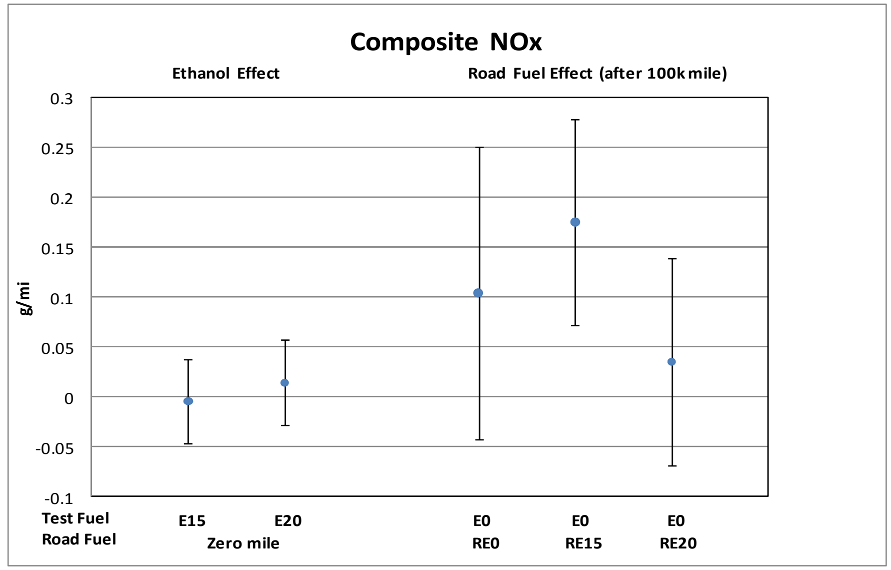
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.71
No Aging Effect with RE0 (Beta0 = 0)	0.14
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.15

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 89k-106k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2000 Honda Accord (Composite Nonmethane Hydrocarbons)

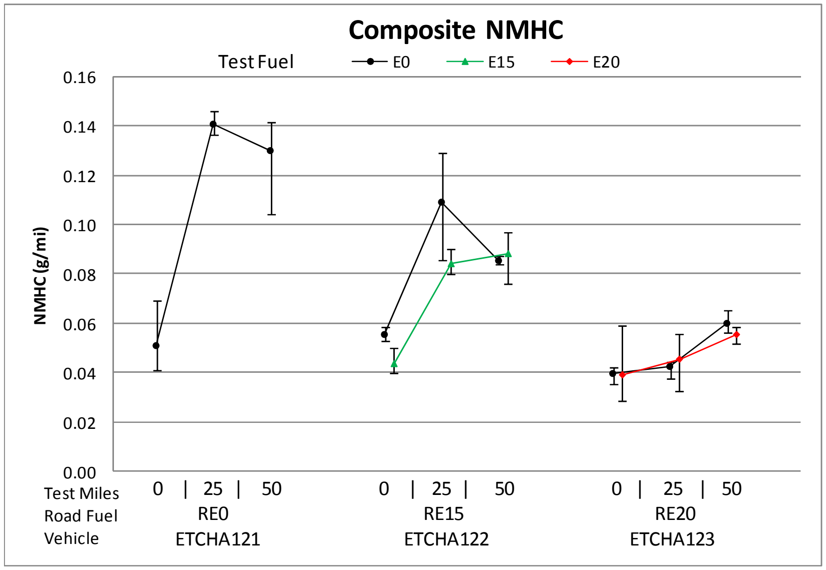
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.011	-0.051	0.028
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.001	-0.040	0.039
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.159*	0.022	0.297
Aging Effect with RE15 (Δg/mi per 100k mi)	0.073	-0.023	0.169
Aging Effect with RE20 (Δg/mi per 100k mi)	0.036	-0.061	0.133

* Indicates estimate is different from zero at the 95% confidence level.

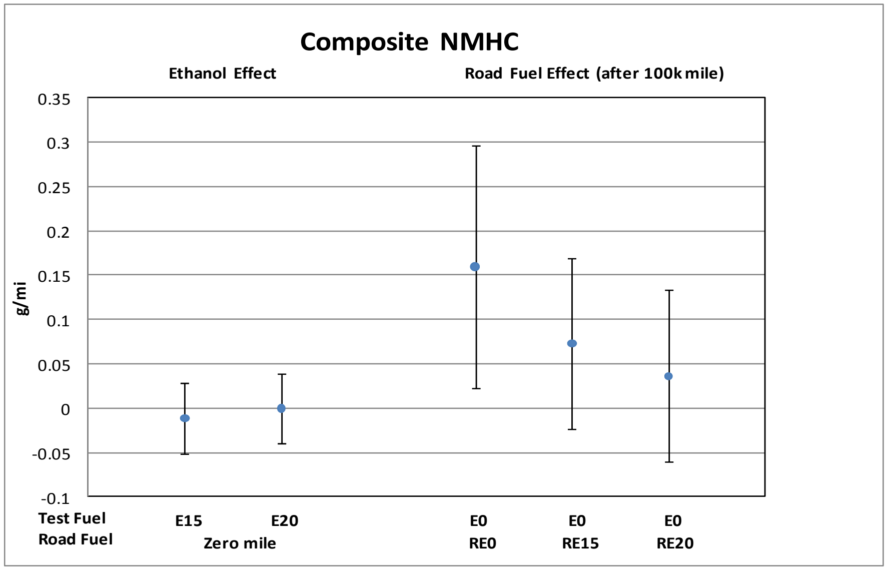
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.80
No Aging Effect with RE0 (Beta0 = 0)	0.03*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.28

