California Environmental Protection Agency

Air Resources Board

E85 Demonstration Program
Final Report

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CALFORNIA AIR RESOURCES BOARD
CALIFORNIA DEPARTMENT OF TRANSPORTATION
CALIFORNIA ENERGY COMMISSION
CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE
CHEVRON TECHNOLOGY VENTURES, LLC
GENERAL MOTORS CORPORATION
PACIFIC ETHANOL, INC.

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State of California
California Environmental Protection Agency
AIR RESOURCES BOARD
Stationary Source Division

E85 Demonstration Program Final Report

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I. SUMMARY

The California Air Resources Board (ARB) in a joint effort with other organizations from both the public and private sectors set out on an effort to demonstrate the viable use of E85, an alternative motor vehicle fuel, in California. The purposes of the Demonstration Program described in this report were to identify potential compatibility and performance issues which may be associated with the operation of vehicles and equipment on E85 fuel, and to evaluate vehicle emissions when operating on E85 fuel. In order to achieve these objectives, in-use studies were conducted to yield one full year's worth of data to evaluate the merits of E85 fuel. In addition, one of the unstated objectives of the program was to pave the way for future alternative fuel installations throughout the state and for E85 to become a mainstream fuel choice.

Besides ARB, key program participants included General Motors Corporation, Chevron Technology Ventures, LLC (CTV), Pacific Ethanol, Inc., and California Department of Transportation (CalTrans).

Two E85 fueling sites were installed at existing CalTrans maintenance stations in Oakland and Marysville. Construction took place July through October, 2006. CTV supplied equipment from Dresser Wayne (dispenser), Bryant Fuel Systems (tank), and CleanFuel USA (systems controls and overall package). Each site used a steel above-ground storage tank with 5,000 gallons nominal capacity and a dispenser designed to be compatible with E85. Each system included a point-of-sale (POS) system to record E85 refueling transactions. Only one retail and a handful of private fleet E85 stations existed in California prior to the program.

Fifty flexible fuel vehicles (FFVs) from CalTrans fleet were selected to participate in the program, 28 sedans, 12 two-wheel drive pickup trucks, and 10 four-wheel drive pickup trucks. The fleet was assigned to the two E85 fueling stations, 15 vehicles in Marysville and 35 vehicles in Oakland. The vehicles were all essentially new at the start of the program.

Chevron Products Company supplied the E85 fuel to CalTrans from their Richmond terminal. The fuel was compliant with the specifications in ASTM D 5798. In order to comply with the minimum vapor pressure requirements, a portion of the gasoline component was replaced by the highly volatile blending component, isopentane. Shortly after each delivery of E85, a sample was drawn from the dispensing nozzle and analyzed to determine its compliance with ASTM D 5798.

The one-year long driving phase of the program ran from November 1, 2006 to October 31, 2007. FFVs can be refueled with either gasoline or E85. The intent of the program was to operate on E85 as much as possible. E85 has about 70% the energy content of California reformulated gasoline (CaRFG3). U.S. EPA mileage ratings and program fleet fuel economies calculated from E85 and gasoline transactions are presented for both gasoline and E85. In addition, fuel economy results from vehicle

emissions testing of two program vehicles on a variety of fuels are presented. In general, mileage on E85 is somewhat less than on gasoline.

Gasoline transactions were (mostly) tracked by the Voyager system. After merging reports from each system and organizing E85 and gasoline refueling data by vehicle, problems with the data set became apparent. The data set was corrected to reflect gasoline transactions not tracked by the Voyager system and missing or nonsensical odometer values. Summary statistics of the refueling transactions for the data set as a whole indicate that total program mileage was 668,000 miles, whereas 30,000 gal of E85 and 9,700 gal if gasoline were consumed.

Having to make these corrections to the data set greatly limited the ability to draw any conclusions about the fuel economy on each fuel from the data set as a whole. Nevertheless, the problems requiring corrections in the data set were not evenly distributed, and periods of uncorrected refueling events were used to calculate fuel economy values. The results indicate that the sedans in Marysville averaged 19.8 miles per gallon (mpg) on E85, and the sedans in Oakland averaged 18.6 mpg on E85 compared to 24.3 mpg on gasoline. The pickup trucks in Oakland averaged 11.9 and 10.9 mpg on E85 for two-wheel drive and four-wheel drive types, respectively. Based upon the Oakland Impala LS sedan data, the fuel economy on E85 was 76.5% of that on gasoline. These results are consistent with expectations.

A subset of 20 vehicles was equipped with Davis Instruments CarChips. The CarChips are a data logging device which plugs into the on-board diagnostics (OBD II) port underneath the dashboard of the vehicle. The CarChips were deployed in order to supplement the E85 and gasoline transactions data to further document vehicle performance, particularly fuel economy. The data were not analyzed for this program.

The same subset of 20 vehicles used special test engine oils for evaluation by Chevron. Three of the engines, one on each of the engine oil formulations, were inspected shortly after conclusion of the one-year long driving phase of the program. The E85 did not contain any deposit control additive. A moderate level of intake valve deposits was observed in the three engines, similar to what would be expected for reformulated gasoline without a deposit control additive. No deposits of sludge or varnish on the rocker covers and the valves decks were observed in the three engines. In addition, the intake manifolds appeared like new with no deposits observed even around the positive crankcase ventilation (PCV) inlet port.

After completion of the one-year long driving phase of the program, ARB conducted vehicle emissions testing on two vehicles from the CalTrans fleet in Oakland: a 2006 Impala LS sedan and a 2007 K1500 Silverado pickup truck, plus another Impala provided by ARB. Testing was conducted on California reformulated gasoline (CaRFG3), E85, and a 50/50 blend of the two fuels. The testing was conducted as part of a larger program which also involved testing on California phase 2 certification gasoline, a special E10 test fuel, and another blend of E85. Four different test

procedures were conducted. Parameters reported included both regulated emissions and selected air toxics compounds.

Results from the vehicle emissions testing were for the most part as expected. The weighted FTP results show that all three vehicles met the applicable emissions standards on gasoline certification fuel. NMOG emissions on E85, however, were mostly greater than the applicable standards. These results suggest that either tighter specifications for E85, or development of a Predictive Model as is used for CaRFG may be appropriate should sales volumes continue to increase as anticipated. The FTP results show that the NMOG emissions on E85 were primarily ethanol, virtually all from the cold start phase (bag 1). NMHC emissions were less than half of the alcohol emissions, and the carbonyls were about half of NMHC emissions. The SC03 and US06 results show that all three vehicles met the applicable emissions standards for NMHC + NO_x and CO on gasoline certification fuel. They were lower than the emissions standards for NMHC + NO_x and CO on all other tested fuels as well. Overall, E85 had a greater compliance margin than gasoline for the SFTP standards, especially for CO.

The air toxics results show that emissions of benzene and 1,3-butadiene were greater on the predominantly hydrocarbon fuels (CaRFG3, E10, and Cert 2) than on E85. The reverse was true for formaldehyde and acetaldehyde – emissions were greater on E85. Acetaldehyde emissions in particular were many times greater on E85. Mirroring the weighted FTP NMOG results, E85-ARB had noticeably higher emissions of air toxics than E85-Chevron on both vehicle #25 and vehicle #26. Out of all the vehicle emissions testing, the difference in emissions from the two sources of E85 is the single most striking result.

A subset of 20 vehicles was selected to participate in a Chevron oil test program. Three test oils were evaluated to ascertain that commercially available passenger car motor oils manufactured by Chevron are appropriate for service on fuel containing increased amounts of ethanol and meet the requirements of this application.

- Chevron Supreme Motor Oil SAE 5W-30 qualified for GM 6094M and API SM/EC (coded as Blue Oil)
- Havoline Synthetic Motor Oil SAE 5W-30 qualified for GM 4718M and API SM/EC (coded as Red Oil)
- Unbranded synthetic SAE 5W-30 motor oil optimized for “Alcool” use in Brazil meeting performance requirements of API SL (coded as Green Oil)

In general, commercially available engine oils manufactured by Chevron provided the expected necessary performance in providing engine protection in this application using E85 fuel. Although the program did not leverage a period of evaluation common in oil testing (60,000 miles), all of the observations from engine oil sampling and engine inspections point to the necessary level of engine protection as provided by Chevron engine oil in the fleet.

II. BACKGROUND

Transportation is a crucial aspect of California's economy. California has more motor vehicles than any other state. Motor vehicles have been almost exclusively dependent upon refined petroleum as their primary source of fuel. In recent years, we have realized that this dependence upon petroleum is leading to enormous problems of resource depletion, energy security, and climate change. Solving these problems will require improved vehicle efficiency and a large-scale shift away from petroleum to alternative fuels primarily deriving from renewable sources of energy.

The California Air Resources Board (ARB) does not have authority or purview related to issues of resource depletion and energy security. Climate change, however, does fall within ARB's direction. There is a consensus in the scientific community that climate change, i.e. global warming, can be attributed to emissions of greenhouse gases (GHG). Carbon dioxide (CO_2), a combustion product, is the largest contributor to climate change. In California, Governor Schwarzenegger issued Executive Order S-3-05[1] on June 1, 2005 setting statewide targets for greenhouse gas (GHG) reductions. At the national level, the Energy Policy Act of 2005 aims to double the use of renewable transportation fuels. There is likely no single answer to these problems, and E85 is just one such alternative.

California has a long history of being a national leader when it comes to tackling these difficult problems. California's overarching goal is for California's energy to be adequate, affordable, technologically advanced, and environmentally-sound. Executive Order S-3-05 helped to establish California's leadership role in reducing GHG emissions. Key actions include ensuring that energy supplies serving California, from any source, are consistent with the Governor's climate change goals. The State's objective is to establish a long-term plan to achieve significant reductions in gasoline use and increase the use of alternative renewable fuels. Key actions of this plan include (a) increasing the use of high-efficiency, flexible fuel vehicles and dedicated non-petroleum-fueled vehicles in the State's fleet of passenger cars and light-duty trucks, and (b) increasing the use of non-petroleum fuels in the State's fleet of medium- and heavy-duty on-road and off-road vehicles. To accomplish these goals, the State is committed to encouraging research, development, and demonstration projects, including projects that promote the availability of renewable fuels.[2]

E85, a nominal blend of 85 percent denatured ethanol and 15 percent gasoline, is an alternative motor vehicle fuel. Flexible fuel vehicles (FFVs) are designed to be refueled with either gasoline (which can contain up to 10 percent ethanol) or E85. To facilitate cold starting, the actual ethanol content of E85 can vary depending upon the month of the year and geographical location, and may be as little as 70 percent ethanol. Fuel properties are discussed further in Section VI.

The purposes of the Demonstration Program were to identify potential compatibility and performance issues which may be associated with the operation of vehicles and equipment on E85 fuel, and to evaluate vehicle emissions when operating on E85 fuel.

In order to achieve these objectives, in-use studies were conducted to yield one full year's worth of data to evaluate the merits of E85 fuel.

A. Greenhouse Gas Emissions

California is the fifteenth largest emitter of greenhouse gases in the world, representing about two percent of worldwide emissions. While CO_2 is the largest contributor to climate change, there are many other gases which also contribute.

According to ARB's greenhouse gas inventory, the transportation sector, largely cars and trucks that move goods and people, is the largest contributor with 38 percent of California's total greenhouse gas emissions. If no action is taken to reduce greenhouse gas emissions the transportation sector is expected to increase by 25 percent by 2020 equating to an increase of 46 million metric tons of CO_2e ($MMTCO_2e$).[3]

B. Previous Studies

At least one other previous E85 demonstration program was identified. In 1996, the State of Ohio established a project to demonstrate the effectiveness of ethanol as an alternative to gasoline in its fleet operations. The program is summarized in a few National Renewable Energy Laboratory documents.[4,5] The overall objectives of the study were to assess whether the operational performance and costs of operating alternative fuel vehicles are similar to, better than, or not as good as those of similar gasoline vehicles.[4] For more information, see Appendix A.

III. STUDY DESIGN

The purposes of the demonstration program described in this report were to identify potential compatibility and performance issues which may be associated with the operation of vehicles and equipment on E85 fuel, and to evaluate vehicle emissions when operating on E85 fuel. In order to achieve these objectives, in-use studies were carried out that yielded one full year's worth of data to evaluate the merits of E85 fuel. The one-year long driving phase of the program ran from November 1, 2006 to October 31, 2007.

At the behest of ARB Chairman Alan Lloyd, the program was initiated November 2005. Representatives from each of the program's participating organizations attended a series of meetings to identify the objectives and to agree upon a conceptual scope of work. This effort resulted in the issuance of a Memorandum of Understanding in December 2005 (see Appendix B).

Further planning work amongst the program's active participants continued to take place. A much more detailed Project Management Plan dated September 12, 2006, was subsequently developed (see Appendix C). This document explained exactly how things were to be done and by whom.

Several organizations and state agencies participated in the E85 Demonstration Program. These groups and their respective roles in the program are discussed below.

A. General Motors Corporation (GM)

GM supplied vehicles to CalTrans fleet. From these, 50 FFVs were selected to participate in the program: 28 Impala LS sedans, 12 C1500 Silverado two-wheel drive pickup trucks, and 10 K1500 Silverado four-wheel drive pickup trucks. All of the sedans and two-wheel drive trucks were 2006 model year vehicles; the four-wheel drive trucks were 2007 model year vehicles.

GM also supplied 20 Davis Instruments CarChips and associated Fleet Management database software to the program.

B. Chevron Technology Ventures, LLC (CTV)

Chevron Products Company supplied the E85 fuel to CalTrans for use in the program vehicle fleet. The Chevron terminal in Richmond was not set up to offer E85 as a commercially available product. E85 which meets the specifications found in Title 13, California Code of Regulations (CCR) section 2292.4 is generally not made by simply blending ethanol and gasoline. Doing so can result in a product with too low a vapor pressure. For this program Chevron implemented a temporary batch process production capability. The fuel was compliant with the specifications in ASTM D 5798. ARB issued an E85 test program exemption to Chevron which allowed them to produce a fuel which did not meet the vapor pressure specifications found in the Title 13,

CCR 2292.4 (see Appendix D). At present no E85 suppliers in California are providing E85 compliant with Title 13, CCR 2292.4, and all of the fuel suppliers operate under test program exemptions. Chevron made available up to 100,000 gallons of E85 fuel for the duration of the program.

CTV provided all necessary fueling equipment (including storage and dispensing equipment) for two demonstration locations and ensured that the fueling equipment, data systems, and other technology required for the turn-key E85 fueling stations are compatible with CalTrans installation and vehicles in accordance with the U.S. Department of Energy's, "Handbook for Handling, Storing and Dispensing E85."

CTV supplied equipment from Dresser Wayne (dispenser), Bryant Fuel Systems (tank), and CleanFuel USA (systems controls and overall package). CTV subcontracted the construction to Trammell Crow Company and Wendt & Sons Construction, Inc. In addition, CleanFuel USA collected E85 refueling data recorded by a point-of-sale (POS) system and reported it to ARB.

The E85 was blended in a bulk delivery truck at Chevron's facility in Richmond. Multiple batches were produced over the life of the program. Chevron analyzed each load before it left the facility to ensure it met the required specifications. Chevron reported the date and volume of each load including the analytical results to ARB.

Chevron Global Lubricants also conducted an engine oil test program using three different FFV compatible engine oils. A subset of 20 program vehicles were equipped with the test oils, three of which were inspected for deposits after the conclusion of the one-year long driving phase of the program, one on each test oil.

Last but not least, CTV took the lead in organizing weekly conference calls between program participants during the crucial construction and early one-year long driving phases to ensure the program remained on track.

C. Pacific Ethanol, Inc.

Pacific Ethanol supplied the denatured ethanol to Chevron used to produce the E85 at below market price. The ethanol was compliant with Health and Safety Code section 43830(d).

D. California Department of Transportation (CalTrans)

CalTrans operates a large fleet of vehicles. Of these, 50 flexible fuel vehicles were selected to participate in the program. They included 28 Impala LS sedans, 12 C1500 Silverado two-wheel drive pickup trucks, and 10 K1500 Silverado four-wheel drive pickup trucks. The vehicles were located in CalTrans District 4 in Oakland and District 3 in Marysville. There were 13 sedans and 22 pickup trucks in Oakland, and 15 sedans in Marysville. These locations were selected on the basis of having both a representative fleet of vehicles near Richmond where the fuel is produced, and CalTrans' willingness and ability to add an E85 tank and dispenser to their facility.

Noteworthy is the fact that the vehicles were expected to operate anywhere within their respective CalTrans district boundaries. For the Oakland location (District 4), the vehicles were primarily working on the nearby Bay Bridge project. For the Marysville location (District 3) however, this included the Lake Tahoe area. If the vehicle was away from its base and required fueling, the vehicle operators would fill up with retail gasoline.

An above ground E85 storage tank and dispenser was installed at each of the two CalTrans sites in Oakland and Marysville. These facilities are owned and operated by CalTrans. The designs incorporated Phase I vapor recovery and included a point-of-sale (POS) card system to authorize dispensing of the fuel and for recordkeeping purposes. Vehicle operators were encouraged to maximize the use of these facilities in order to generate as much useful information for the program as possible. CalTrans reported retail gasoline sales to program vehicles recorded by the Voyager system to ARB. A subset of 20 program vehicles were equipped with Davis Instruments CarChips to record vehicle trip and engine performance data which were used to supplement the POS and Voyager data.

CalTrans monitored E85 storage tank inventories and placed fuel orders with Chevron. CalTrans also provided periodic vehicle mileage and fueling data, and vehicle maintenance records to ARB.

E. California Air Resources Board (ARB)

ARB staff coordinated the program, including providing regulatory permitting assistance. The vehicle emissions testing was conducted at ARB's facilities in El Monte. ARB staff also compiled and analyzed the vehicle mileage and fueling data, the vehicle emissions testing data, and produced the draft final report.

As an additional quality assurance step, at the end of the one-year long driving phase of the program ARB collected a sample of the fuel from the dispenser in Marysville for subsequent analysis by Chevron.

The vehicle emissions testing was conducted on one sedan and one four-wheel drive pickup truck after the conclusion of the one-year long driving phase of the program. Testing was conducted on program E85, on California Reformulated Gasoline (CaRFG3) oxygenated with approximately 5.7% ethanol, and on a 50/50 blend by volume of the two fuels. The 50/50 blend was produced in the fuel tank of each of the two vehicles. ARB sent a sample of each 50/50 batch to an independent laboratory for analysis of the fuel properties (detailed HC analysis by ASTM D 6730). Four different test procedures were conducted:

- Enhanced Cold CVS II test (EC1), the Federal Test Procedure (FTP)
- US06 One-Bag Sampling (US1B)
- SC03 One-Bag Sampling (SC1B)
- Unified Cycle (UC)

Parameters reported included both criteria pollutants and selected air toxics compounds:

- hydrocarbons (HC)
- carbon monoxide (CO)
- carbon dioxide (CO_2)
- methane (CH_4)
- oxides of nitrogen (NO_x)
- nitrogen oxide (NO)
- non-methane hydrocarbons (NMHC)
- NMHC + NO_x
- non-methane organic gases (NMOG)
- ARB Method 1001[6]: Determination of Alcohols in Automotive Source Samples by Gas Chromatography, including ethanol and total alcohols
- ARB Method 1002[6]: Determination of C_2 to C_5 Hydrocarbons in Automotive Source Samples by Gas Chromatography, including 1,3-butadiene and total light-end HC
- ARB Method 1003[6]: Determination of C_6 to C_{12} Hydrocarbons in Automotive Source Samples by Gas Chromatography , including methyl tert-butyl ether (MTBE), benzene, total mid-range HC, and total ethers
- ARB Method 1004[6]: Determination of Aldehyde and Ketone Compounds in Automotive Source Samples by High Performance Liquid Chromatography, including formaldehyde, acetaldehyde, and total carbonyls

F. Other California State Agencies

Several other California State agencies helped to design the program and contributed to the program in various ways. These included:

1. Department of General Services (DGS)

DGS was involved with procurement of the E85 fuel and the E85 tank and dispenser installations.

2. California Energy Commission (CEC)

CEC was to review the costs of production, distribution, and end-use of E85 during the pilot project as part of their efforts to prepare a plan for increasing alternative fuels use, as called for in AB 1007. Although they took part in the discussions that led to the Memorandum of Understanding (see Appendix B), they did not subsequently take an active role in the program.

3. Department of Forestry and Fire Protection, Office of the State Fire Marshal

The State Fire Marshal reviewed and approved the design of the E85 tanks and dispensers prior to their installation.

4. Department of Food and Agriculture, Division of Measurement Standards (DMS)

DMS is responsible for enforcing applicable provisions of Business and Professions Code pertaining to Weights and Measures and Petroleum Products found in Title 4, California Code of Regulations (CCR), sections 13400-13490. Although they took part in the discussions that led to the Memorandum of Understanding (see Appendix B), they did not subsequently take an active role in the program.

IV. SELECTION OF FUELING SITES AND VEHICLES

A. Fueling Sites

E85 fueling stations were installed at two existing CalTrans maintenance stations, 210 Burma Road in Oakland and 320 E. 12th Street in Marysville. These locations were selected on the basis of having both a representative fleet of vehicles which could be made available to the program, for their relative proximity to Richmond where the fuel is produced, and CalTrans' willingness and ability to add an E85 tank and dispenser to their facility.

Noteworthy is the fact that the vehicles were expected to operate anywhere within their respective CalTrans district boundaries. For the nine-county District 4 location in Oakland, the vehicles were primarily working on the nearby Bay Bridge project. For the eleven-county District 3 location in Marysville, this included the Lake Tahoe area. If the vehicle was away from its base and required fueling, the vehicle operators would fill up with retail gasoline.

CalTrans also operates a gasoline dispenser near each of the E85 sites. This is discussed in Section VII.

Construction took place July 24 through October 27, 2006. CTV supplied equipment from Dresser Wayne (dispenser), Bryant Fuel Systems (tank), and CleanFuel USA (systems controls and overall package). Each site used a steel above-ground storage tank with 5,000 gallons nominal capacity and a dispenser designed to be compatible with E85. The tank and dispenser were placed on a reinforced concrete pad; the adjacent vehicle refueling apron was also reinforced concrete. Tanks and dispensers listed by Underwriters Laboratories for E85 service were not available at the time of construction. The construction effort included the use of subcontractors Trammell Crow Company and Wendt & Sons Construction, Inc. Each installation also included a POS system to record refueling transactions.

With assistance from ARB, Wendt & Sons Construction, Inc. applied for the necessary regulatory permits. The tank and dispenser designs were reviewed and approved by the State Fire Marshal prior to construction. In addition, the City of Oakland Fire Department, Fire Prevention Bureau required an Above Ground Storage Tank Installation permit (see Appendix E). Given that the installation was on state owned and operated property this should not have been necessary, however, it was easier to secure the permit than to get the two agencies to resolve a jurisdictional dispute.

Authority to Construct/Permit to Operate a gasoline dispensing facility permits were secured from the Bay Area Air Quality Management District (Oakland) and Feather River Air Quality Management District (Marysville), see Appendix F. The BAAQMD permit application package was submitted under their Accelerated Permit Program. The application included an estimate of uncontrolled source emissions made with software from the U.S. Environmental Protection Agency Technology Transfer Network

Clearinghouse for Inventories & Emission Factors (CHIEF), Tanks 4.0.9d. Each installation was equipped with Phase I vapor recovery. Phase II vapor recovery systems were not required.

Because no vapor recovery systems have been approved by ARB for E85 service, it was necessary for CalTrans to apply for a Research and Development Test Site Status for the two fueling sites. See Appendix G.

Given that E85 is principally composed of ethanol, there were initial questions as to whether an E85 installation required a gasoline dispensing facility permit. Both local air districts confirmed that the permits were necessary. Only one retail and a handful of private fleet E85 stations existed in California prior to the E85 Demonstration Program. Because of this, program participants, regulatory agencies and consumers alike were unfamiliar with many aspects of the fuel. One of the unstated objectives of the program was to pave the way for future alternative fuel installations throughout the state and for E85 to become a mainstream fuel choice.

Finally, a Spill Prevention Control and Countermeasure (SPCC) Plan update to reflect the installation of an E85 tank was secured for each installation (see Appendix E). ARB contracted this effort to Apex Envirotech, Inc.

After construction was completed, CalTrans District 3 subsequently modified the fueling installation with the addition of an overhead canopy. This modification was designed, constructed, and paid for outside of the E85 Demonstration Program.

CalTrans will be responsible for renewing the permits and maintaining the facilities after the conclusion of the E85 Demonstration Program.

B. CalTrans Flexible Fuel Vehicle Fleet

Fifty flexible fuel vehicles (FFVs) were selected to participate in the program: 28 Impala LS sedans, 12 C1500 Silverado two-wheel drive pickup trucks, and 10 K1500 Silverado four-wheel drive pickup trucks. The sedans were equipped with a LZE 3.5-liter V6 engine, a 4-speed automatic transmission, and front-wheel drive. The pickup trucks were equipped with a L59 5.3-liter V8 engine, a 4-speed automatic transmission, and either rear-wheel drive or four-wheel drive. Both engines have the same horsepower and torque ratings whether on gasoline or E85. All of the sedans and two-wheel drive trucks were 2006 model year vehicles; the four-wheel drive trucks were 2007 model year vehicles.

The E85 demonstration program fleet was assigned to the two E85 fueling stations, 15 vehicles to District 3 (Marysville) and 35 vehicles to District 4 (Oakland). All of Marysville's vehicles were Chevrolet Impala LS sedans. The Oakland fleet consisted of 13 Chevrolet Impala LS sedans, 12 Chevrolet C1500 Silverado two-wheel drive pickup trucks, and 10 Chevrolet K1500 Silverado four-wheel drive pickup trucks with extended cabs. Twenty of the test vehicles used special test engine oils (discussed in Section X).

