CRC Report No. E-90

IMPACT OF E15/E20 BLENDS ON OBDII SYSTEMS -- PILOT STUDY

March 2010

COORDINATING RESEARCH COUNCIL, INC.

3650 MANSELL ROAD·SUITE 140·ALPHARETTA, GA 30022

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CRC E-90 PROJECT

IMPACT OF E15/E20 BLENDS ON OBDII SYSTEMS – PILOT STUDY

Final Report

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1. Illinois Environmental Protection Agency (IEPA)
2. The Texas Commission on Environmental Quality (TCEQ)
3. Applus Technologies, Inc.
4. Dekra Emission Test, Inc.
5. The Sticker Store

This project would not have been possible without their support. Finally, dKC would like to acknowledge the skill and determination of Graham Waak who collected most of the data and the CRC E-90 Committee for their guidance on this project.

EXECUTIVE SUMMARY

de la Torre Klausmeier Consulting, Inc. (dKC) was contracted by the Coordinating Research Council (CRC) to study the potential impact of 15% and 20% ethanol/gasoline blends (E15/E20) on the onboard diagnostic (OBDII) system of in-use vehicles. The goal of this study was to collect and analyze OBDII and related data from in-use vehicles to determine the potential for more frequent malfunction indicator light (MIL) illuminations when a vehicle is fueled with E15 or E20. To meet this goal, dKC identified inspection/maintenance (I/M) programs that were operated in areas where gasoline with no ethanol (E0) and 10% ethanol (E10) was dispensed. dKC then set-up a test program where long-term fuel trim (LTFT) and other parameters were recorded over a 10 minute period after vehicles received their periodic I/M test.

Findings and conclusions from this study are listed below:

- Operation on 10% ethanol/gasoline blends (E10) increases LTFT over E0 levels for most vehicles. The sensitivity varies by original equipment manufacturer (OEM), but all OEMs show the trend.
- The tests conducted in this study provide evidence that operation on 15% or 20% ethanol/gasoline blends (E15 or E20) may cause a subset of problem-free vehicles to illuminate their malfunction indicator light (MIL) due to excessively lean[1] operation. The fraction depends on the assumed LTFT threshold[2] and the fuel ethanol content and is roughly estimated to be of the order of a percent or so. A more precise estimate of this fraction cannot be made with the available data.
- There is also evidence that operation on E15 and E20 may cause some vehicles that currently have illuminated MILs due to rich[3] operation to appear to be problem free, but no vehicles with this type of illuminated MIL were detected in this program.
- Additional study is needed to better quantify potential ethanol-related issues with OBD MIL. Vehicle testing on E15 or E20 is needed to confirm that false positive or negative MIL illumination will occur. Further analysis of MIL status from I&M data and more detailed MIL illumination thresholds for different OEMs will also help to better define the scope of this problem.
- Not ready rates[4] for the evap monitor in Texas were higher in the E10 area than in the E0 area. More data would also be required to determine if ethanol was affecting this parameter.

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[1] Lean: More air than required for optimum combustion.

[2] LTFT threshold: The LTFT value at which the OBD system illuminates the MIL.

[3] Rich: More fuel than required for optimum combustion.

[4] OBDII systems have up to 11 diagnostic monitors, which run periodic tests on specific systems and components to ensure that they are performing within their prescribed range. OBDII systems must indicate whether or not the onboard diagnostic system has monitored each component. Components that have been diagnosed are termed “ready”, meaning they were tested by the OBDII system.

1.0 INTRODUCTION

Due to state and federal encouragement of increased ethanol production and use, by 2013 the supply of ethanol will likely exceed the amount required to blend into the national motor gasoline fuel pool at the current maximum permissible per gallon limit of 10% by volume (E10). One suggested solution for the disposition of this "extra" ethanol is to introduce an intermediate blend; e.g. a gasoline containing either 15% ethanol by volume (E15) or 20% ethanol by volume (E20). There have recently been attempts to expedite the introduction of these fuels, even before the 10% blend wall is reached.

de la Torre Klausmeier Consulting, Inc. (dKC) was contracted by the Coordinating Research Council (CRC) to study the potential impact of 15% and 20% ethanol/gasoline blends (E15/E20) on the onboard diagnostic (OBDII) system of in-use vehicles. Automobile manufacturers have expressed concern that vehicles running on E15 or E20 may experience more frequent malfunction indicator light (MIL) illuminations than vehicles running on E10 and below. They have identified the need for a study of how ethanol blends will impact OBDII system performance, particularly on high mileage vehicles.

How Ethanol Could Affect MIL Illumination

Automobile manufacturers have expressed concerns over two types of events that could affect MIL illumination:

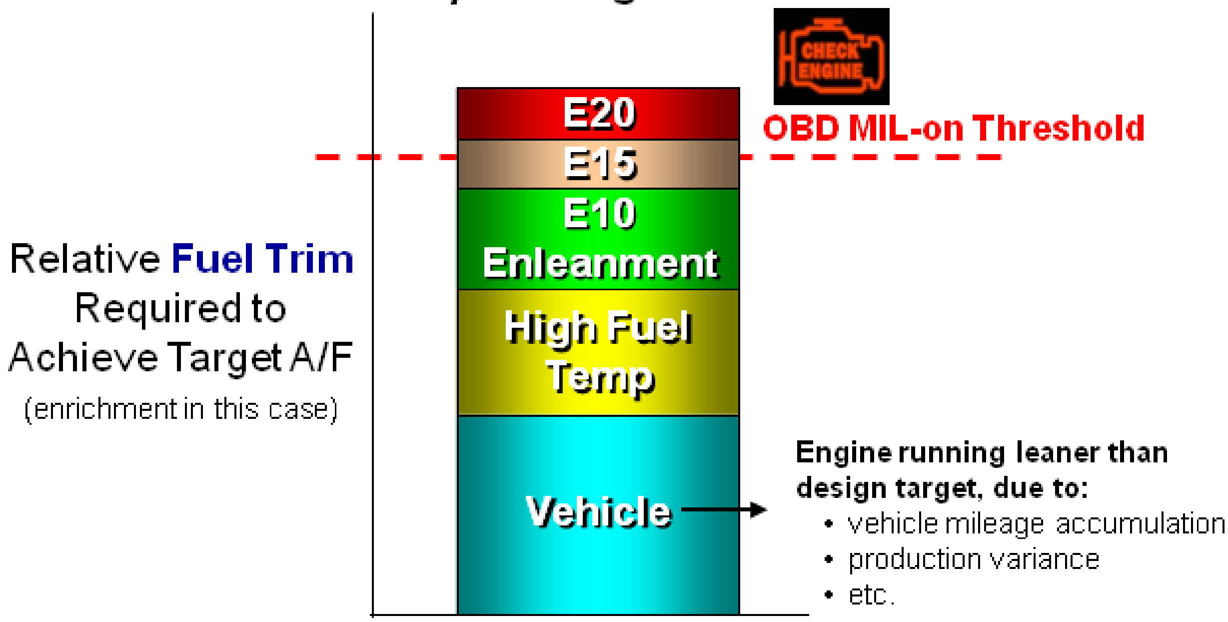
1. A vehicle operating close to an OBD-II threshold level when consuming E0 or E10 might exceed the MIL-on criterion when fueled with E15 or E20, thereby causing the MIL to illuminate when nothing is wrong with the vehicle.
2. In the case of vehicles running too rich, ethanol-induced enleanment might move the vehicle back from beyond the OBD threshold and create a "false negative" situation where the MIL does not illuminate when it should.

The OBDII threshold of most interest with respect to ethanol effects is long-term fuel trim (LTFT). Fuel trim refers to dynamic adjustments to algorithms stored in the powertrain control module PCM) that determine the fuel injector pulse for the proper fuel/ air ratio applicable to the engine operating conditions. Short term fuel trim refers to adjustments being made in response to temporary conditions. Long term fuel trim is used to compensate for issues that seem to be present over a much longer period[5].

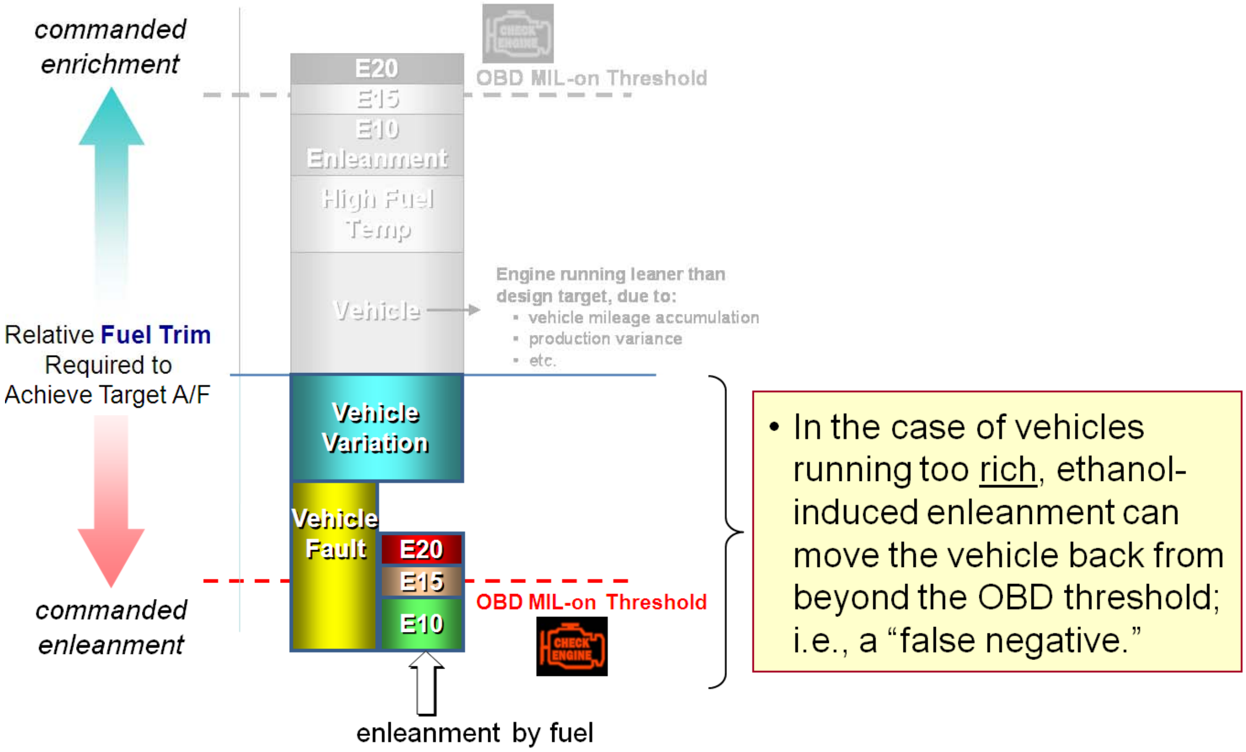
The picture below highlights the concern over the 1st problem – false MIL illumination. In this case, a vehicle is operating correctly on E10 but is close to the fuel trim limit. Operation on fuels containing 15% or 20% ethanol could push this vehicle over the limit and illuminate the MIL when in fact nothing is wrong with the vehicle.

[5] Description provided by http://www.obd2crazy.com/techdata.html.

Potential Compounding of Enleanment Factors



The picture below highlights the concern over the 2nd problem – failure to properly illuminate the MIL when a vehicle is running too rich because ethanol-induced enleanment can move the vehicle back from beyond the OBD threshold.



Objectives and Strategy

The goal of this study was to collect and analyze OBDII and related data from in-use vehicles to determine the potential for MIL illumination when a vehicle is fueled with an intermediate ethanol blend. Vehicles were tested after they received their periodic inspection/maintenance (I/M) test. Target data included long-term fuel trim (LTFT) and OBD diagnostic trouble codes (DTCs) related to enleanment. To ensure that data were collected in a consistent manner and under the conditions of interest, a specific test protocol was followed. To facilitate data interpretation, vehicle testing was performed in regions where E10 was marketed exclusively, and also in a region where E0 was marketed exclusively.

Report Organization

This report is organized as follows:

- Test procedures are described below.
- Analysis of data collected in the program is presented in Section 3.0.
- Conclusions are presented in section 4.0.

2.0 TEST PROCEDURES

In this project, vehicles were tested after they received their periodic inspection/maintenance (I/M) test. The text below describes the test procedures for this project.

2.1 Inspection/Maintenance (I/M) Sites for Testing

Table 1 presents the sites selected for testing. All testing was done at stations that were licensed to perform state inspection/maintenance (I/M) tests. We tested 140 vehicles in an E0 location (Austin, TX) and 443 vehicles in E10 locations (Dallas-Ft. Worth and Chicago). Tests were conducted in high volume centralized and decentralized facilities. We initiated testing at the end of April 2009 and completed testing in the end of July 2009. We tested about the same number of vehicles in Chicago and Dallas-Ft. Worth to avoid overweighting the sample with tests conducted during hot weather conditions. Exhibits 1-3 show pictures of the testing sites. These exhibits are presented at the end of the section.

Table 1-- I /M Sites for Testing

Site	Type of I/M Facility	Expected Ethanol Content	# of vehicles tested
Austin TX	Decentralized	E0	140
Chicago IL	Centralized	E10	218
Plano (DFW) TX	Decentralized	E10	225

2.2 Fuel Samples

We collected 20 fuel samples at different gasoline stations in the Austin area and sent them to Southwest Research Institute for analysis. As shown on Table 2, none of the samples had significant amounts of ethanol. Confidential information from an oil industry representative indicated that the Dallas-Ft Worth and Chicago areas only dispense E10.

Table2—Results of Fuel Sampling in the Austin Area

Sample	API@60F	SPGr@60F	EtOH Vol%
1	57.7	0.7478	**<0.1**
2	57.8	0.7474	**<0.1**
3	57.5	0.7488	**<0.1**
4	58.2	0.746	**<0.1**

Sample	API@60F	SPGr@60F	EtOH Vol%
5	57.1	0.7501	**<0.1**
6	57.2	0.75	**<0.1**
7	57.3	0.7496	**<0.1**
8	57.9	0.7472	**<0.1**
9	57.8	0.7475	**<0.1**
10	58.3	0.7457	**<0.1**
11	58.1	0.7465	**<0.1**
12	58.1	0.7465	**<0.1**
13	57.7	0.7479	**<0.1**
14	58.2	0.7459	**<0.1**
15	57.7	0.7479	**<0.1**
16	57.5	0.7486	**<0.1**
17	57.3	0.7495	**<0.1**
18	57.7	0.7481	**<0.1**
19	58.4	0.7451	**<0.1**
20	56.9	0.7509	**<0.1**

2.3 Site Test Plan

The following vehicle solicitation and test procedures were used:

1. **Vehicle Solicitation:**
    a. **Vehicle Mix:** 1996 and newer model vehicles were picked at random when they showed up for their state emissions test. The following vehicles were not tested:
        i. Flexible Fuel Vehicles (FFVs) – FFVs were not included, because they are already designed for intermediate ethanol/gasoline blends.
        ii. Hybrids – Hybrids were not included, because some of them turn the engine off at idle.

b. **Motorist Participation:**

   i. **Centralized Lanes:** In centralized test lanes, motorists driving 1996 and newer vehicles[6] were approached while they were waiting in line in their vehicles and were asked if they wanted to participate in the study. At the beginning of the day, the motorist at the front of the line was asked to participate. If that person declined, then the next motorist was asked to participate, and so forth. Motorists were provided with the flyer shown in Appendix A-1 to introduce them to the program. After the vehicle was tested, we repeated the process described above.

   ii. **Decentralized Facilities:** The poster shown on Appendix A-1 was set up in the lobby of decentralized test facilities to provide an introduction to the program. Motorists driving 1996 and newer models were asked to participate when they came into the office. The tester followed the same selection protocol as described above for centralized facilities.

   iii. **Incentive:** The tester offered motorists $20 in cash to participate.

c. **Questionnaire:** Motorists agreeing to participate were asked to fill out the questionnaire shown on Appendix A-2. The tester entered the VIN and odometer information and recorded the ambient temperature.

d. **Log of vehicles whose owner declines to participate:** The tester maintained a log of the following information on vehicles whose owner declined to participate:

   i. **Year, Make, Model**

   ii. **Reason for not participating**

e. **List of all other vehicles undergoing I/M procedures at the site during the test days of this study:** A list of all vehicles tested at the Plano and Chicago I/M stations during the days in which this study was conducted was obtained from the station manager. This type of list was not available for the Austin station.

2. Vehicle Testing: The test procedure was as follows:

a. The tester followed the checklist shown on Appendix A-3 to ensure that all required data recording and vehicle prep tasks were done.

b. The motorist or state inspector was instructed to park the vehicle in a designated area.

c. The motorist or state inspector was instructed to turn off the engine.

d. The tester took the following pictures of the vehicle:

   i. Overall vehicle: Front, back, left side, right side

[6] Illinois only tests 1996 and newer vehicles.

    ii. Underhood Emissions Label (see Appendix A-4)
    iii. VIN (see Appendix A-5)

e. Test equipment was hooked-up while the vehicle engine was off. The test equipment consisted of a laptop with OBDII connector. Details can be found at http://www.autoenginuity.com.

f. The vehicle was placed in the key-on engine off position to establish communication with the test equipment.
    i. The tester selected the “Generic Test” mode.
    ii. The tester first checked if any Diagnostic Trouble Codes (DTCs) were recorded. If they were, the tester recorded a screen print of the DTC screen.
    iii. The tester then went to the OBD Status screen and made a screen print of the readiness status.
    iv. The tester then went to the data logging page and initiated data logging. Table 2 lists the data that are recorded on most vehicles in “Generic Test” mode.

g. The vehicle remained off for about 10 minutes. At the end of the soak period, the vehicle was started and about five minutes of additional data was logged. If possible, the tester tested for a longer period, especially if long-term fuel trim had not stabilized.

h. At the completion of the test, the vehicle was turned off, test equipment was removed and the motorist was paid the incentive.