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 89k-106k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2000 Honda Accord (Composite Nonmethane Organic Gases)

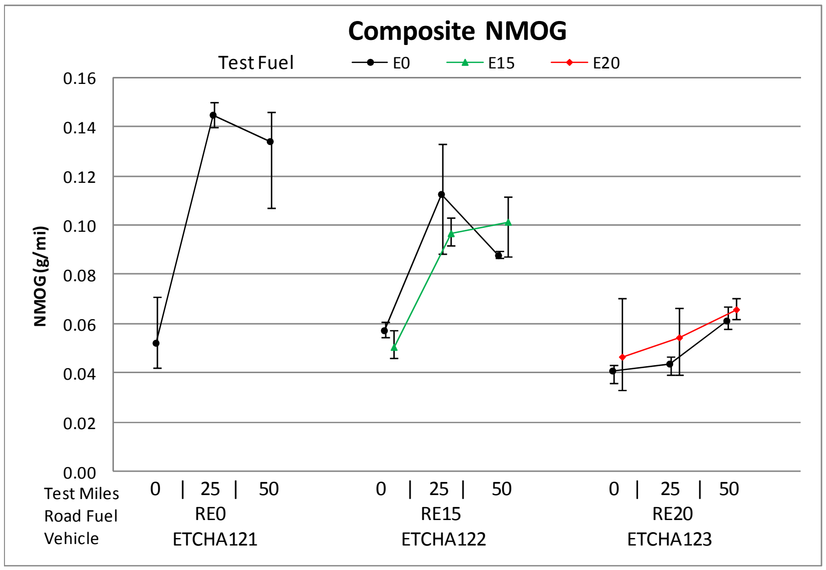
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.003	-0.045	0.038
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.007	-0.034	0.049
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.165*	0.021	0.308
Aging Effect with RE15 (Δg/mi per 100k mi)	0.080	-0.021	0.180
Aging Effect with RE20 (Δg/mi per 100k mi)	0.040	-0.061	0.141

* Indicates estimate is different from zero at the 95% confidence level.

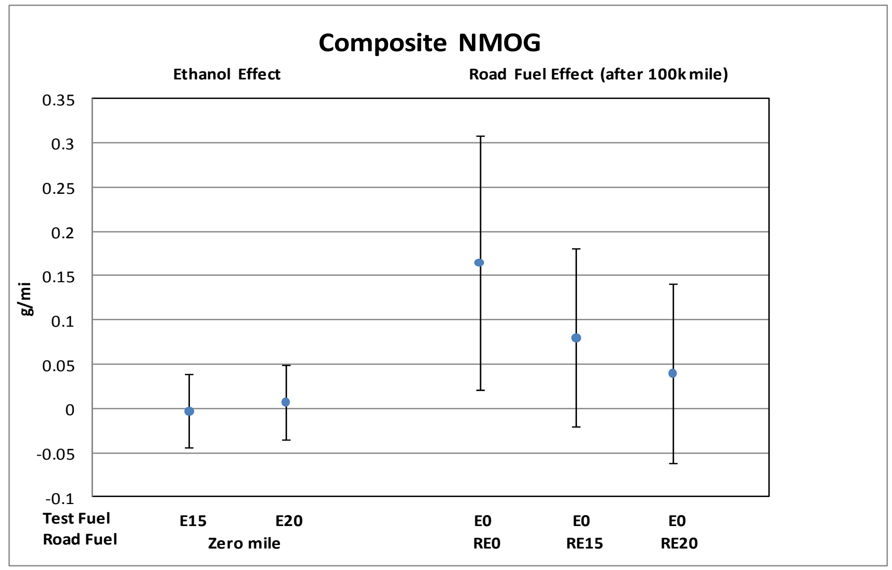
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.91
No Aging Effect with RE0 (Beta0 = 0)	0.03*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.30

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 89k-106k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2000 Honda Accord (Composite Fuel Economy)

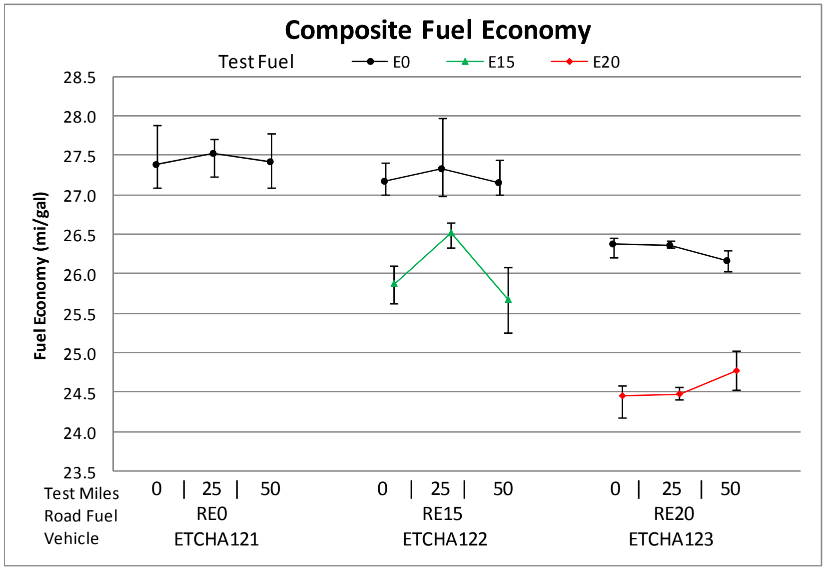
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmi/gal)	-1.201*	-1.715	-0.686
Ethanol Effect (E20 vs. E0) (Δmi/gal)	-1.740*	-2.255	-1.226
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmi/gal per 100k mi)	0.043	-1.732	1.818
Aging Effect with RE15 (Δmi/gal per 100k mi)	-0.208	-1.455	1.039
Aging Effect with RE20 (Δmi/gal per 100k mi)	0.105	-1.150	1.360