Each vehicle in CalTrans fleet is provided with a unique identification number. The program fleet is shown in Table 4.1.

The vehicles were all essentially new at the start of the program. Before being placed into service, CalTrans equips their vehicles with some accessories, which takes some time. Thus, they did not go into service immediately upon delivery pending addition of accessories and they accumulated differing amounts of mileage before the November 1, 2006, start of the one-year long driving phase. For the Impala sedans, CalTrans had ordered CARB LEV II units (test group 6GMXV03.5050). What was actually delivered were ULEV (LEV I) units (test group 6GMXV03.5051). These two vehicle types are physically identical in every way, differing only in the non-methane organic gas (NMOG) and oxides of nitrogen (NO_x) emissions standards they were certified to. There was some discussion at the time as to whether these would be acceptable to the state, it was ultimately decided that they would be.

Table 4.1 E85 Demonstration Program Vehicle Fleet

Oakland			Marysville		
Equipment ID	**Vehicle Type**	**Test Oil**	**Equipment ID**	**Vehicle Type**	**Test Oil**
7003475	C1500 Silverado pickup	blue	7003352	Impala LS sedan	-
7003476	C1500 Silverado pickup	blue	7003357	Impala LS sedan	-
7003477	C1500 Silverado pickup	blue	7003389	Impala LS sedan	-
7003478	C1500 Silverado pickup	blue	7003390	Impala LS sedan	red
7003479	C1500 Silverado pickup	green	7003391	Impala LS sedan	-
7003480	Impala LS sedan	-	7003392	Impala LS sedan	-
7003481	C1500 Silverado pickup	-	7003393	Impala LS sedan	red
7003482	Impala LS sedan	-	7003394	Impala LS sedan	-
7003497	Impala LS sedan	-	7003395	Impala LS sedan	red
7003499	Impala LS sedan	-	7003396	Impala LS sedan	-
7003500	Impala LS sedan	-	7003397	Impala LS sedan	red
7003504	Impala LS sedan	green	7003398	Impala LS sedan	-
7003505	Impala LS sedan	green	7003399	Impala LS sedan	-
7003506	Impala LS sedan	-	7003401	Impala LS sedan	red
7003508	C1500 Silverado pickup	-	7003402	Impala LS sedan	-
7003510	Impala LS sedan	-	-	-	-
7003511	C1500 Silverado pickup	green	-	-	-
7003512	C1500 Silverado pickup	green	-	-	-
7003514	Impala LS sedan	blue	-	-	-
7003516	Impala LS sedan	red	-	-	-
7003517	Impala LS sedan	red	-	-	-
7003523	C1500 Silverado pickup	red	-	-	-
7003524	C1500 Silverado pickup	red	-	-	-
7003526	C1500 Silverado pickup	red	-	-	-
7003527	K1500 Silverado pickup 4WD	-	-	-	-
7003528	K1500 Silverado pickup 4WD	-	-	-	-
7003529	K1500 Silverado pickup 4WD	-	-	-	-
7003530	K1500 Silverado pickup 4WD	-	-	-	-
7003531	K1500 Silverado pickup 4WD	-	-	-	-
7003532	K1500 Silverado pickup 4WD	-	-	-	-
7003533	K1500 Silverado pickup 4WD	-	-	-	-
7003536	K1500 Silverado pickup 4WD	-	-	-	-
7003537	K1500 Silverado pickup 4WD	-	-	-	-
7003538	K1500 Silverado pickup 4WD	-	-	-	-
7003580	Impala LS sedan	-	-	-	-

V. E85 ABOVE GROUND TANKS AND DISPENSERS

CTV supplied equipment from Dresser Wayne (dispenser), Bryant Fuel Systems (tank), and CleanFuel USA (systems controls and overall package). Each site used a steel above-ground storage tank with 5,000 gallons nominal capacity and a dispenser designed to be compatible with E85. The tank and dispenser were placed on a reinforced concrete pad; the adjacent vehicle refueling apron was also reinforced concrete. Tanks and dispensers listed by Underwriters Laboratories for E85 service were not available at the time of construction. The construction effort included the use of subcontractors Trammell Crow Company and Wendt & Sons Construction, Inc. Each installation also included a POS system to record refueling transactions.

Photocopy reductions of the tank and dispenser as-built drawings are in Appendix H. ARB and CalTrans Equipment Division headquarters in Sacramento maintain a set of full-size drawings on file. Tank Integrity Test results are in Appendix I.

Figure 5.1 depicts the Oakland installation being readied to go into service in this October 12, 2006 photo. In the background is I-80, just east of the Bay Bridge toll plaza.

VI. E85 BLENDING AND INSPECTION RESULTS

Chevron Products Company supplied the E85 fuel to CalTrans for use in the program vehicle fleet. The Chevron terminal in Richmond was not set up to offer E85 as a commercially available product. E85 which meets the specifications found in Title 13, CCR section 2292.4 is generally not made by simply blending ethanol and gasoline. Doing so can result in a product with too low a vapor pressure. For this program Chevron implemented a temporary batch process production capability. The fuel was compliant with the specifications in ASTM D 5798. ARB issued an E85 test program exemption to Chevron which allowed them to produce a fuel which did not meet the vapor pressure specifications found in the Title 13, CCR 2292.4 (see Appendix D). At present no E85 suppliers are providing E85 compliant with Title 13, CCR 2292.4, and all of the fuel suppliers operate under test program exemptions. Chevron made available up to 100,000 gallons of E85 fuel for the duration of the program.

A. E85 Specifications

The California Department of Measurement Standards specifies in its regulations that E85 Ethanol Fuel shall meet the specifications set forth by ASTM International in the latest version of Standard Specification for Fuel Ethanol (Ed75-Ed85) for Automotive Spark-Ignition Engines, D 5798. The current ASTM version is D 5798-07 and the following Table a shows the property limits for the three E85 volatility classes:

Table a
Requirements for Fuel Ethanol (Ed75-Ed85)

Properties	Class 1[A]	Class 2	Class 3
Ethanol + higher alcohols, min, volume %	79	74	70
Hydrocarbon/aliphatic ether, volume %	17–21	17–26	17–30
Vapor pressure, kPa	38–59	48–65	66–83
(psi)	5.5–8.5	7.0–9.5	9.5–12.0
Sulfur, max, mg/kg	210	260	300
		All Classes	
Methanol, volume %, max		0.5	
Higher alcohols (C_3–C_8), max, volume %		2	
Acidity, (as acetic acid CH3COOH), mass % (mg/L), max		0.005 (40)	
Solvent-washed gum content, max, mg/100 mL		5	
pH_e		6.5 to 9.0	
Unwashed gum content, max, mg/100 mL		20	
Inorganic chloride, max, mg/kg		1	
Copper, max, mg/L		0.07	
Water, max, mass %		1.0	
Appearance	This product shall be visibly free of suspended or precipitated contaminants (clear and bright). This shall be determined at ambient temperature or 21°C (70°F), whichever is higher.		

The three volatility classes shown above are assigned based on the expected 90th percentile maximum ambient temperature and expected 6 hour 10th percentile minimum ambient temperature for the area where the fuel is to be used. The class assignments for Oakland (North Coast) and Marysville (Interior) are shown in Table b.

Table b
E85 Volatility Class Assignments

Area	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
North Coast	2	2	2	2	2	2/1	1	1	1	1/2	2	2
Interior	2	2	2	2	2	2/1	1	1	1	1/2	2	2

Meeting the specifications is not assured by simply blending 15 vol % gasoline with 85 vol % denatured fuel ethanol. The most difficult property limit to meet is the minimum vapor pressure. The nominal vapor pressure of pure ethanol is 2.3 psi. In the summertime in California, the base gasoline available at terminals for blending with the denatured fuel ethanol is referred to as CARBOB. It is designed to meet California Phase 3 Reformulated Gasoline (CaRFG3) specifications after 5.7 vol % denatured fuel ethanol is added to it. In order to comply with the maximum flat summertime vapor pressure limit of 7.00 psi for the CaRFG3, the vapor pressure of the summertime CARBOB has to be 5.5 to 5.7 psi. When the CARBOB is blended at 15 vol % with denatured fuel ethanol, the resulting vapor pressure is 4.5 to 5.3 psi. The value is influenced by the amount (1.96 to 5.0 vol %) and vapor pressure of the hydrocarbon denaturant used in the denatured fuel ethanol. The resulting vapor pressure does not meet the 5.5 psi minimum vapor pressure for volatility Class 1. It is even more difficult to meet the minimum specification when volatility Class 2 is required in the spring and fall because the CARBOB summertime vapor pressure maximum limit (April 1 through October 31) extends into the Class 2 period with its 7.0 psi minimum limit. Thus, in order to comply with the minimum vapor pressure requirements of ASTM D 5798, a portion of the 15 vol % gasoline has to be replaced by a highly volatile hydrocarbon such as isopentane.

B. Making an E85 Blend

The blending process was initiated with an order being placed with Chevron by CalTrans. A truck (4,000 gallon capacity with an on-board transfer pump) was ordered and the Richmond Loading Rack was advised of the order. The Loading Rack advised the Chevron Products and Oronite people at the Richmond Technology Center of the order. A recipe was developed (ethanol content, CARBOB content, and isopentane content) based on the current vapor pressure of the CARBOB, the E85 volatility class requirement for month, and the vapor pressure and quantity of the E85 already in the on-site storage tank. The Richmond Loading Rack was advised of the recipe to be blended into the truck. The recipe varied from batch to batch to ensure that the final blend in the storage tank meets the requirements specified in ASTM D 5798. The tank truck was filled sequentially—first with the denatured fuel ethanol, then with the unleaded CARBOB at the Richmond Loading Rack. During the loading of the CARBOB, the Techron additive injection system was turned off.

Upon completion of the tank truck loading at the Richmond Loading Rack, the truck was driven to the Richmond Technology Center (RTC) for the addition of the isopentane. Prior to the tank truck arriving at the Richmond Loading Rack, a 499-gallon pressure tank on a wheeled trailer was towed into the Richmond Refinery LPG area loading rack and filled with isopentane. The pressure vessel on the trailer then was towed to the RTC loading pad area. When the tank truck arrived, its bottom loading fitting was connected to a pneumatic pump and meter, which in turn was connected to the pressure tank containing the isopentane. An activated charcoal drum vapor control system was connected to the vapor return fitting of the tank truck. After opening the tank truck's internal vapor valves, the appropriate volume of isopentane was pumped into the tank truck compartment at a rate of 10 gpm. Since the blend components cannot be mechanically mixed, the tank truck dome covers were not opened and no samples were withdrawn.

The tank truck was then driven to the Oakland or Marysville E85 refueling facility and its load was discharged into the above ground storage tank. Quality control samples were drawn from the dispensing nozzles at the test sites after each delivery allowing time for the new blend to be dispensed by the nozzle. The samples were inspected to determine that they met the ASTM D 5798 specification limits.

The following photographs pictorial show the E85 blending procedure:

Prior to a tank truck arriving for the blending of E85, a pressure tank mounted on a trailer was towed into the Richmond Refinery and loaded with isopentane as shown in Figure a.

Figure a

The tank truck arrived at the Richmond Loading Rack and the denatured fuel ethanol and CARBOB were sequentially loaded into the tank truck as shown in Figure b.

Figure b

The tank truck was connected to the pump and meter for loading the isopentane. The tank truck venting system was connected to an activated charcoal drum vapor control system as shown in Figure c to capture displaced vapors.

Figure c

The isopentane was metered into the tank truck as shown in Figure d.

Figure d

After delivery from the tank truck into the above ground storage tank, the E85 was dispensed from the E85 fueling facility into the test vehicles. The tank and dispenser at Oakland are shown in Figure e.

Figure e

C. E85 Blend Compositions

The recipes, component volumes, and total volumes of the E85 blends for the demonstration program are shown in Table c for Oakland and in Table d for Marysville.

Table c
Oakland E85 Blends

	Denatured Ethanol	CARBOB Regular	Isopentane	Total
Date	Gallons	Gallons	Gallons	Gallons
10/5/2006	3400	400	200	4000
1/11/2007	2905	595	89	3589
2/20/2007	2500	300	200	3000
4/9/2007	2800	275	225	3300
6/6/2007	2975	315	210	3500
7/24/2007	2975	315	210	3500
9/11/2007	2677	309	164	3150
Total				24039

Table d
Marysville E85 Blends

	Denatured Ethanol	CARBOB Regular	Isopentane	Total
Date	Gallons	Gallons	Gallons	Gallons
10/9/2006	3400	400	200	4000
3/20/2007	1600	180	120	2000
6/28/2007	2550	360	90	3000
10/3/2007	2125	245	130	2500
Total				11500

D. Quality Control

Shortly after each delivery of E85 into one of the above ground storage tanks, a one-gallon sample was drawn from the dispensing nozzle. The sample was inspected to determine its compliance with ASTM D 5798. The results of the inspections are shown in Table e for Oakland and in Table f for Marysville.

Table e
California E85 Fuel Inspections--Oakland

Sample Date			11/3/2006*	11/17/2006	1/27/2007	2/20/2007	4/10/2007	6/14/2007	7/27/2007	9/20/2007
Property	**Method**	**Units**	**44674**	**44706**	**44816**	**44965**	**45076**	**45387**	**45534**	**45722**
Gravity	ASTM D4052	°API	49.7	50.5	50.8	51.5	50.5	50.1	50.5	50.6
Relative Density		g/gal	0.7809	0.7775	0.7762	0.7732	0.7775	0.7792	0.7775	0.7770
Uncorrected Ethanol	ASTM D5501	wt %	85.70	82.69	83.52	80.50	84.89	87.00	86.20	-
Ethanol	ASTM D5501	vol %	83.84	80.68	81.32	78.06	82.76	84.84	84.42	-
Methanol	ASTM D5501	vol %	0	0	0	0	0	0	0	-
Water	ASTM E203	wt. %	0.70	0.48	0.52	0.56	0.58	0.82	0.57	0.63
Water	ASTM E203	vol %	0.55	0.37	0.40	0.43	0.45	0.64	0.44	0.49
Estimated Hydrocarbon		vol %	15.62	18.95	18.27	21.50	16.79	14.51	15.58	-
Uncorrected Ethanol	ASTM D4815	wt %	83.50	83.90	82.30	82.10	84.10	86.20	85.90	81.80
Ethanol	ASTM D4815	vol %	81.68	81.86	80.14	79.61	81.99	84.06	83.75	79.67
Methanol	ASTM D4815	vol %	0	0	0	0	0	0	0	0
Water	ASTM E203	wt. %	0.70	0.48	0.52	0.56	0.58	0.82	0.57	0.63
Water	ASTM E203	vol %	0.55	0.37	0.40	0.43	0.45	0.64	0.44	0.49
Estimated Hydrocarbon		vol %	17.77	17.77	19.46	19.95	17.56	15.30	15.80	19.84
DVPE	ASTM D5191	psi	7.03	7.11	7.78	8.62	7.36	7.25	7.27	7.10
Distillation	ASTM D86									
Initial Boiling Point		°F	111.0	108.3	103.8	102.0	97.8	113.9	108.5	111.7
5% Evaporated		°F	140.5	139.4	138.7	130.8	132.9	145.7	140.9	136.7
10% Evaporated		°F	156.0	155.3	154.5	148.2	151.8	159.4	153.8	150.8
20% Evaporated		°F	167.9	167.5	166.8	166.4	167.0	168.8	167.1	166.1
30% Evaporated		°F	170.6	170.4	169.5	169.5	170.0	170.6	170.0	169.7
40% Evaporated		°F	171.3	171.3	170.6	170.6	170.9	171.1	170.9	170.9
50% Evaporated		°F	171.6	171.6	171.1	171.1	171.3	171.5	171.3	171.3
60% Evaporated		°F	171.8	171.8	171.5	171.5	171.6	171.6	171.5	171.6
70% Evaporated		°F	172.0	172.0	171.8	171.6	171.8	171.8	171.6	171.8
80% Evaporated		°F	172.2	172.2	172.0	172.0	172.0	172.0	171.8	172.0
90% Evaporated		°F	172.4	172.4	172.4	172.2	172.2	172.4	172.0	172.2
95% Evaporated		°F	172.9	172.9	172.7	172.9	172.4	172.9	172.5	172.5
End Point		°F	173.6	174.3	174.3	174.3	173.4	174.7	174.2	174.5
Recovery		vol %	97.0	98.0	98.0	97.5	97.9	97.9	97.5	96.5
Residue		vol %	2.0	1.0	1.0	1.6	1.1	1.1	1.5	1.0
Loss		vol %	1.0	1.0	1.0	0.9	1.0	1.0	1.0	2.5
Unwashed gum	ASTM D381	mg/100ml	868	1	2	2	1	3	2	3
Solvent washed gum	ASTM D381	mg/100ml	0	0	0	1	0	2	1	0
Acidity	ASTM D1613	ppm	87.2	32.0	36.9	39.6	30.2	33.0	36.9	27.0
pHe	ASTM D6423		6.82	7.83	7.92	8.19	7.93	7.95	7.75	7.78
Copper	Mod D1688	ppb	432	209	14	10	15.5	33.8	<7	<7
Inorganic Chlorides	IC DI	ppm	8.2	<1	<1	<1	<1	<1	<1	<1
Sulfates	IC DI	ppm	0.3	<1	<1	<1	<1	<1	1	<1
Sulfur	ASTM D5453	ppm	24.7	<6	<6	<6	<6	<6	<6	<6
Benzene	ASTM D3606	vol %	0.09	0.09	0.12	0.09	0.07	0.08	0.09	0.08

*The E85 had been in the hose without flowing for some unknown period before the sample was obtained.

Table f
California E85 Fuel Inspections--Marysville

Sample Date			11/3/2006*	12/7/2006	5/11/2007	7/20/2007	11/4/2007
Property	**Method**	**Units**	**44680**	**44742**	**45230**	**45514**	**45861**
Gravity	ASTM D4052	°API	49.4	49.8	51.3	49.7	50.3
Relative Density		g/gal	0.7822	0.7805	0.7741	0.7809	0.7783
Uncorrected Ethanol	ASTM D5501	wt %	86.80	86.87	80.50	86.30	84.30
Ethanol	ASTM D5501	vol %	85.13	85.09	78.13	84.43	82.21
Methanol	ASTM D5501	vol %	0	0	0.0	0	0
Water	ASTM E203	wt. %	0.59	0.47	0.59	0.69	0.67
Water	ASTM E203	vol %	0.46	0.37	0.46	0.54	0.52
Estimated Hydrocarbon		vol %	14.41	14.54	21.40	15.03	17.27
Uncorrected Ethanol	ASTM D4815	wt %	85.20	85.90	82.60	81.65	-
Ethanol	ASTM D4815	vol %	83.56	84.14	80.17	79.88	-
Methanol	ASTM D4815	vol %	0	0	0	0	-
Water	ASTM E203	wt. %	0.59	0.47	0.59	0.69	-
Water	ASTM E203	vol %	0.46	0.37	0.5	0.54	-
Estimated Hydrocarbon		vol %	15.98	15.49	19.4	19.58	-
DVPE	ASTM D5191	psi	5.85	6.05	8.86	6.85	7.15
Distillation	ASTM D86						
Initial Boiling Point		°F	119.8	81.6	102.0	112.2	110.4
5% Evaporated		°F	150.6	149.3	127.5	143.2	140.0
10% Evaporated		°F	161.2	160.3	144.3	154.9	153.5
20% Evaporated		°F	168.2	168.2	166.1	166.8	167.1
30% Evaporated		°F	170.4	170.4	170.0	169.5	170.4
40% Evaporated		°F	171.1	171.1	170.9	170.6	171.5
50% Evaporated		°F	171.5	171.5	171.5	171.1	171.8
60% Evaporated		°F	171.8	171.6	171.6	171.5	172.2
70% Evaporated		°F	172.0	172.0	171.8	171.6	172.4
80% Evaporated		°F	172.0	172.0	172.0	171.8	172.5
90% Evaporated		°F	172.4	172.4	172.4	172.2	172.7
95% Evaporated		°F	172.9	172.9	172.9	172.7	173.1
End Point		°F	173.8	174.3	174.5	174.2	174.7
Recovery		vol %	97.8	98.5	97.6	97.3	97.6
Residue		vol %	1.4	0.9	1.5	1.5	1.4
Loss		vol %	0.8	0.6	0.9	1.2	1.0
Unwashed gum	ASTM D381	mg/100ml	249	3	0	3	3
Solvent washed gum	ASTM D381	mg/100ml	2	1	0	2	2
Acidity	ASTM D1613	ppm	50.4	35.4	31.5	26.7	31.0
pHe	ASTM D6423		6.91	7.43	7.97	7.68	7.85
Copper	Mod D1688	ppb	208	199	63.9	<7	16.8
Inorganic Chlorides	IC DI	ppm	2.8	<1	<1	<1	<1
Sulfates	IC DI	ppm	0.1	<1	<1	1.3	<1
Sulfur	ASTM D5453	ppm	11.3	<6	<6	<6	6.25
Benzene	ASTM D3606	vol %	0.08	0.09	0.07	0.09	0.09

*The E85 had been in the hose without flowing for some unknown period before the sample was obtained.

Comparing the inspected properties against the limits in ASTM D 5798 shows the vapor pressure for the first blend for Marysville (shown twice as FR44680 and FR44742) did not meet the Class 2 minimum. This occurred because of a metering problem with the isopentane injection system which shorted the blend of isopentane. There also appeared that some blends at both locations do not meet the 17 vol % minimum hydrocarbon requirement. This was not a composition problem except for the Marysville blend that was shorted in isopentane. The problem is with the ASTM D 5501 test method. It was developed to measure 93 to 97 mass % ethanol in denatured fuel ethanol. It was modified to extend its measuring ability to cover E85. It is calibrated using n-heptane as the hydrocarbon. However, when accurate hand blends made using CARBOB plus isopentane as the hydrocarbon were tested, the ethanol contents measured higher than the known amounts. Apparently some hydrocarbons are being covered by the large ethanol peak in this gas chromatographic analysis. Also the large amount of different hydrocarbon may be affecting the column retention times. ASTM is working this issue. Some studies were undertaken using a modified version ASTM D 4815 to determine the ethanol content and these data are also shown in the inspection tables. The total of the volume of hydrocarbon reported by the meters plus hydrocarbon used as a denaturant show all but the first Marysville blend to be on specification for hydrocarbon content. The unwashed gum contents of the first samples from both Oakland and Marysville were extremely high. Analysis of the gums showed them to be plasticizer from the dispenser hoses. Because of initial problems with the fuel dispensers, no E85 had been pumped through the hoses for an extend time. Apparently, soaking new hoses in E85 caused some plasticizer to be extracted by the E85. Samples of the same blends drawn after the dispensers were regularly delivering product showed low gum contents.

For vehicle emissions testing, six drums of E85 were obtained from the Marysville tank on October 29, 2007. The inspections for this fuel are shown for a sample drawn on November 4, 2007, as FR45861 for a delivery made on October 3, 2007. In addition, carbon, hydrogen, and oxygen contents were needed for the emissions testing. Table g shows these additional inspections determined by two methods—detailed hydrocarbon analysis (DHA) by gas chromatograph and Carlo-Erba elemental analysis.

Table g
Carbon, Hydrogen, Oxygen Determination for Emissions Testing
11/4/2007 E85 Sample

	Units	DHA	Carlo-Erba
Carbon	wt %	56.54	56.120
Hydrogen	wt %	13.36	13.256
Carbon + Hydrogen	wt %	69.90	69.876
Oxygen	wt %	30.10	30.624

VII. E85 AND CARFG FUELING AND MILEAGE RESULTS

A kick-off training session for CalTrans personnel was held in Marysville and in Oakland on October 11-12, 2006, respectively. The training was led by key ARB, Chevron, and CalTrans staff. The kick-off training presentation materials are provided in Appendix J. The one-year long driving phase of the program began on November 1, 2006, soon after site construction was completed. It continued until October 31, 2007.

Flexible fuel vehicles can be refueled with either gasoline or E85. The intent of the program was to operate the program vehicles on E85 as much as possible. However, it was known from the start that this would not be possible in all cases. Vehicles at times would require refueling when they were not located near CalTrans' E85 dispensers in Oakland or Marysville. What was not known was how much this would be the case.

Due primarily to the different energy content in E85 and gasoline, vehicles operated on these two fuels have different expected fuel economies. The actual difference in the real world is not exactly proportional to the difference in the energy content. Other fuel properties, such as its higher octane number and latent heat of vaporization, as well as some engine design engineering measures used in flexible fuel vehicles result in a somewhat better fuel economy on E85 than the lower energy content suggests. Engines must be designed for a specific fuel and will not normally run efficiently on other blends.[7]

Simply replacing gasoline with ethanol without specifically redesigning the engine to utilize the new fuel properties results in reduced vehicle range. However, properly designing the engine to utilize the higher octane rating of ethanol and its increased latent heat of vaporization may result in an engine with greater fuel conversion efficiency and overall improved vehicle range compared to current engine technology.[8]

E85 has about 70% of the energy content of California reformulated gasoline (CaRFG3) oxygenated with approximately 5.7% ethanol. The energy content will vary somewhat depending upon the ethanol concentration. The program E85 contained near the maximum allowable ethanol content. Based on the percentages of ethanol and hydrocarbons in E85 and CaRFG3 and reference lower heating values from GREET[9], the E85 had an estimated 73.4% of the energy content of the gasoline.

FFV engines are designed to run on fuels ranging from straight gasoline to ethanol blends containing up to 85 volume % denatured ethanol (E85). For this program, the gasoline consisted of California reformulated gasoline (CaRFG3) oxygenated with approximately 5.7% ethanol. An algorithm in the engine computer fuel control system calibrates the air-fuel ratio after each tank filling of more than three gallons. The engine control module (ECM) chips in the test vehicles had to be reflashed because of a "bug" that required fixing.