3. **Data Compilation:** Data were compiled after each day of testing. Copies were sent to the study project officer and dKC project manager. After field tests were completed, dKC distributed individual test results to the appropriate manufacturer for analysis.

Table 2 – Typical OBDII Generic Data Parameters Recorded on a Second-by-Second Basis ((Note DTCs, MIL Status and Readiness Status were recorded on all vehicles)

Parameter	Example Value
Time	02:28:11
Calculated Load (%) [0 - 100]	14
Coolant Temperature (F) [-40 - 419]	194
Short Term FT B1 (%) [-100.00 - 99.22]	-0.78
Long Term FT B1 (%) [-100.00 - 99.22]	-2.34
Engine RPM (r/min) [0 - 9000]	660
Vehicle Speed (MPH) [0 - 158]	0
Ign. Timing Adv. C1 (deg) [-64.0 - 63.5]	13.5
Intake Air Temp. (F) [-40 - 419]	124
MAF Air Flow Rate (lb/min) [0.00 - 86.70]	0.28
Abs. Throttle Pos. (%) [0 - 100]	15
B1S2 O2 Voltage (V) [0.000 - 1.275]	0.095
B1S2 O2 Fuel Trim (%) [-100.00 - 99.22]	99.06

Exhibit 1 – Austin TX Site

Exhibit 2 – Chicago (Addison) Illinois Site

Exhibit 3 – Dallas Ft. Worth (Plano) Texas Site

3.0 DATA ANALYSIS

3.1 Data Compilation

Prior to analyzing results, dKC developed spreadsheets that summarized test results for each vehicle. Table 3 presents information that was summarized for each vehicle that was tested. The long-term fuel trim (LTFT) values recorded in the summary database were based on the second-by-second results recorded on each vehicle. To facilitate a systematic analysis, dKC categorized the following parameters:

- Assumed Ethanol Content (E0 or E10)
- Odometer (<100,000 miles, >100,000 miles)
- Ambient Temperature (<90 deg F, >90 deg F)
- Max, Min, and Last LTFT value
- MIL-Command status
- Readiness status

Table 3 – Data Analyzed for E-90 Study

Field	Description
Site	Austin, Chicago, Plano
Ethanol	E0, E10
Date	
Plate	
Year	
Make	
MFR	Groups of Makes manufactured by same company, e.g. Honda: Honda + Acura
Model	
Odometer	
Odometer Category	<100,000, >100,000
VIN	
Temperature	
Temp_Category	<90 deg F, >90 deg F
Engine Family	From Label if available
Evap Family	From Label if available
COM	Was system able to communicate? (0=no, 1=yes)
LTFT B1 Min	Min Long-Term Fuel Trim (LTFT) value for Bank 1
LTFT B1 Min Category	Grouped in 2% increments: e.g., (1) -1=0, 1-3= 2, (1)-(3)=-2, … Note, values>13=14, values<(13)=-14
LTFT B1 Max	Max LTFT value for Bank 1

Field	Description
LTFT B1 Max_Category	Grouped in 2% increments: e.g., (1) -1=0, 1-3= 2, (1)-(3)=-2, … Note, values>13=14, values<(13)=-14
LTFT B1 Last	Last LTFT value for Bank 1
LTFT B1 Last Category	Grouped in 2% increments: e.g., (1) -1=0, 1-3= 2, (1)-(3)=-2, … Note, values>13=14, values<(13)=-14
LTFT B2 Min	Min LTFT value for Bank 2
LTFT B2 Max	Max LTFT value for Bank 2
LTFT B2 Last	Last LTFT value for Bank 2
Diagnostic Trouble Codes 1	1st DTC
Diagnostic Trouble Codes 2	2nd DTC
Diagnostic Trouble Codes 3	3rd DTC
Diagnostic Trouble Codes 4	4th DTC
MIL-On	Is MIL commanded-on? 0=no, 1=yes
Unset Monitors	What non-continuous monitors were not ready
Not Ready	Any monitors not ready? 0=no, 1=yes
Fail EPA Ready	Fail EPA readiness criteria for I/M programs: 1996-2000 models: >2 monitors not ready 2001+ models: >1 monitor not ready

dKC developed a spreadsheet summarizing information on vehicles whose owners declined our request for participation in the study. Data on this spreadsheet is presented on Table 4.

Table 4 – Data Recorded on Vehicles Whose Owners Rejected Test Request

Date
Year
Make
Model
Reason for Rejection
Site

dKC also provided each manufacturer with second-by-second test results and summary spreadsheets on their vehicles.

3.1.1 Analyzer Issues

Below is a discussion of analyzer issues that impacted test results for some of the vehicles.

No Communication

The testing system could not communicate with 8% of the vehicles. Table 5 shows the communication rates by model year. Table 6 shows rates by manufacturer. Rates were fairly uniform by model year and manufacturer, so it does not appear that lack of communication between the test system and the analyzer biased the results. Included in the no communication category are test results on two vehicles that had errors recording long-term fuel trim (LTFT), even though the test system accurately reported other parameters from these vehicles.

Table 5 – Communication Rates by Model Year

Model Year	# Communicated with Test System	# Tested	% Communication
1996	16	17	94.12%
1997	27	28	96.43%
1998	28	30	93.33%
1999	57	66	86.36%
2000	43	45	95.56%
2001	58	62	93.55%
2002	44	47	93.62%
2003	75	82	91.46%
2004	35	35	100.00%
2005	83	89	93.26%
2006	35	38	92.11%
2007	29	33	87.88%
2008	7	9	77.78%
2009	2	2	100.00%
ALL	539	583	92.45%

Table 6 – Communication Rates by Manufacturer

MFR	% Communication
OEM1	91.30%
OEM2	92.92%
OEM3	87.50%
OEM4	89.52%
OEM5	98.67%
OEM6	95.83%
OEM7	88.89%
OEM8	89.61%
OEM9	95.59%
ALL	92.45%

Communication Ceased When Engine Was Started

As noted in section 2, we initiated data logging while the vehicle was in the key-on engine-off position. When the engine was started, the test system lost communication with a few vehicles. When this happened, we had to re-start the analyzer and re-initialize communication. In these cases, we were not able to capture data parameters for 1-2 minutes after the engine was started. As noted later in this section, the LTFT values that were of greatest interest were recorded at the end of the test period, and not immediately after the engine was started.

3.1.2 Missing Information

Changes in Data Recording Procedures

Based on feedback from the Committee, after the first week of testing we started to record additional data, including the following:

- Engine Family (from Emissions Label)
- Evap Family (from Emissions Label)
- Ambient Temperature

We used ambient temperature to group tests into two categories: < 90 deg F, > 90 deg F. The maximum temperature during the first week of testing was less than 90 deg F, so we grouped all the test results for the first week into the less than 90 deg F category.

Missing Emissions Labels

Some of the older vehicles had missing or obscured emission control system labels, so we were not able to record engine or evap families.

No Odometer Reading

Some vehicles had inoperative odometers, so we were not able to record an odometer on them.

3.2 Representativeness of Test Samples

We evaluated the representativeness of the sample using several metrics:

- Model year distribution of the sample:
    - E0 vs. E10 sample
    - Tested vehicles vs. Rejects
    - Comparison with all vehicles tested at station or in region.
- Percent of vehicles with OBD faults
- Distribution of Makes tested

3.2.1 Model Year

Figure 1 shows the distribution of model years by test site. Figure 2 compares the distribution of model years for E0 and E10 samples. The odd even variation for the Chicago sample reflects the fact that Chicago's program is biennial and more odd-model year vehicles are tested in odd years, and vice versa. Overall as shown on Figure 2, there is good agreement between the E0 and E10 samples.

Figure 1

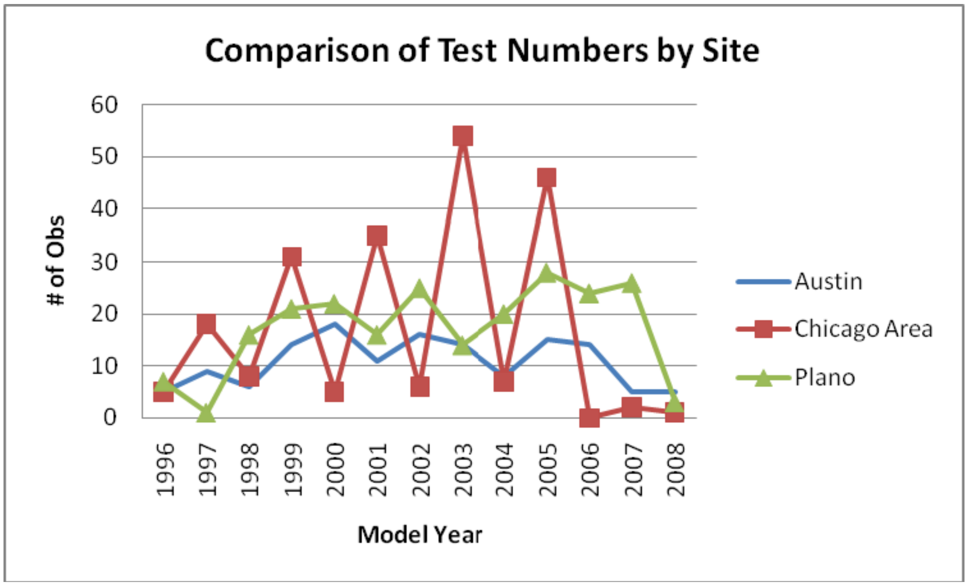


Figure 2

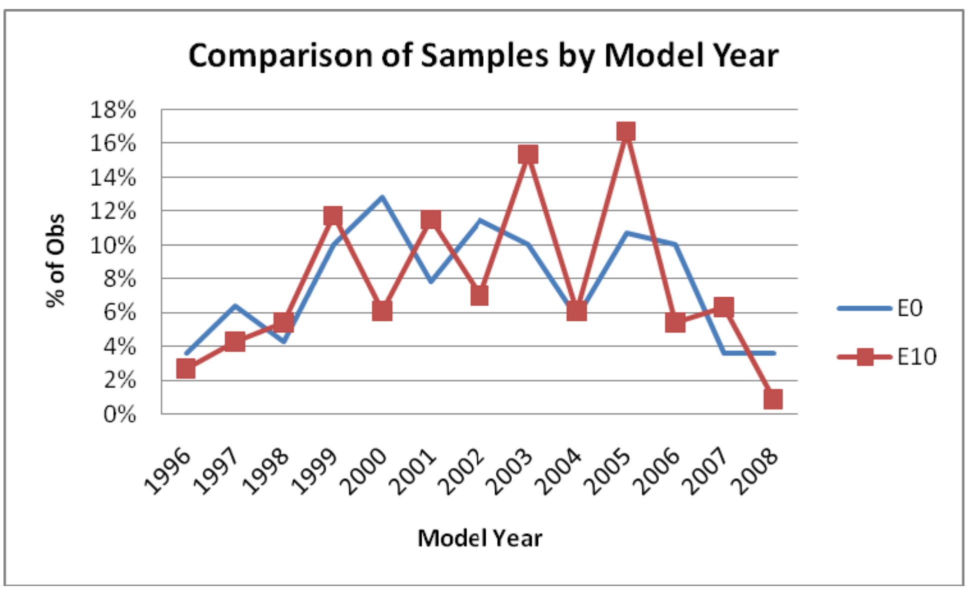


Table 7 shows a tabular breakdown of test counts by model year for E0 and E10 samples. Table 8 shows a breakdown of test counts by model year for the three sites.

Table 7 -- Test Vehicle Counts by Assumed Ethanol Content

Model Year	E0	E10
1996	5	12
1997	9	19
1998	6	24
1999	14	52
2000	18	27
2001	11	51
2002	16	30
2003	14	68
2004	8	27
2005	15	74
2006	14	24
2007	5	28
2008	5	4
2009		2
Total	140	443

Table 8 -- Test Vehicle Counts by Test Site

Model Year	Austin	Chicago Area	Plano
1996	5	5	7
1997	9	18	1
1998	6	8	16
1999	14	31	21
2000	18	5	22
2001	11	35	16
2002	16	6	25
2003	14	54	14
2004	8	7	20
2005	15	46	28
2006	14		24
2007	5	2	26
2008	5	1	3
2009			2
Total	140	218	225

Comparison of Study Sample with All Tests In Area or Station

We were not able to get a list of all vehicles tested at the Austin test site while the tests for this study were done, so we compared our sample from the Austin test site with the distribution of all tests done in the Austin area. Figure 3 compares the model year distribution of the Austin sample with the model year distribution of all vehicles tested in Austin in June 2009. The study sample appears to have a higher percentage of older models than the overall Austin sample. This could be due to the sampling site being located in an area that has lower than average income levels.

Figure 3

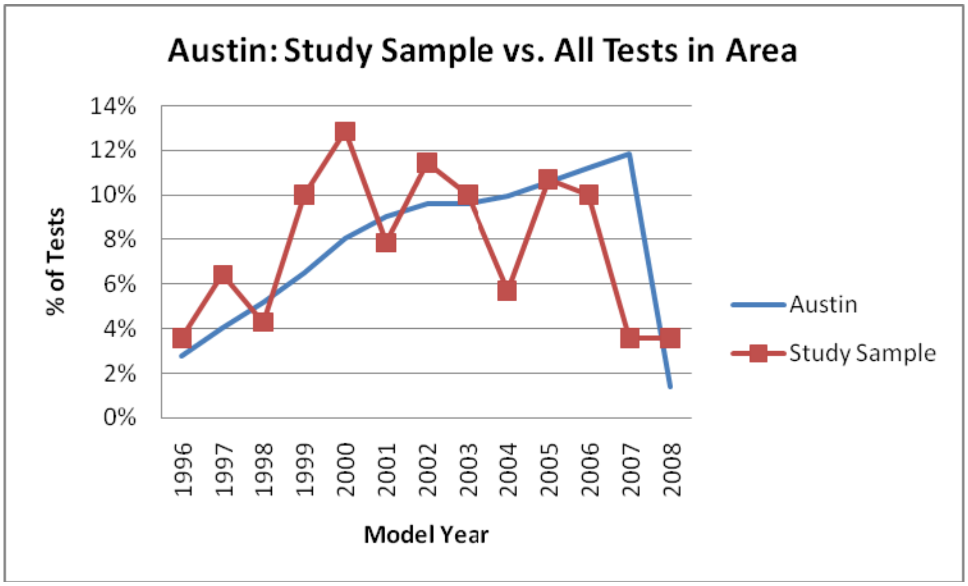


Figure 4 compares the model year distribution of the Plano study sample with the model year distribution of all vehicles tested at the Plano station during the days that our tests were done. The two distributions agree well.

Figure 4

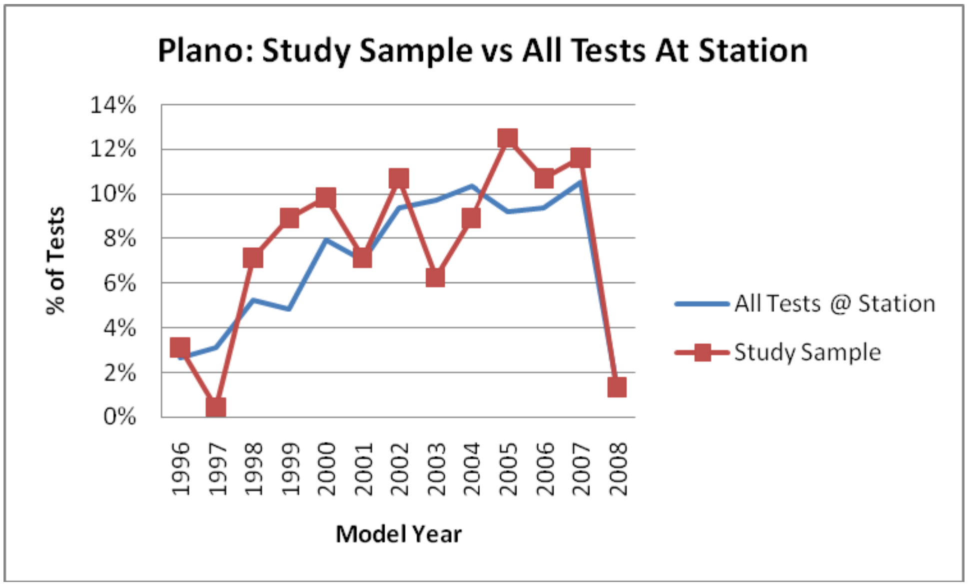
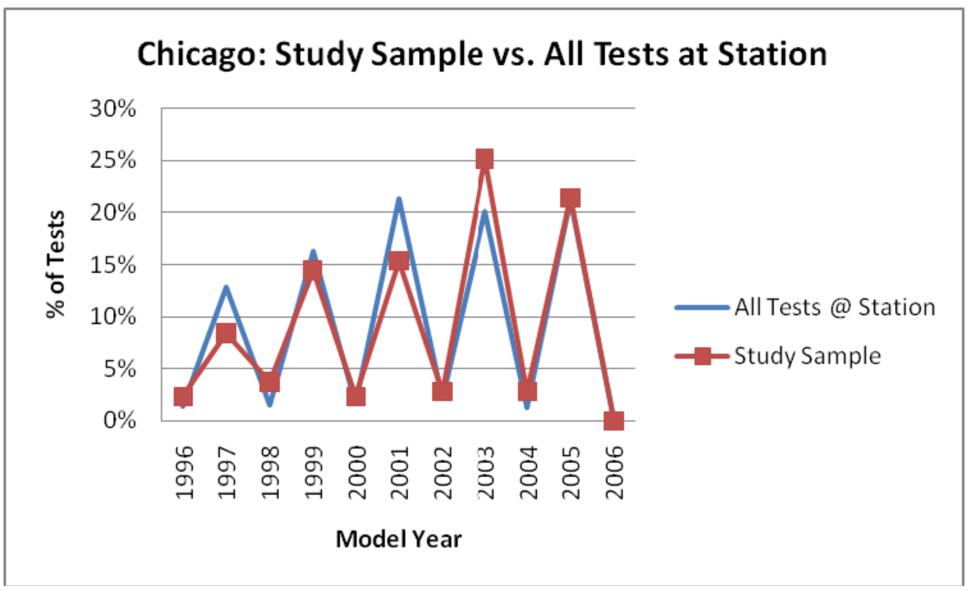


Figure 5 compares the model year distribution of the Chicago study sample with the model year distribution of all vehicles tested at the Chicago station (Addison) during the days that our tests were done. The two distributions agree extremely well.