* Indicates estimate is different from zero at the 95% confidence level.

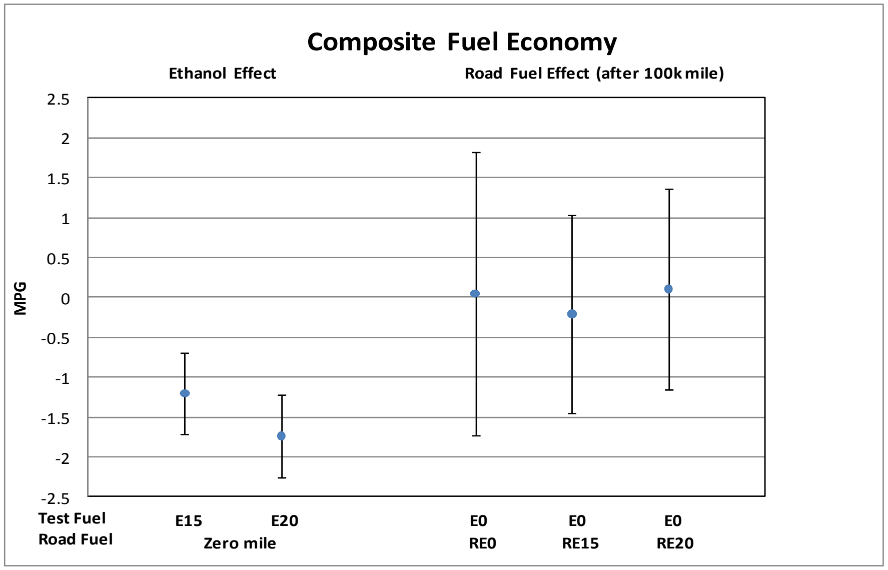
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.96
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.91

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 89k-106k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2000 Honda Accord (Composite CH_4)

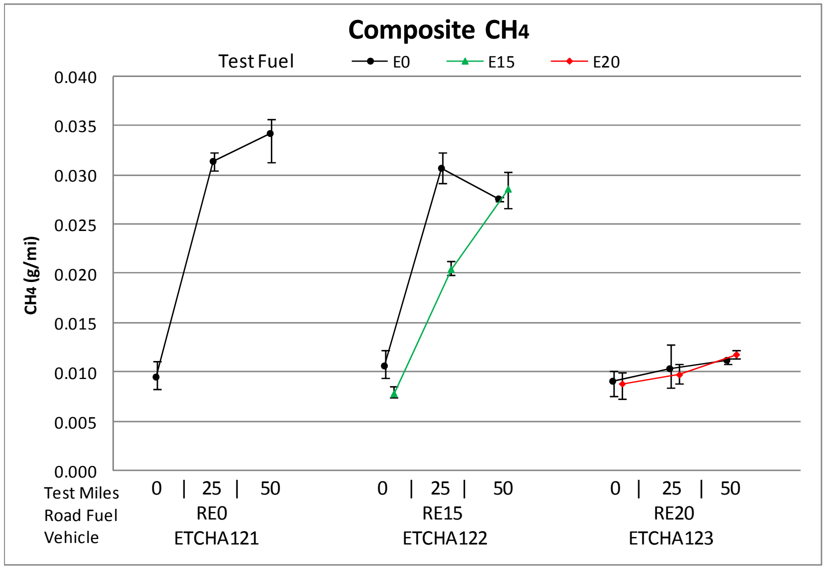
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.0040	-0.0131	0.0050
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.0000	-0.0091	0.0090
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0500*	0.0185	0.0813
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0372*	0.0152	0.0592
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0051	-0.0170	0.0272

* Indicates estimate is different from zero at the 95% confidence level.