During the program, no fuel system problems occurred as a result of using E85. There were some driveability problems that occurred when the vehicles were switched from

CaRFG3 to E85. The malfunction indicator light (MIL) on the dash illuminated when this problem occurred. This problem occurred because insufficient mileage was driven after the fuel switch to allow the algorithm to calibrate the engine. When this upset happened, the vehicle had to be taken to the dealership to have the computer reset. Reflashing the ECM computer chips helped eliminate this situation.

During a cold snap early in the program at Marysville some vehicles required two cranking attempts before the engine started. After starting, the engine ran fine. Because of a blending problem, the E85 did not meet the required minimum vapor pressure of a volatility Class 2 ASTM D 5798 E85 fuel (6.0 psi instead of 7.0 psi).

Vehicle operators noted that the smell of alcohol was present at times especially during cold starts. This was due to the presence of uncombusted fuel in the exhaust before the catalytic converter fully warmed up to operating temperature, and is consistent with how the engine and emission control system are designed to operate. It does not necessarily indicate a malfunction or excessive exhaust emissions (see Section IX).

Equipment 7003510, an Impala LS sedan, was involved in an accident and deemed a total loss at 12,371 miles in April 2007. All of the other vehicles remained in service throughout the one-year long driving phase of the program.

A. U.S. EPA Mileage Ratings

Mileage ratings from the U.S. Environmental Protection Agency (EPA) are as follows. Note EPA's mileage rating methodology changed starting with the 2008 model year to incorporate faster speeds and acceleration, air conditioner use, and colder outside temperatures – values using both old and new methodologies are shown.

EPA city, highway mileage ratings[10] in miles per gallon.

	2006 Impala LS	**2006 C1500 Silverado**	**2007 K1500 Silverado**
E85	16, 23 (old) 14, 21 (new)	12, 16 (old) 11, 15 (new)	11, 14 (old) 10, 13 (new)
Gasoline	21, 31 (old) 18, 28 (new)	16, 20 (old) 14, 19 (new)	15, 19 (old) 13, 17 (new)

B. Vehicle Emissions Testing Fuel Economy Results

Fuel economy values are also calculated as part of the vehicle emissions testing (see Section IX). These data are summarized as follows:

Vehicle emissions testing fuel economy results, Vehicle #25 2006 Impala LS sedan 7003506 in miles per gallon (gasoline gallon equivalent)

Fuel	Driving Cycle		
	EC1 (weighted)	**SC1B**	**US1B**
E85 – ARB	16.1 (21.9)	13.2 (18.1)	17.6 (24.1)
E85 – Chevron	15.6 (21.3)	13.0 (17.8)	17.3 (23.6)
50/50	18.2 (21.3)	15.4 (18.0)	20.0 (23.4)
CaRFG3	21.0	17.4	23.1
E10	21.1	17.4	23.2
Cert 2	20.7	17.1	23.0

Vehicle emissions testing fuel economy results, Vehicle #26 2007 K1500 Silverado pickup truck 7003538 in miles per gallon (gasoline gallon equivalent)

Fuel	Driving Cycle		
	EC1 (weighted)	**SC1B**	**US1B**
E85 – ARB	11.2 (15.3)	9.7 (13.2)	11.3 (15.4)
E85 – Chevron	11.0 (14.9)	9.5 (12.9)	11.0 (14.9)
50/50	12.9 (15.2)	11.0 (13.0)	12.8 (15.0)
CaRFG3	15.1	13.0	14.8
E10	-	-	-
Cert 2	15.0	13.1	14.9

While the driving cycle fuel economies are not necessarily what would be experienced in the real world, they do provide reproducible results and a means to compare the results from one fuel to another. It can be seen from the above that depending upon the driving cycle, the Impala's fuel economy on program E85 (E85 – Chevron) ranged from 74.2 to 75.0% of that on CaRFG3, a figure consistent with the 76.5% value seen from Oakland's fleet of Impala LS sedans as a whole. And the Silverado's comparative fuel economies, which ranged from 72.6 to 74.1%, are in line with expectations. Based on the percentages of ethanol and hydrocarbons in the E85 – Chevron and CaRFG3 used for the vehicle emissions testing and reference lower heating values from GREET[9], the E85 had an estimated 73.4% of the energy content of the gasoline. Also interesting, the program E85 fuel economy shows a small but consistent difference from the E85 procured for the vehicle emissions testing program (E85 – ARB), despite having a similar ethanol content (83.7% vs. 83.4% by weight, respectively).

C. E85 and Gasoline Transactions

E85 transactions were recorded sequentially by the point-of-sale (POS) system at each fueling station. At each fueling location, vehicle operators were required to insert a passcard to authorize the transaction, and were prompted to record the vehicle odometer reading and identification number. The POS system also recorded the date, time, and quantity of fuel dispensed for each transaction. CleanFuel USA subsequently reported the transactions to ARB in electronic format.

Gasoline transactions were (mostly) tracked by the Voyager system which is used by California state employees including CalTrans for retail gasoline purchases. Voyager is a centralized billing system and the cards function much like a credit or debit card. Vehicle operators were prompted to enter the vehicle odometer reading and identification number. The Voyager system also recorded the date, time, quantity of fuel dispensed, product description, and retailer location for each transaction. CalTrans extracted the program vehicle transactions from the system and subsequently reported the transactions to ARB in electronic format.

Raw POS and Voyager data were compiled into spreadsheets and organized by vehicle with transactions in sequential order. The Voyager data were especially difficult to process as the transactions sometimes included non-gasoline purchases like motor oil, car washes, or other miscellaneous items. In addition, although all of the program vehicles required only regular grade gasoline, some purchases of premium grade gasoline were made. Merging multiple reports from each system into one organized and reconciled data set was extremely time-consuming.

Problems with the data set immediately became apparent, as there were a significant number of missing or nonsensical odometer values and in general unexplained gaps between vehicle odometer readings. Vehicle fuel capacities were known with certainty, and given estimated fuel economy for each vehicle type, approximate maximum vehicle ranges could be calculated. The data set frequently indicated that transactions took place at mileage intervals longer than was physically possible. For example, a pickup truck simply doesn't get 50 or more miles per gallon no matter how it is driven. This could be explained by the fact that CalTrans also had a gasoline dispenser available in both Oakland and Marysville that had no transaction reporting system associated with it. Thus, it was possible for a vehicle to be refueled without it showing up in the data set. This proved to be especially problematic.

Vehicle operators had a long history of using these facilities. Not all of them were diligent about switching to the new fuel and entering correct odometer readings. ARB observed this trend midway through the program and was able to alert CalTrans for the need to enter correct odometer readings and not only refuel with E85 as much as possible, but also to refuel with gasoline from CalTrans' facilities as little as possible. Subsequently, data reporting improved greatly.

Using best engineering judgment, ARB made corrections to the data set to reconcile the problems. Odometer readings were corrected to expected values based upon estimated fuel economy. And still unexplained gaps between vehicle odometer readings were made up with gasoline transactions assumed to come from CalTrans' facilities. It was assumed that all refueling events were fill-ups (not short fills), an unsubstantiated but necessary assumption. If a vehicle were operated on only one fuel type, this wouldn't be an issue. But the vehicles could be refueled on two types of fuel, each with a different expected fuel economy, and as apparent in the data set, vehicle operators frequently switched between one fuel and the other. Unfortunately it was not possible to overcome the limitations posed by these problems.

Having to make these corrections to the data set greatly limited the ability to draw any conclusions about the fuel economy on each fuel from the data set as a whole. Nevertheless, the problems were not evenly distributed, and for some vehicles there were extended stretches of transactions in which no corrections were necessary. For example, over a 6 month period vehicle 7003480, an Impala LS in Oakland, was refueled with E85 and valid odometer readings were entered into the POS system 55 consecutive times, the best effort seen. These cases presented the best opportunities in which to draw conclusions about the fuel economy on each fuel.

Refueling transaction summary tables are presented in Appendix K. Raw data are presented in uncorrected tables from both the POS system reports (E85 transactions) and the Voyager system reports (gasoline transactions). These reports were then merged and reorganized by vehicle and corrected as necessary (corrections shown in italics).

Summary statistics of the refueling transactions for the data set as a whole are presented in Table 7.1. This table is useful to see the best estimates of total program mileage, 668,000 miles, and fuel consumed, 30,000 gal of E85 and 9,700 gal of gasoline. Gasoline transactions assumed to come from CalTrans' facilities, for lack of a better term, were dubbed phantom tanks. The data from each individual vehicle used to compile Table 7.1 is presented in Appendix L. Fuel economy values in these tables should be considered as approximations.

Table 7.1 Summary Statistics by Vehicle Type

	Marysville	**Oakland**		
	Impala LS sedan	**Impala LS sedan**	**C1500 Silverado pickup truck**	**K1500 Silverado pickup truck extended cab 4x4**
Number of vehicles	15	13	12	10
Program miles 11/1/06 - 10/31/07	235435	212851	98736	120933
E85 refueling events	853	568	330	376
Chevron tanks	7	26	2	4
Phantom tanks	11	76	0	23
Gasoline refueling events	322	288	34	126
Total refueling events	1175	856	364	502
Avg. miles/tank	200	249	271	241
Avg. gallons/tank	9.4	11.8	22.5	21.5
Max. miles/tank E85	390	416	493	513
Max. miles/tank gasoline	470	442	514	481
Max. gallons/tank	16.13	16.2	32.4	33.5
Gallons E85	7770.927	6651.171	7490.419	8466.902
Gallons gasoline	3253.4	3424.38	714.94	2322.00
Miles on E85	162845	130763	89585	93766
Miles on gasoline	72590	82088	9151	27167
Miles/gallon E85	21.0	19.7	12.0	11.1
Miles/gallon gasoline	22.3	24.0	12.8	11.7

For more accurate fuel economy values, stretches of uncorrected refueling events were selected. In doing so, the first tank after a switch in fuel type was not counted in order to minimize the effect of dilution in any fuel remaining in the tank when refueling occurred (for subsequent tanks this effect was considered negligible). These are summarized below and shown in more detail in Appendix L.

Summary of fuel economies by fuel and vehicle type in miles per gallon (gasoline gallon equivalent).

	Marysville	**Oakland**		
	Impala LS	**Impala LS**	**C1500 Silverado**	**K1500 Silverado**
E85	19.8 (27.0)	18.6 (25.4)	11.9 (16.2)	10.9 (14.8)
Gasoline	25.2[1]	24.3	11.7[1]	9.1[1]

Note:

1. Based on very few data points.

It can be seen that fuel economies for the Impala LS sedans are better than the Silverado pickup trucks. And, at least for the Impala LS sedans, fuel economies on gasoline are better than on E85. These results are as expected. For the Silverado pickup trucks, however, fuel economies on gasoline are worse than on E85. One possible explanation for this apparent contradiction is that there were very few instances of consecutive uncorrected gasoline transactions available, and is most likely an anomaly and should be disregarded. While not inconsistent with expectations, the gasoline fuel economy value for the Marysville Impala LS sedans was also based on very few data points. The longer the stretch of uncorrected data, the more reliable the result should be. The only gasoline fuel economy value based on a large number of data points was for the Oakland Impala LS sedans. Based upon the Oakland Impala LS sedan data, the fuel economy on E85 was 76.5% of that on gasoline. Unknown is whether instances of refueling with gasoline, presumably away from the vehicle's home base, could be associated with different vehicle usage (e.g., highway vs. city driving). Keep in mind that these conclusions were based on those limited instances where the data set did not require significant corrections, and not the data set as a whole.

It can also be seen from Table 7.1 that the amount of fuel delivered to the vehicle fleet is somewhat less than the amount of fuel delivered to the tanks from Chevron as indicated in Section VI Tables c and d. Not shown in this table were six drums (330 gallons) of E85 dispensed from Marysville on October 29, 2007, and transported to ARB's facilities in El Monte for use in the vehicle emissions testing portion of the program (see Section IX). The totals for the amount of fuel delivered to the vehicle fleet also exclude a few transactions for fuel quality control samples, dispenser calibration, or for which equipment ID numbers were missing (170 gallons in Marysville and 74 gallons in Oakland). There are not believed to be any instances of unreported E85 transactions and no fuel spills occurred from either tank during the program. The remaining differences (less than 5,000 gallons each) are presumed to be fuel left in the tanks on October 31, 2007, at the end of the one-year long driving phase of the program.

And except for the Silverado gasoline results, these results are also consistent with mileage ratings from EPA.

D. Davis Instruments CarChips Data

A subset of 20 vehicles were equipped with Davis Instruments CarChips Fleet model number 8241 as shown in Table 7.2. This is the same subset of vehicles which were chosen for Chevron's oil test program (see Section X). The CarChips are a data logging device which plugs into the on-board diagnostics (OBD II) port underneath the dashboard of the vehicle. In addition to trip start and end time, they record vehicle speed at 5 second intervals. From these data, idle time, time in motion, average speed and distance traveled of each trip can be calculated.

In addition, up to four engine data parameters can be selected to be recorded at user selected intervals. They were set up to monitor (engine intake) air flow rate, fuel system status (open or closed loop), short term fuel trim, and long term fuel trim at 10 second intervals. They can store 512K of data each, equivalent to between 42 and 300 hours of driving depending upon the number of data parameters and selected time interval. Data were downloaded to a personal computer using the Fleet Management database software.

Table 7.2 CarChip deployment

Equipment ID	Location	Vehicle Type	CarChip S/N
7003526	Oakland	C1500 Silverado pickup truck	L-7273-D
7003524	Oakland	C1500 Silverado pickup truck	L-7274-D
7003505	Oakland	Impala LS sedan	L-7277-D
7003517	Oakland	Impala LS sedan	L-7278-D
7003514	Oakland	Impala LS sedan	L-7283-D
7003516	Oakland	Impala LS sedan	L-7287-D
7003511	Oakland	C1500 Silverado pickup truck	L-7337-D
7003475	Oakland	C1500 Silverado pickup truck	L-7338-D
7003476	Oakland	C1500 Silverado pickup truck	L-7351-D
7003477	Oakland	C1500 Silverado pickup truck	L-7356-D
7003478	Oakland	C1500 Silverado pickup truck	L-7359-D
7003512	Oakland	C1500 Silverado pickup truck	M-7335-D
7003479	Oakland	C1500 Silverado pickup truck	M-7336-D
7003504	Oakland	Impala LS sedan	M-7342-D
7003523	Oakland	C1500 Silverado pickup truck	M-7399-D
7003390	Marysville	Impala LS sedan	M-7402-D
7003401	Marysville	Impala LS sedan	M-7420-D
7003395	Marysville	Impala LS sedan	M-7424-D
7003393	Marysville	Impala LS sedan	M-7426-D
7003397	Marysville	Impala LS sedan	-

GM kept one of the CarChips for testing and it was unavailable to be used during the program.

The CarChips were deployed in order to supplement the E85 and gasoline transactions data to help shed light on vehicle performance, particularly fuel economy. While doing so is theoretically possible, in practice the data were exceptionally difficult to analyze. The devices are capable of recording only data available from the OBD II port. The program vehicle fleet from GM uses a combination of assumptions (fuel added to the tank is either gasoline or E85) and measured values (volume of fuel added to the tank, fuel trim, and oxygen sensor values) to calculate the amount of alcohol in the fuel and adjust the ECM accordingly. In the absence of a fuel composition sensor which measures the amount of alcohol present, there was no way to directly determine whether a vehicle was refueled with gasoline or E85. This limitation greatly affected the utility of the data collected by the CarChips for the program. In the end, any conclusions about fuel economy drawn from the CarChip data would have been no more robust than the conclusions from the transactions data. As a result, ARB elected to not extensively analyze the CarChip data. The data do remain available for future analysis should it be desired.

The CarChips were deployed on September 14, 2006, although most of the vehicles did not go into service until a few weeks later. Collecting stored data from the CarChips required removing the devices from the vehicles and connecting them to a laptop personal computer for downloading. The CarChips memories were cleared and then reinstalled in the vehicles. ARB was limited to collecting the data when it would not be disruptive to the vehicle operators' normal routines, typically when the vehicles were in for service as they were away from the storage yard during normal business hours. Attempts to arrange meetings with the vehicle operators at the E85 dispensers or in the field proved impractical.

Stored data were collected from four vehicles in Oakland on October 12, 2006: 7003516, 7003517, 7003475, and 7003478. Stored data were collected from four vehicles in Marysville on December 19, 2006: 7003390, 7003393, 7003395, and 7003401. All of the CarChips were removed from service on August 27, 2007 (Oakland) and November 5, 2007 (Marysville) and the stored data remain available for analysis.

VIII. ENGINE DEPOSIT INSPECTIONS

A. Inspection Procedure

At the beginning of the demonstration program it was decided that three engines, one on each of the three test engine oils, would be inspected for deposits. CalTrans did not wish to have the engine cylinder heads removed for the inspection, which is the normal procedure used to inspect engines. Therefore, it was agreed to just remove the intake manifold, the fuel injectors, and one rocker cover. The intake valves would be inspected, photographed, and deposit rated using a borescope (fiber optic device with a light). The individual fuel injector nozzles would be individually inspected and photographed. The intake manifold would be visually inspected. One rocker cover and the corresponding valve deck for that cylinder head of each engine would be visually inspected, deposit rated, and photographed.

B. Deposit Rating Procedure

The Coordinating Research Council (CRC) deposit rating scales were used to visually rate the intake valve deposits and the rocker cover and valve deck sludge and varnish deposits. The intake valve deposits were viewed on the borescope LCD screen and from photographic prints. The rocker cover and valve deck were viewed directly in normal room lighting in the CalTrans San Francisco and Marysville shops. The rating scale used is a merit scale where a rating of 10 = clean. Thus, the higher the reported value, the cleaner is the engine part.

C. Photography

The intake valve deposits were photographed digitally with the recorder system built-in the borescope. The parts were illuminated by the built-in light at the tip of the borescope. The fuel injectors, rocker covers, and valve decks were photographed with a reflex digital camera using a ring light flash.

D. Vehicles Inspected

The criteria for selecting the three vehicles for inspection were: inspect both car 3.5L V6 and truck 5.8L V8 engines, have a high percentage use of E85 along with highest mileages, and one each using the three engine oil formulations. Table h shows the vehicles selected, the date they were inspected, the engine oil used, the odometer reading at the time of the inspection, the total miles on test since the vehicles had accumulated some mileage before being put on test, the miles accumulated after being filled with E85, the gallons of E85 used, and the gallons of gasoline used. Also shown are the percentages of miles on E85 and of E85 fuel used. The first vehicle, a car, was from the CalTrans Marysville fleet and was inspected in the CalTrans Marysville shop. The second and third vehicles were a pickup truck and a car from the CalTrans Oakland fleet and were inspected in the CalTrans San Francisco shop. Each engine was partially disassembled, inspected, photographed, rated, and reassembled in less than a day.

Table h
Information of Inspected Vehicles

Vehicle Code	7003393	7003476	7003504
Engine	3.5L V6	5.3L V8	3.5L V6
Date of Inspection	11/27/2007	11/15/2007	11/14/2007
Fuel	E85	E85	E85
Engine Oil	Red	Blue	Green
Odometer Miles at Inspection	13,512	20,358	22,410
Miles on Test	13,482	19,943	20,236
Miles on E85	11,997	18,645	18,439
Percent Miles on E85	89	94	91
E85 Gallons	622	1,487	826
CaRFG3 Gallons	81	96	85
Percent E85	88.5	93.9	90.7

E. Deposit Rating Results

The deposit ratings for the intake valves for the three inspected vehicles are summarized in Table i. The level of deposits is very similar for the three vehicles. The E85 did not contain any deposit control additive. These results show that E85 forms a moderate level of intake valve deposits. No similar vehicles that had operated on CaRFG3 without additive were available for inspection for comparison. Past experience suggests that the deposit level shown for E85 is about the same as for reformulated gasoline without a deposit control additive.

Table i
Borescope Intake Valve Deposit Rating

	Cylinder								
Vehicle	1	2	3	4	5	6	7	8	Average
7003393	7.25	7.75	8.00	8.00	7.75	7.75	-	-	7.75
7003476	7.25	7.75	7.50	7.50	8.00	8.00	8.25	7.25	7.75
7003504	7.50	7.25	7.50	7.50	7.50	7.75	-	-	7.50

Merit Deposit Scale Where 10 = Clean

The sludge and varnish ratings of the rocker covers and the valves decks are summarized in Table j. As shown in the ratings, these parts appeared like new with no deposits, just engine oil, on them. The performance of the three engine oils was outstanding for these vehicles fueled on E85.

Table j
Engine Rocker Area Deposit Ratings

Vehicle	Side Inspected	Sludge Deposit Rating			Varnish Deposit Rating		
		Rocker Cover	Valve Deck	Rocker Assembly	Rocker Cover	Valve Deck	Rocker Assembly
7003393	Left	10	10	10	10	10	10
7003476	Right	10	10	10	10	10	10
7003504	Left	10	10	10	10	10	10

Merit Deposit Scale Where 10 = Clean

Although not rated, the intake manifolds appeared like new with no deposits even around the positive crankcase ventilation (PCV) inlet port. The fuel injectors appeared to be free of critical deposits in the spray holes, but were not flow tested as time was not available to do so.

F. Photographs of Engine Parts

Representative intake valve and fuel injector photographs were selected to illustrate the level and appearance of the deposits.

Typical intake valve deposits are shown in Figure 8.1 for each of the inspected vehicles.

Figure 8.1

7003393

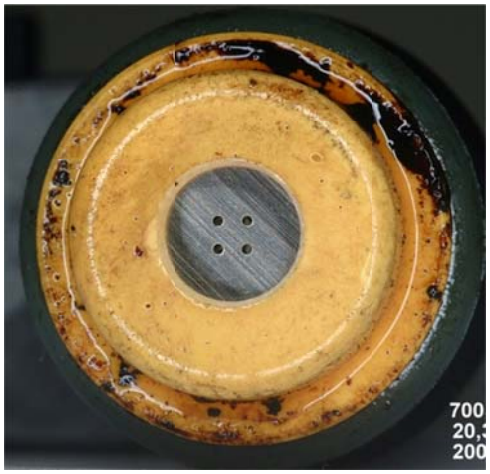
7003476

7003504

Typical fuel injector nozzle faces showing the spray holes are presented in Figure 8.2.

Figure 8.2

7003393



7003476

7003504

One rocker cover from each of the three inspected engines is shown in Figure 8.3.

Figure 8.3

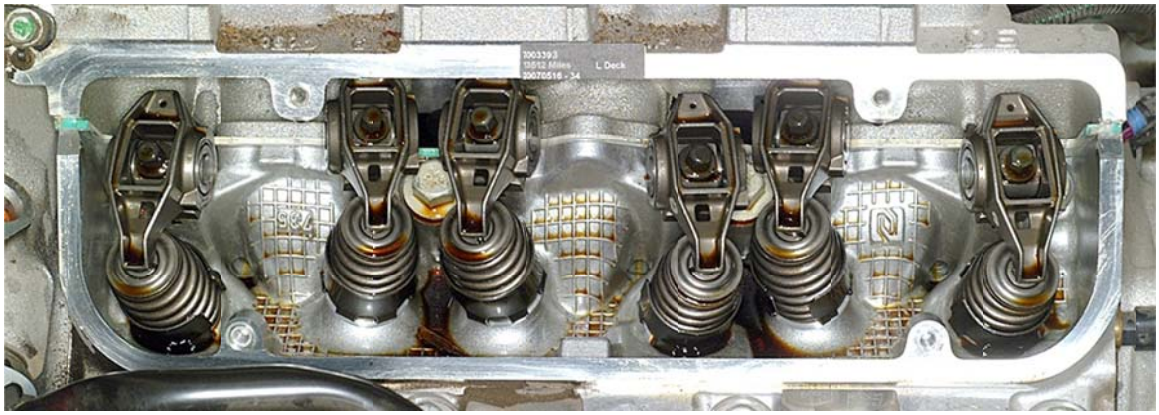
7003393

7003476

7003504

One valve deck from each of the three inspected engines is shown in Figure 8.4.

Figure 8.4



7003393

7003476

7003504

Only one PCV area of the intake manifold was inspected and photographed as shown in Figure 8.5. The source of the intake valve deposits was not from the PCV system which was a possibility.

Figure 8.5

7003393

IX. ARB VEHICLE EMISSIONS TESTING ON CARFG, E85, AND A 50/50 BLEND OF THE TWO FUELS

After completion of the one-year long driving phase of the program, ARB conducted vehicle emissions testing on two vehicles from CalTrans fleet in Oakland: a 2006 Impala LS sedan, 7003506 and a 2007 K1500 Silverado pickup truck, 7003538. These vehicles were selected on the basis of having relatively high mileages and a relatively high E85 use as opposed to gasoline. The pickup truck was also selected on the basis of being counted as a ARB LEV II exhaust emission standard category, as opposed to a 2006 C1500 Silverado pickup truck which was required to meet a less stringent NO_x emission standard.

Each vehicle tested has an associated ARB Executive Order, A-006-1277 for the Impala sedans, and A-006-1396-1 for the K1500 Silverado pickup trucks. Another Executive Order, A-006-1306 covers the 2006 C1500 Silverado pickup trucks which were not tested during this program. These documents detail the applicable emissions standards and certification values, and can be found in Appendix M.

It was decided early on during the program to conduct emissions testing on California reformulated gasoline (CaRFG3), E85, and a 50/50 blend of the two fuels. The latter fuel was intended to represent what can happen in the real world when consumers refuel with a different fuel type with a partially full tank remaining.