Figure 5



Comparison of Study Sample with Vehicles Whose Owner Declined Participation

As part of the vehicle procurement process, dKC maintained a log of vehicles whose owners declined the solicitation to participate in our test program. Overall, 73% of the motorists agreed to participate. Figures 6 to 8 show comparisons by model year of the study sample with non-participating vehicles. There do not appear to be significant differences between the two groups.

Figure 6

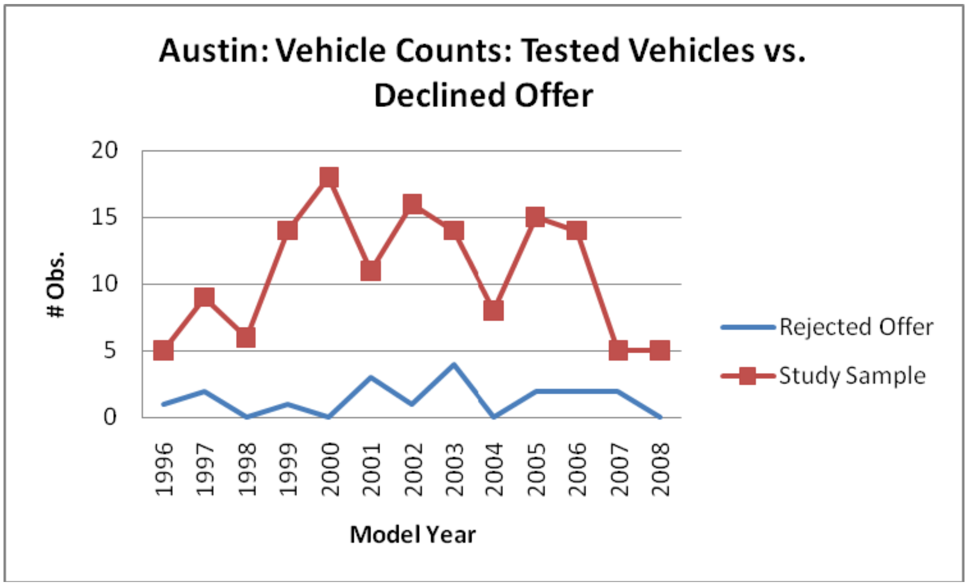


Figure 7

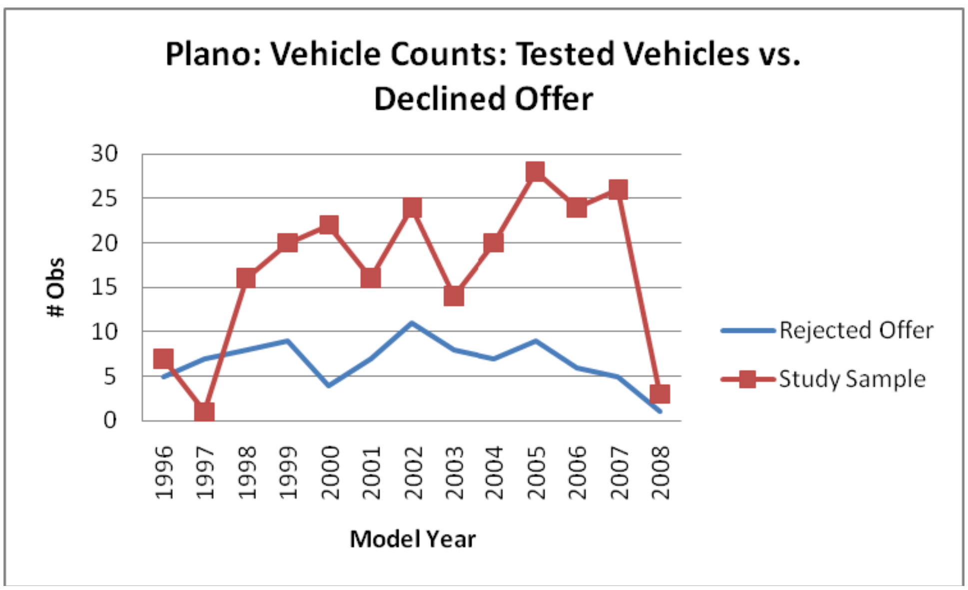


Figure 8

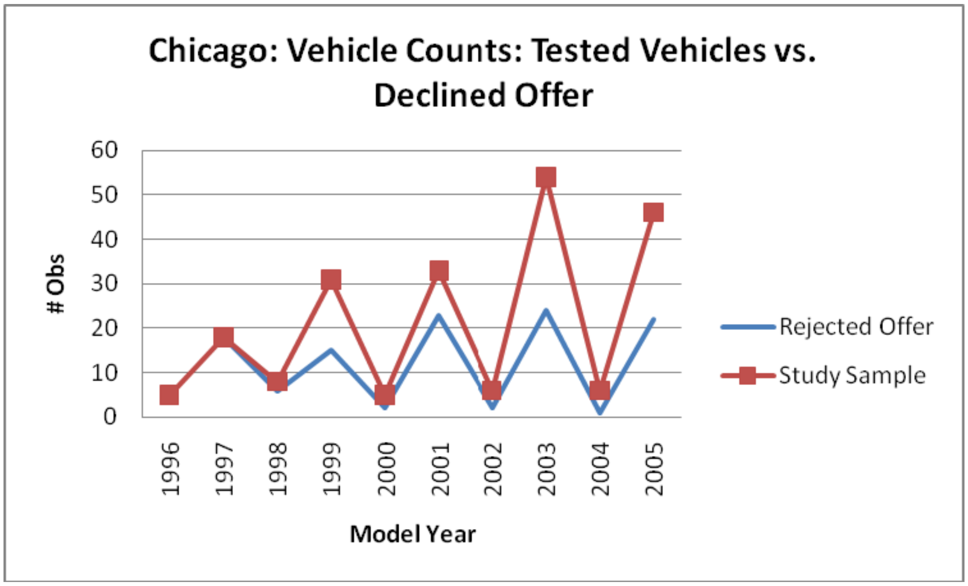


Table 9 presents the reasons why motorists did not participate. The most common reason was that they were in a rush.

Table 9 – Reasons for Not Participating in the CRC Program

Reason	Austin	Chicago	Plano	Grand Total
Couldn't speak English			1	1
Failed Inspection, Rush			1	1
Not Interested	4	26	26	56
Not Owner		1		1
Rush	12	86	50	148
Skeptical		1	7	8
Other	1			1
Grand Total	18	114	87	219

3.2.2 OBDII Status

The samples were compared with regard to faults identified by the OBDII system. We specifically investigated differences in Malfunction Indicator Light (MIL[7]) commanded-on

[7] MIL is a term used for the light on the instrument panel, which notifies the vehicle operator of an emission related problem. The MIL is required to display the phrase “check engine” or “service engine soon” or the ISO engine symbol. The MIL is required to illuminate when a problem has been identified that could cause emissions to exceed a specific multiple of the standards the vehicle was certified to meet.

rates and not ready rates[8]. Vehicles with monitors not ready may have had codes cleared prior to inspection in an attempt to mask a MIL-on situation[9].

MIL Command Status

Table 10 compares the percent of vehicles with MIL commanded on for E0 and E10 areas. Vehicles that failed to communicate with the test system are excluded from this analysis. Figure 9 compares the percent of vehicles with MILs on in the CRC study sample with the percent of vehicles with MILs on in the sample area. Unlike Texas which tests all vehicles more than one year old, in Chicago the newest 4 years are exempted from testing. This explains why MIL command-on rates are higher in Chicago than in the two Texas sites. The MIL-command on rates for each site compare reasonably well with a sample of all vehicles tested in the area, as shown on Figure 9. Note that none of the MIL-command on cases was due to lean operation (as indicated by the DTC[10] stored).

Table 10 – MIL-On Rates in E0 vs E10 Samples

Ethanol	MIL-On Rates: E10 vs. E0 Sample		
	Off	**On**	**%**
E0	132	3	2.2%
E10	391	13	3.2%

Readiness Status

Figure 10 compares the percent of vehicles with at least one monitor not ready. The CRC study sample sites are compared with each other and with a sample of tests in the area. The not ready rates for each site compare well with a sample of all vehicles tested in the area, as shown on Figure 10.

[8] OBDII systems have up to 11 diagnostic monitors, which run periodic tests on specific systems and components to ensure that they are performing within their prescribed range. OBDII systems must indicate whether or not the onboard diagnostic system has monitored each component. Components that have been diagnosed are termed “ready”, meaning they were tested by the OBDII system.

[9] Readiness status for all non-continuous monitors sets to not ready when codes are cleared to extinguish an illuminated MIL.

[10] When a MIL is illuminated a diagnostic trouble codes (DTCs) should be stored. DTCs describe problems identified by the OBDII system.

Figure 9

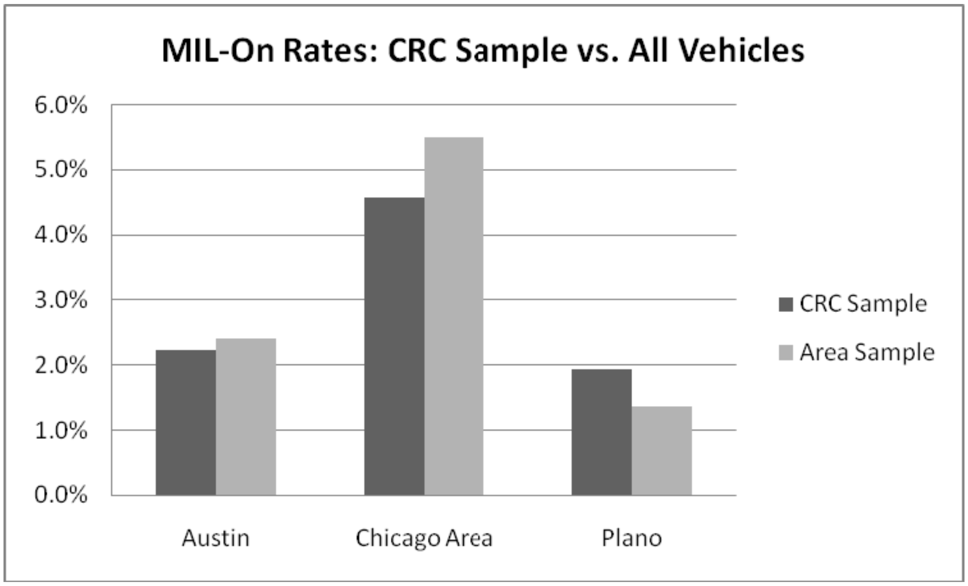
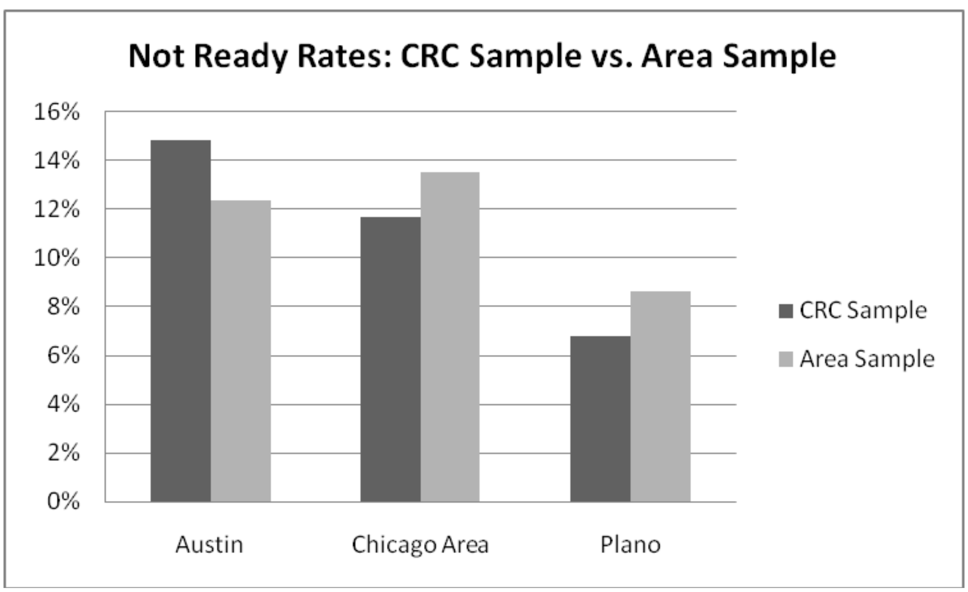


Figure 10



3.2.3 Make

Table 11 ranks the number of tests by manufacturer for the three sites. The Austin and Chicago sites appear to test more domestic models than the Plano site.

Table 11 Ranking of Manufacturers by Site –Study Sample

Make	Austin	Chicago Area	Plano
Ford	1	2	4
GM	2	1	3
Other Japanese	3	4	5
Honda	4	6	1
Chrysler	5	3	6
Toyota	6	5	2
German	7	7	8
Hyundai/Kia	8	9	7
Other European	9	8	9

3.2.4 Conclusions Regarding Representativeness of CRC Study Sample

The distributions of model years and OBDII identified faults in the CRC study samples agree well with the distributions of model years and OBDII identified faults in all tests at the station or in the area. The distribution of model years for vehicles that were tested also agrees well with the distribution of model years for vehicles that were in the group that rejected the offer to participate. dKC concludes that the CRC study sample is representative of the overall vehicle population.

3.3 Long-Term Fuel Trim (LTFT) Trends

A major focus of the CRC test program was on collecting data on long-term fuel trim (LTFT) for vehicles in E0 and E10 areas.

3.3.1 What is Long-Term Fuel Trim?

Fuel trim refers to adjustments being made dynamically to the fuel metering system (termed fuel table) to get the proper ratio of fuel to air. Short term fuel trim refers to adjustments being made in response to temporary conditions. Long term fuel trim (LTFT) is used to compensate for issues that seem to be present over a much longer period. Fuel trims are expressed in percentages; positive values indicate lean (add fuel) and negative values indicate rich (subtract fuel). Fuel trim banks refer to the cylinder banks in a V style engine. Cylinder #1 is always in bank 1. Fuel trim is generally calculated by using a wide set of data values, including front oxygen sensors, intake air temperature/pressure sensor, air mass sensor, engine (coolant) temp sensor, anti-knock sensors, engine load, throttle position (and change in throttle position) sensor, and even battery voltage.

Example Trends for Individual Vehicles

The test system recorded LTFT and other parameters on a second-by-second basis while the engine was off and for 5 to 10 minutes after the engine was started. Figures

11 and 12 show two examples of LTFT trends before and after engine start-up. Figure 11 shows trends for a four cylinder engine with only one bank of cylinders (B1). Figure 12 shows trends for a V-6 so values for bank 1 (B1) and bank 2 (B2) are recorded. In both cases, LTFT increased after start-up. In the example shown in Figure 11, LTFT increased to a maximum value and then dropped slightly before the test ended. In the example shown on Figure 12, LTFT reached a maximum value about mid-way through the test and then stayed at this value for the remainder of the test.