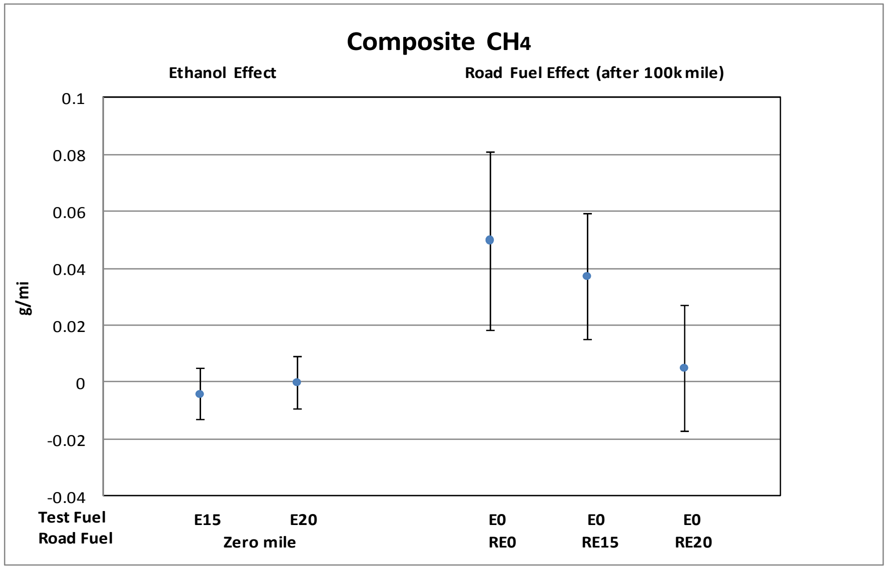
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.60
No Aging Effect with RE0 (Beta0 = 0)	<0.01*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.05*

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 89k-106k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2000 Ford Focus- Composite Emissions Summary

Emisssion Parameter (units)	Ethanol Effect				Aging Effect with RE0		RExx Aging Effect on E0 Emissions				RExx Aging Effect on Exx Emissions			Road and Test Fuel Effects are Additive
	Δ units vs. E0			Overall p-value	Δ units per 100K mi	Overall p-value	Δ units per 100K mi			Overall p-value	Δ units per 100K mi			Overall p-value
Fuels	E10	E15	E20		RE0/E0		RE10/E0	RE15/E0	RE20/E0		RE10/E10	RE15/E15	RE20/E20	
CO (g/mi)[a]	NA	-0.135	-0.372	0.12	1.389*	0.04*	NA	0.028	1.672*	0.06	NA	NA	NA	0.35
NOx (g/mi)	NA	0.030	0.013	0.51	0.028	0.77	NA	0.061	0.194*	0.29	NA	NA	NA	0.26
NMHC (g/mi)	NA	-0.013	-0.002	0.68	0.015	0.78	NA	-0.040	0.048	0.28	NA	NA	NA	0.79
NMOG (g/mi)	NA	-0.010	0.006	0.77	0.015	0.78	NA	-0.041	0.052	0.27	NA	NA	NA	0.83
Fuel Econ (mi/gal)	NA	-0.752*	-1.753*	<0.01*	-1.494*	0.05*	NA	-0.992	0.198	0.11	NA	NA	NA	0.30
CH_4 (g/mi)	NA	0.0005	-0.0003	0.87	0.0055	0.20	NA	0.0047	0.0133*	0.13	NA	NA	NA	0.79

Log-normal model was used. Results are presented as changes in emissions at 0k mile.

Data did not support the assumption of linear effects with mileage.

* Indicates estimate is different from zero at the 95% confidence level.

a test "116866" and test "116873" are identified outliers and excluded from the analysis

2000 Ford Focus (Composite CO)

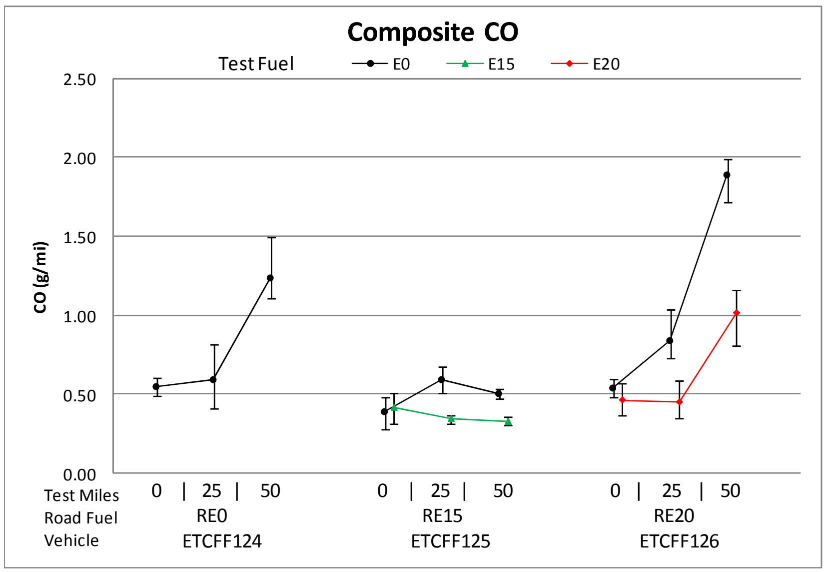
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.135	-0.521	0.252
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.372	-0.761	0.017
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	1.389*	0.050	2.727
Aging Effect with RE15 (Δg/mi per 100k mi)	0.028	-0.920	0.975
Aging Effect with RE20 (Δg/mi per 100k mi)	1.672*	0.718	2.626

* Indicates estimate is different from zero at the 95% confidence level.