For expediency the testing on the two vehicles was rolled into an already on-going emissions testing program to support proposed changes to the Supplemental Federal Test Procedure (SFTP), involving at least two dozen vehicles at ARB's facilities in El Monte. These facilities are heavily used and scheduled well in advance. The SFTP II program entailed testing on several fuels including:

- California phase 2 certification gasoline, oxygenated with approximately 11% by volume MTBE
- Commercially available California reformulated gasoline (CaRFG3), oxygenated with approximately 5.7% by volume ethanol
- E10, in this case a blend of California certification gasoline not containing any MTBE, and ethanol (Reid vapor pressure 8.15 psi) – this fuel does not meet the requirements of ARB's predictive model and is a test fuel only
- E85

Among the objectives of the SFTP II program were to identify any differences in emission levels between each of the fuels. This was consistent with the objectives of the E85 Demonstration Program, and although it resulted in a greatly extended period in which to complete testing and QA/QC review of the data, ultimately both programs benefitted from the increased size of the data set.

ARB's existing emissions testing program had its own vehicle identification numbering sequence, the Impala 7003506 is identified as vehicle #25, and the Silverado 7003538 is identified as vehicle #26. In addition, another 2006 Impala LS FFV (not part of CalTrans fleet or the E85 Demonstration Program) was also tested on E85 as part of the SFTP II program, this was vehicle #16.

Summarized below are odometer readings from each vehicle at the start and end of the one-year long driving phase, and the start of the emissions testing. Also shown is the number of gallons of each type of fuel consumed. These values are based on corrected data (see Section VII). Refueling patterns between the end of the one-year long driving phase and the start of emissions testing are believed to have continued unchanged. Although the history of vehicle #16 was not researched for this report, unlike vehicles #25 and #26 which accumulated approximately 90% of their total program miles on E85, given the dearth of E85 stations in the state at the time, vehicle #16 was almost certainly refueled exclusively on gasoline prior to the start of emissions testing.

Table 9.1 Refueling history of vehicles undergoing emissions testing.

	Vehicle #16 2006 Impala LS	**Vehicle #25 2006 Impala LS 7003506**	**Vehicle #26 2007 K1500 Silverado 7003538**
Start one-year driving phase odometer	-	5,347	347
End one-year driving phase odometer	-	27,448	18,166
Program miles	-	22,101	17,819
Miles on E85	-	20,425	15,494
Miles on gasoline	-	1,676	2,325
Gallons E85	-	995.4	1372.7
Gallons gasoline	-	73.7	164.0
Start emissions testing odometer (date)	5,221 (9/22/06)	29,547 (1/23/08)	25,378 (7/18/08)

Even though vehicle #16 was not part of the E85 Demonstration Program, results of the emissions testing have been included in the report because it offers an opportunity to compare the results from like vehicles with different refueling histories.

Each vehicle was tested on a different batch of fuel. The properties of each batch of fuel are shown in Tables 9.2, 9.3, and 9.4. There were two sources of E85, and although both were produced by Chevron, only one was E85 Demonstration Program fuel (E85 – Chevron), the other was for the SFTP II program (E85 – ARB). The source of the E85 Demonstration Program fuel was from the six drums of fuel shipped from CalTrans' Marysville site on October 29, 2007 (see Section VII). Vehicles #25 and #26 were tested on both sources of E85. Vehicle #16 was tested on only E85 from the SFTP II program.

This generation of GM FFVs does not employ a fuel composition sensor to determine the alcohol concentration and were designed to be fueled with only gasoline (0-10% ethanol) or E85 (70-83% ethanol). Fueling events must be a minimum of 11 liters (3 gallons) to ensure the engine computer learning mode is triggered to calibrate the engine on the new fuel. A rigorous fuel flushing procedure plus driving approximately 60 miles was followed between each different fuel to ensure the engine was operating properly on the fuel in the tank before testing. The 50/50 blend was prepared in the vehicle fuel tank by addition of approximately one-half tank of E85 Demonstration Program fuel and one-half tank of the same batch of CaRFG3 as was used by itself with that vehicle.

ARB collected a sample of the 50/50 blend from the fuel tank of each vehicle being tested. The ARB lab is not equipped to determine the composition of fuel samples with an ethanol content this high – the samples were sent to an independent laboratory, Saybolt LP, for analysis of the fuel properties (detailed HC analysis by ASTM D 6730). The sample from vehicle #25 was collected April 1, 2008 and from vehicle #26 on August 22, 2008. The lab reports for these two analyses can be found in Appendix N. The Saybolt analyses were supplemented by additional analyses performed by ARB. The ARB results influenced some of the values shown in Tables 9.3 and 9.4 and explain why they are not exactly equal to the Saybolt results; different methods can yield slightly different results on samples of the same fuel.

Four different test procedures were conducted:

- Enhanced Cold CVS II test (EC1), the Federal Test Procedure (FTP)
- US06 One-Bag Sampling (US1B)
- SC03 One-Bag Sampling (SC1B)
- Unified Cycle (UC)

The SFTP specified by ARB's regulations adds two driving cycles not covered by the Federal Test Procedure (FTP): US06 uses aggressive driving, and SC03 uses air conditioning. The EC1, SC03, and US06 tests are specified to determine whether the vehicles meet the applicable emissions standards. The UC test results are used primarily for ARB emissions inventory purposes.

ARB's dynamometer is not compatible with four-wheel drive vehicles. Testing of the four-wheel drive pickup truck necessitated disconnecting the drive shaft to the front axle.

Each vehicle and fuel combination was scheduled for a minimum of three test runs. Although some runs were aborted or had the results invalidated, 94% of the data survived QA/QC review. With only one exception there are at least two runs for each vehicle and fuel combination. Despite the variety of driving cycles and fuels and large number of test runs, the results need to be considered qualitative due to the limited number of vehicles which were tested. For practical time and cost considerations it was not possible to test more than one sedan and one pickup truck from the E85

Demonstration Program fleet. Due to variations between vehicles (even of the same type), it is not possible to draw quantitative conclusions about a particular fuel or vehicle, let alone FFVs in general. Nevertheless, the results are a worthwhile demonstration of the emissions performance of FFVs which have been used in real world driving conditions.

Parameters reported included both criteria pollutants and selected air toxics compounds:

- hydrocarbons (HC)
- carbon monoxide (CO)
- carbon dioxide (CO_2)
- methane (CH_4)
- oxides of nitrogen (NO_x)
- nitrogen oxide (NO)
- non-methane hydrocarbons (NMHC)
- NMHC + NO_x
- non-methane organic gases (NMOG)
- ARB Method 1001[6]: Determination of Alcohols in Automotive Source Samples by Gas Chromatography, including ethanol and total alcohols
- ARB Method 1002[6]: Determination of C_2 to C_5 Hydrocarbons in Automotive Source Samples by Gas Chromatography, including 1,3-butadiene and total light-end HC
- ARB Method 1003[6]: Determination of C_6 to C_{12} Hydrocarbons in Automotive Source Samples by Gas Chromatography , including methyl tert-butyl ether (MTBE), benzene, total mid-range HC, and total ethers
- ARB Method 1004[6]: Determination of Aldehyde and Ketone Compounds in Automotive Source Samples by High Performance Liquid Chromatography, including formaldehyde, acetaldehyde, and total carbonyls

Although the on-going emissions testing program included evaporative emissions testing, due to scheduling limitations it was not possible to conduct evaporative emissions testing on the two program vehicles #25 and #26. A report of a more thorough emissions testing program conducted at approximately the same time by the Coordinating Research Council (CRC) was being finalized at the time this report was released and is expected to be published soon.[11] The CRC investigation included both exhaust and evaporative emissions testing of seven 2006 or 2007 model year FFVs on CaRFG3, E85, and intermediate blends.

Complete results are in Appendix O.

A. CO_2 Emissions and Fuel Economy

The weighted FTP CO_2 and fuel economy results are plotted in Figures 9.1 and 9.2.

Figure 9.1 Weighed FTP CO_2 Emissions

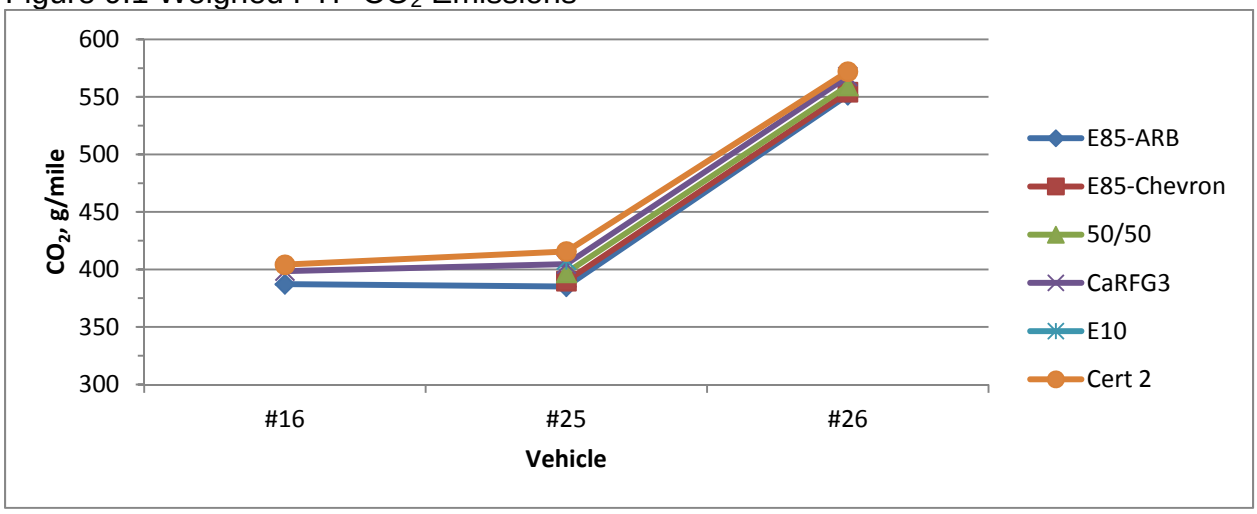
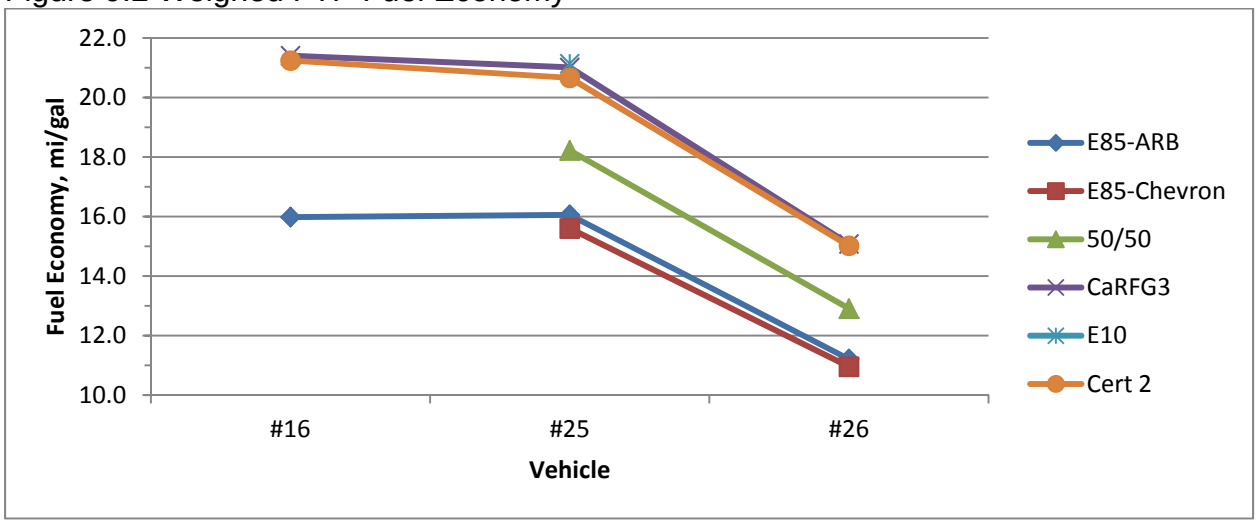


Figure 9.2 Weighed FTP Fuel Economy



B. Regulated Emissions

A summary of emissions test results compared to applicable emissions standards for each of the three vehicles tested is presented in Tables 9.5, 9.6, and 9.7. The weighted FTP results are plotted in Figures 9.3, 9.4, 9.5, and 9.6. The SFTP (US06, SC03, and composite) results are plotted in Figures 9.7, 9.8, 9.9, 9.10, and 9.11.