Figure 11

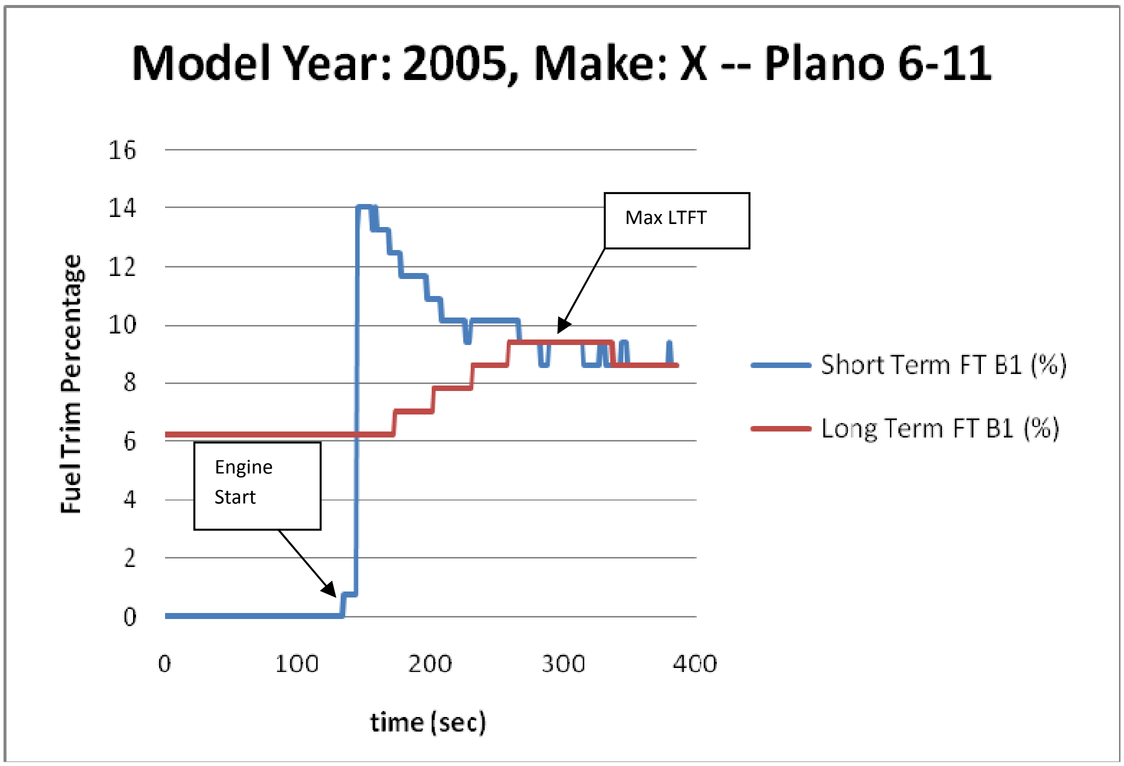
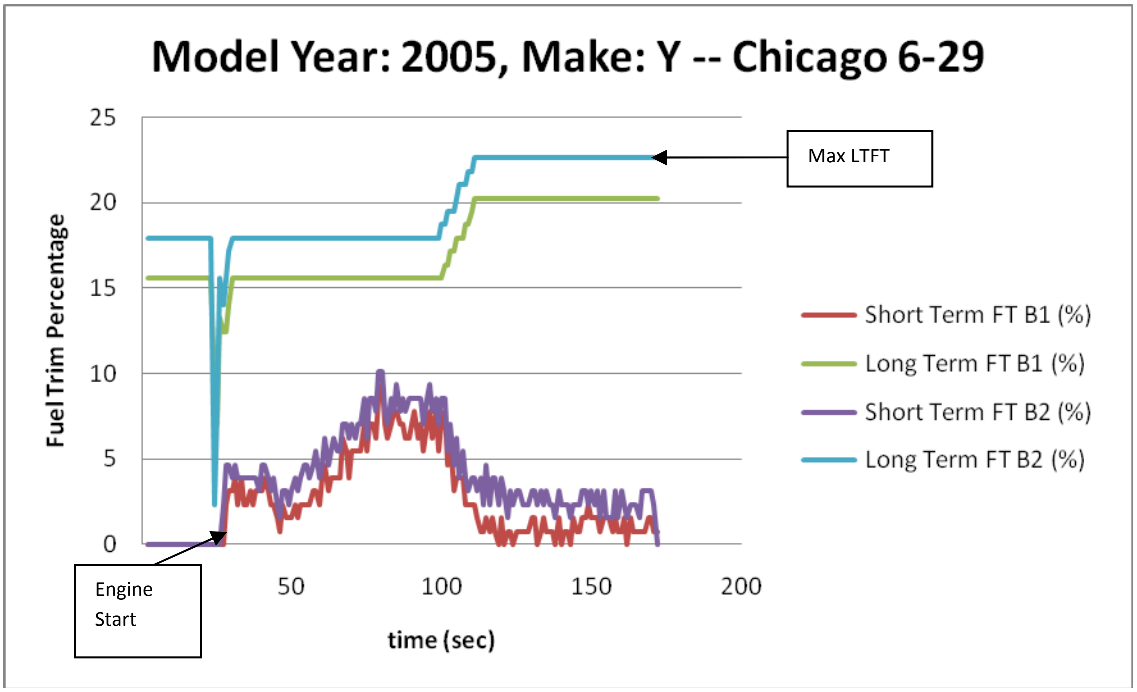


Figure 12



What Fuel Trim Parameters are of Interest: Max LTFT vs. Last LTFT

We compiled summary statistics for each vehicle tested. As stated in Section 2, LTFT and other data parameters were collected for about 10 minutes while the vehicle soaked with the engine off and about 5 minutes after the engine was started. To facilitate an orderly analysis, the following parameters were binned[11]into positive and negative LTFT groups:

- Min LTFT: The minimum LTFT value observed during the test
- Max LTFT: The maximum LTFT value observed during the test
- Last LTFT: The LTFT value at the end of the test

Below we analyze these parameters to determine which parameter best represents the correct LTFT value for the vehicle tested.

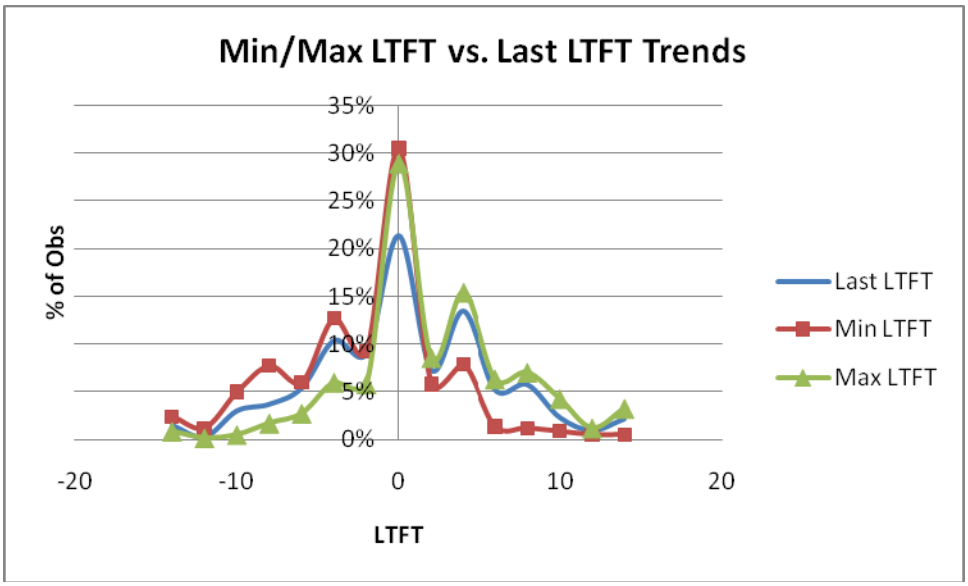
Figure 13 compares binned values of minimum, maximum and last LTFT values for the study sample. This figure charts the percentage of observations that fell into the bins based on what parameter was used to describe LTFT, i.e., minimum LTFT, maximum LTFT, or last LTFT. As Figure 13 shows, max LTFT trends are about the same as last

[11] The bins are groups in 2% increments. Example values: <(13)=-14, >13=14, (11)-(13)=-12, 11-13=12,…Note, <(13)=-14, >13=14

LTFT trends for positive LTFT bins, i.e., the distributions of positive LTFT values are nearly identical for the max LTFT value and last LTFT values. Both values are much greater than min LTFT values. However, for negative LTFT values, min LTFT trends are similar to last LTFT trends; max LTFT trends show much lower incidence of negative LTFT values. From this analysis, we conclude that the last LTFT value recorded during the test is the best overall indicator of LTFT for the vehicle being tested.

The summary trends shown in this section will be based on last LTFT values. Examination of false MIL illumination events with E15 and E20 (when the MIL comes on but nothing is wrong with the vehicle) will be based on max and last LTFT values. Examination of false positive MIL illumination events (when the MIL should come on but does not) will be based on min and last LTFT values.

Figure 13



3.3.2 Overall LTFT Trends

Figures 14 to 17 show overall trends in distributions of LTFT values by site. 95% confidence intervals are indicated on Figures 16 and 17. The last LTFT value is used for this analysis. As shown, E10 locations have higher LTFT values than the E0 location. Overall, as shown on Figure 17 average LTFT values in E10 areas are about 4 absolute percent higher than average LTFT values in E0 locations. Tables 12 and 13 shows the binned numbers of last LTFT values by site and fuel.

Figure 14

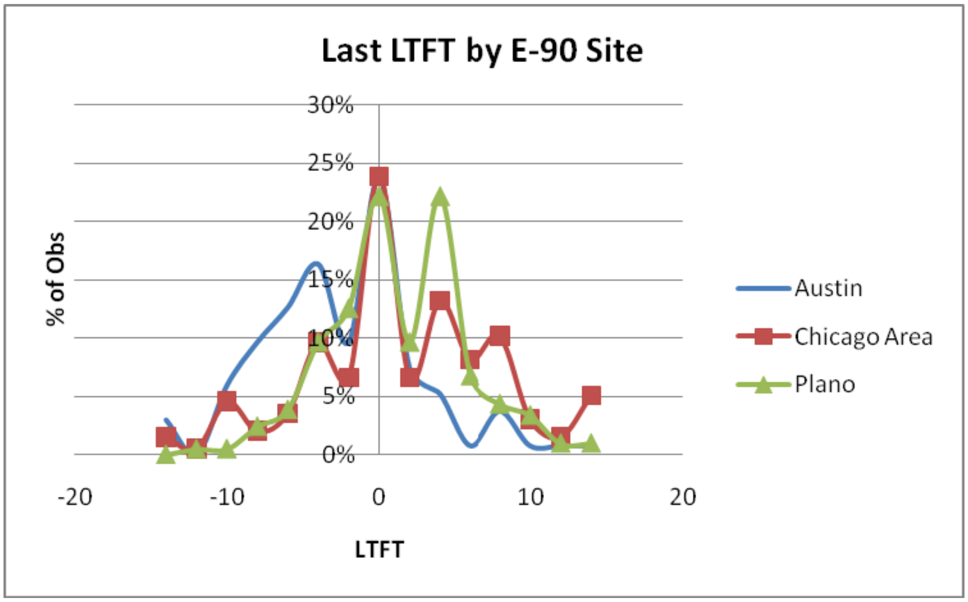


Figure 15

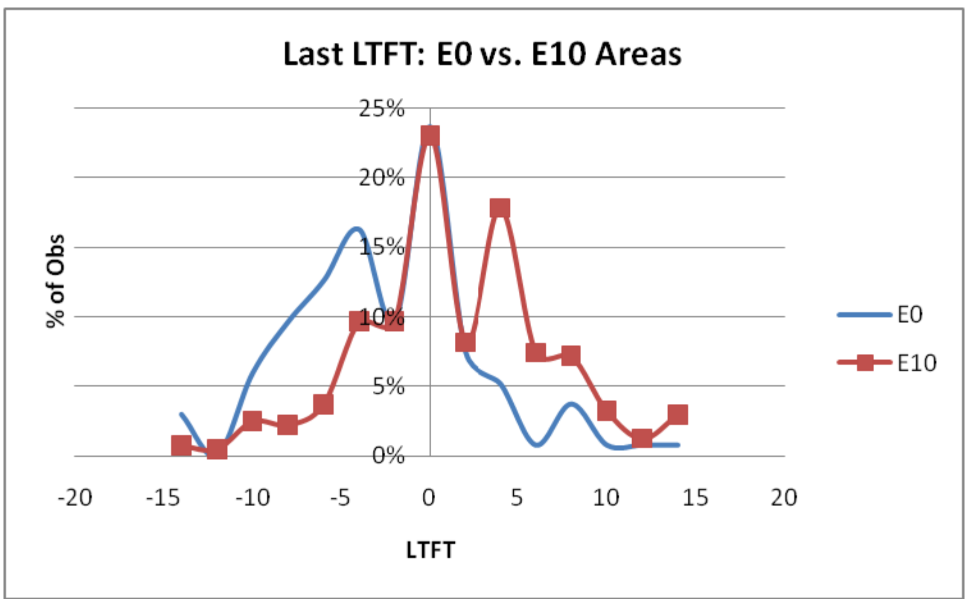


Figure 16

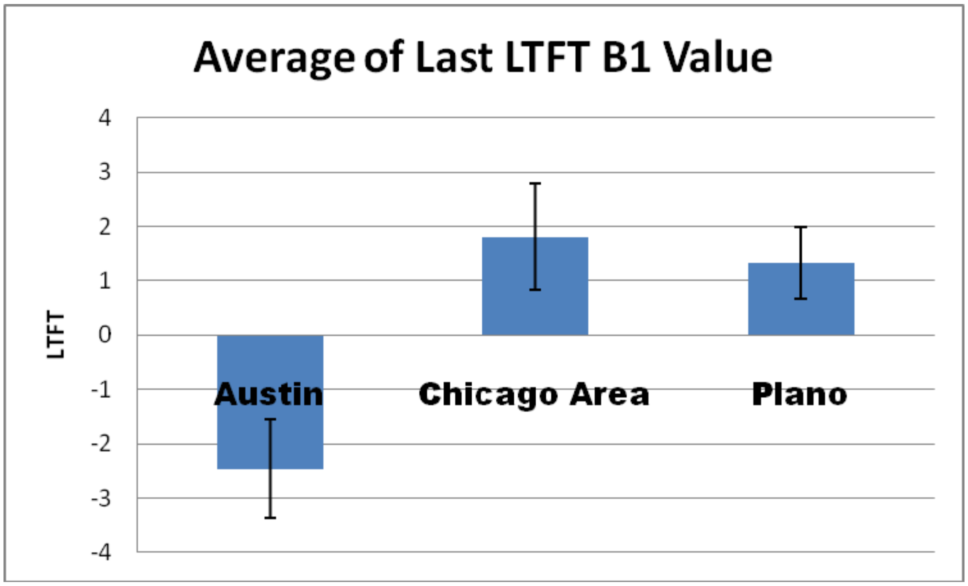


Figure 17

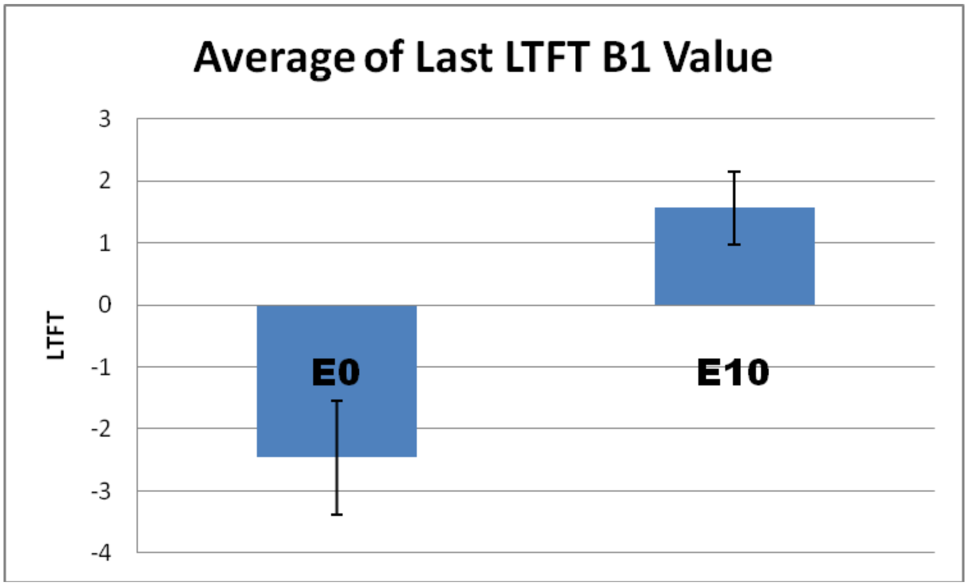


Table 12 Test Counts by Last LTFT Value and Site

Site	Last LTFT Value														
	-14	-12	-10	-8	-6	-4	-2	0	2	4	6	8	10	12	14
Austin	4	0	8	13	17	22	13	32	10	7	1	5	1	1	1
Chicago Area	3	1	9	4	7	19	13	47	13	26	16	20	6	3	10
Plano	0	1	1	5	8	20	26	46	20	46	14	9	7	2	2

Table 13 Test Counts by Last LTFT Value and Fuel

Fuel	Last LTFT Value														
	-14	-12	-10	-8	-6	-4	-2	0	2	4	6	8	10	12	14
E0	4	0	8	13	17	22	13	32	10	7	1	5	1	1	1
E10	3	2	10	9	15	39	39	93	33	72	30	29	13	5	12

LTFT Trends By Odometer

Table 14 provides a breakdown of the sample by odometer reading. Figures 18 and 19 compare LTFT values by odometer in the E0 and E10 locations. Overall, there's good agreement in trends for the less than 100,000 mile and greater than 100,000 mile groups. Figures 20 and 21 compare the effects of ethanol for the less than 100,000 mile and greater than 100,000 mile groups. The effects of ethanol appear to be similar for both groups.