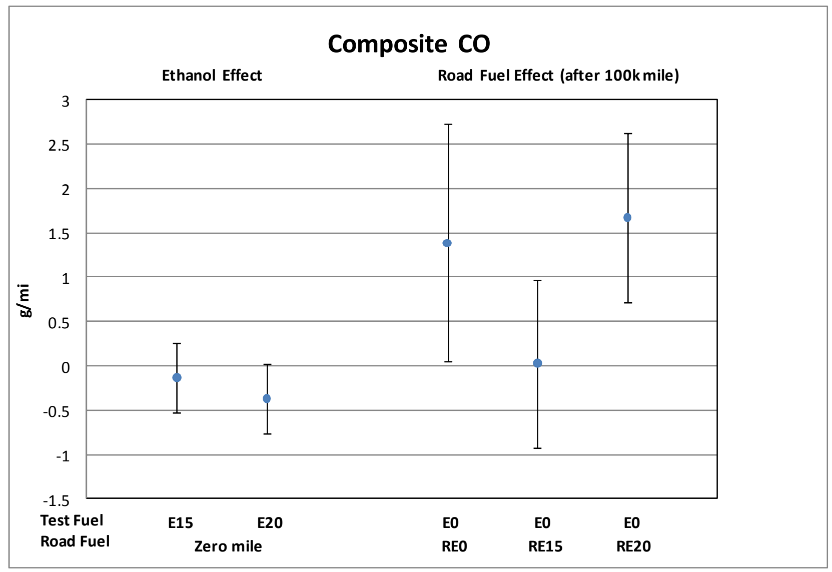
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.12
No Aging Effect with RE0 (Beta0 = 0)	0.04*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.06

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 85k-103k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2000 Ford Focus (Composite NOx)

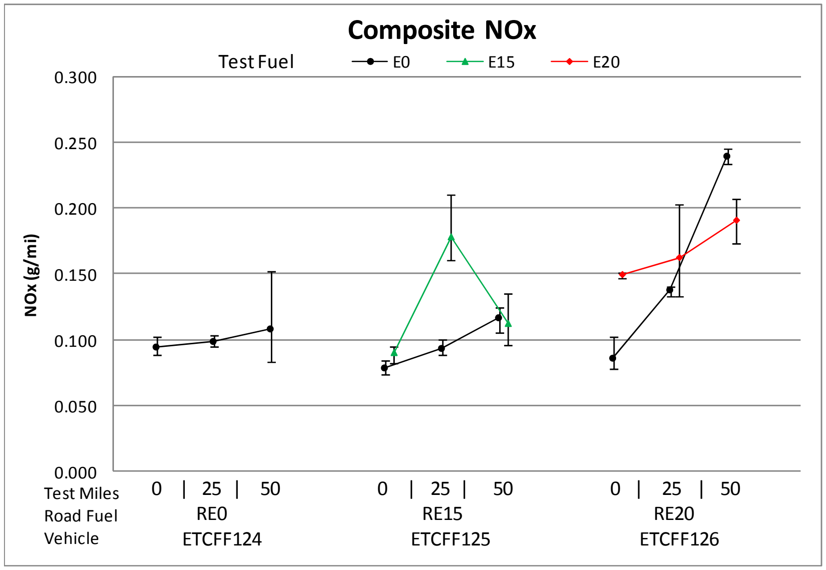
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.030	-0.034	0.094
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.013	-0.051	0.077
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.028	-0.193	0.249
Aging Effect with RE15 (Δg/mi per 100k mi)	0.061	-0.096	0.218
Aging Effect with RE20 (Δg/mi per 100k mi)	0.194*	0.038	0.350

* Indicates estimate is different from zero at the 95% confidence level.

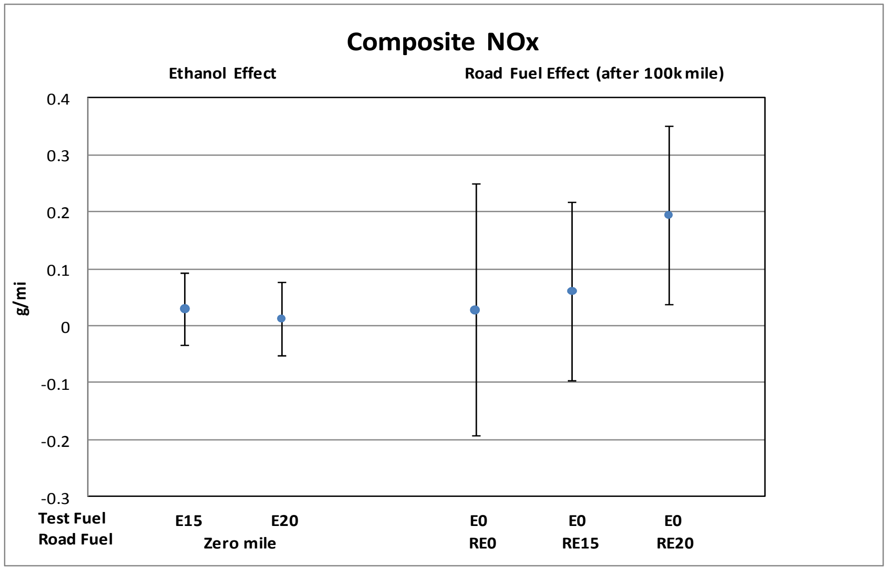
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.51
No Aging Effect with RE0 (Beta0 = 0)	0.77
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.29

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 85k-103k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2000 Ford Focus (Composite Nonmethane Hydrocarbons)