Figure 9.3 Weighted FTP NMOG Emissions

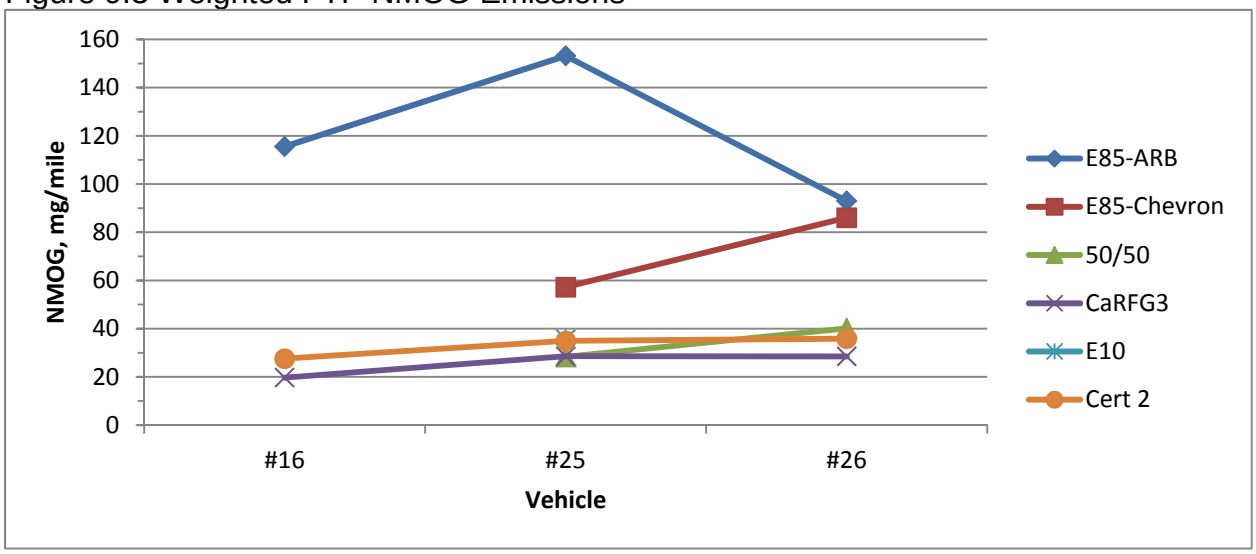


Figure 9.4 Weighted FTP CO Emissions

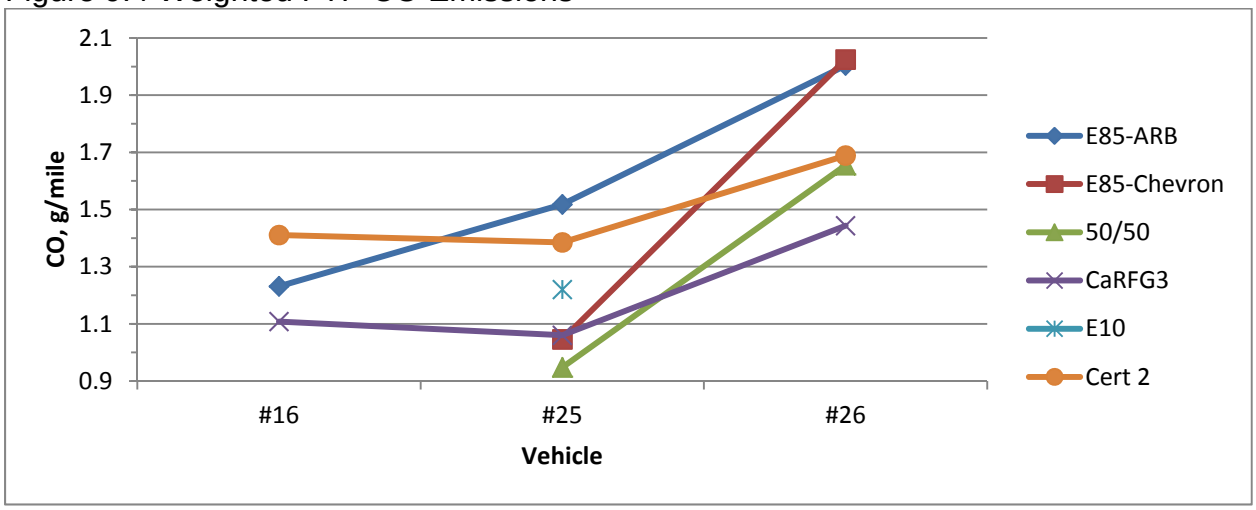


Figure 9.5 Weighted FTP NO_x Emissions

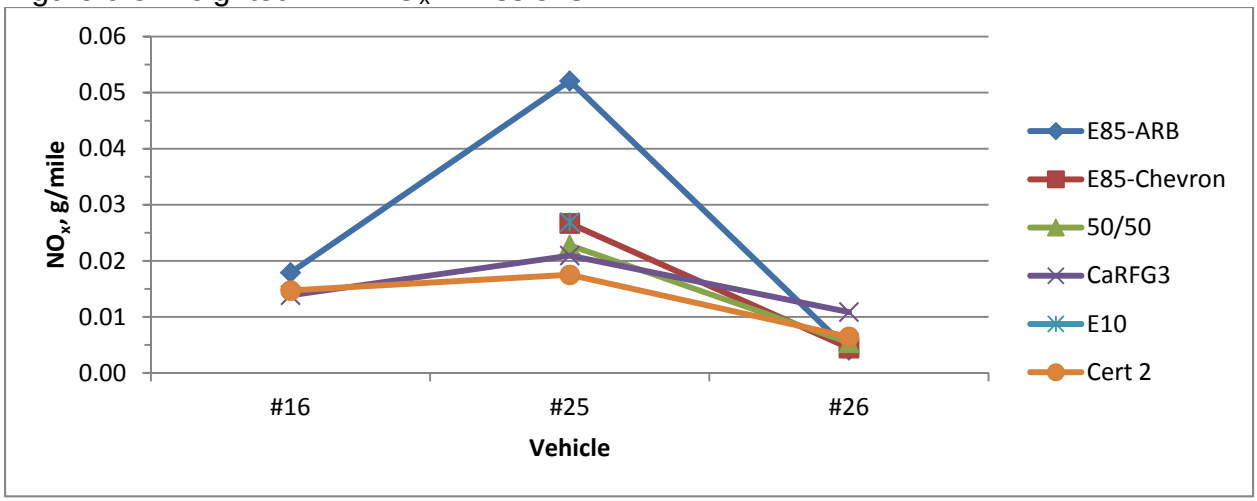


Figure 9.6 Weighted FTP Formaldehyde Emissions

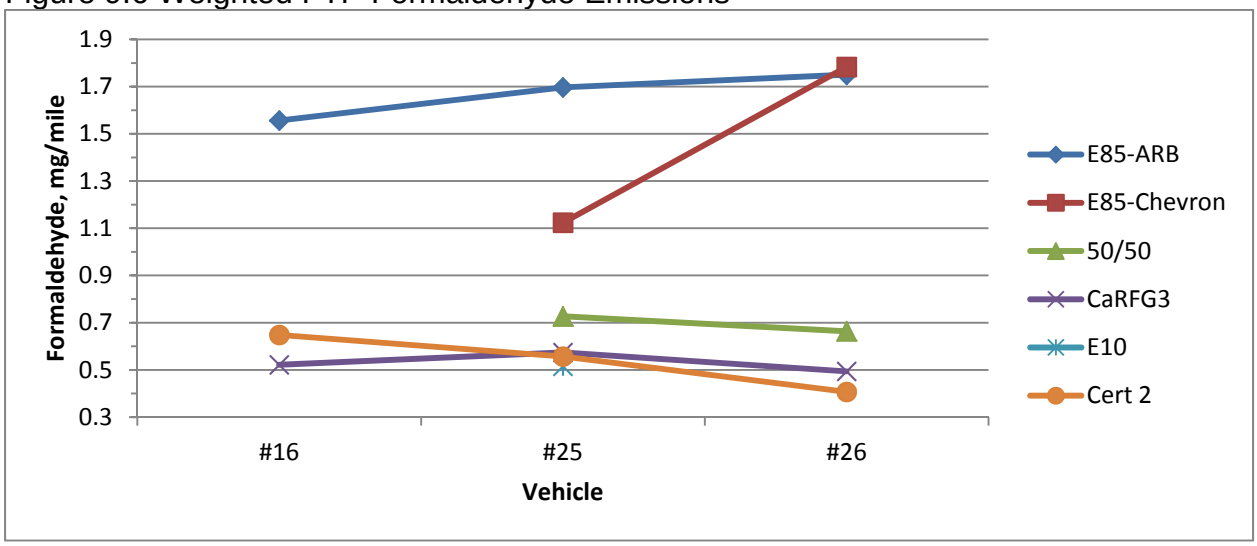


Figure 9.7 US06 NMHC + NO_x Emissions

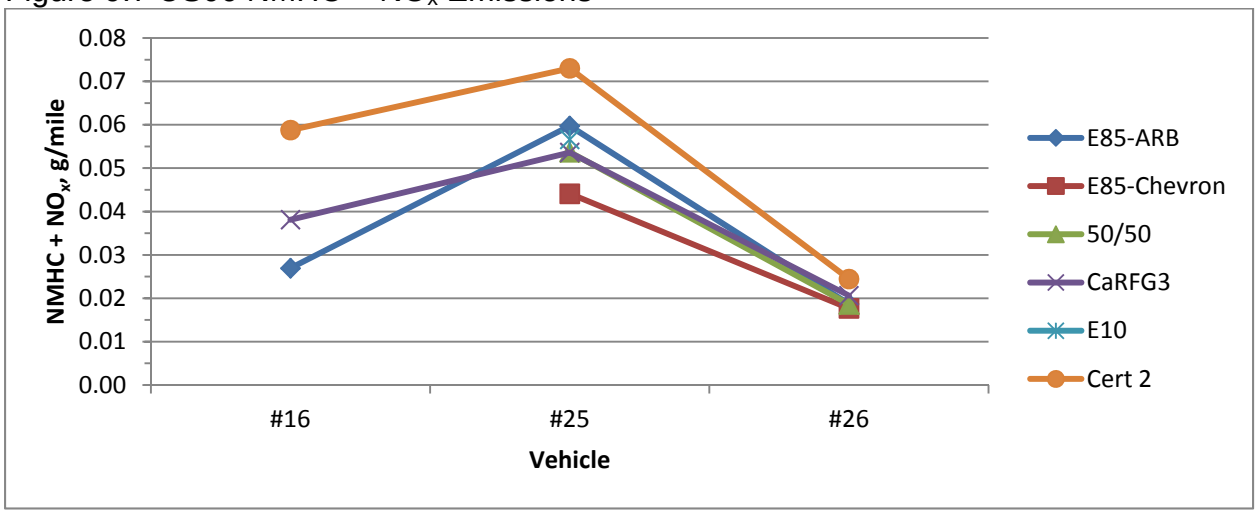


Figure 9.8 US06 CO Emissions

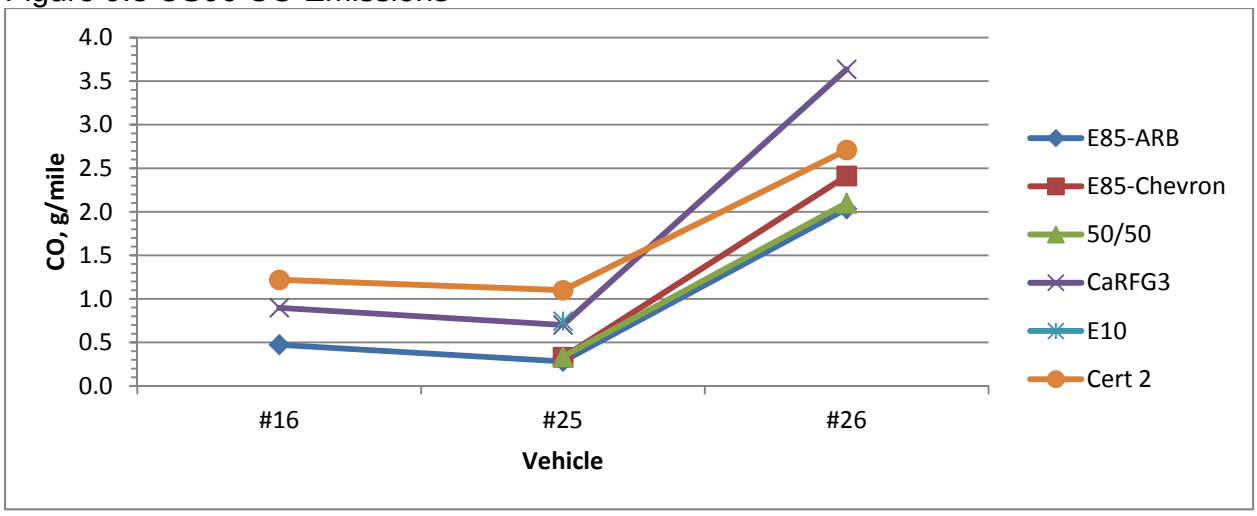


Figure 9.9 SC03 NMHC + NO_x Emissions

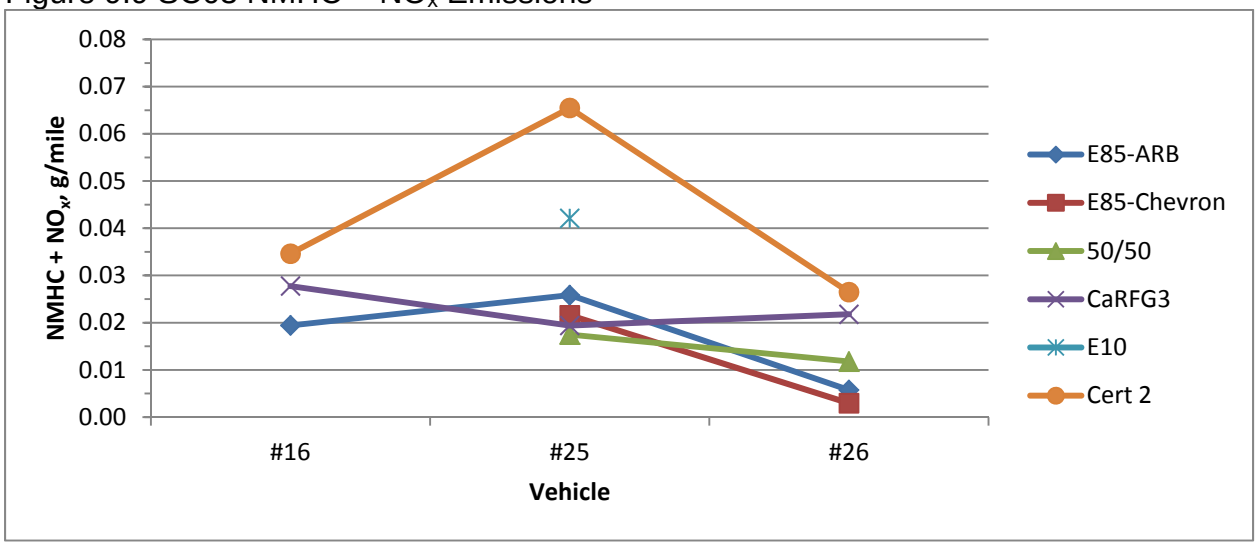


Figure 9.10 SC03 CO Emissions

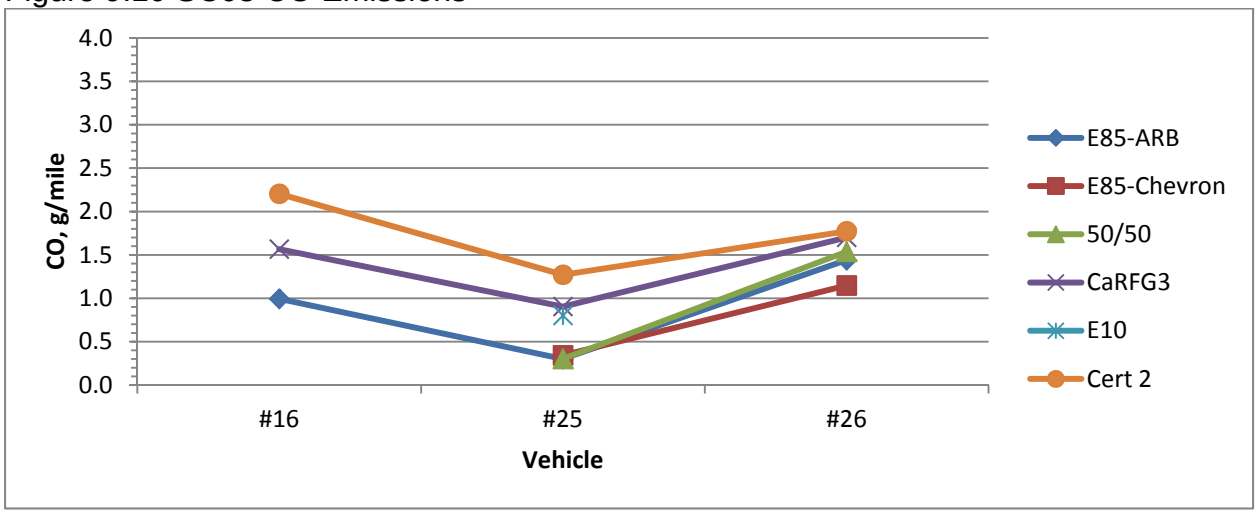
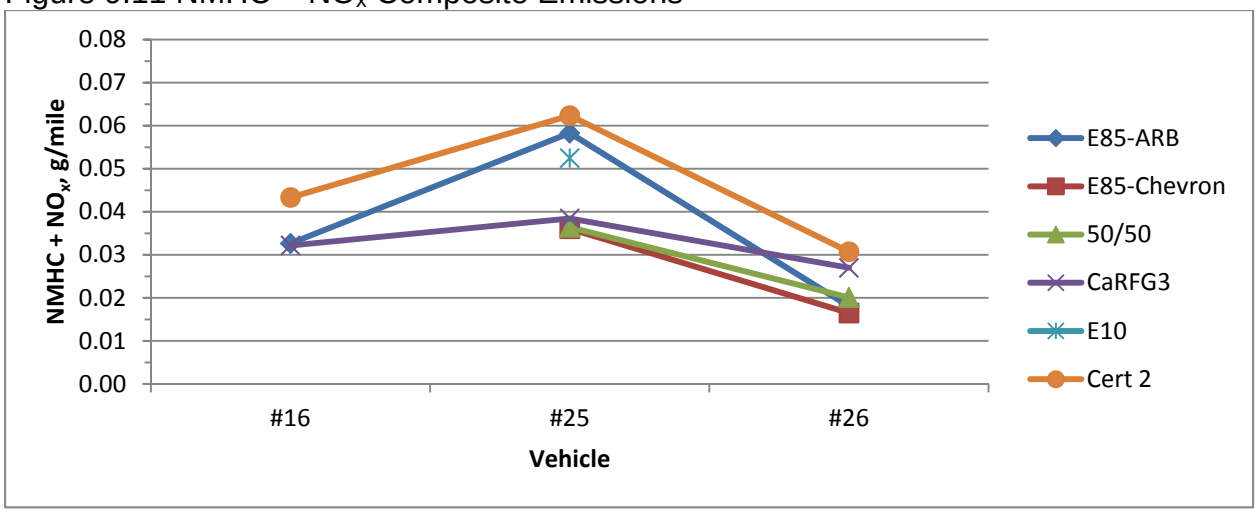


Figure 9.11 NMHC + NO_x Composite Emissions



C. Air Toxics

The emissions testing results contain speciated hydrocarbon data from each test run. For purposes of this report, rather than tabulating data on over 200 compounds, a limited number of air toxics compounds were selected, which represent the bulk of the potential differences in health risk: benzene, 1,3-butadiene, formaldehyde, and acetaldehyde. Weighted FTP results are summarized in Table 9.8; also shown to provide some perspective are emissions of ethanol, MTBE, NMHC, and NMOG. Similarly, air toxics results for USO6 and SC03 are summarized in Tables 9.9 and 9.10, respectively.

D. Discussion

E85's lower CO_2 emissions results from the fuel's lower carbon content. This is reflected in E85's lower fuel economy. Fuel economy is discussed further in Section VII.

In order to demonstrate compliance with applicable emissions regulations, vehicle manufacturers submit weighted FTP results of NMOG, CO, NO_x, and formaldehyde from testing on certification fuel. Applicable emissions standards on FFVs are the same on both gasoline and E85. In addition, SC03 and US06 (SFTP) results of NMHC + NO_x and CO from testing on gasoline certification fuel only are submitted. The results of the vehicle emissions testing may serve as a spot check of the data submitted by the vehicle manufacturers. The results are not intended to be used to demonstrate compliance or non-compliance with the applicable emissions standards.

Specifications for gasoline and E85 certification fuel composition are presented in Table 9.11. The only specifications for E85 certification fuel are gasoline content and RVP, however the range of several of the remaining properties can be determined from the gasoline certification fuel and denatured ethanol limits. There are no legally enforceable specifications for denatured ethanol for use as a blend component in E85, however, there are for use in California gasoline (Title 13, CCR 2262.9), and it is a fair assumption that the same source is used for blending both fuels.

The weighted FTP results show that all three vehicles met the applicable emissions standards for NMOG, CO, NO_x, and formaldehyde on gasoline certification fuel. The RVP was lower (6.35 psi) than provided for in the regulations (6.7-7.0 psi), otherwise it met all the specifications for gasoline certification fuel. They were lower than the emissions standards for NMOG on E10, CaRFG3, and 50/50 blend fuels, and for CO, NO_x, and formaldehyde on all tested fuels as well.

NMOG emissions on E85, however, were mostly greater than the applicable standards. E85-ARB had noticeably higher emissions than E85-Chevron on both vehicle #25 and vehicle #26. This is most likely attributable to the differences in the fuel composition. Both sources of E85 had a very similar ethanol content, the single biggest variable. E85-ARB had a somewhat higher aromatics content (4.1 vs. 2.25 volume %), sulfur content (16 vs. 6 ppm), and RVP (7.99 vs. 7.11 psi) than E85-Chevron. Even after

accounting for the isopentane added to the E85-Chevron, the gasolines used to blend the two sources of E85 were very different. These results suggest that either tighter specifications for E85, or development of a Predictive Model as is used for CaRFG may be appropriate should sales volumes continue increase as anticipated. A thorough compositional analysis of the two sources of E85, including total carbon number basis, hydrocarbon type, and specific hydrocarbon compounds, is found in Appendix P.

It should also be noted both sources of E85 were in-use fuels, not certification fuel. Neither contained any MTBE. E85-ARB was a bit lower in benzene (0.11 volume %) than provided for as shown in Table 9.11 (0.12-0.25 volume %). And E85-Chevron was more substantially lower in aromatics (2.25 volume %), benzene (0.1 volume %), and RVP (7.11 psi) than provided for as shown in Table 9.11 (3.3-6.5 volume %, 0.12-0.25 volume %, and 8.0-8.5 psi, respectively).

The higher NMOG emissions from E85-ARB on #25 and #26 shown by the weighted FTP test results, however, were not consistent with the results of the other driving cycles. The SC03, US06, and UC NMOG results were about equally split between the two sources of E85 as to whether one or the other had higher emissions. Additional test runs would be necessary to determine whether there is a statistically significant difference between the emissions from the two fuels.

The FTP results show that the NMOG emissions on E85 were primarily ethanol, virtually all from the cold start phase (bag 1). NMHC emissions were less than half of the alcohol emissions, and the carbonyls were about half of that. The engines are designed to use more E85 when cold starting to offset the fuel's lower volatility, resulting in more NMOG emissions before the catalyst warms up. This is consistent with expectations and the observations of vehicle operators who noted the smell of alcohol was present at times especially during cold starts (see Section VII). The fact that the emissions are greater than the NMOG standard is something that should be investigated more thoroughly.

The SC03 and US06 results show that all three vehicles met the applicable emissions standards for NMHC + NO_x and CO on gasoline certification fuel. They were lower than the emission standards for NMHC + NO_x and CO on all other tested fuels as well.

Overall, E85 had a greater compliance margin than gasoline for the SFTP standards, especially for CO.

The air toxics benzene, 1,3-butadiene, formaldehyde, and acetaldehyde are products of incomplete combustion; benzene can also pass through the engine uncombusted as it is present in the fuel. These results show that emissions of benzene and 1,3-butadiene were greater on the predominantly hydrocarbon fuels (CaRFG3, E10, and Cert 2) than on E85. The reverse was true for formaldehyde and acetaldehyde – emissions were greater on E85. Acetaldehyde emissions in particular were many times greater on E85. These results support well established beliefs about emissions of air toxics from the various fuel types.

Mirroring the weighted FTP NMOG results, E85-ARB had noticeably higher emissions of air toxics than E85-Chevron on both vehicle #25 and vehicle #26. Out of all the vehicle emissions testing, the difference in emissions from the two sources of E85 is the single most striking result.

The question is often asked, which fuel has less emissions, gasoline or E85? There is no clear cut answer. In general, the results show that there are tradeoffs of between the two fuels. This is true for both the regulated emissions, as well as air toxics compounds. Emissions standards are the same for both types of fuel. Excepting NMOG emissions on E85, the regulated emissions testing results meet the applicable standards for both types of fuel. A review of California certification data for 2008 and 2009 model year FFVs found that, while differences were slight, emissions of CO and NO_x tended to be less on E85 than on gasoline, while emissions of NMOG tended to be greater on E85 than on gasoline.[12]

Given the high NMOG emissions on E85 relative to the applicable standards, consideration was given to the possibility that insufficient mileage was accumulated between changes in fuel types to allow for the fuel trim to properly adapt. Tests were arranged in successive order and the number of miles between each test run was calculated, as shown in Tables 9.12, 9.13, and 9.14. If the fuel trim were off, there would be trends of decreasing emissions with time. No such trends were apparent.

No appreciable difference in emissions was apparent between vehicle #16 and vehicle #25. This suggests that the vehicles aged similarly despite the different refueling histories.

Finally, no surprises were seen with the results from any of the 50/50 blend testing. As might be expected, results were mostly midway between E85 and CaRFG3.

Table 9.2 Vehicle #16 2006 Impala LS Sedan Fuel Properties

Fuel Code		**EN06**	**GN19**	**GC01**
Batch		**1**	**3**	**10**
Sample		**1**	**1**	**1**
Name		**E85-ARB**	**CaRFG3**	**Cert 2**
Property	**Method**			
Aromatics, vol%	ASTM D5580	4.1	19	23.9
Multi-sub Alkyl Arom HC, vol%	CARB DHA	-	-	13.68
Benzene, vol%	ASTM D5580	0.11	0.55	0.84
Olefin, vol%	ASTM 6550	-	6.5	5.2
MTBE, vol%	ASTM 4815-94	-		11.07
Ethanol, wt%	ASTM 4815-94	83.4	6.01	-
Oxygen, wt%	ASTM 4815-94	29.3	2.09	2.04
Sulfur, ppm	ASTM 5453	16	18	33
RVP, psi	ASTM D5191	7.99	7.08	6.35
T10, F	ASTM D86	164	133	144
T50, F	ASTM D86	171	214	209
T90, F	ASTM D86	173	309	295
End Point, F	ASTM D86	177	-	-
Distillation loss	ASTM D86	0.7	-	-
Distillation residue	ASTM D86	1.3	-	-
Cu corrosion, 50C, 3h	ASTM D130	3	-	-
Gum washed, mg/100 ml	ASTM D381	1.5	-	-
Carbon, wt%		57.3	83.8	84.1
Hydrogen, wt%		13.4	14.11	13.86

Table 9.3 Vehicle #25 2006 Impala LS Sedan 7003506 Fuel Properties

Fuel Code		**EN06**	**EN06**	**EN06**	**GN19**	**EN07**	**GC01**
Batch		**1**	**2**	**3**	**5**	**1**	**10**
Sample		**1**	**1**	**1**	**1**	**1**	**1**
Name		**E85-ARB**	**E85-Chevron**	**50/50**	**CaRFG3**	**E10**	**Cert 2**
Property	**Method**						
Aromatics, vol%	ASTM D5580	4.1	2.25	9.33	17.56	31.47	23.9
Multi-sub Alkyl Arom HC, vol%	CARB DHA	-	-	-	-	-	13.68
Benzene, vol%	ASTM D5580	0.11	0.1	0.28	0.5	0.35	0.84
Olefin, vol%	ASTM 6550	-	-	-	5.3	1.8	5.2
MTBE, vol%	ASTM 4815-94	-	-	-	0	-	11.07
Ethanol, wt%	ASTM 4815-94	83.4	83.73	49.31	5.97	10.78	-
Oxygen, wt%	ASTM 4815-94	29.3	29.06	17.11	2.08	3.74	2.04
Sulfur, ppm	ASTM 5453	16	6	9.7	10	24	33
RVP, psi	ASTM D5191	7.99	7.11	6.96	6.9	8.15	6.35
T10, F	ASTM D86	164	155	139	135	130	144
T50, F	ASTM D86	171	171	165	206	221	209
T90, F	ASTM D86	173	172	174	308	302	295
End Point, F	ASTM D86	177	-	-	-	-	-
Distillation loss	ASTM D86	0.7	-	-	-	-	-
Distillation residue	ASTM D86	1.3	-	-	-	-	-
Cu corrosion, 50C, 3h	ASTM D130	3	-	-	-	-	-
Gum washed, mg/100 ml	ASTM D381	1.5	-	-	-	-	-
Carbon, wt%		57.3	56.84	69.22	83.72	83.15	84.1
Hydrogen, wt%		13.4	14.10	13.67	14.20	13.11	13.86

Table 9.4 Vehicle #26 2007 K1500 Silverado Pickup Truck 7003538 Fuel Properties

Fuel Code		**EN06**	**EN06**	**EN06**	**GN19**	**GC01**
Batch		**1**	**2**	**3**	**6**	**10**
Sample		**1**	**1**	**2**	**1**	**1**
Name		**E85-ARB**	**E85-Chevron**	**50/50**	**CaRFG3**	**Cert 2**
Property	**Method**					
Aromatics, vol%	ASTM D5580	4.1	2.25	11.95	22.67	23.9
Multi-sub Alkyl Arom HC, vol%	CARB DHA	-	-	-	-	13.68
Benzene, vol%	ASTM D5580	0.11	0.1	0.29	0.53	0.84
Olefin, vol%	ASTM 6550	-	-	-	-	5.2
MTBE, vol%	ASTM 4815-94	-	-	-	-	11.07
Ethanol, wt%	ASTM 4815-94	83.4	83.73	50.13	6.08	-
Oxygen, wt%	ASTM 4815-94	29.3	29.06	17.46	2.11	2.04
Sulfur, ppm	ASTM 5453	16	6	7.6	10	33
RVP, psi	ASTM D5191	7.99	7.11	7.27	6.83	6.35
T10, F	ASTM D86	164	155	142	134	14430
T50, F	ASTM D86	171	171	167	212	209
T90, F	ASTM D86	173	172	242	316	295
End Point, F	ASTM D86	177	-	-	-	-
Distillation loss	ASTM D86	0.7	-	-	-	-
Distillation residue	ASTM D86	1.3	-	-	-	-
Cu corrosion, 50C, 3h	ASTM D130	3	-	-	-	-
Carbon, wt%		57.3	56.84	68.75	83.94	84.1
Hydrogen, wt%		13.4	14.10	13.79	13.95	13.86

Table 9.5 Summary of Emissions Test Results Compared to Applicable Emissions Standards, Vehicle #16 2006 Impala LS Sedan (grams/mile)

Name	California				Federal					
	NMOG	CO	NO_x	Formaldehyde	$NMHC+NO_x$	CO	$NMHC+NO_x$	CO	$NMHC+NO_x$	CO
	EC1	EC1	EC1	EC1	composite	composite	US06	US06	SC03	SC03
	@ 50K miles				SFTP @ 4K miles					
Standard	0.100	3.4	0.14	0.015	-	-	0.14	8.0	0.20	2.7
E85-ARB	0.116	1.0	0.01	0.002	-	-	0.03	0.5	0.02	1.0
CaRFG3	0.020	1.1	0.01	0.001	-	-	0.04	0.9	0.03	1.6
Cert 2	0.028	1.4	0.01	0.001	-	-	0.06	1.2	0.03	2.2
					SFTP @ UL					
Standard					0.71	-	-	11.1	-	3.7
E85-ARB					0.03	-	-	0.5	-	1.0
CaRFG3					0.03	-	-	0.9	-	1.6
Cert 2					0.04	-	-	1.2	-	2.2
					Note: SFTP composite = (0.35 x FTP) + (0.28 x US06) + (0.37 x SC03)					

Table 9.6 Summary of Emissions Test Results Compared to Applicable Emissions Standards, Vehicle #25 2006 Impala LS Sedan 7003506 (grams/mile)

Name	California				Federal					
	NMOG	CO	NO_x	Formaldehyde	$NMHC+NO_x$	CO	$NMHC+NO_x$	CO	$NMHC+NO_x$	CO
	EC1	EC1	EC1	EC1	composite	composite	US06	US06	SC03	SC03
	@ 50K miles				SFTP @ 4K miles					
Standard	0.100	3.4	0.14	0.015	-	-	0.14	8.0	0.20	2.7
E85-ARB	0.153	1.5	0.05	0.002	-	-	0.06	0.3	0.03	0.3
E85-Chevron	0.057	1.0	0.03	0.001			0.04	0.3	0.02	0.3
50/50	0.028	0.9	0.02	0.001			0.05	0.3	0.02	0.3
CaRFG3	0.029	1.1	0.02	0.001	-	-	0.05	0.7	0.02	0.9
E10	0.036	1.2	0.03	0.001			0.06	0.7	0.04	0.8
Cert 2	0.035	1.4	0.02	0.001	-	-	0.07	1.1	0.07	1.3
					SFTP @ UL					
Standard					0.71	-	-	11.1	-	3.7
E85-ARB					0.06	-	-	0.3	-	0.3
E85-Chevron					0.04			0.3		0.3
50/50					0.04			0.3		0.3
CaRFG3					0.04	-	-	0.7	-	0.9
E10					0.05			0.7		0.8
Cert 2					0.06	-	-	1.1	-	1.3
					Note: SFTP composite = (0.35 x FTP) + (0.28 x US06) + (0.37 x SC03)					

Table 9.7 Summary of Emissions Test Results Compared to Applicable Emissions Standards, Vehicle #26 2007 K1500 Silverado Pickup Truck 7003538 (grams/mile)

Name	**California**				**Federal**					
	NMOG	**CO**	**NO_x**	**Formaldehyde**	**$NMHC+NO_x$**	**CO**	**$NMHC+NO_x$**	**CO**	**$NMHC+NO_x$**	**CO**
	EC1	**EC1**	**EC1**	**EC1**	**composite**	**composite**	**US06**	**US06**	**SC03**	**SC03**
	@ 50K miles				**SFTP @ 4K miles**					
Standard	0.075	3.4	0.05	0.015	-	-	0.4	10.5	0.31	3.5
E85-ARB	0.093	2.0	0.00	0.002	-	-	0.02	2.0	0.01	1.4
E85-Chevron	0.086	2.0	0.00	0.002			0.02	2.4	0.00	1.1
50/50	0.040	1.7	0.01	0.001			0.02	2.1	0.01	1.5
CaRFG3	0.028	1.4	0.01	0.000	-	-	0.02	3.6	0.02	1.7
Cert 2	0.036	1.7	0.01	0.000	-	-	0.02	2.7	0.03	1.8
					SFTP @ UL					
Standard					0.99	-	-	16.9	-	5.6
E85-ARB					0.02	-	-	2.0	-	1.4
E85-Chevron					0.02			2.4		1.1
50/50					0.02			2.1		1.5
CaRFG3					0.03	-	-	3.6	-	1.7
Cert 2					0.03	-	-	2.7	-	1.8
					Note: SFTP composite = (0.35 x FTP) + (0.28 x US06) + (0.37 x SC03)					

Table 9.8 Weighted FTP Results of Selected Air Toxics Compounds (mg/mile)

	Benzene	1,3-Butadiene	Formal-dehyde	Acetal-dehyde	Ethanol	MTBE	NMHC	NMOG
	Vehicle #16 2006 Impala LS Sedan							
E85-ARB	0.97	0.05	1.56	13.01	67.09	0.00	33.30	115.54
CaRFG3	1.02	0.15	0.52	0.36	0.00	0.00	18.24	19.73
Cert 2	1.66	0.14	0.65	0.18	0.00	0.57	25.47	27.56
	Vehicle #25 2006 Impala LS Sedan 7003506							
E85-ARB	1.20	0.06	1.70	14.46	96.27	<L	39.36	153.18
E85-Chevron	0.39	0.04	1.12	8.20	28.94	<L	18.34	57.25
50/50	0.78	0.12	0.73	2.66	4.91	<L	19.81	28.32
CaRFG3	1.31	0.21	0.57	0.42	0.98	<L	25.54	28.56
E10	2.00	0.14	0.52	0.58	0.44	<L	33.24	35.69
Cert 2	2.08	0.16	0.56	0.19	<L	0.38	33.04	34.94
	Vehicle #26 2007 K1500 Silverado Pickup Truck 7003538							
E85-ARB	0.87	0.87	1.75	11.92	49.83	<L	26.50	93.00
E85-Chevron	0.71	0.71	1.78	11.33	46.67	<L	25.40	86.04
50/50	1.08	1.08	0.66	3.34	11.23	<L	24.63	40.15
CaRFG3	1.27	1.27	0.49	0.56	0.39	<L	26.73	28.48
Cert 2	1.95	1.95	0.41	0.28	<L	0.86	33.83	35.82

Note: <L = less than level of detection, for averages <L assumed to be = 0

Table 9.9 US06 Results of Selected Air Toxics Compounds (mg/mile)

	Benzene	1,3-Butadiene	Formal-dehyde	Acetal-dehyde	Ethanol	MTBE	NMHC	NMOG
	Vehicle #16 2006 Impala LS Sedan							
E85-ARB	3.88	0.02	0.07	0.49	0.00	0.00	6.70	7.31
CaRFG3	8.90	0.29	0.01	0.17	19.14	0.00	24.67	64.04
Cert 2	17.15	0.37	0.00	0.06	0.00	0.14	41.24	41.74
	Vehicle #25 2006 Impala LS Sedan 7003506							
E85-ARB	0.31	<L	0.14	0.81	<L	<L	6.49	7.41
E85-Chevron	0.28	0.06	0.16	0.79	4.31	<L	7.81	12.80
50/50	0.71	0.13	0.22	0.36	<L	<L	16.67	17.28
CaRFG3	1.89	0.28	0.09	0.10	<L	<L	30.81	31.03
E10	1.93	0.25	0.07	0.12	2.99	<L	29.52	30.75
Cert 2	2.46	0.25	0.08	0.04	<L	0.29	38.54	39.10
	Vehicle #26 2007 K1500 Silverado Pickup Truck 7003538							
E85-ARB	0.52	0.06	0.01	0.54	<L	<L	7.70	9.65
E85-Chevron	0.45	0.06	0.16	0.34	<L	<L	6.77	7.36
50/50	0.89	0.14	0.07	0.16	<L	<L	10.82	11.15
CaRFG3	1.17	0.19	<L	0.50	<L	<L	13.04	13.52
Cert 2	1.57	0.22	<L	0.46	<L	<L	16.81	17.36

Note: <L = less than level of detection, for averages <L assumed to be = 0

Table 9.10 SC03 Results of Selected Air Toxics Compounds (mg/mile)

	Benzene	1,3-Butadiene	Formal-dehyde	Acetal-dehyde	Ethanol	MTBE	NMHC	NMOG
	Vehicle #16 2006 Impala LS Sedan							
E85-ARB	0.22	0.00	0.12	0.04	0.00	0.00	4.44	5.34
CaRFG3	1.11	0.00	0.06	0.04	0.00	0.00	13.26	14.98
Cert 2	1.82	0.02	0.09	0.05	0.00	0.00	23.72	26.23
	Vehicle #25 2006 Impala LS Sedan 7003506							
E85-ARB	0.14	<L	0.32	0.17	<L	<L	2.59	3.18
E85-Chevron	0.10	<L	0.15	0.16	<L	<L	3.72	3.96
50/50	0.24	<L	0.24	0.10	<L	<L	6.01	6.34
CaRFG3	0.45	<L	0.06	0.03	11.17	<L	12.69	17.62
E10	1.83	<L	0.15	0.07	<L	<L	33.97	34.09
Cert 2	3.04	0.38	0.05	0.07	<L	0.40	47.03	47.79
	Vehicle #26 2007 K1500 Silverado Pickup Truck 7003538							
E85-ARB	0.26	<L	0.05	0.39	<L	<L	3.93	9.39
E85-Chevron	0.17	<L	0.07	0.45	<L	<L	2.91	3.50
50/50	0.80	<L	0.02	0.14	<L	<L	9.50	9.66
CaRFG3	1.32	0.08	0.03	0.31	<L	<L	15.71	16.00
Cert 2	2.08	0.10	0.04	0.05	<L	0.13	23.71	24.08

Note: <L = less than level of detection, for averages <L assumed to be = 0

Table 9.11 Selected Gasoline Certification Fuel, Denatured Ethanol, and E85 Certification Fuel Specifications[1]

	Gasoline Certification Fuel		**Denatured Ethanol[2]**		**E85 Certification Fuel**	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**
Ethanol[3], vol%			**92.1**	*98.04*	*72.8*	*83.33*
Certification gasoline, vol%					**15**	**21**
MTBE[4], vol%	**10.8**	**11.2**			*1.6*	*2.4*
Aromatics, vol%	**22**	**25**	*0.0*	**1.7**	*3.3*	*6.5*
Multi-substituted alkyl aromatic HC, vol[4]%	**12**	**14**			*2*	*3*
Benzene, vol %	**0.8**	**1.0**	*0.00*	**0.06**	*0.12*	*0.25*
Olefins, vol%	**4.0**	**6.0**	*0.0*	**0.5**	*0.6*	*1.6*
Sulfur, ppm	**30**	**40**	*0*	**10**	*5*	*16*
RVP, psi	**6.7**	**7.0**			**8.0**	**8.5**
Gum, washed, mg/100 ml	*0.0*	**3.0**	*0.0*	**5.0**	*0.0*	*4.6*

Notes:

1. Specified values shown in bold, calculated values shown in italic.
2. From 13 CCR 2262.9.
3. Gasoline certification fuel value assumed to be 0.
4. Denatured ethanol values assumed to be 0.