Table 14 – Test Counts by Odometer (Tests that Successfully Communicated)

Odometer Group	E0 Count	E10 Count
<100,000 miles	72	271
>100,000 miles	57	130
Odometer Not Avail.	6	3

Figure 18

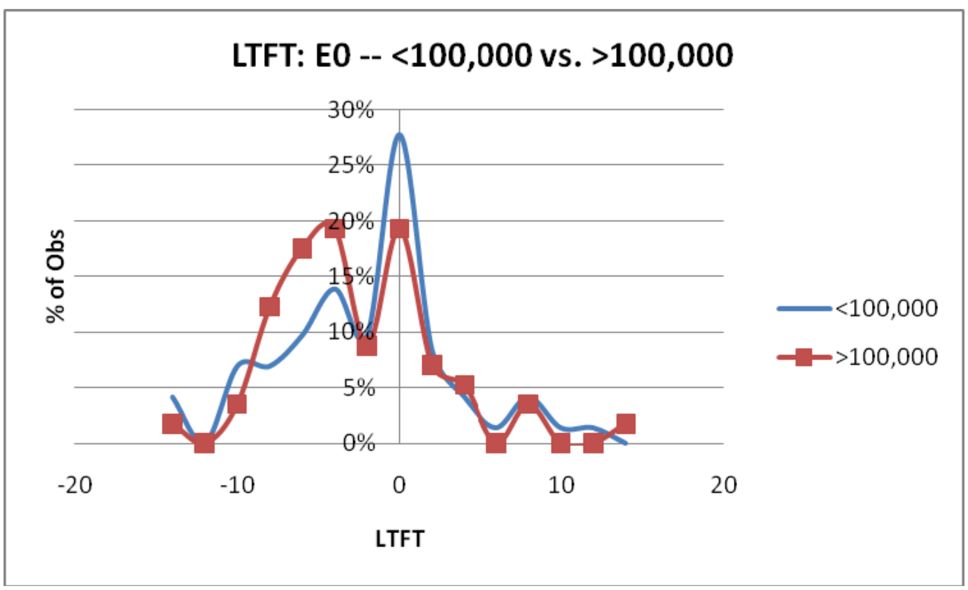


Figure 19

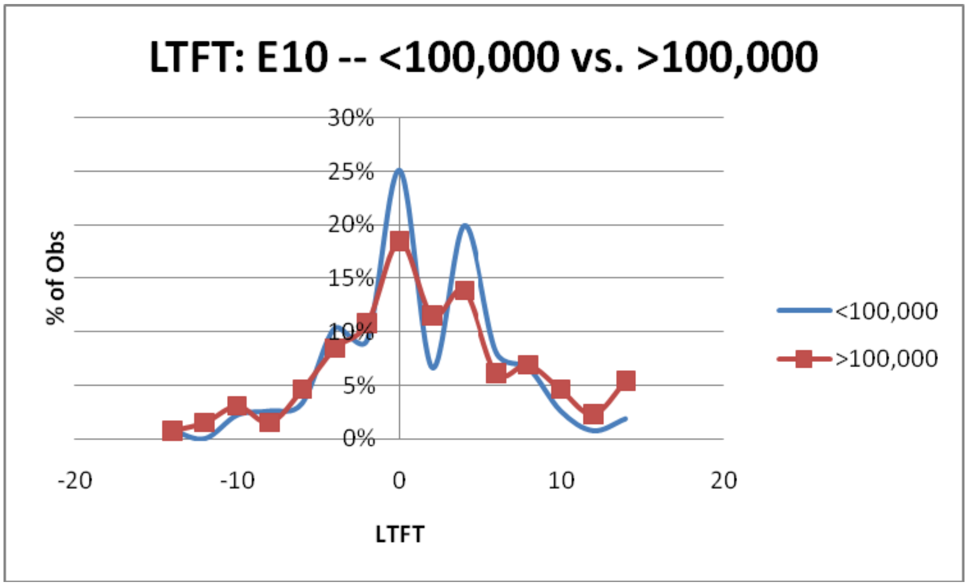


Figure 20

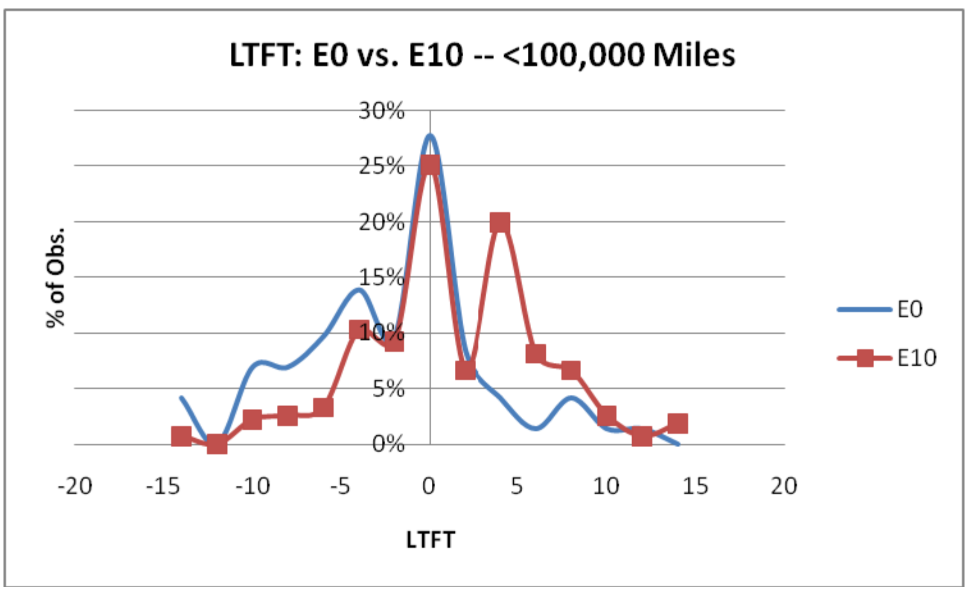
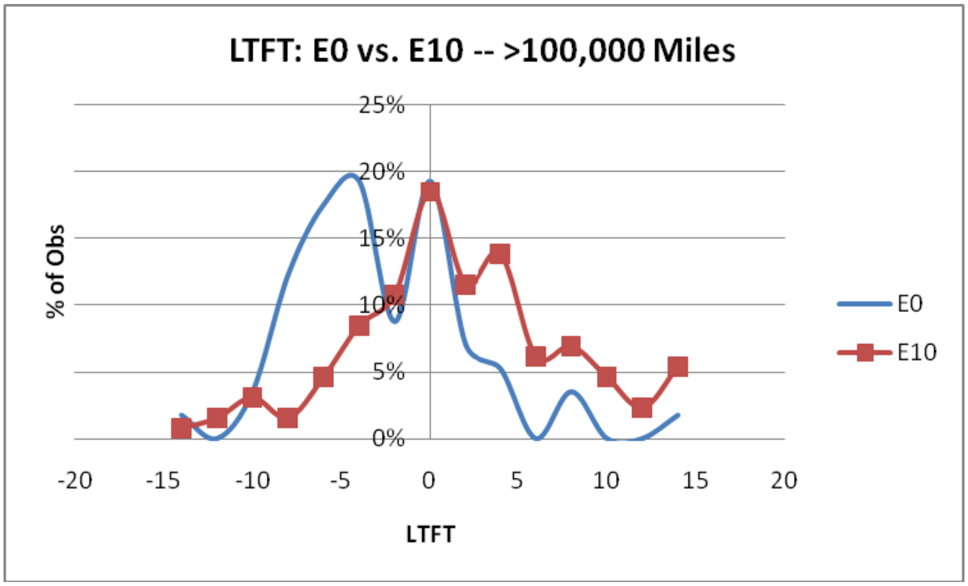


Figure 21



3.3.3 LTFT Trends By Ambient Temperature

Table 15 presents a breakdown of the sample by ambient temperature. Figures 22 and 23 compare LTFT values by ambient temperature in the E0 and E10 locations. Overall, there's good agreement in trends for the less than 90 degree F and greater than 90 degree F groups. Figures 24 and 25 compare the effects of ethanol for the less than 90 degree F and greater than 90 degree F groups. The effects of ethanol appear to be similar for both groups.

Table 15 – Test Counts by Ambient Temperature

Ambient Temperature Group	E0 Count	E10 Count
<90 deg F	95	330
>90 deg F	40	74

Figure 22

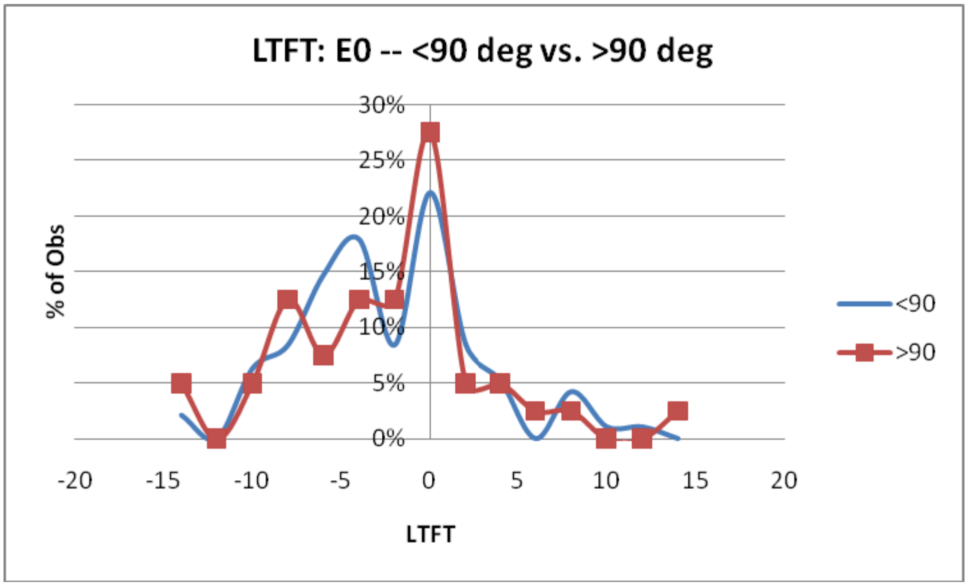


Figure 23

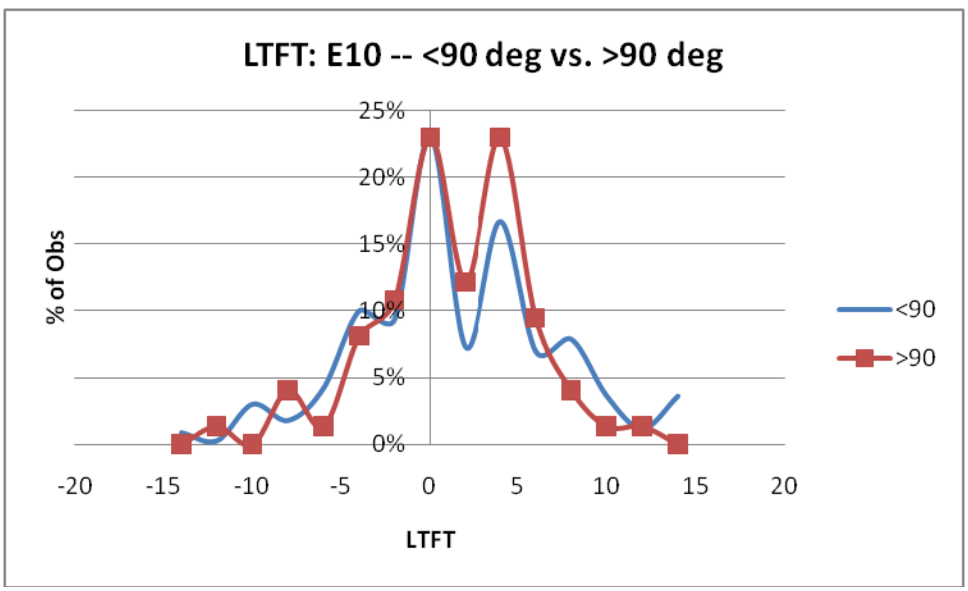


Figure 24

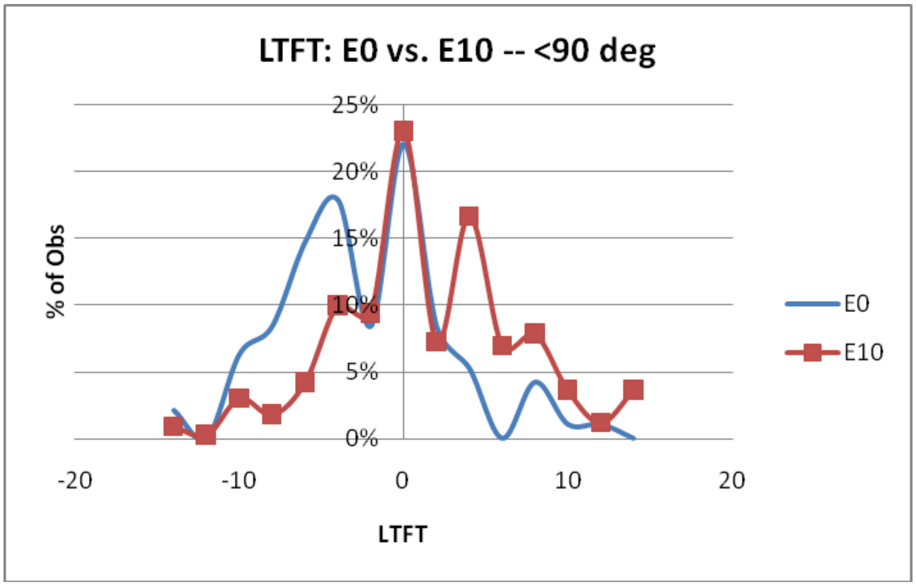
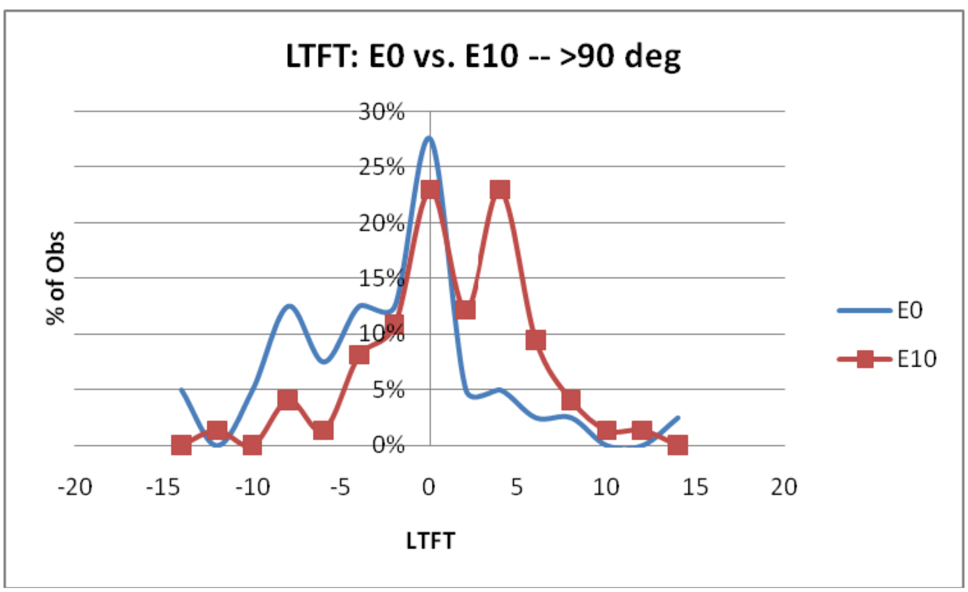


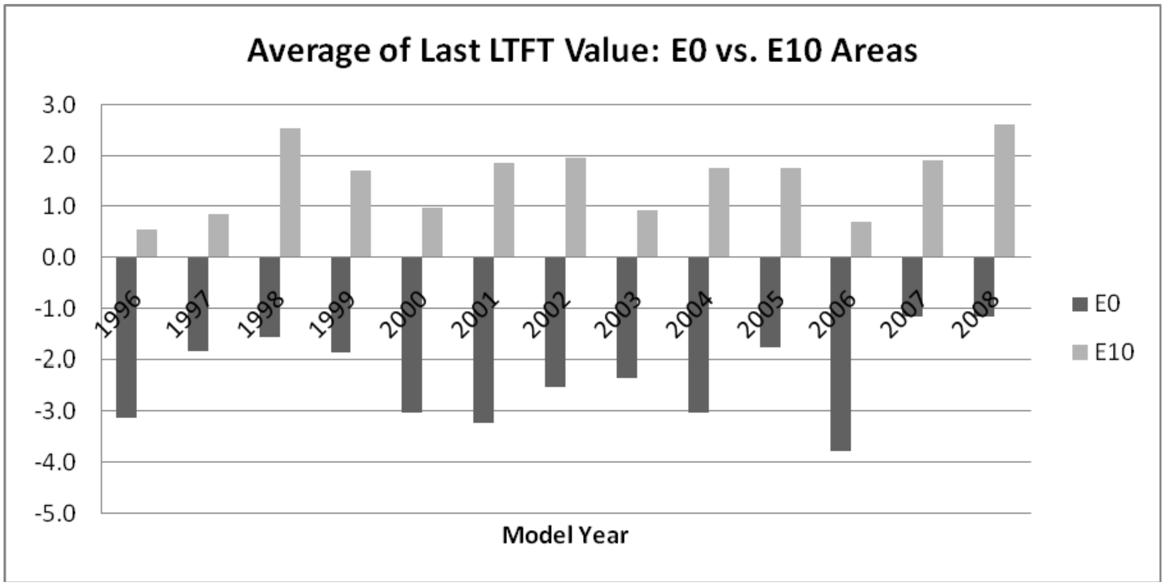
Figure 25



3.3.4 LTFT Trends By Model Year (Age)

Figure 26 shows average LTFT values for E0 and E10 areas broken down by model year. All the averages for the E0 sample were negative, while all the averages for E10 areas were positive. There does not appear to be a clear trend by model year.

Figure 26



3.3.5 LTFT Trends By Make

Figure 27 compares the average increase in LTFT levels from E10 by original equipment manufacturer (OEM). Comparisons are shown for OEMs that had a minimum of 10 observations in E0 areas; 6 OEMs had enough observations for comparisons. The increase is defined as the average E10 level by OEM minus the average E0 level by OEM. The last and max LTFT were used to calculate the increase. As shown, there’s considerable variation in the calculated increase by OEM, although all OEMs show an increase in LTFT from E10 use. Figure 28 shows average last LTFT values for E0 and E10 with 95% confidence intervals. For 3 of the 6 OEMs evaluated, the error bars do not overlap.

Figures 29 to 34 show the distributions of LTFT values (last LTFT) by OEM. All the OEMs show a shift in LTFT from E10. For some of OEMs, e.g. OEM5 and OEM7, the E10 distribution has a similar shape to the E0 distribution; it just shifted to the right.