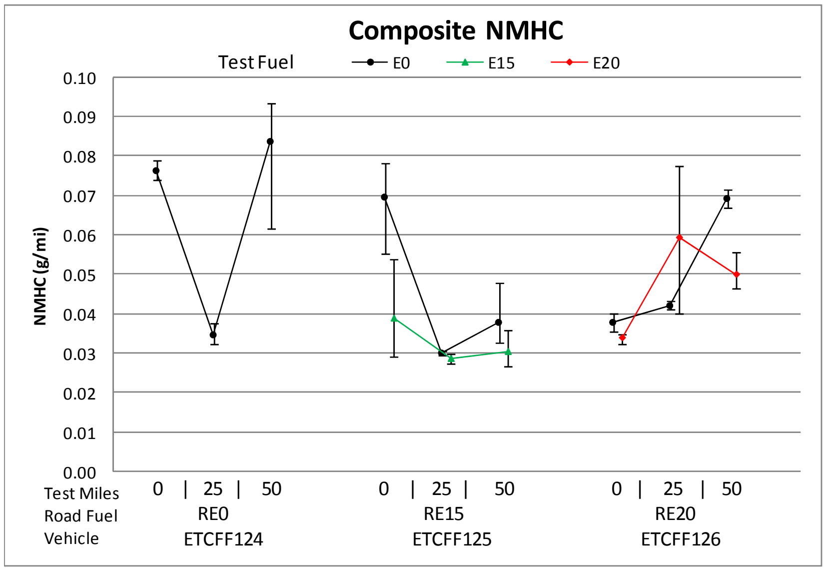
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.013	-0.048	0.022
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.002	-0.037	0.033
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.015	-0.106	0.135
Aging Effect with RE15 (Δg/mi per 100k mi)	-0.040	-0.126	0.045
Aging Effect with RE20 (Δg/mi per 100k mi)	0.048	-0.037	0.132

* Indicates estimate is different from zero at the 95% confidence level.

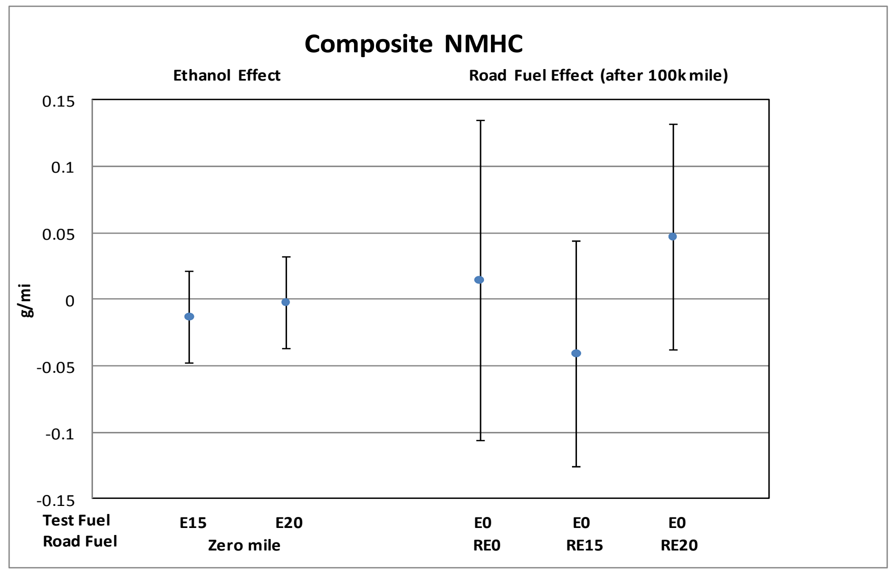
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.68
No Aging Effect with RE0 (Beta0 = 0)	0.78
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.28

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 85k-103k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2000 Ford Focus (Composite Nonmethane Organic Gases)

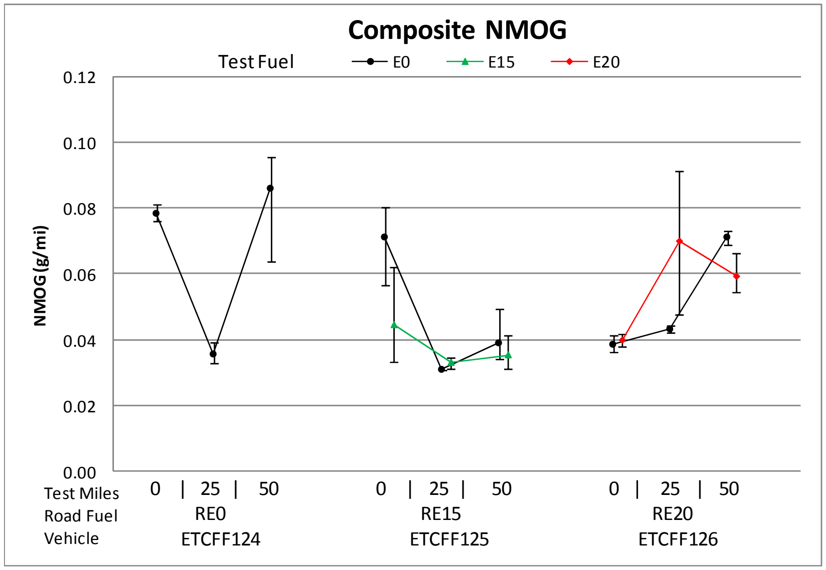
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	-0.010	-0.046	0.026
Ethanol Effect (E20 vs. E0) (Δg/mi)	0.006	-0.030	0.042
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.015	-0.109	0.140
Aging Effect with RE15 (Δg/mi per 100k mi)	-0.041	-0.129	0.047
Aging Effect with RE20 (Δg/mi per 100k mi)	0.052	-0.036	0.140

* Indicates estimate is different from zero at the 95% confidence level.