Table 9.12 Vehicle Emissions Testing, Vehicle #16 2006 Impala LS Sedan

Test ID	Start Odometer (mi)	Calc. End Odometer (mi)	Calc. Between Tests (mi)	Fuel	Driving Cycle	NMHC (mg/mi)	NMOG (mg/mi)	NMOG Standard (mg/mi)
1018259	5221	5232		CaRFG3	EC1	16.11	17.49	100
1018195	5232	5240	0	CaRFG3	US90	23.65	23.97	
1018194	5248	5252	8	CaRFG3	SCDL	9.80	9.99	
1018295	5270	5281	18	CaRFG3	EC1	16.46	18.38	100
1018357	5289	5300	8	CaRFG3	EC1	20.10	21.29	100
1018453	5310	5321	10	CaRFG3	EC1	14.39	15.40	100
1018454	5321	5329	0	CaRFG3	US90	25.69	104.10	
1018455	5337	5341	8	CaRFG3	SCDL	17.63	17.70	
1018457	5352	5363	11	CaRFG3	EC1	24.15	26.07	100
1018459	5363	5371	0	CaRFG3	US90			
1018458	5379	5383	8	CaRFG3	SCDL	12.34	17.26	
1018493	5445	5456	**62**	Cert 2	EC1	23.23	25.48	100
1018494	5456	5464	0	Cert 2	US90	34.34	34.73	
1018495	5478	5482	14	Cert 2	SCDL	22.15	22.49	
1018499	5492	5503	10	Cert 2	EC1	32.95	34.82	100
1018500	5503	5511	0	Cert 2	US90			
1018501	5519	5523	8	Cert 2	SCDL	26.17	33.26	
1018513	5534	5545	11	Cert 2	EC1	18.68	21.19	100
1018593	5561	5572	16	Cert 2	EC1	27.01	28.75	100
1018662	5587	5598	15	Cert 2	EC1			100
1018641	5598	5606	0	Cert 2	US90	48.14	48.75	
1018640	*5614*	5618	8	Cert 2	SCDL	22.84	22.94	
1018895	5679	5690	**61**	E85-ARB	EC1	27.88	82.57	100
1018897	5690	5690	0	E85-ARB	US90			
1018896	5706	5710	16	E85-ARB	SCDL	7.05	7.40	
1018907	5728	5739	18	E85-ARB	EC1	30.01	97.57	100
1018909	5739	5747	0	E85-ARB	US90	8.48	9.31	

Table 9.12 Vehicle Emissions Testing, Vehicle #16 2006 Impala LS Sedan

Test ID	Start Odometer (mi)	Calc. End Odometer (mi)	Calc. Between Tests (mi)	Fuel	Driving Cycle	NMHC (mg/mi)	NMOG (mg/mi)	NMOG Standard (mg/mi)
1018908	5755	5759	8	E85-ARB	SCDL	3.61	6.51	
1018921	5770	5781	11	E85-ARB	EC1	34.39	121.07	100
1018922	5781	5789	0	E85-ARB	US90	5.83	6.64	
1018923	5797	5801	8	E85-ARB	SCDL	3.63	4.00	
1018929	5812	5823	11	E85-ARB	EC1			100
1018932	5823	5831	0	E85-ARB	US1B	5.79	5.97	
1018933	5839	5843	8	E85-ARB	SC1B	3.45	3.46	
1018957	5854	5865	11	E85-ARB	EC1	38.40	153.67	100
1019037	5876	5887	11	E85-ARB	EC1	35.82	122.85	100

Note: Estimated values in italics.

Table 9.13 Vehicle Emissions Testing, Vehicle #25 2006 Impala LS Sedan 7003506

Test ID	Start Odometer (mi)	Calc. End Odometer (mi)	Calc. Between Tests (mi)	Fuel	Driving Cycle	NMHC (mg/mi)	NMOG (mg/mi)	NMOG Standard (mg/mi)
1020654	29547	29558		E85-ARB	EC1	40.96	149.57	100
1020628	29558	29566	0	E85-ARB	US1B	8.05	9.33	
1020629	29574	29578	8	E85-ARB	SC1B	2.64	3.28	
1020718	29616	29627	38	E85-ARB	EC1	30.03	116.03	100
1020668	29627	29635	0	E85-ARB	US1B	6.65	7.41	
1020669	29643	29647	8	E85-ARB	SC1B	2.63	3.42	
1020723	29657	29668	10	E85-ARB	EC1	47.09	193.95	100
1020724	29677	29685	9	E85-ARB	US1B	4.77	5.48	
1020725	29693	29697	8	E85-ARB	SC1B	2.50	2.83	
1020767	29760	29771	**63**	E85-Chevron	EC1	17.76	58.38	100
1020769	29771	29779	0	E85-Chevron	US1B	8.09	9.12	
1020768	29787	29791	8	E85-Chevron	SC1B	4.27	4.55	
1020795	29801	29812	10	E85-Chevron	EC1	18.59	55.84	100
1020797	29812	29820	0	E85-Chevron	US1B	9.17	12.91	
1020796	29828	29832	8	E85-Chevron	SC1B	4.58	4.83	
1020811	29843	29854	11	E85-Chevron	EC1	18.67	57.54	100
1020813	29854	29862	0	E85-Chevron	US1B	6.18	16.37	
1020812	29870	29874	8	E85-Chevron	SC1B	2.31	2.50	
1020836	29935	29946	**61**	50/50	EC1	19.04	27.01	100
1020839	29946	29954	0	50/50	US1B	20.43	21.33	
1020837	29962	29966	8	50/50	SC1B	8.12	8.50	
1020852	29977	29988	11	50/50	EC1	20.22	27.94	100
1020854	29988	29996	0	50/50	US1B			
1020853	30004	30008	8	50/50	SC1B			
1020877	30018	30029	10	50/50	EC1	20.16	30.01	100
1020879	30029	30037	0	50/50	US1B	12.91	13.23	
1020878	30045	30049	8	50/50	SC1B	3.90	4.18	

Table 9.13 Vehicle Emissions Testing, Vehicle #25 2006 Impala LS Sedan 7003506

Test ID	Start Odometer (mi)	Calc. End Odometer (mi)	Calc. Between Tests (mi)	Fuel	Driving Cycle	NMHC (mg/mi)	NMOG (mg/mi)	NMOG Standard (mg/mi)
1020883	30064	30075	15	50/50	UC	255.18	353.28	
1020901	30078	30089	3	50/50	UC	278.16	419.24	
1020988	30126	30137	37	50/50	UC	255.02	375.19	
1021081	30195	30206	**58**	E85-ARB	UC	415.84	1349.45	
1021123	30213	30224	7	E85-ARB	UC	518.48	1550.84	
1021144	30232	30243	8	E85-ARB	UC	450.06	1563.41	
1021232	30301	30312	**58**	E85-Chevron	UC	263.45	778.20	
1021239	30319	30330	7	E85-Chevron	UC	238.12	671.25	
1021248	30338	30349	8	E85-Chevron	UC	260.00	757.38	
1021287	30409	30420	**60**	CaRFG3	EC1	26.05	27.14	100
1021289	30420	30428	0	CaRFG3	US1B	32.90	33.20	
1021288	30439	30443	11	CaRFG3	SC1B	13.25	13.32	
1021311	30454	30465	11	CaRFG3	EC1	25.63	30.54	100
1021312	30465	30473	0	CaRFG3	US1B	32.64	32.79	
1021313	30481	30485	8	CaRFG3	SC1B	9.41	9.45	
1021369	30510	30521	25	CaRFG3	EC1	24.94	27.99	100
1021329	30521	30529	0	CaRFG3	US1B	26.89	27.11	
1021328	30537	30541	8	CaRFG3	SC1B	15.40	30.10	
1021387	*30552*	30563	11	CaRFG3	UC	378.13	390.46	
1021394	30570	30581	7	CaRFG3	UC	248.21	287.97	
1021427	30588	30599	7	CaRFG3	UC	284.26	312.22	
1021450	30658	30669	**59**	E10	EC1	31.85	35.71	100
1021452	30669	30677	0	E10	US1B	29.51	29.73	
1021451	30685	30689	8	E10	SC1B	27.81	27.87	
1021471	30700	30711	11	E10	EC1	22.13	23.29	100
1021473	30711	30719	0	E10	US1B	32.36	32.57	
1021472	30727	30731	8	E10	SC1B	49.27	49.46	

Table 9.13 Vehicle Emissions Testing, Vehicle #25 2006 Impala LS Sedan 7003506

Test ID	Start Odometer (mi)	Calc. End Odometer (mi)	Calc. Between Tests (mi)	Fuel	Driving Cycle	NMHC (mg/mi)	NMOG (mg/mi)	NMOG Standard (mg/mi)
1021492	30741	30752	10	E10	EC1	31.09	33.38	100
1021494	30752	30760	0	E10	US1B	26.68	29.94	
1021493	30768	30772	8	E10	SC1B	24.84	24.94	
1021554	30783	30794	11	E10	EC1	24.48	27.52	100
1021630	30852	30863	58	E10	EC1	22.85	27.55	100
1021673	30871	30882	8	E10	EC1	33.71	35.36	100
1021734	30889	30900	7	E10	EC1	65.44	66.85	100
1021797	30908	30919	8	E10	EC1	34.40	35.83	100
1021854	30926	30937	7	E10	UC	345.76	363.18	
1021872	30945	30956	8	E10	UC	479.29	497.18	
1021893	30963	30974	7	E10	UC	457.94	475.59	
1021934	31032	31043	**58**	Cert 2	EC1	40.34	42.04	100
1021936	31043	31051	0	Cert 2	US1B			
1021935	31059	31063	8	Cert 2	SC1B	40.96	41.93	
1021952	31074	31085	11	Cert 2	EC1	28.53	30.55	100
1021954	31085	31093	0	Cert 2	US1B	48.61	49.13	
1021953	31101	31105	8	Cert 2	SC1B	28.49	29.06	
1021960	31116	31127	11	Cert 2	EC1	30.26	32.24	100
1021962	31127	31127	0	Cert 2	US1B	28.47	29.07	
1021961	31143	31147	16	Cert 2	SC1B	71.64	72.38	
1021971	31157	31168	10	Cert 2	UC	333.48	361.18	
1021993	31176	31187	8	Cert 2	UC	402.46	425.32	
1022014	31194	31205	7	Cert 2	UC	378.90	398.67	

Note: Estimated values in italics.

Table 9.14 Vehicle Emissions Testing, Vehicle #26 2007 K1500 Silverado Pickup Truck 7003538

Test ID	Start Odometer (mi)	Calc. End Odometer (mi)	Calc. Between Tests (mi)	Fuel	Driving Cycle	NMHC (mg/mi)	NMOG (mg/mi)	NMOG Standard (mg/mi)
1022113	25378	25378		E85-ARB	EC1			75
1022115	25390	25398	12	E85-ARB	US1B	8.96	10.22	
1022114	25406	25410	8	E85-ARB	SC1B	4.78	19.53	
1022127	25421	25421	11	E85-ARB	EC1			75
1022129	25432	25440	11	E85-ARB	US1B	7.34	7.89	
1022128	25448	25452	8	E85-ARB	SC1B	4.39	5.90	
1022163	25463	25474	11	E85-ARB	EC1	26.50	93.00	75
1022165	25474	25482	0	E85-ARB	US1B	6.79	10.84	
1022164	25490	25494	8	E85-ARB	SC1B	2.63	2.75	
1022171	25505	25516	11	E85-ARB	UC	332.80	1004.62	
1022195	25524	25535	8	E85-ARB	UC			
1022210	25545	25556	10	E85-ARB	UC	324.84	940.70	
1022256	25609	25620	**53**	E85-Chevron	EC1	21.22	68.66	75
1022258	25620	25628	0	E85-Chevron	US1B	6.93	7.40	
1022257	25636	25640	8	E85-Chevron	SC1B	3.54	3.81	
1022265	25651	25662	11	E85-Chevron	EC1	24.38	93.12	75
1022267	25662	25670	0	E85-Chevron	US1B	6.11	7.01	
1022266	25678	25682	8	E85-Chevron	SC1B	3.10	4.31	
1022272	25693	25704	11	E85-Chevron	EC1	30.59	96.34	75
1022274	25703	25711	-1	E85-Chevron	US1B	7.28	7.67	
1022273	25720	25724	9	E85-Chevron	SC1B	2.08	2.37	
1022312	25735	25746	11	E85-Chevron	UC	374.03	1374.14	
1022319	25754	25765	8	E85-Chevron	UC	295.48	897.48	
1022331	25773	25784	8	E85-Chevron	UC	282.27	827.46	
1022368	25844	25855	**60**	50/50	EC1	23.09	35.68	75
1022369	25855	25863	0	50/50	US1B	12.69	12.82	
1022370	25871	25875	8	50/50	SC1B	8.66	8.74	

Table 9.14 Vehicle Emissions Testing, Vehicle #26 2007 K1500 Silverado Pickup Truck 7003538

Test ID	Start Odometer (mi)	Calc. End Odometer (mi)	Calc. Between Tests (mi)	Fuel	Driving Cycle	NMHC (mg/mi)	NMOG (mg/mi)	NMOG Standard (mg/mi)
1022376	25886	25897	11	50/50	EC1	23.11	37.46	75
1022378	25897	25905	0	50/50	US1B	9.99	10.03	
1022377	25913	25917	8	50/50	SC1B	6.02	6.10	
1022396	25928	25939	11	50/50	EC1	27.69	47.30	75
1022398	25939	25947	0	50/50	US1B	9.79	10.60	
1022397	25955	25959	8	50/50	SC1B	13.83	14.15	
1022411	*25970*	25981	11	50/50	UC			
1022433	25989	26000	8	50/50	UC	293.63	435.41	
1022452	26008	26019	8	50/50	UC	348.16	565.13	
1022536	26120	26131	**101**	CaRFG3	EC1	25.14	26.59	75
1022514	26133	26141	2	CaRFG3	US1B	11.78	11.78	
1022513	26149	26153	8	CaRFG3	SC1B	22.29	22.83	
1022552	26164	26175	11	CaRFG3	EC1	22.68	23.85	75
1022554	26175	26183	0	CaRFG3	US1B	15.17	15.77	
1022553	26191	26195	8	CaRFG3	SC1B	6.47	6.59	
1022559	26206	26217	11	CaRFG3	EC1	32.37	35.00	75
1022561	26217	26225	0	CaRFG3	US1B	12.16	13.02	
1022560	26233	26237	8	CaRFG3	SC1B	18.37	18.58	
1022572	26248	26259	11	CaRFG3	UC	500.27	542.66	
1022579	26267	26278	8	CaRFG3	UC			
1022593	26285	26296	7	CaRFG3	UC			
1022615	26304	26315	8	CaRFG3	UC	417.49	446.76	
1022693	26374	26385	**59**	Cert 2	EC1	30.37	32.66	75
1022694	26385	26393	0	Cert 2	US1B	16.01	16.10	
1022695	26402	26406	9	Cert 2	SC1B	26.66	27.00	
1022712	26416	26427	10	Cert 2	EC1	31.86	33.62	75
1022714	26426	26434	-1	Cert 2	US1B	17.36	18.30	

Table 9.14 Vehicle Emissions Testing, Vehicle #26 2007 K1500 Silverado Pickup Truck 7003538

Test ID	Start Odometer (mi)	Calc. End Odometer (mi)	Calc. Between Tests (mi)	Fuel	Driving Cycle	NMHC (mg/mi)	NMOG (mg/mi)	NMOG Standard (mg/mi)
1022713	26444	26448	10	Cert 2	SC1B	23.97	24.34	
1022733	26459	26470	11	Cert 2	EC1	39.27	41.19	75
1022735	26470	26478	0	Cert 2	US1B	12.89	13.55	
1022734	26486	26490	8	Cert 2	SC1B	16.69	17.07	
1022776	26501	26512	11	Cert 2	UC	527.18	549.08	
1022789	26520	26531	8	Cert 2	UC	492.82	515.42	
1022794	26538	26549	7	Cert 2	UC	502.48	522.93	
1022856	26549	26557	0	Cert 2	US1B	20.99	21.48	
1022855	26566	26570	9	Cert 2	SC1B	27.53	27.92	

Note: Estimated values in italics.

X. CHEVRON OIL TEST PROGRAM

A subset of 20 vehicles was selected to participate in a Chevron oil test program. This is the same subset of vehicles which were chosen for monitoring with the Davis Instruments CarChips (see Section VII).

Figure 11.1 E85 Demonstration Program Chevron test oils

A. Lubricants Evaluation

Conventional engine oils known as Passenger Car Motor Oils (PCMO) have been used in the crankcase of gasoline fired light duty engines. No particular modifications to the formulation of these motor oils have been necessary when gasoline is mixed with moderate level of oxygenates, e.g., E10 fuel. However, some engine and fleet experience have intimated that when ethanol mixture is increased, e.g., exceeding 75%, adjustments to PCMO formulations may be necessary to compensate for potentially expanded service requirements. However, these observations have been limited to situations where excessive climatic conditions and/or absence of quality control have influenced PCMO performance.

The Lubricant Evaluation component was part of the California E85 Demonstration Program to ascertain that commercially available PCMO manufactured by Chevron are appropriate for this service and meet the requirements of this application.

B. Elements of the Evaluation Program

1. Vehicles

Twenty vehicles in total were in the Engine Oil Performance Evaluation comprising two different model types; Chevrolet Impala sedans equipped with GM 3.5 liter engines and Silverado half-ton pick-trucks equipped with GM 5.3 liter engines.

2. Location

The evaluation was conducted at two separate locations at Marysville and Oakland CalTrans facilities. Three engine oils were evaluated in the E85 Demonstration Program; all three at the Oakland facility, and only one at the Marysville facility. Oakland utilized the sedan and pick-up trucks while Marysville utilized only the sedan for the evaluation.

3. Engine Oils

Three engine oil types were evaluated for potential differentiation of performance attributes between premium and conventional oil quality. The oils are listed below:

- Chevron Supreme Motor Oil SAE 5W-30 qualified for GM 6094M and API SM/EC (coded as Blue Oil)
- Havoline Synthetic Motor Oil SAE 5W-30 qualified for GM 4718M and API SM/EC (coded as Red Oil)
- Unbranded synthetic SAE 5W-30 motor oil optimized for “Alcool” use in Brazil meeting performance requirements of API SL (coded as Green Oil)

Relevant physical and chemical properties of these oils are shown in Figures 10.1 to 10.9.

4. Engine Oil Sampling

Engine oils were sampled periodically using a common suction method that collects a 4 ounce sample through the engine dipstick tube.

The sampling plan was devised in such way to provide one or two “interim” samples prior to the end engine oil service life, and one sample at the end of engine oil service life when the engine oil was drained.

All used oil samples were sent to Southwest Research Institute in San Antonio, Texas, for thorough oil analysis according to methods proscribed by ASTM and other industry conventions. The result of this analysis provides the overall picture for evaluating the performance attributes of the engine oil.

Table 10.1 shows the complete list of vehicles, their location, allocated PCMO, and the oil samples that were collected for the evaluation.

Table 10.1 Chevron Oil Test Program.

Vehicle Location	Vehicle Number	Oil Code	Vehicle Type	Date Sampled	Odometer at Sampling	Miles Since Last Drain
Marysville	7003390	Red	Impala	03/12/07	4839	4815
Marysville	7003390	Red	Impala	06/20/07	8479	**8479
Marysville	7003390	Red	Impala	10/29/07	17518	9039
Marysville	7003393	Red	Impala	02/26/07	2851	2830
Marysville	7003393	Red	Impala	06/22/07	8289	8268
Marysville	7003395	Red	Impala	02/27/07	3939	3965
Marysville	7003395	Red	Impala	06/04/07	8872	8846
Marysville	7003397	Red	Impala	02/23/07	2465	2465
Marysville	7003397	Red	Impala	07/05/07	8556	8535
Marysville	7003401	Red	Impala	02/16/07	3370	3370
Oakland	7003475	Blue	Silverado	02/20/07	3657	3657
Oakland	7003475	Blue	Silverado	06/28/07	6733	6733
Oakland	7003476	Blue	Silverado	03/01/07	2572	2572
Oakland	7003476	Blue	Silverado	04/23/07	7633	7633
Oakland	7003476	Blue	Silverado	08/06/07	14005	**6372
Oakland	7003477	Blue	Silverado	03/05/07	3403	3403
Oakland	7003478	Blue	Silverado	02/23/07	3786	3786
Oakland	7003478	Blue	Silverado	07/19/07	8330	8330
Oakland	7003479	Green	Silverado	03/20/07	3028	3028
Oakland	7003504	Green	Impala	03/01/07	6453	6453
Oakland	7003504	Green	Impala	04/01/07	6664	211
Oakland	7003504	Green	Impala	09/13/07	19925	11312
Oakland	7003505	Green	Impala	03/01/07	3098	3098
Oakland	7003505	Green	Impala	04/24/07	8613	8613
Oakland	7003511	Green	Silverado	03/01/07	1404	1404
Oakland	7003511	Green	Silverado	07/26/07	5774	**5774
Oakland	7003512	Green	Silverado	03/16/07	2496	2496
Oakland	7003514	Blue	Impala	03/01/07	8668	8668
Oakland	7003514	Blue	Impala	07/31/07	14466	5636
Oakland	7003516	Red	Impala	03/22/07	2266	2266
Oakland	7003517	Red	Impala	03/16/07	3285	3285
Oakland	7003517	Red	Impala	06/26/07	6109	6109
Oakland	7003523	Red	Silverado	03/01/07	3473	3473
Oakland	7003524	Red	Silverado	03/20/07	1020	1020
Oakland	7003526	Red	Silverado	03/13/07	4472	4472
Oakland	Fresh Oil	Green	n/a	04/27/07	n/a	0
Oakland	Fresh Oil	Red	n/a	04/27/07	n/a	0
Oakland	Fresh Oil	Blue	n/a	04/27/07	n/a	0

** Calculated information (not reported on sample bottle)

C. Overall Findings

In general, commercially available engine oils manufactured by Chevron provided the necessary expected performance in providing engine protection in this application using E85 fuel.

The E85 Demonstration Program, however, did not leverage a period of evaluation common to engine oil testing. Normally, vehicle service should be extended to 60,000 miles for obtaining six to eight drain samples at long drain intervals. Additionally, operating in extreme weather conditions could exacerbate effects of E85 fuel dilution and provide a severe background for evaluating engine oil performance.

The industry has long suspected that potentially the most deleterious effect of E85 from the engine oil perspective may be due to fuel dilution with a possibility of forming emulsions. The industry, therefore, has been formulating engine oils with an anticipation of FFV operation.