Figure 27

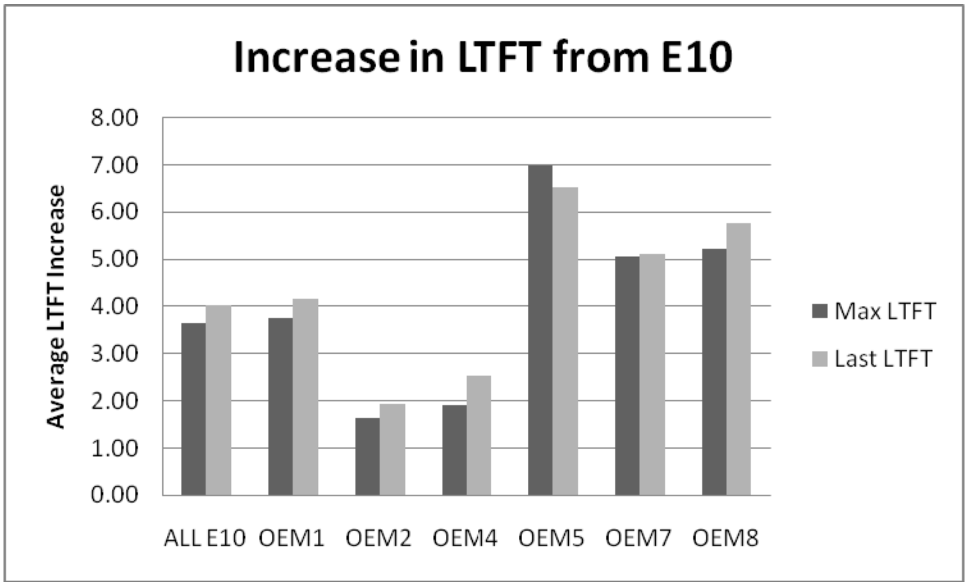


Figure 28

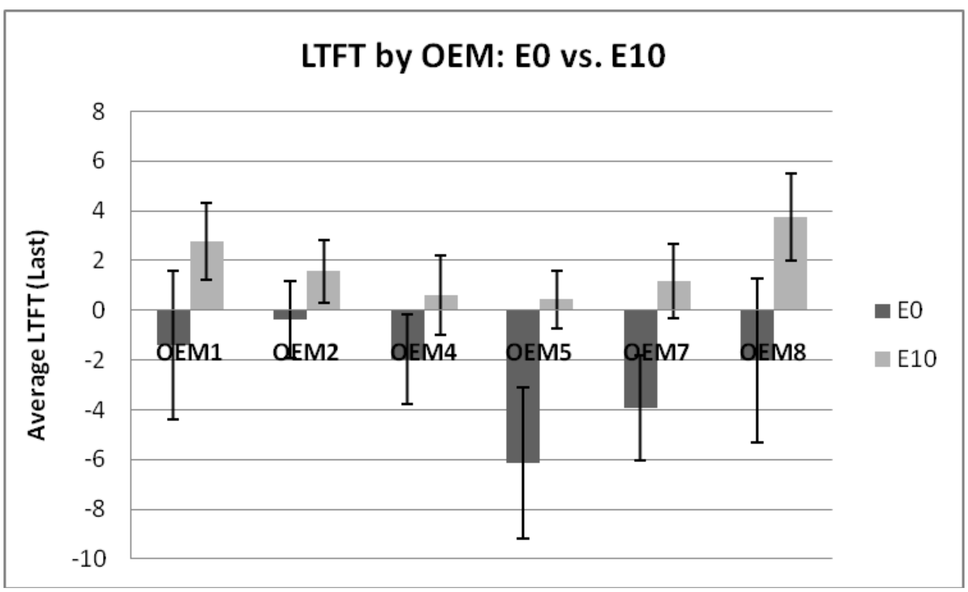


Figure 29

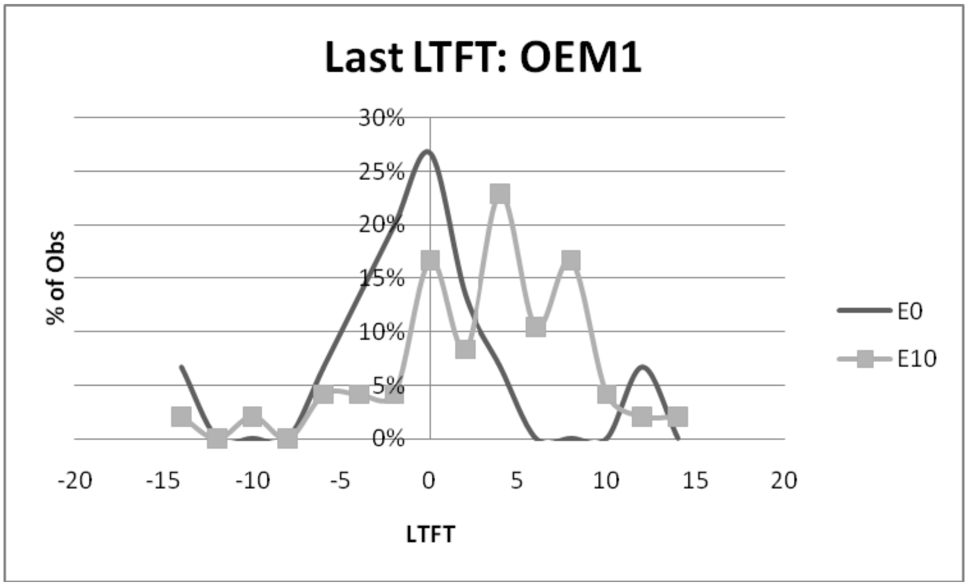


Figure 30

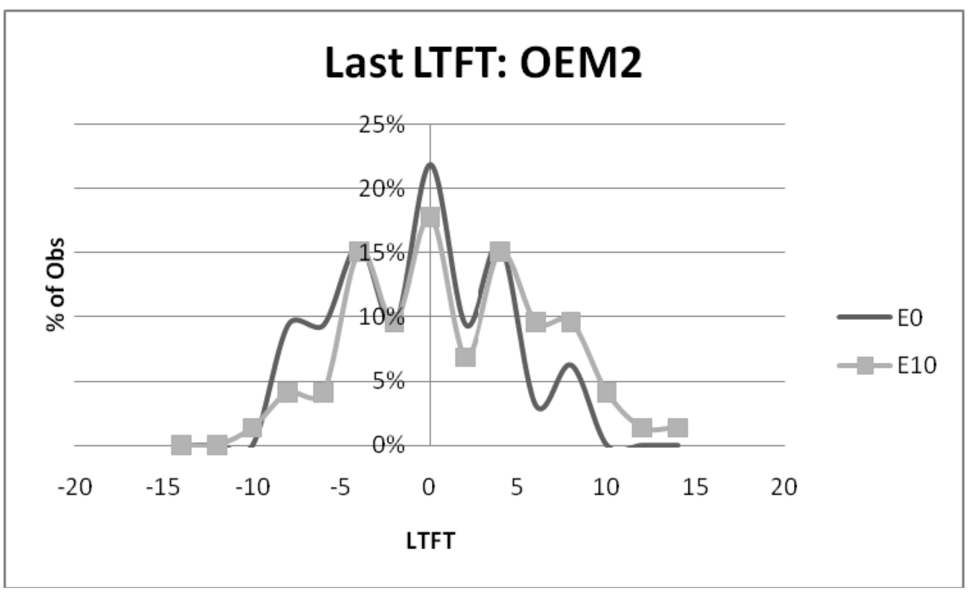


Figure 31

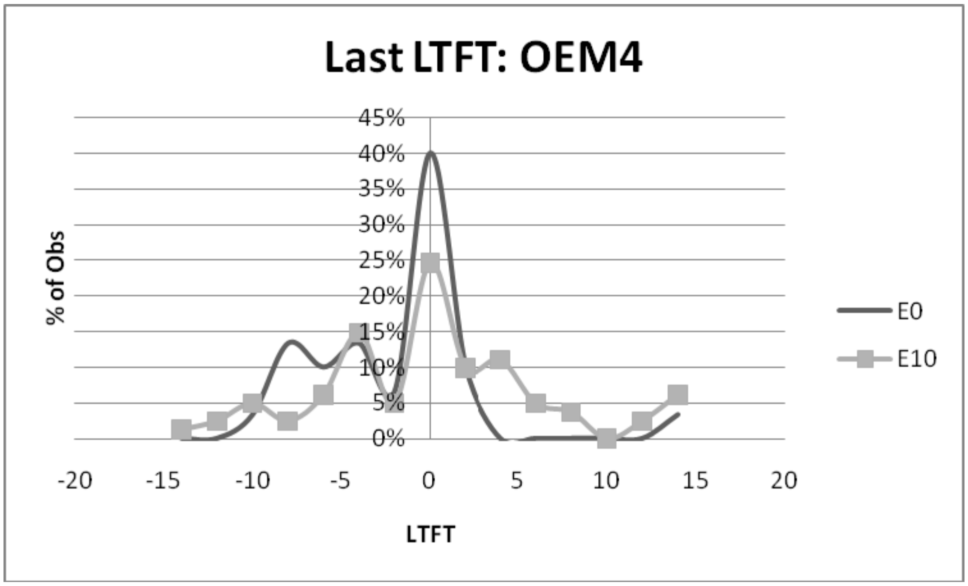


Figure 32

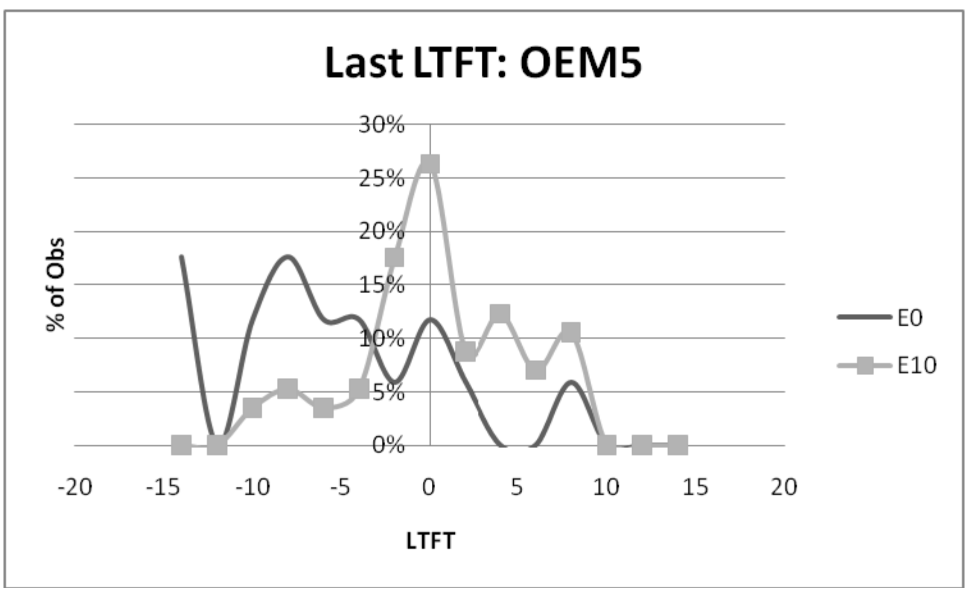


Figure 33

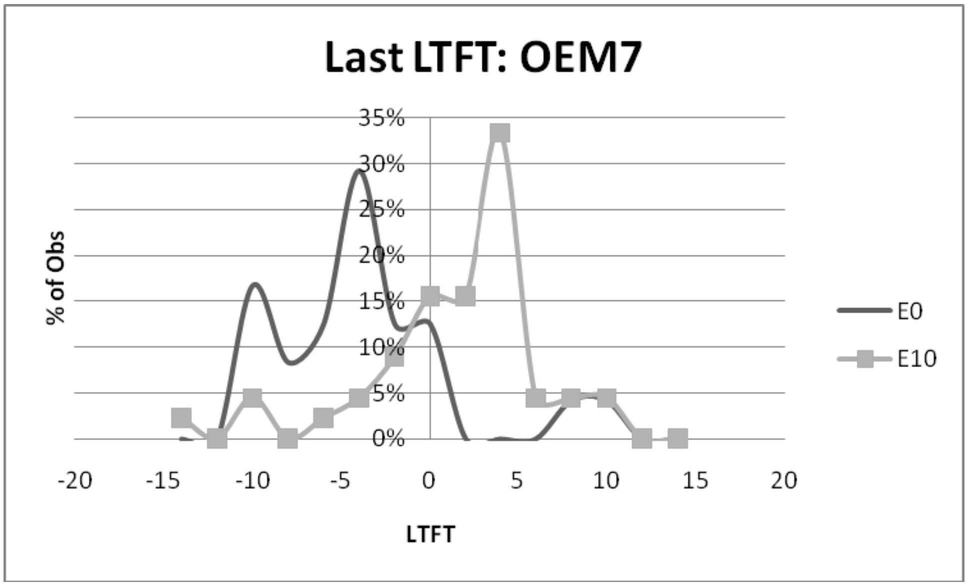
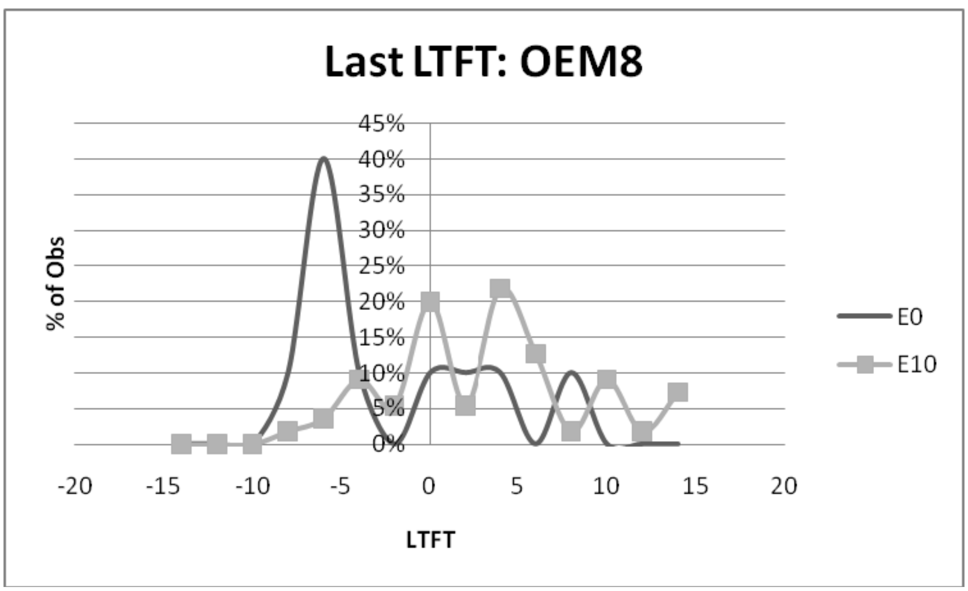


Figure 34



3.4 Projection of MIL Illumination Events

Using data on ethanol effects by OEM, we projected the impact of using gasoline mixed with 15% and 20% ethanol on MIL illumination. As previously mentioned, we are concerned with two types of ethanol effects:

1. A vehicle operating close to an OBD-II threshold level might exceed the MIL-on criterion when fueled with E15 or E20 when nothing is wrong with the vehicle.
2. In the case of vehicles running too rich, ethanol-induced enleanment might move the vehicle back from beyond the OBD threshold and create a "false negative" situation where the MIL does not illuminate when it should.

We took two general approaches to evaluate how increased ethanol use might affect MIL illumination:

1. Each individual test was subject to hypothetical LTFT increases based on observed trends by OEM. The resultant LTFT values were subject to different MIL illumination criteria to determine the potential number of vehicles that would either falsely illuminate the MIL or fail to correctly illuminate the MIL.
2. We assumed that LTFT was normally distributed. We then projected whether ethanol use would shift the tail of the distribution into a potential MIL illumination zone.

3.4.1 Projections Based on Individual Test Results

Methodology

Following is the methodology used to project the possibility based on individual test results that vehicles fueled with E15 or higher blends would either falsely illuminate the MIL or fail to correctly illuminate the MIL:

- The dataset was adjusted as follows:
    - All vehicles with MILs already on were removed.
    - The dataset was limited to OEMs that had both E0 and E10 observations.
    - The resultant dataset had 515 observations.
- LTFT values (last and max) for E0 observations were converted to E10 values by adding the observed impact of E10 (by OEM) to the E0 LTFT value.
- E15 projections were made by adding 50% of the observed impact of E10 to the E10 levels[12].

[12] Based on consultations with OEMs, the impact of ethanol was assumed to be proportional to ethanol content. Therefore, E15 is assumed to increase LTFT by 50% of the observed increase from E10. E20 is assumed to double the observed impact of E10.

- E20 projections were made by adding 100% of the observed impact of E10 to the E10 levels.
- The percent of vehicles exceeding specific LTFT illumination thresholds were calculated two ways:
  - A range of thresholds were applied to the complete dataset.
  - Manufacturer specific thresholds were applied to results for OEMs that provided thresholds.

Reported LTFT Thresholds

Four OEMs provided information on LTFT thresholds that would trigger MIL illumination. Two of the OEMs provided a range of LTFTs that would trigger MIL illumination. Two provided one value that would trigger MIL illumination. The minimum LTFT threshold was 17%; the maximum threshold was 30%.

Percent Exceeding Hypothetical Thresholds

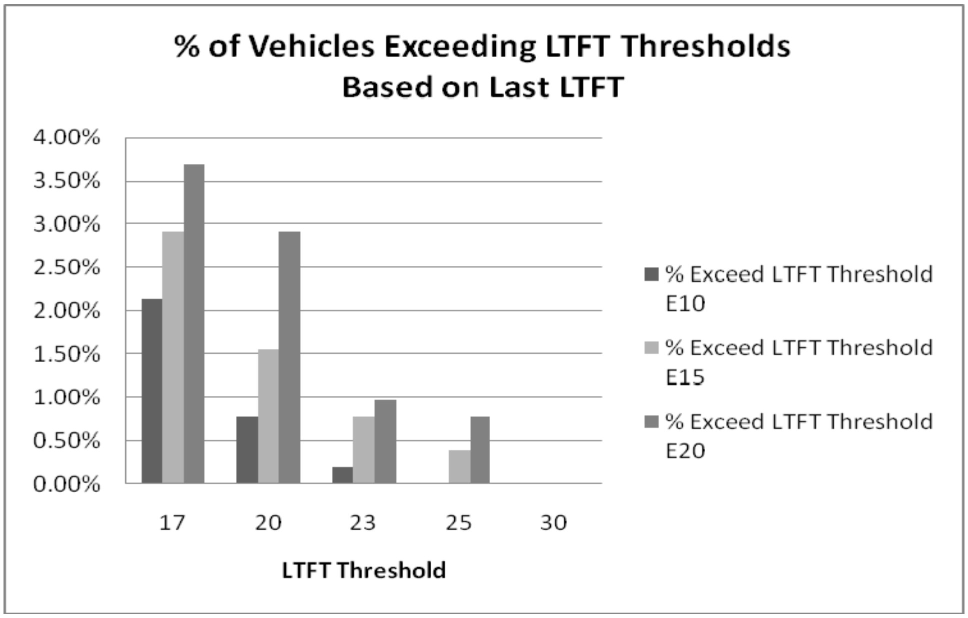
We applied five different hypothetical thresholds to the LTFTs projected for E10, E15 and E20: 17%, 20%, 23%, 25% and 30%. Table 16 shows the percent of vehicles exceeding the different LTFT thresholds. Table 16 is based on last and max LTFT. The projected percentages of vehicles that exceed thresholds are about the same for both LTFT parameters, last or max LTFT. None of the projected LTFTs exceeded the high value of 30%. When hypothetical thresholds of 17% to 25% are applied to last LTFT values, E15 is projected to increase MIL illumination rates by 0.39% to 0.77%; E20 is projected to increase MIL illumination rates by 0.78% to 2.13%[13]. When these same thresholds are applied to max LTFT values, E15 is projected to increase MIL illumination rates by 0.39% to 0.77%; E20 is projected to increase MIL illumination rates by 0.78% to 1.75%. Figure 35 charts the analysis results based on last LTFT values.