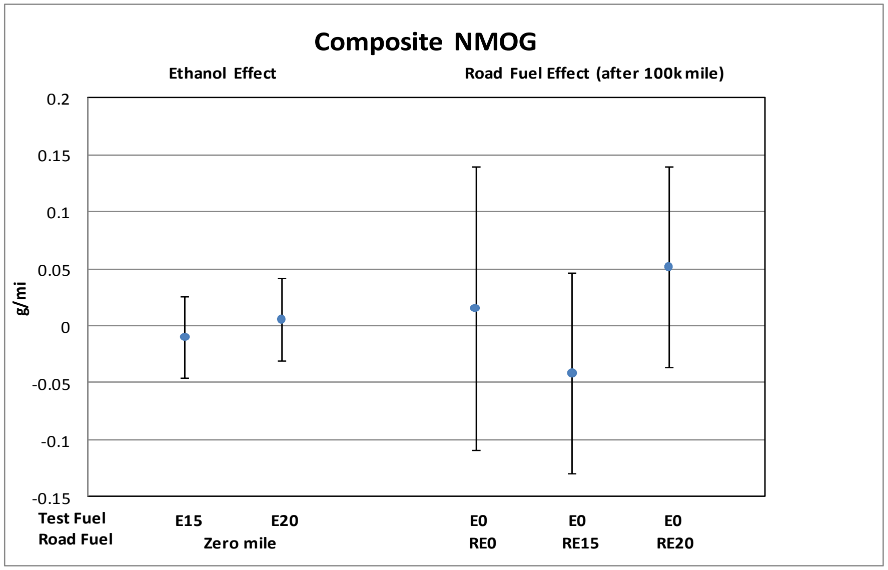
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.77
No Aging Effect with RE0 (Beta0 = 0)	0.78
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.27

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 85k-103k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2000 Ford Focus (Composite Fuel Economy)

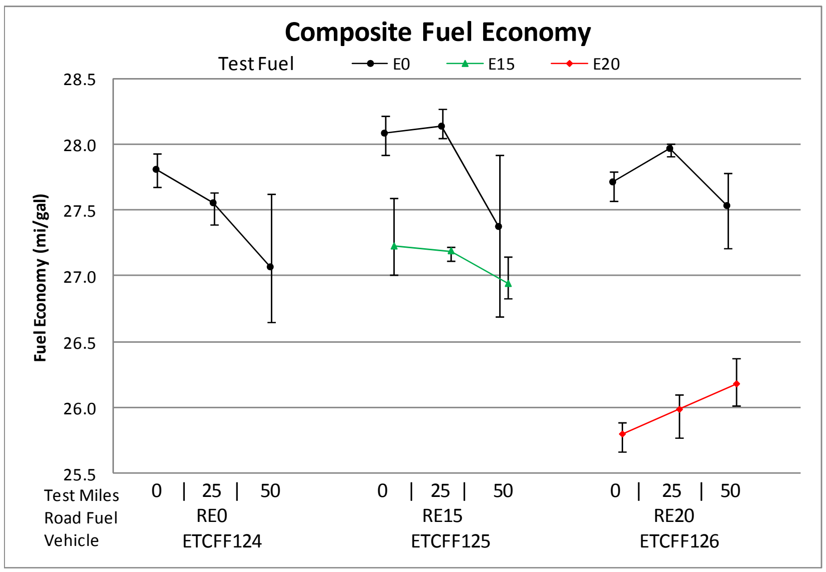
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δmi/gal)	-0.752*	-1.173	-0.332
Ethanol Effect (E20 vs. E0) (Δmi/gal)	-1.753*	-2.174	-1.333
Road Fuel Aging Effect			
Aging Effect with RE0 (Δmi/gal per 100k mi)	-1.494*	-2.946	-0.042
Aging Effect with RE15 (Δmi/gal per 100k mi)	-0.992	-2.022	0.037
Aging Effect with RE20 (Δmi/gal per 100k mi)	0.198	-0.829	1.225

* Indicates estimate is different from zero at the 95% confidence level.

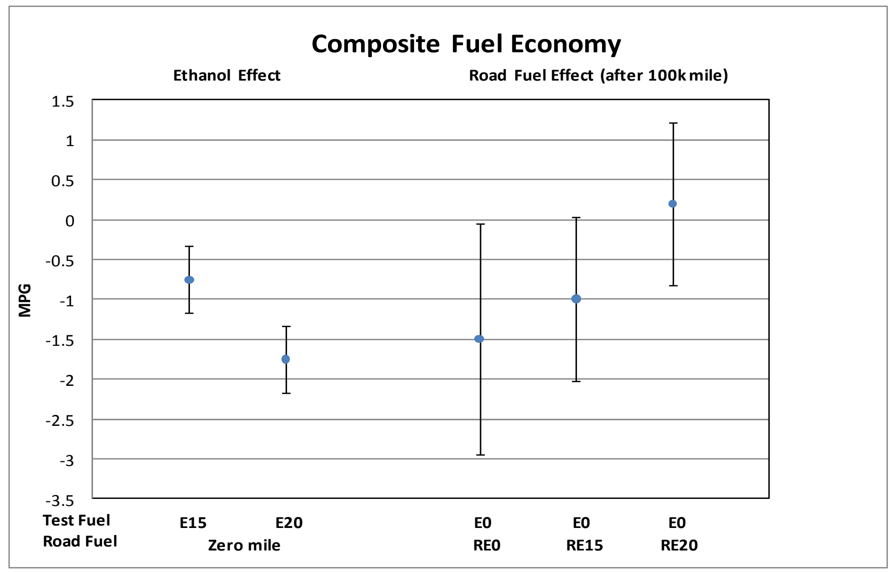
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	<0.01*
No Aging Effect with RE0 (Beta0 = 0)	0.05*
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.11