For the E85 Demonstration Program Chevron employed several methods in detecting fuel dilution in addition to the normal slate of test methods for used oil analysis. Although, overall fuel dilution increased along with engine oil service, none of the methods revealed an exacerbated level of dilution. In the end no signs of emulsion were observed during engine inspection. Additionally, the levels of fuel dilution did not stress critical engine oil attributes such as desirable viscosity or retained alkalinity. Furthermore, Chevron did not observe deposit precursors, noticeable oxidation, excessive acidity, or unexpected signs of wear as detected by used oil analysis.

All of these observations point to the necessary level of engine protection as provided by Chevron engine oil in this fleet in spite of relatively dominant use of E85.

D. Discussion of Oil Analysis

Critical used oil performance attributes are measured and the data is charted against miles accumulated on the oil to graphically present oil's performance in the particular service. These charts appear successively after this section but are discussed as follows.

Used oil viscosity is a critical measure of the oil's performance in maintaining proper flow and protection to engine components. Used oil Kinematic Viscosity is measured at 100 and 40°C as the engine oil ages with accumulating service miles. Although the three oils differ slightly in the way they maintain their viscosity characteristics, used oil data indicate that oil viscosity remains in the expected range throughout the oil's service life providing ample flow and protection.

Total Base Number (TBN) and Total Acid Number (TAN) are measures of oil's remaining alkalinity as it wards off the increasing acidity, a natural product of dilution of combustion gasses in the oil. Used oil data shows while TAN is increasing normally, the oil's TBN reserve is adequate to prevent corrosion of the engine components.

To ensure excessive fuel dilution is not occurring, four different methods for detecting fuel dilution were used to gauge presence of alcohol groups, water, and gasoline. One method in particular was adapted from the experience of Chevron technical teams in Brazil where ethanol use as fuel in the form of “Alcool” is prevalent. None of the methods revealed appreciable fuel dilution given this service application.

Finally, the most critical function of an engine lubricant is to prevent wear as measured by presence of iron particles in the used oil. Elemental analysis of the used oil samples show that while iron particles increase with oil service life, the level of wear remains significantly below alarming levels that are indicative of excessive engine wear.

Figure 10.1 Kinematic Viscosity at 100 °C

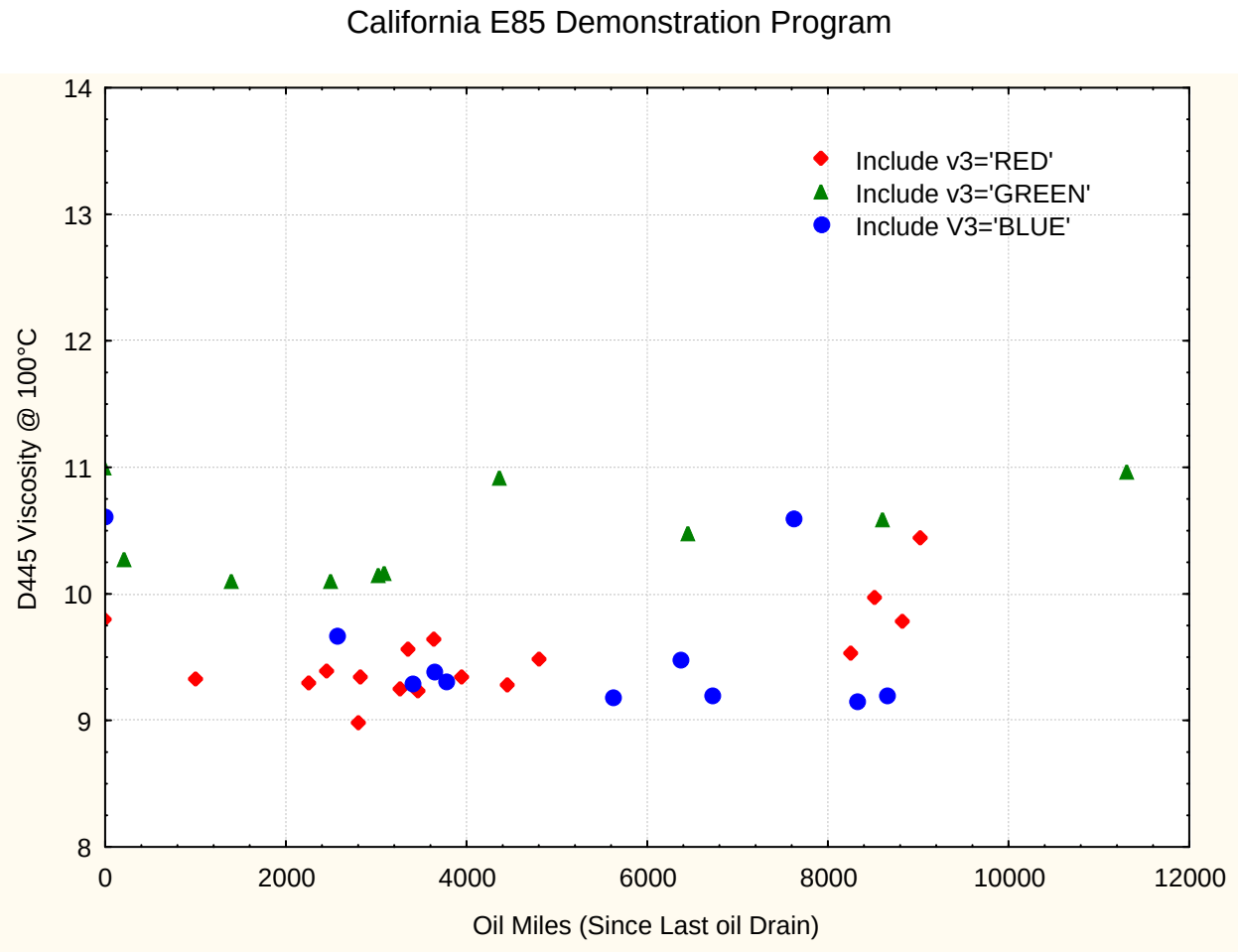


Figure 10.2 Kinematic Viscosity at 40 °C

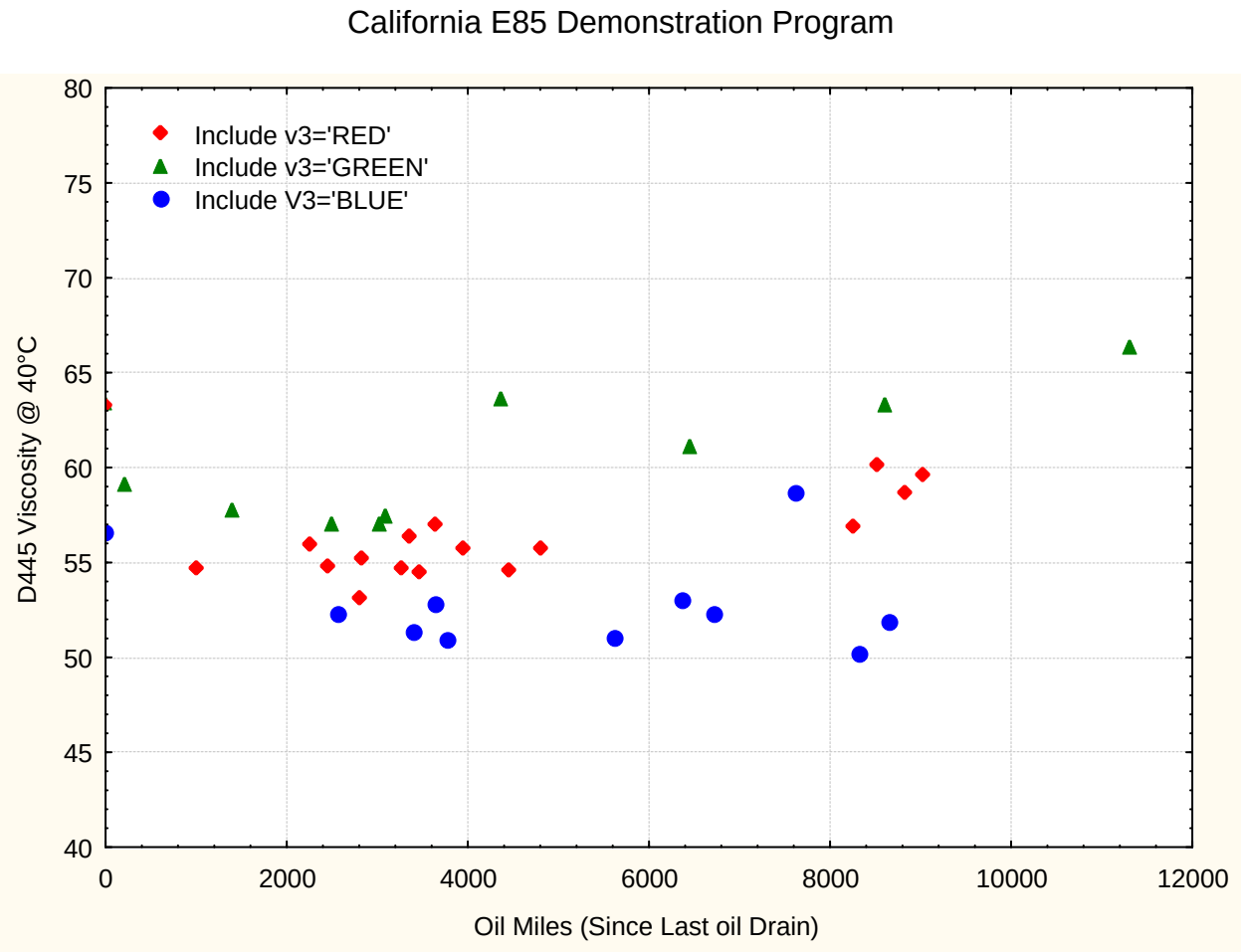


Figure 10.3 Total Base Number

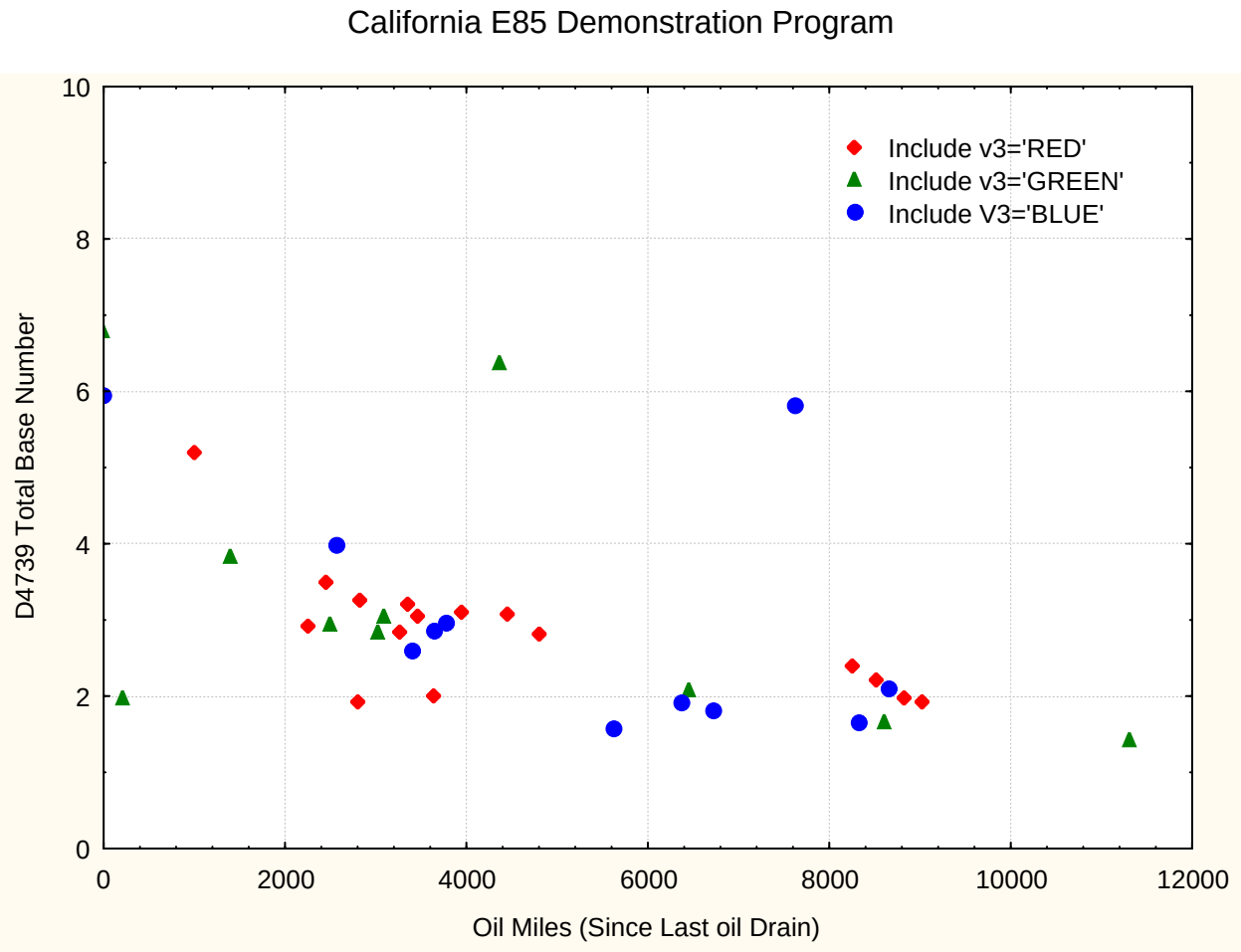


Figure 10.4 Total Acid Number

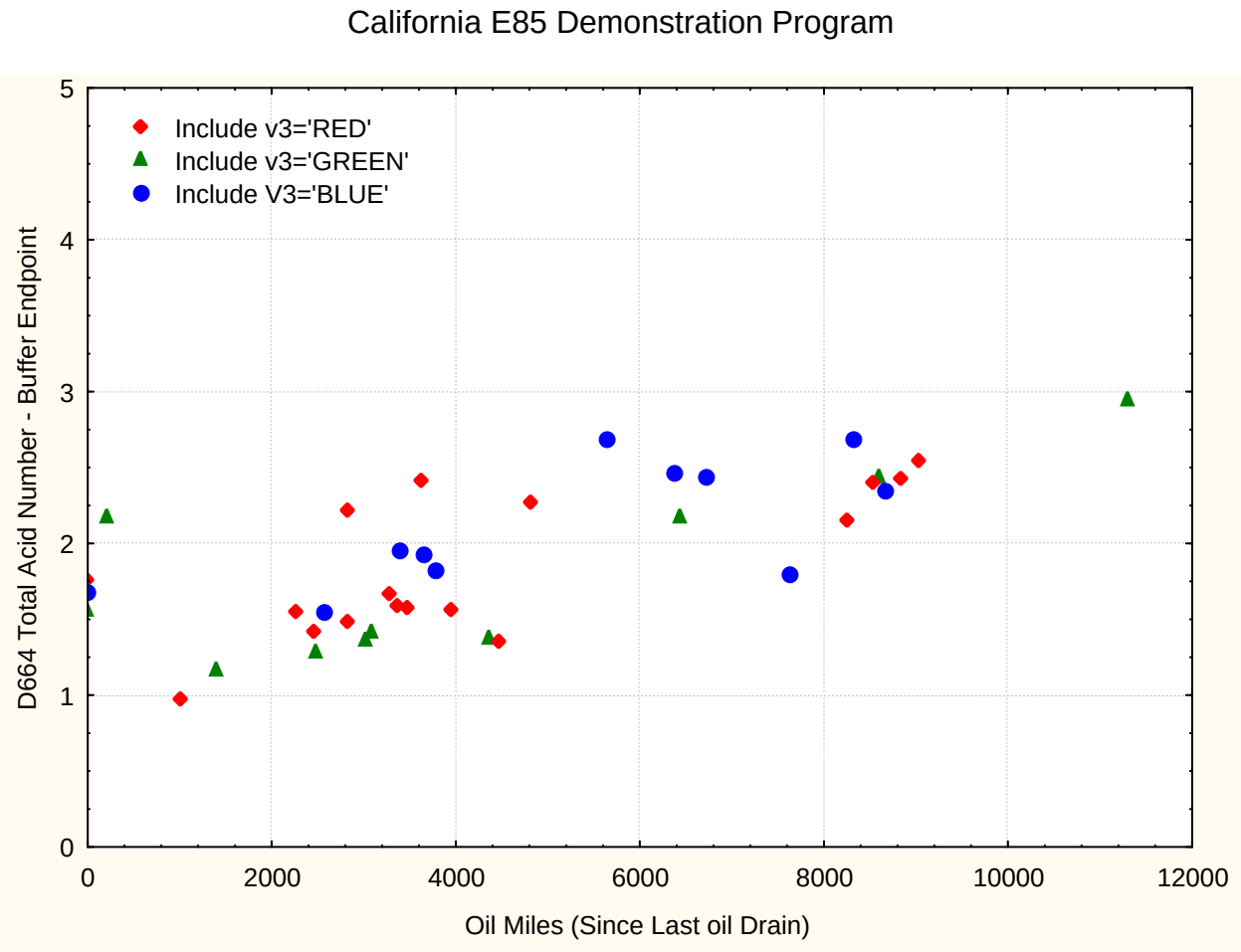


Figure 10.5 Water Dilution (%)

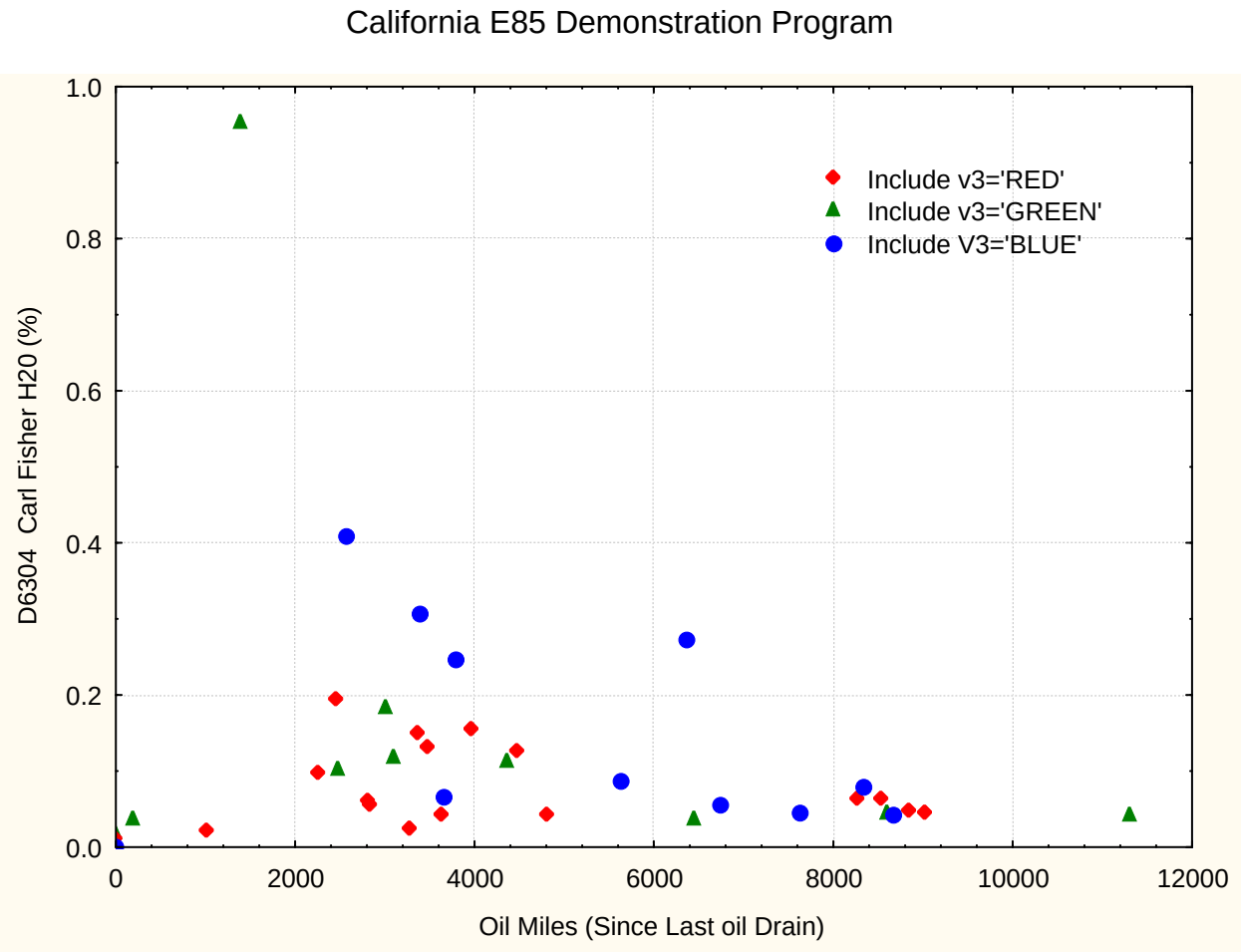


Figure 10.6 Fuel Dilution (%)

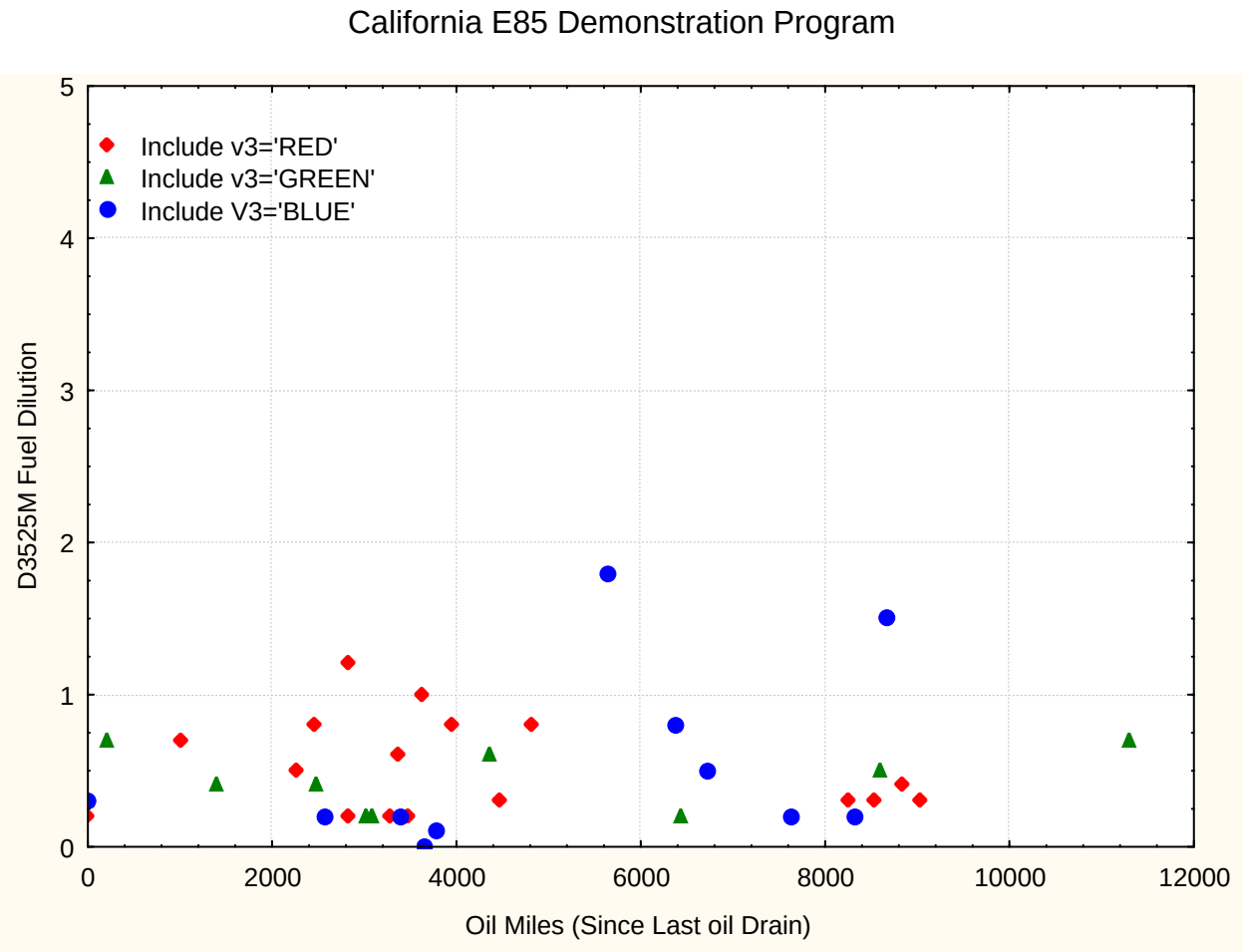


Figure 10.7 Gasoline Dilution (%)