Table 16 – Percent Exceeding Specific Positive LTFT Thresholds Based on Last and Max LTFT Value

LTFT Threshold	% Exceed LTFT Threshold E10 (last/max)	% Exceed LTFT Threshold E15 (last/max)	% Exceed LTFT Threshold E20 (last/max)
>17%	2.14%/2.72%	2.91%/3.11%	3.69%/4.08%
>20%	0.78%/0.97%	1.55%/1.94%	2.91%/2.72%
>23%	0.19%/0.19%	0.78%/0.58%	0.97%/0.97%
>25%	0.00%/0.00%	0.39%/0.39%	0.78%/0.78%
>30%	0.00%/0.00%	0.00%/0.00%	0.00%/0.00%

[13] The percent increases for E15 and E20 are based on the percent that exceed thresholds with E15 or E20 minus the percent that exceed thresholds with E10.

Figure 35



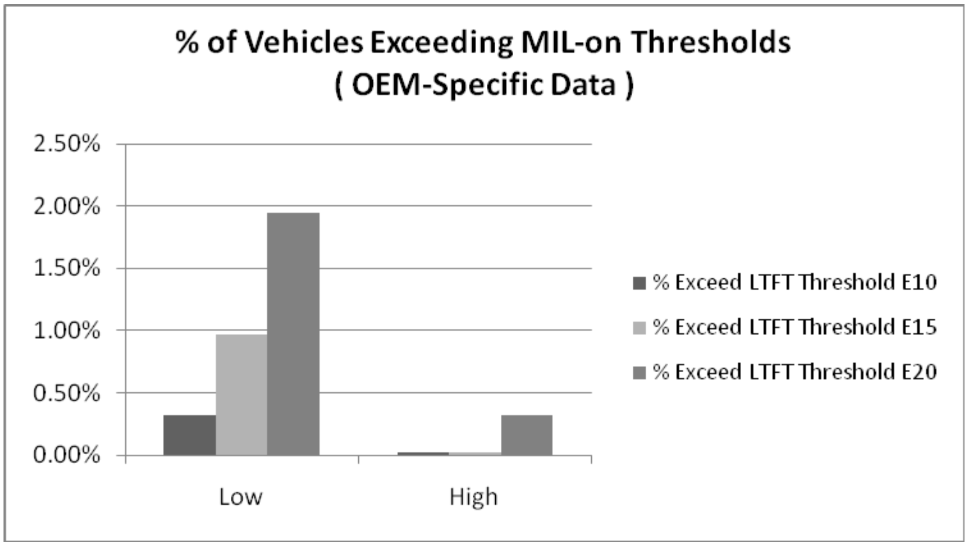
Percent Exceeding Manufacturer Specific Thresholds

As mentioned, four OEMs provided information on LTFT thresholds. We applied OEM specific thresholds to the LTFT results for a specific OEM. Table 17 presents the results for different ethanol concentration scenarios. Figure 36 shows this information graphically. The low threshold represents the lowest threshold for MIL illumination for a specific OEM. The high threshold represents the highest threshold for MIL illumination for a specific OEM. Note that we did not have information on thresholds by model, so we cannot definitively determine if a vehicle would exceed the LTFT threshold and illuminate the MIL. Based on the difference between the percent of vehicles that exceed the low thresholds with E10 vs. E15, E15 has potential to increase MIL illumination rates by up to 1.0%. E20 has potential to increase MIL illumination rates by up to 1.6%. More detailed MIL illumination thresholds for different OEMs will help to better define the scope of this problem, but actual testing on E15 or E20 is needed to determine if in-use vehicles will experience false MIL illumination.

Table 17 – Percent of Vehicles Projected Exceed Manufacturer's Thresholds Based on Last and Max LTFT Value

Thresholds	% Exceed LTFT Threshold E10 (last/max)	% Exceed LTFT Threshold E15 (last/max)	% Exceed LTFT Threshold E20 (last/max)
Low	0.32%/0.32%	0.97%/1.29%	1.94%/1.94%
High	0.00%/0.00%	0.00%/0.00%	0.32%/0.32%

Figure 36



Evaluation of False Negatives

We also evaluated the potential for increased fractions of ethanol in gasoline to create a "false negative" situation where the MIL does not illuminate when it should be on. In this case we looked at negative LTFT thresholds of -17 and -20. No vehicles had LTFT values below -20 on E10. Table 18 shows the percent of vehicles that exceeded negative LTFT thresholds. There is potential for E15 or E20 to shift a vehicle out of MIL illumination conditions. There were no vehicles in the dataset that had MILs on due to rich LTFT values, so we cannot definitively evaluate the "false negative" case.

Table 18 – Percent Exceeding Specific Negative LTFT Thresholds Based on Last and Min LTFT Value

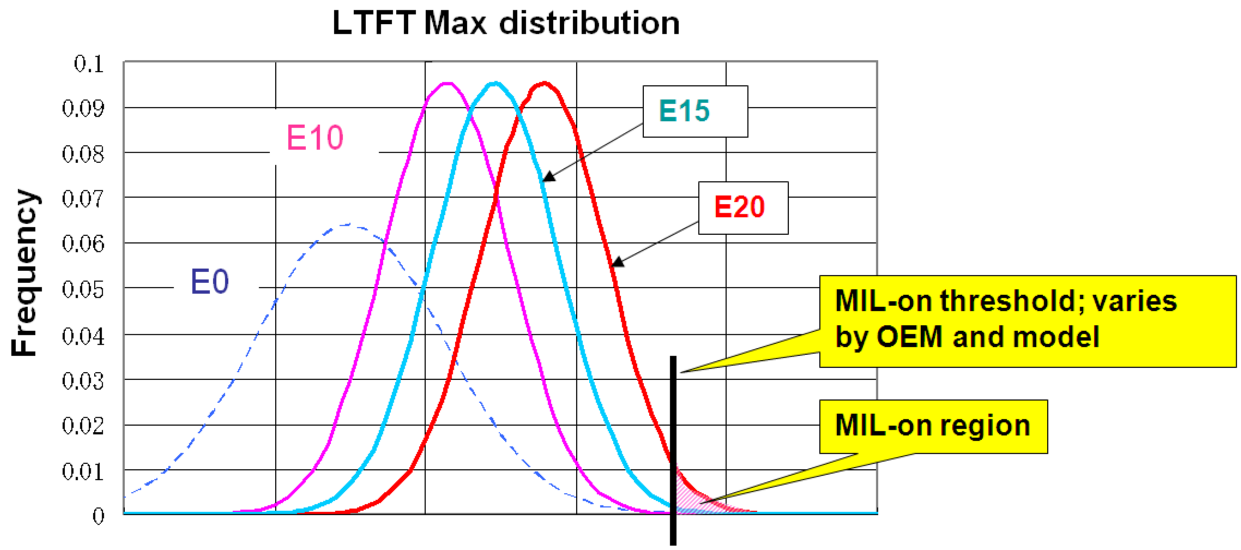
LTFT Threshold	% Exceed LTFT Threshold E10 (last/min)	% Exceed LTFT Threshold E15 (last/min	% Exceed LTFT Threshold E20 (last/min
<-17%	0.19/0.39%	0.00/0.00%	0.00/0.00%
<-20%	0.00/0.00%	0.00/0.00%	0.00/0.00%

3.4.2 Projections Based on Statistical Trends by Manufacturer

Methodology

The possibility of exceeding positive LTFT MIL thresholds was also investigated using statistical projections of LTFT values, assuming LTFT is normally distributed. The example shown on Figure 37 illustrates how this analysis was performed.

Figure 37 – Hypothetical Shift in LTFT from E15 and E20



The following steps were performed to investigate the possibility that increased ethanol content in gasoline will lead to false MIL illumination:

- The average and standard deviation of the last LTFT was calculated for combinations of OEM and fuel.
- The increase in LTFT from E10 based on last LTFT was calculated by OEM.
- E0 levels equal the observed average by OEM for the E0 sample.
- E10 levels equal the observed average by OEM for the E10 sample.
- E15 projections were made by adding 50% of the observed impact of E10 to the E10 levels.
- E20 projections were made by adding 100% of the observed impact of E10 to the E10 levels.
- The "tail" of the distribution was calculated by adding two and three standard deviations to the projected E15 and E20 values.

Projected LTFT Levels for the Tails of the Distribution

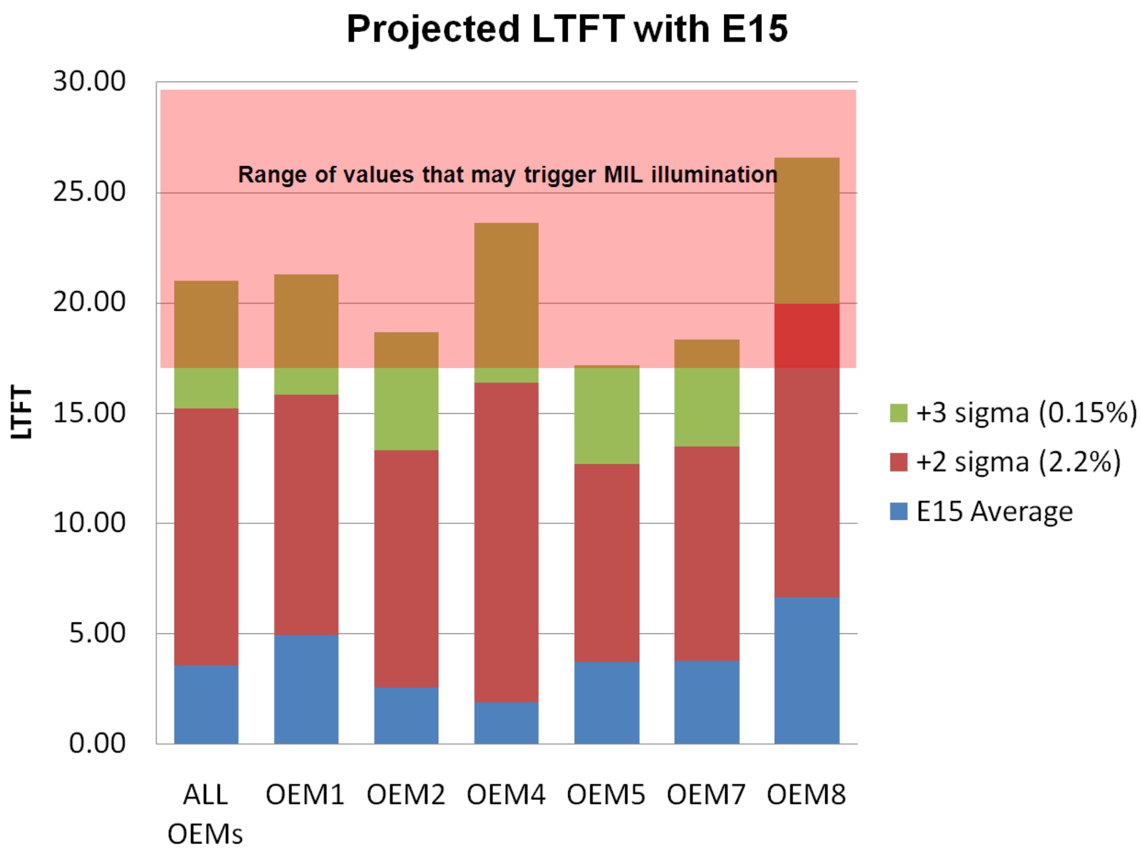
Table 19 shows the averages and standard deviations for the E0 and E10 samples broken down by OEM. Assuming that the standard deviation for E15 and E20 are the same as the standard deviation for E10, we projected the two and three standard deviation "tails" for E15 and E20. Figure 38 shows projected LTFT values for E15. Figure 39 shows projected LTFT values for E20. The region of possible MIL illumination is highlighted on the figures. Two standard deviations above the expected average represent 2.2% of the population, assuming a normal distribution. Three standard deviations represent 0.15% of the population.

The two standard deviation tail for one OEM equals or exceeds 20% when fueled with E15 or E20. If you add three standard deviations to the expected average, the E15 tail for the overall sample is 21% and the E20 tail is 23%. Several OEMs turn MILs on when LTFTs are in this range. Although three standard deviations represent only 0.15% of the population, considering that there are over 50 million OBDII vehicles operating in the US, the number of vehicles impacted could be significant.

Table 19 – Averages and Standard Deviations by Fuel and Original Equipment Manufacturer (OEM)

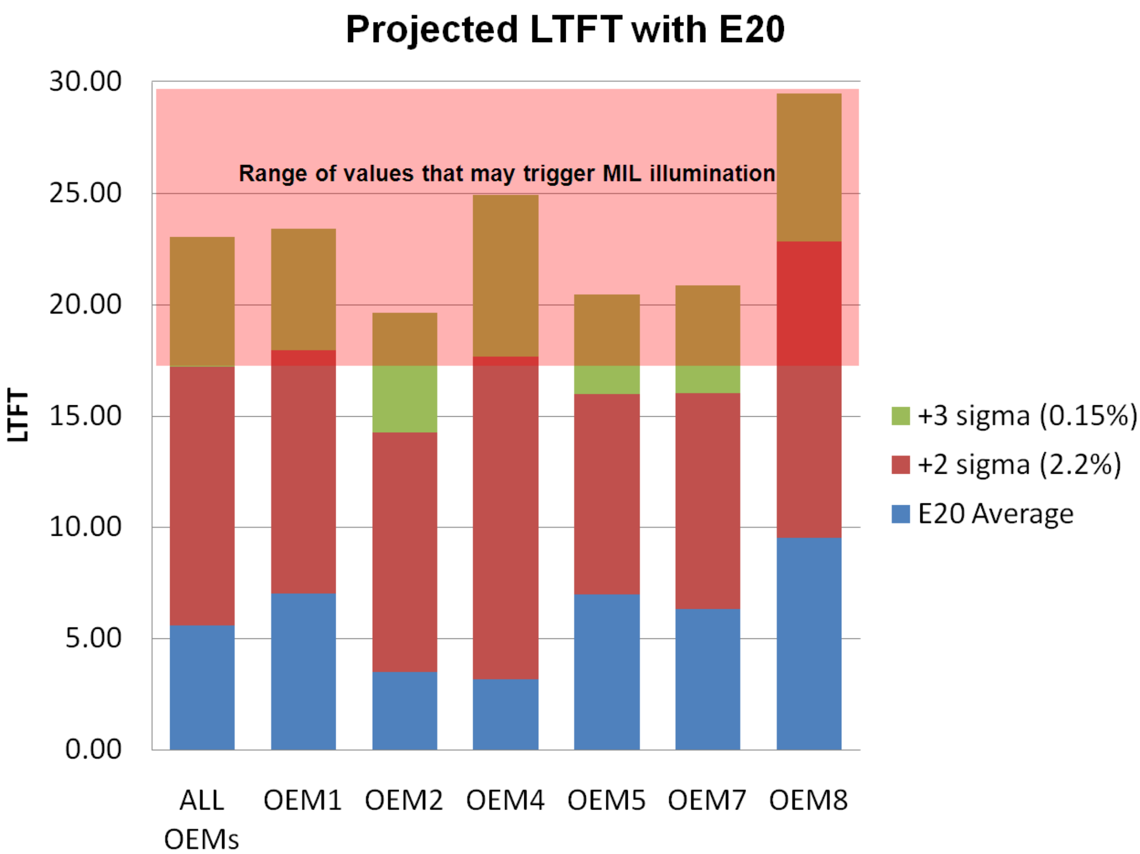
Fuel/OEM	Average of Last LTFT B1	Standard Deviation of Last LTFT B1
E0	-2.50	5.38
OEM1	-1.39	5.68
OEM2	-0.38	4.41
OEM4	-1.95	5.06
OEM5	-6.15	6.38
OEM7	-3.94	5.21
OEM8	-2.03	5.29
E10	1.54	5.81
OEM1	2.83	5.44
OEM2	1.56	5.37
OEM4	0.62	7.24
OEM5	0.44	4.47
OEM7	1.18	4.86
OEM8	3.74	6.65

Figure 38



Projected LTFT with E15
30.00
25.00
20.00
15.00
10.00
5.00
0.00
LTFT
Range of values that may trigger MIL illumination
+3 sigma (0.15%)
+2 sigma (2.2%)
E15 Average
ALL OEMs
OEM1
OEM2
OEM4
OEM5
OEM7
OEM8

Figure 39



3.5 Analysis of Texas Inspection/Maintenance Data

dKC requested and received data from the Texas Commission of Environmental Quality (TCEQ) on OBDII inspections conducted in June 2009 in the Austin and Dallas-Ft. Worth areas. The dataset had the following numbers of initial OBDII tests:

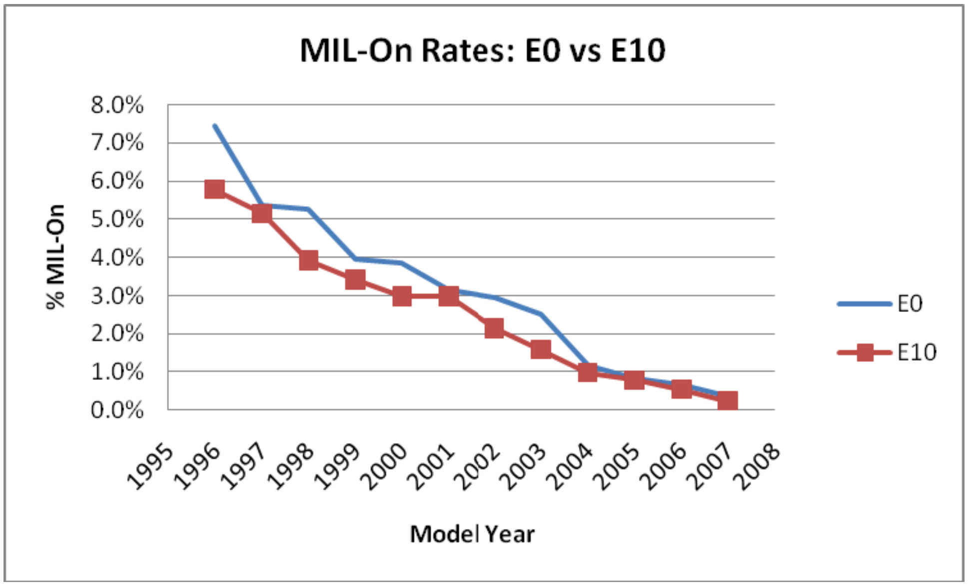
- Austin: 45,150 initial tests
- Dallas-Ft. Worth: 187,674 initial tests

Based on fuel property information collected for the present study, dKC assumes that data from Austin represents E0 and data from Dallas-Ft. Worth represents E10.