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 85k-103k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects

2000 Ford Focus (Composite CH_4)

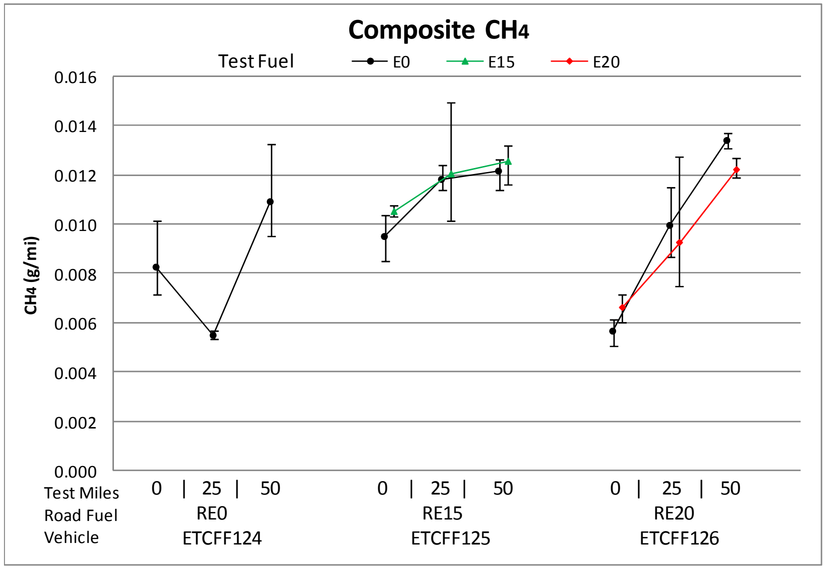
Effect	Estimate	95% C.I. Lower	95% C.I. Upper
Ethanol Effect (E15 vs. E0) (Δg/mi)	0.0005	-0.0021	0.0032
Ethanol Effect (E20 vs. E0) (Δg/mi)	-0.0003	-0.0030	0.0024
Road Fuel Aging Effect			
Aging Effect with RE0 (Δg/mi per 100k mi)	0.0055	-0.0037	0.0147
Aging Effect with RE15 (Δg/mi per 100k mi)	0.0047	-0.0019	0.0112
Aging Effect with RE20 (Δg/mi per 100k mi)	0.0133*	0.0068	0.0199

* Indicates estimate is different from zero at the 95% confidence level.

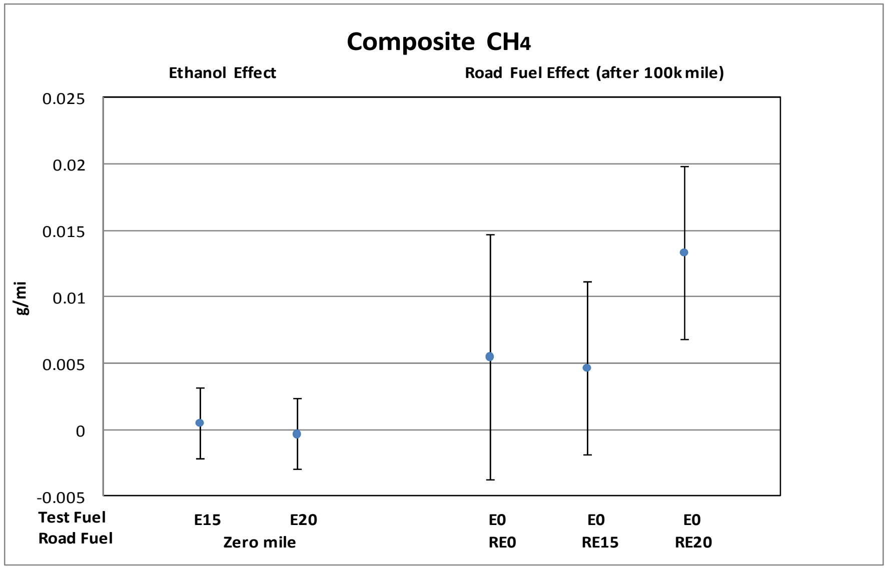
Hypothesis	p-value
No Effect of Ethanol in the Test Fuel (Gamma = 0)	0.87
No Aging Effect with RE0 (Beta0 = 0)	0.20
No Effect of Ethanol in Road Fuel Aging (Beta1s=0)	0.13

* Indicates effect is statistically significant at the 95% confidence level.

Initial Odometers 85k-103k



Error bars represent min and max measurements



Error bars represent 95% confidence intervals on the estimated effects