MIL-On Rates: E0 vs. E10 Areas

Figure 40 summarizes overall MIL-On rates by model year for the two samples. Rates are slightly higher in the E0 area. This could be due to the fact that OBDII inspections commenced in Austin in 2005, while they have been doing them in the Dallas-Ft. Worth area since 2002.

Figure 40



Diagnostic Trouble Codes (DTCs) In E0 vs. E10 Areas

During OBDII inspections in Texas and other states, diagnostic trouble codes (DTCs) are recorded. DTCs describe problems identified by the OBDII system. In most cases (99%), when the MIL is on a DTC will be stored. In cases when the MIL is off but a DTC is stored, the OBDII system is either awaiting further confirmation from the on-board computer that the MIL should be on, or the problem was not seen in three consecutive trips, so the on-board computer turned off the MIL.

dKC identified DTCs that are related to enleanment (running too lean) or enrichment (running too rich). DTC related to enleanment are presented below:

DTC	Description
P0171	System too Lean (Bank 1)
P0174	System too Lean (Bank 2)

DTC related to enrichment are presented below:

DTC	Description
P0172	System too Rich (Bank 1)
P0175	System too Rich (Bank 2)

Table 20 shows the percent of vehicles that had DTCs related to either lean or rich operation. Results are broken down into E0 and E10 areas. As shown, there were about 6% more vehicles with enleanment DTCs in the E10 area than in the E0 area. On the other hand, the percentage of vehicles with enrichment DTCs were about 60% lower in the E10 area than in the E0 area. In terms of ranking, P0171 was the 3rd most common DTC in the E10 area, while it was the 5th most common DTC in the E0 area. P0172 was the 15th most common DTC in the E0 area, while it was the 34th most common DTC in the E10 area. Clearly, ethanol reduces the percent of vehicles with enrichment related DTCs.

Table 20 – Percent of Tests with DTCs Related to Enleanment (P0171/P0174) or Enrichment (P0172/P0175)

Area	Percent of Initial Tests with DTC	
	Lean: P0171/P0174	**Rich: P0172/P0175**
E0	0.432%	0.206%
E10	0.459%	0.077%
% Diff E10	6.2%	-62.8%

dKC investigated two models that had high LTFT values in E10 areas. Both models had 0% incidence of P0171/P0174 DTCs in the E0 area, while in the E10 area, 0.6% to 2% of these models had P0171/P0174 DTCs.

Not Ready Rates

Vehicles fail inspection if too many monitors are not ready. Figure 41 shows the percent of vehicles failing for readiness. Rates were similar for 2001 and newer models, but for the older models, not ready rates were higher for the E0 sample. Like MIL-on rates, this could be due to the fact that the program in Dallas Ft. Worth is more established than the program in Austin.

Figure 42 shows not ready rates for key monitors. Not ready rates for the evap monitor are significantly higher in the E10 area. As shown on Figure 43, evap monitor not ready rates are consistently higher in the E10 area across a range of model years. Not ready rates for the catalyst monitor are slightly higher in the E10 area, while rates for other key monitors are about the same for both samples. Even though there were more vehicles in the Dallas Ft. Worth sample than in the Austin sample, the differences are statistically significant. It's not clear why ethanol may cause more evap monitors to be not ready. Analysis of data from other I/M programs is needed to confirm that this issue is related to the use of E10.

Figure 41

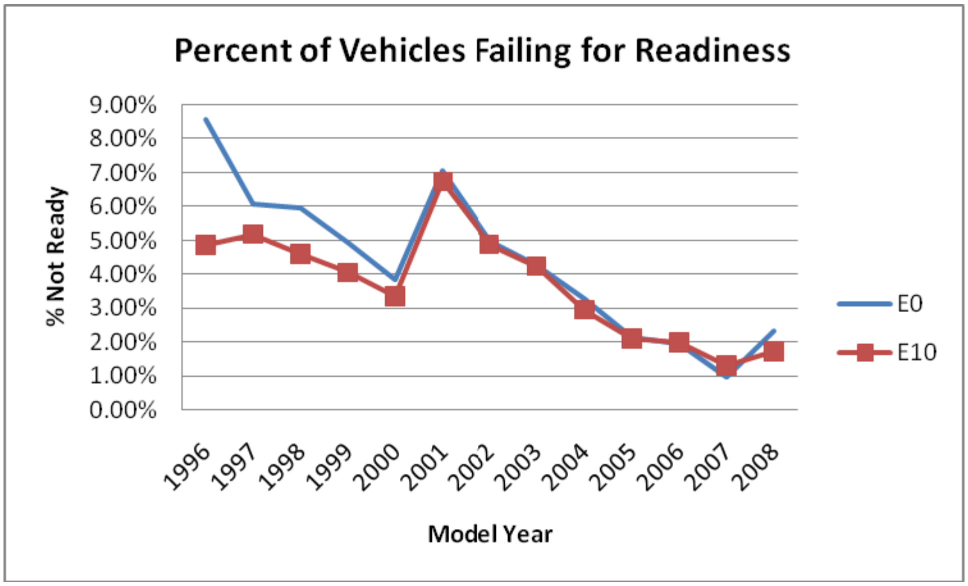


Figure 42

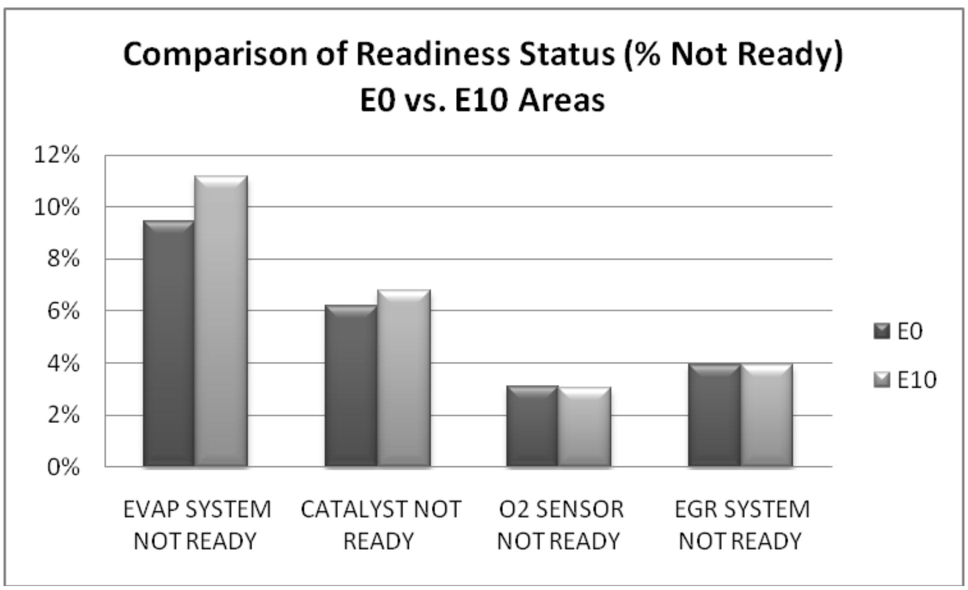
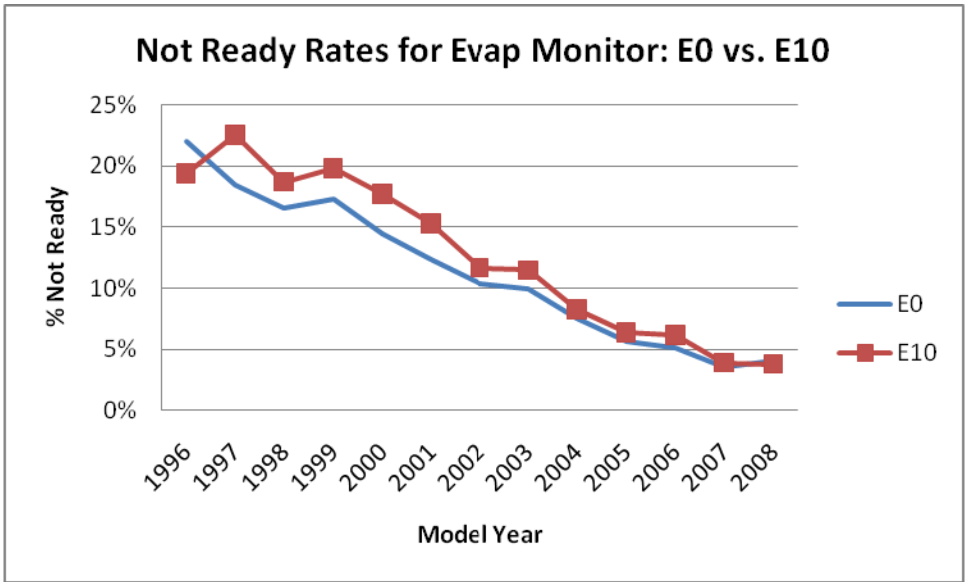


Figure 43



Not Ready Rates for Evap Monitor: E0 vs. E10
25%
20%
15%
10%
5%
0%
% Not Ready
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Model Year
E0
E10

4.0 CONCLUSIONS

Conclusions from this study are listed below:

- Operation on 10% ethanol/gasoline blends (E10) increases LTFT over E0 levels for most vehicles. The sensitivity varies by original equipment manufacturer (OEM), but all OEMs show the trend.
- The tests conducted in this study provide evidence that operation on 15% or 20% ethanol/gasoline blends (E15 or E20) may cause a subset of problem-free vehicles to illuminate their malfunction indicator light (MIL) due to excessively lean[14] operation. The fraction depends on the assumed LTFT threshold[15] and the fuel ethanol content and is roughly estimated to be of the order of a percent or so. A more precise estimate of this fraction cannot be made with the available data.
- There is also evidence that operation on E15 and E20 may cause some vehicles that currently have illuminated MILs due to rich[16] operation to appear to be problem free, but no vehicles with this type of illuminated MIL were detected in this program.
- Additional study is needed to better quantify potential ethanol-related issues with OBD MIL. Vehicle testing on E15 or E20 is needed to confirm that false positive or negative MIL illumination will occur. Further analysis of MIL status from I&M data and more detailed MIL illumination thresholds for different OEMs will also help to better define the scope of this problem.
- Not ready rates[17] for the evap monitor in Texas were higher in the E10 area than in the E0 area. More data would be required to determine if ethanol was affecting this parameter.

[14] Lean: More air than required for optimum combustion.

[15] LTFT threshold: The LTFT value at which the OBD system illuminates the MIL.

[16] Rich: More fuel than required for optimum combustion.

[17] OBDII systems have up to 11 diagnostic monitors, which run periodic tests on specific systems and components to ensure that they are performing within their prescribed range. OBDII systems must indicate whether or not the onboard diagnostic system has monitored each component. Components that have been diagnosed are termed “ready”, meaning they were tested by the OBDII system.

Appendix A

Handouts, Posters, Questionnaires and Examples of Pictures Taken During Test

Appendix A-1 – Flyer/Poster At Test Stations

NOTICE

Would you like to be paid to participate in an environmental study?

dKC is doing research for the Coordinating Research Council on the environmental impact of ethanol in gasoline.

We'd like to test your car after your vehicle emissions inspection:

- **The test takes 10-15 minutes. It will take place immediately after your vehicle inspection.**
- **We will pay you $20.**
- **Participation is not a requirement of the State inspection and results have no impact on the outcome of your State inspection.**

Thank you for your support!

dKC -- de la Torre Klausmeier Consulting, Inc.

Austin TX

Coordinating Research Council

Atlanta, GA

Appendix A-2 – Owner Questionnaire

Participation in CRC Test Program

I agree to accept compensation of $20 to allow de la Torre Klausmeier Consulting, Inc. (dKC) to test my vehicle after it undergoes its normal DPS inspection.

Owner Signature ____

Print name ____

Date ____

Vehicle Plate____

Year ____

Model____

Make ____

<u>Pre-Test Questionnaire</u>

How long have you owned this vehicle? ______________________________

Where do you normally fill up your vehicle?____

Where was the last station that you filled up your vehicle?____

The following items will be filled out by the tester:

Odometer____

VIN____

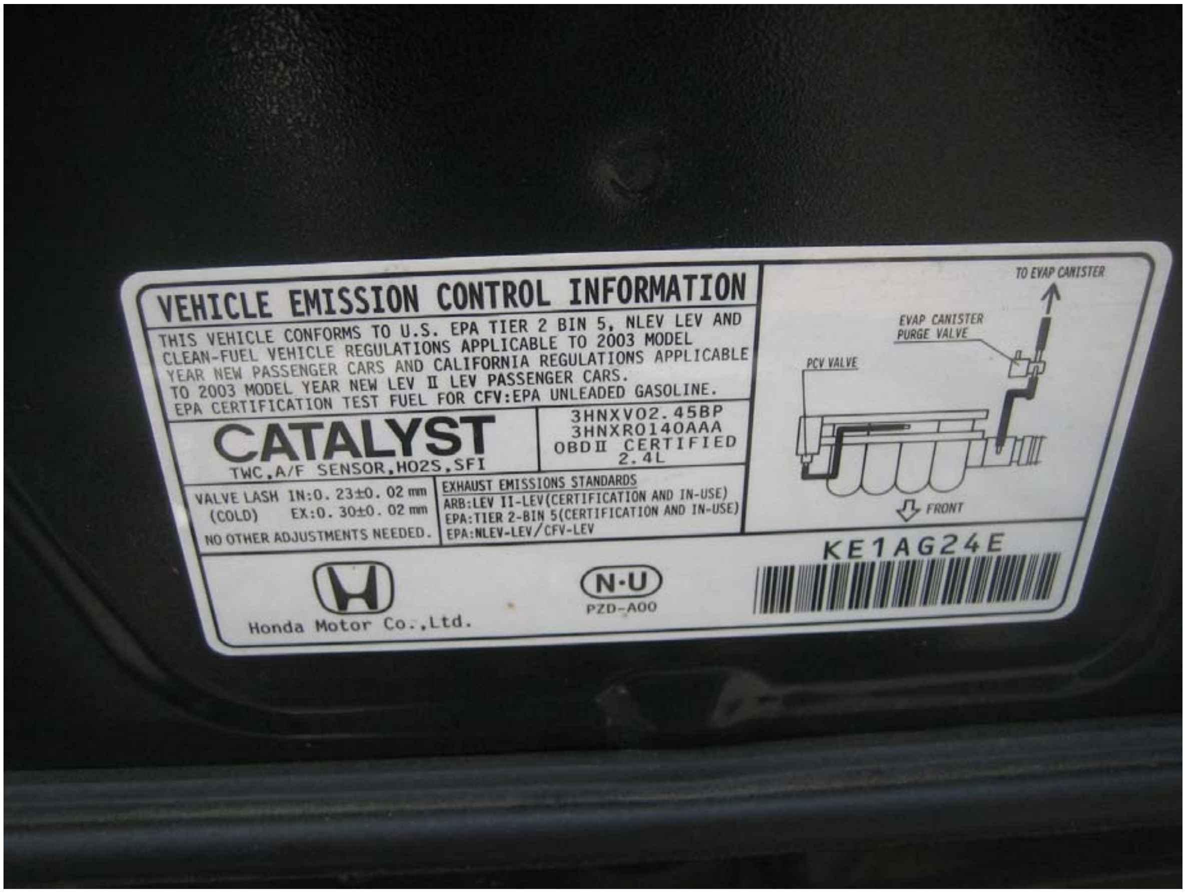
Ambient Temperature____

Appendix A-3

Checklist for CRC E-90 Test Program

Date	
Vehicle	
Previous Rejects Recorded	
Questionnaire Completed	
Check for FFV/Hybrid	
Vehicle warmed up (look at temperature gauge)	
Time engine turned off	
Data recorded correctly	
Underhood Label and VIN Pictures	
Ambient Temperature	
Hood Shut?	

Appendix A-4 – Example Picture of Emissions Label



Appendix A-5– Example Picture of VIN