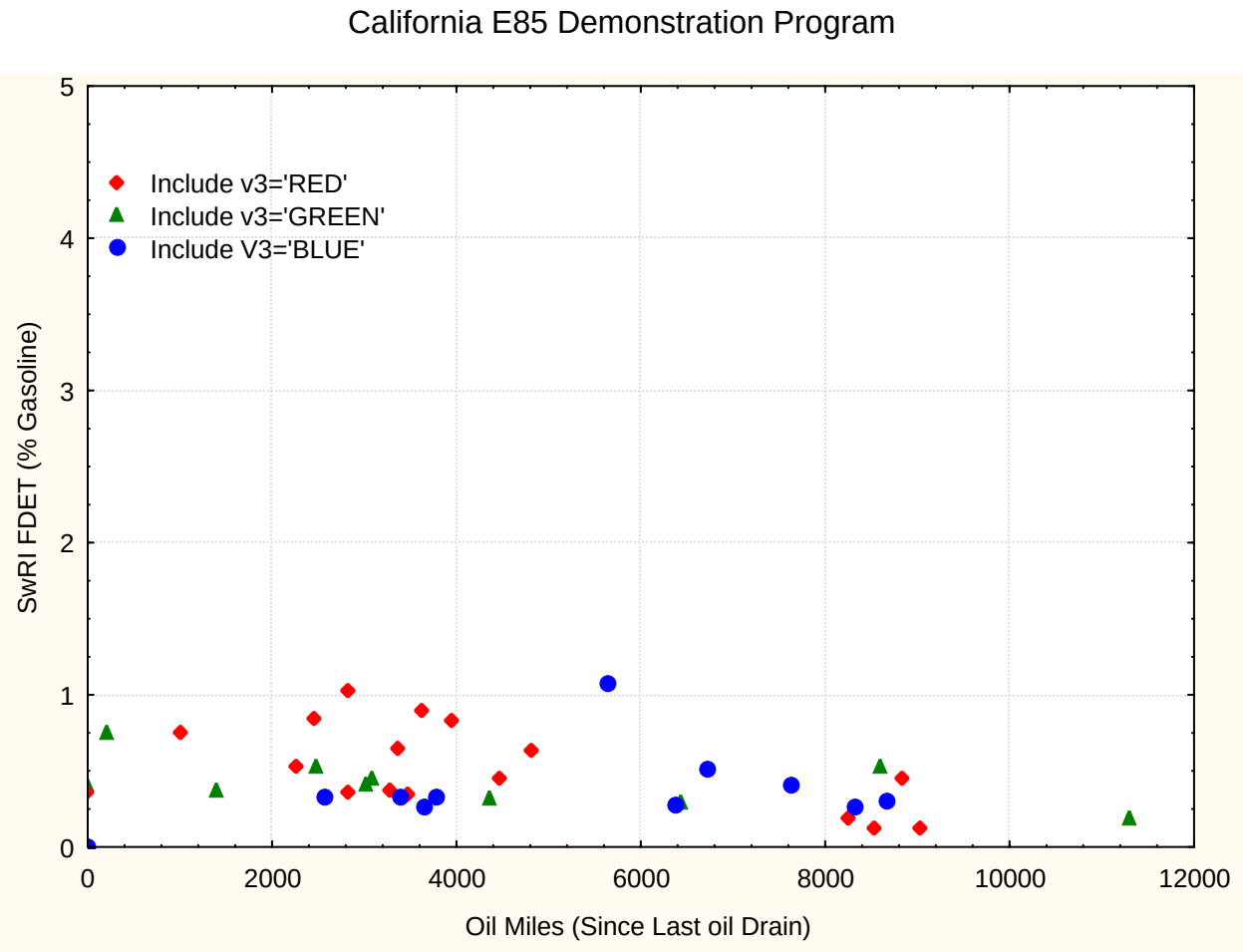


Figure 10.8 Ethanol Dilution (%)

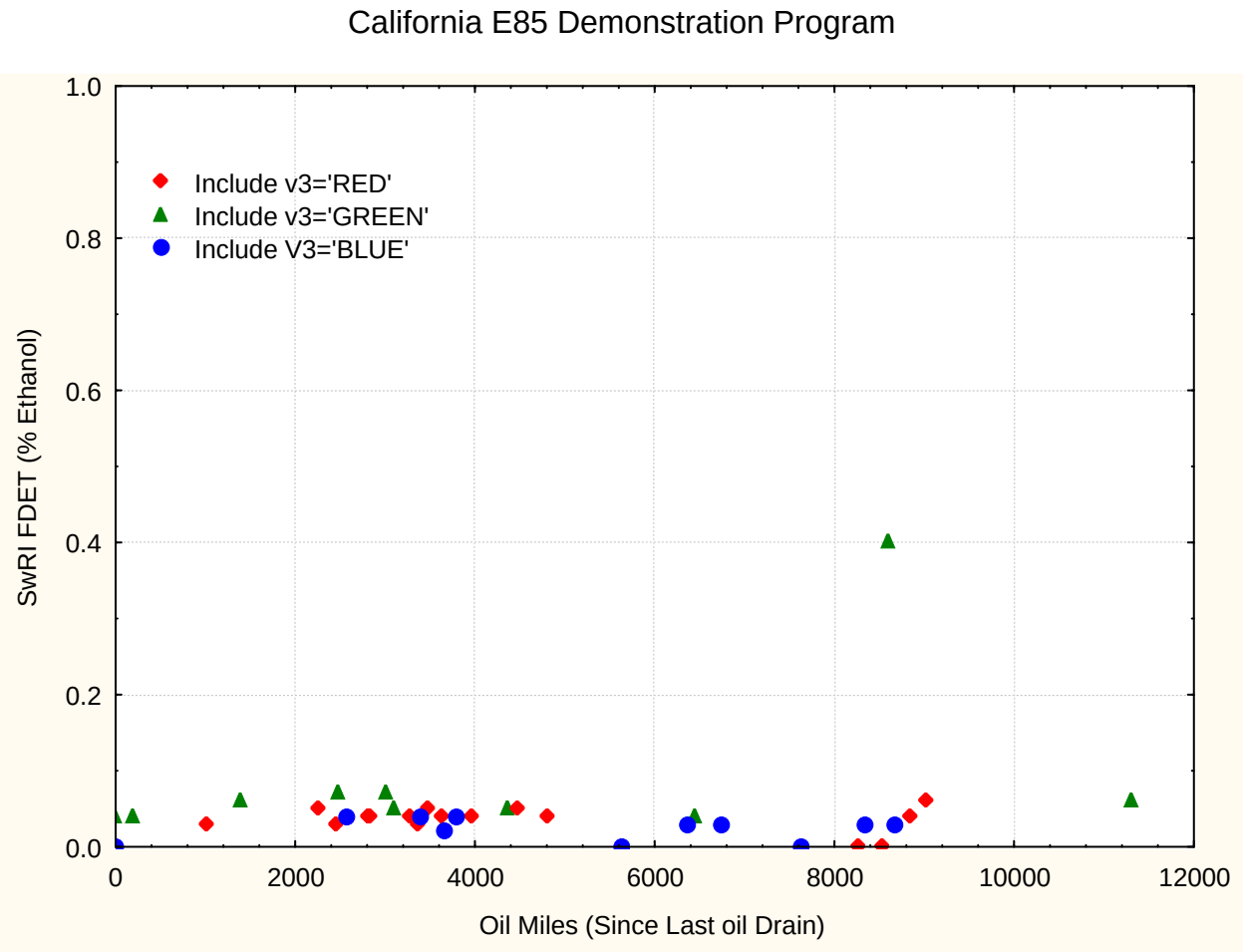
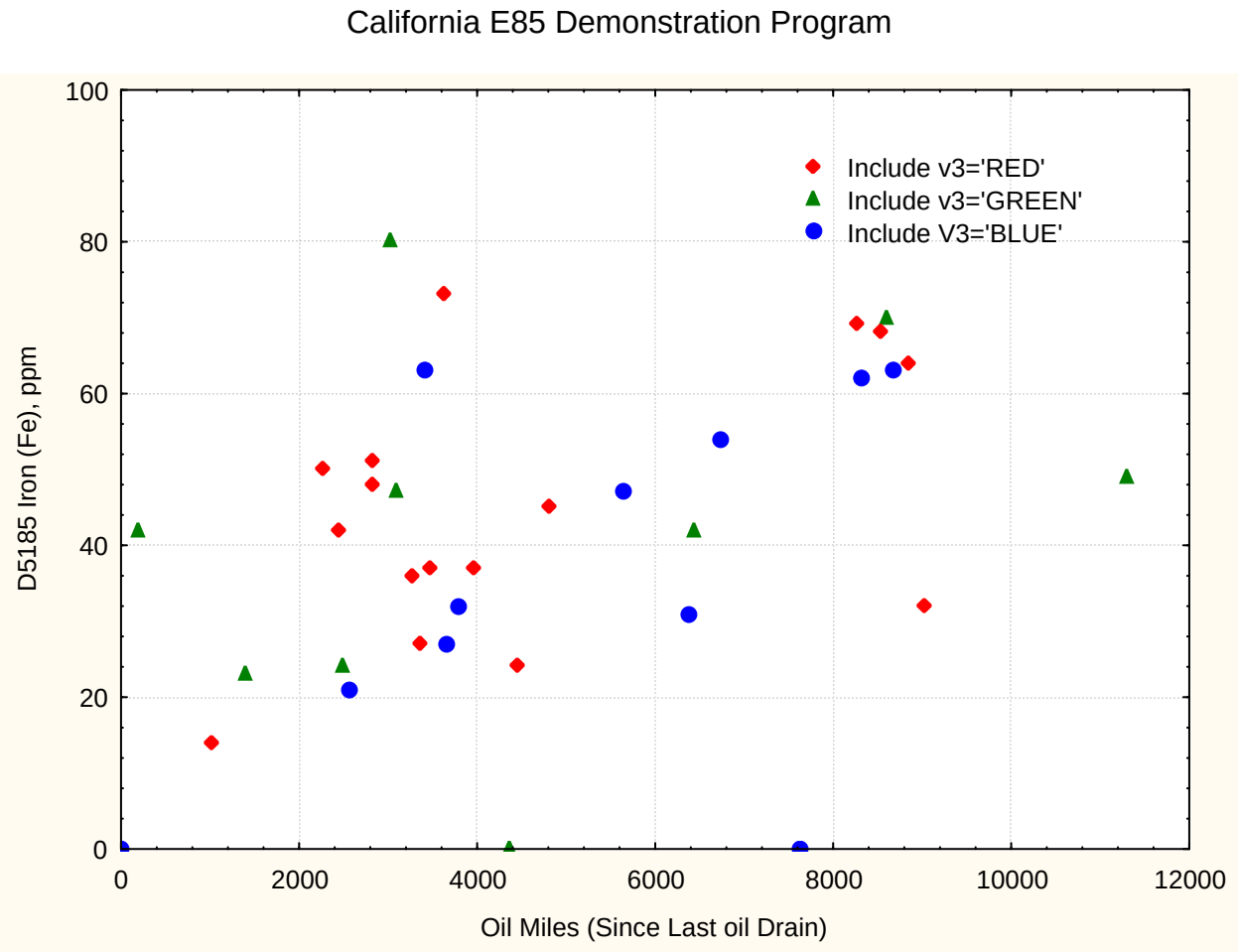


Figure 10.9 Iron Wear Particle Count (parts per million)



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APPENDIX A

PREVIOUS STUDIES: STATE OF OHIO

At least one other previous E85 demonstration program was identified. In 1996, the State of Ohio established a project to demonstrate the effectiveness of ethanol as an alternative to gasoline in its fleet operations. The program is summarized in a couple of National Renewable Energy Laboratory documents.[4,5] The overall objectives of the study were to assess whether the operational performance and costs of operating alternative fuel vehicles are similar to, better than, or not as good as those of similar gasoline vehicles.[4]

The study used 1996 model year Ford Tauruses: ten were E85 flexible fuel vehicles (FFVs) and three were standard gasoline models. The vehicles had a 3.0 liter V6 engine. The FFVs used an alcohol fuel sensor and had a larger fuel tank than their gasoline counterpart, 18.4 gallons vs. 16 gallons. The vehicles were generally used for local trips around the Columbus area. Two E85 refueling sites were established to serve the fleet, one using an existing 500 gallon tank and the other using a new 2,000 gallon tank. Issues related to getting the proper permits delayed the opening of the new station several times, about six months late.[4]

The study period ran for two years. Vehicles accumulated approximately 14,000 miles annually. The E85 use in the FFVs averaged 63% (by volume). During the second half of the study, E85 use increased to 73% (by volume) after the new fueling station opened. None of the FFVs operated exclusively on E85.[5]

Fuel use logs and receipts were kept to determine operational costs. The average fuel economy of the FFVs was a little more than 23 miles per gallons (mpg), lower than the average 24.6 mpg for the gasoline vehicles. There was little difference in vehicle range. Fuel prices fluctuated significantly during the study period. Fuel cost for the FFVs was about 15% higher than for gasoline, at 6.55 cents per mile compared to 5.01 cents per mile.[5]

Very little unscheduled maintenance or repairs were required for either the FFVs or gasoline study vehicles. The only major difference in service between the FFVs and gasoline vehicles was that the FFVs required special low-ash engine oil. During the course of the project, Ford eliminated the requirement for using the special oil. The change to standard oil during the last 6 to 12 months of the project did not result in any problems with the FFVs.[4]

Emissions testing was conducted on two FFVs and two gasoline vehicles at Automotive Testing Laboratories in East Liberty, Ohio. The tests were conducted following the Federal Test Procedure (FTP). California Phase 2 certification gasoline was used as the baseline gasoline fuel (designated RFG). The results followed some trends seen in more extensive test programs, including decreased carbon monoxide (CO) and oxides of nitrogen (NO_x) for the FFVs compared to the gasoline vehicles.[4] The authors state that differences between emissions results are by-products of calibration compromises required to enable the FFVs to operate on E85, gasoline, and blends of the two fuels, and that differences between E85 and gasoline can be expected to decrease as the automobile manufacturers continue to improve control technologies. Regardless of test

fuel or vehicle type, all the emissions results from the project were well below the applicable EPA certification life standards.[5]

FFV and Standard Gasoline Vehicles – Average Emissions Results[4]

Type	**FFV**		**Standard Gasoline**	**EPA**
Fuel	**E85**	**RFG**	**RFG**	**Tier 1**
Regulated Emissions				
NMHC (E) (g/mi)	0.149	0.101	0.114	0.25
THC (E) (g/mi)	0.189	0.117	0.132	0.41
CO (g/mi)	1.33	1.01	1.39	3.4
NOx (g/mi)	0.09	0.08	0.22	0.4
Greenhouse Gases				
CO_2 (g/mi)	389.8	412.1	407.6	-
Methane (g/mi)	0.046	0.021	0.023	-
Aldehydes				
Formaldehyde (g/mi)	0.00226	0.00099	0.00127	-
Acetaldehyde (g/mi)	0.01302	0.00030	0.00035	-
Fuel Economy				
MPG (actual)	15.8	21.1	21.3	-
MPEG	21.4			

Conclusions include:

- Fuel flexibility and availability play into alternative fuel vehicle selection
- Overall performance of the FFVs was the same as the fleet's gasoline vehicles
- Higher operating costs are driven by the price of E85

Overall, the State of Ohio's staff was pleased with the Taurus FFVs.[5]

APPENDIX B

MEMORANDUM OF UNDERSTANDING

APPENDIX C

PROJECT MANAGEMENT PLAN

APPENDIX D

CHEVRON TECHNOLOGY VENTURES, LLC APPLICATION LETTER AND ARB TEST PROGRAM EXEMPTION LETTER

APPENDIX E

OTHER STATE AND LOCAL PERMITTING CONSIDERATIONS

APPENDIX F

WENDT AND SONS CONSTRUCTION, INC. APPLICATIONS AND BAY AREA AIR QUALITY MANAGEMENT DISTRICT AND FEATHER RIVER AIR QUALITY MANAGEMENT DISTRICT AUTHORITY TO CONSTRUCT/PERMIT TO OPERATE GASOLINE DISPENSING FACILITY

APPENDIX G

CALIFORNIA DEPARTMENT OF TRANSPORTATION APPLICATION LETTER AND ARB RESEARCH AND DEVELOPMENT TEST SITE STATUS LETTER

APPENDIX H

TANK AND DISPENSER AS-BUILT DRAWINGS

APPENDIX I

TANK INTEGRITY TEST RESULTS

APPENDIX J

KICKOFF TRAINING PRESENTATION
(OCTOBER 11-12, 2006)

APPENDIX K

REFUELING TRANSACTION SUMMARY TABLES

APPENDIX L

FUEL ECONOMY SUMMARY TABLES

Table L. 1 Summary Statistics by Vehicle, Marysville

	7003352	7003357	7003389	7003390	7003391	7003392	7003393	7003394	7003395
	Impala LS sedan	**Impala LS sedan**	**Impala LS sedan**	**Impala LS sedan**	**Impala LS sedan**	**Impala LS sedan**	**Impala LS sedan**	**Impala LS sedan**	**Impala LS sedan**
Start one-year driving phase odometer	3995	5421	5117	58	4465	5885	30	2888	10
Program miles 11/1/06 - 10/31/07	16698	12974	16863	17319	14353	23226	12739	14005	18522
E85 refueling events	47	53	46	65	80	75	76	47	57
Chevron tanks	0	0	0	1	1	3	1	0	0
Phantom tanks	0	6	2	0	0	0	0	0	1
Gasoline refueling events	35	6	31	30	7	31	8	16	31
Total refueling events	82	59	77	95	87	106	84	63	88
Avg. miles/tank	204	220	219	182	165	219	152	222	210
Avg. gallons/tank	8.98	9.85	9.73	9.10	9.91	10.08	7.98	9.62	9.38
Max. miles/tank E85	361	342	351	321	263	352	374	331	366
Max. miles/tank gasoline	400	378	448	446	265	433	365	414	360
Max. gallons/tank	14.5	15.3	15.5	15.8	16.1	16.0	15.0	14.2	15.5
Gallons E85	387.223	522.052	429.611	559.78	796.219	763.886	589.305	430.137	500.177
Gallons gasoline	349.53	59.10	319.78	304.39	65.71	304.07	81.35	176.02	324.90
Miles on E85	9776	11082	9369	11460	13529	15339	11039	9845	11789
Miles on gasoline	6922	1892	7494	5859	824	7887	1700	4160	6733
Miles/gallon E85	25.25	21.23	21.81	20.47	16.99	20.08	18.73	22.89	23.57
Miles/gallon gasoline	19.80	32.01	23.43	19.25	12.54	25.94	20.90	23.63	20.72

Table L.1 cont. Summary Statistics by Vehicle, Marysville

	7003396	7003397	7003398	7003399	7003401	7003402
	Impala LS sedan	**Impala LS sedan**	**Impala LS sedan**	**Impala LS sedan**	**Impala LS sedan**	**Impala LS sedan**
Start one-year driving phase odometer	3996	317	1866	3491	88	4491
Program miles 11/1/06 - 10/31/07	17424	12482	7419	16362	15412	19637
E85 refueling events	53	54	27	51	57	65
Chevron tanks	1	0	0	0	0	0
Phantom tanks	0	0	1	0	0	1
Gasoline refueling events	36	6	7	29	17	32
Total refueling events	89	60	34	80	74	97
Avg. miles/tank	196	208	218	205	208	202
Avg. gallons/tank	8.64	9.86	10.93	9.24	9.59	9.06
Max. miles/tank E85	390	378	340	319	382	308
Max. miles/tank gasoline	370	470	387	371	335	402
Max. gallons/tank	16.1	16.1	16.0	15.8	15.2	15.5
Gallons E85	449.407	508.141	286.014	429.849	545.293	573.833
Gallons gasoline	319.99	83.56	85.71	309.47	164.59	305.23
Miles on E85	9399	10730	5859	10107	11744	11778
Miles on gasoline	8025	1752	1560	6255	3668	7859
Miles/gallon E85	20.91	21.12	20.49	23.51	21.54	20.53
Miles/gallon gasoline	25.08	20.97	18.20	20.21	22.29	25.75

Table L.2 Summary Statistics by Vehicle, Oakland

	7003475	7003476	7003477	7003478	7003479	7003480	7003481	7003482	7003497
	C1500 Silverado pickup truck	**C1500 Silverado pickup truck**	**C1500 Silverado pickup truck**	**C1500 Silverado pickup truck**	**C1500 Silverado pickup truck**	**Impala LS sedan**	**C1500 Silverado**	**Impala LS sedan**	**Impala LS sedan**
Start one-year driving phase odometer	915	415	181	402	92	4860	1589	4108	4659
Program miles 11/1/06 - 10/31/07	8040	19470	7669	11392	6463	23297	4494	16188	17585
E85 refueling events	38	59	33	33	20	66	16	48	47
Chevron tanks	0	1	0	0	0	0	0	1	0
Phantom tanks	0	0	0	0	0	2	0	2	3
Gasoline refueling events	4	6	4	2	1	28	3	30	22
Total refueling events	42	65	37	35	21	94	19	78	69
Avg. miles/tank	191	300	207	325	308	248	237	208	255
Avg. gallons/tank	17.91	24.18	19.31	22.97	24.39	12.58	20.85	9.66	12.49
Max. miles/tank E85	374	394	341	430	443	346	452	272	329
Max. miles/tank gasoline	406	416	344	93	322	442	282	373	372
Max. gallons/tank	31.2	30.6	29.2	29.8	30.4	15.4	26.5	12.8	15.7
Gallons E85	692.321	1452.459	636.488	778.961	492.554	827.799	328.67	451.813	562.573
Gallons gasoline	59.95	119.00	78.04	25.00	19.69	354.76	67.41	301.64	299.25
Miles on E85	6930	18097	7122	11223	6141	14823	3763	9388	11097
Miles on gasoline	1110	1373	547	169	322	8474	731	6800	6488
Miles/gallon E85	10.01	12.46	11.19	14.41	12.47	17.91	11.45	20.78	19.73
Miles/gallon gasoline	18.52	11.54	7.01	6.76	16.35	23.89	10.84	22.54	21.68

Table L.2 cont. Summary Statistics by Vehicle, Oakland

	7003499	7003500	7003504	7003505	7003506	7003508	7003510	7003511	7003512
	Impala LS sedan	**Impala LS sedan**	**Impala LS sedan**	**Impala LS sedan**	**Impala LS sedan**	**C1500 Silverado pickup truck**	**Impala LS sedan**	**C1500 Silverado pickup truck**	**C1500 Silverado pickup truck**
Start one-year driving phase odometer	3974	5526	2174	1440	5347	3769	5034	450	659
Program miles 11/1/06 - 10/31/07	15080	20514	19329	21201	22101	6605	7085	7899	5161
E85 refueling events	34	43	71	47	76	19	24	28	20
Chevron tanks	1	0	8	0	1	0	1	0	1
Phantom tanks	2	11	12	11	0	0	0	0	0
Gasoline refueling events	22	32	20	33	5	1	5	5	3
Total refueling events	56	75	91	80	81	20	29	33	23
Avg. miles/tank	269	274	212	265	273	330	244	239	224
Avg. gallons/tank	13.92	11.83	10.81	10.97	13.20	29.35	11.53	22.35	22.67
Max. miles/tank E85	370	416	314	335	333	377	335	326	270
Max. miles/tank gasoline	441	398	383	438	387	461	363	386	266
Max. gallons/tank	16.2	14.6	14.0	15.6	16.1	32.4	14.9	29.0	27.1
Gallons E85	460.831	491.585	768.815	491.562	995.388	557.918	270.675	614.888	446.3
Gallons gasoline	318.78	395.35	214.97	386.15	73.66	29.09	63.59	122.66	75.10
Miles on E85	8308	10525	13970	10663	20425	6144	5815	6396	4405
Miles on gasoline	6772	9989	5359	10538	1676	461	1270	1503	756
Miles/gallon E85	18.03	21.41	18.17	21.69	20.52	11.01	21.48	10.40	9.87
Miles/gallon gasoline	21.24	25.27	24.93	27.29	22.75	15.85	19.97	12.25	10.07

Table L.2 cont. Summary Statistics by Vehicle, Oakland

	7003514	7003516	7003517	7003523	7003524	7003526	7003527	7003528	7003529
	Impala LS sedan	**Impala LS sedan**	**Impala LS sedan**	**C1500 Silverado pickup truck**	**C1500 Silverado pickup truck**	**C1500 Silverado pickup truck**	**K1500 Silverado pickup truck extended cab 4x4**	**K1500 Silverado pickup truck extended cab 4x4**	**K1500 Silverado pickup truck extended cab 4x4**
Start one-year driving phase odometer	2100	36	308	481	445	2516	463	473	442
Program miles 11/1/06 - 10/31/07	23757	6577	8943	9294	1815	10434	14427	17174	3896
E85 refueling events	39	19	33	27	3	34	34	38	12
Chevron tanks	13	1	0	0	0	0	1	0	1
Phantom tanks	32	0	0	0	0	0	0	0	0
Gasoline refueling events	46	13	7	1	2	2	9	32	1
Total refueling events	85	32	40	28	5	36	43	70	13
Avg. miles/tank	279	206	224	332	363	290	336	245	300
Avg. gallons/tank	11.24	11.22	12.48	26.13	27.03	20.61	26.61	19.16	27.16
Max. miles/tank E85	388	295	363	433	362	493	411	513	349
Max. miles/tank gasoline	386	329	326	429	402	514	481	481	0
Max. gallons/tank	15.0	15.5	15.9	29.3	28.8	30.6	32.3	27.7	30.5
Gallons E85	442.528	232.304	409.893	704.342	82.312	703.206	930.622	904.413	341.638
Gallons gasoline	513.00	126.83	89.38	27.24	52.85	38.91	213.45	436.95	11.40
Miles on E85	9415	4207	7204	8865	1061	9438	11523	10981	3896
Miles on gasoline	14342	2370	1739	429	754	996	2904	6193	0
Miles/gallon E85	21.28	18.11	17.58	12.59	12.89	13.42	12.38	12.14	11.40
Miles/gallon gasoline	27.96	18.69	19.46	15.75	14.27	25.60	13.61	14.17	0.00

Table L.2 cont. Summary Statistics by Vehicle, Oakland

	7003530	7003531	7003532	7003533	7003536	7003537	7003538	7003580
	K1500 Silverado pickup truck extended cab 4x4	**K1500 Silverado pickup truck extended cab 4x4**	**K1500 Silverado pickup truck extended cab 4x4**	**K1500 Silverado pickup truck extended cab 4x4**	**K1500 Silverado pickup truck extended cab 4x4**	**K1500 Silverado pickup truck extended cab 4x4**	**K1500 Silverado pickup truck extended cab 4x4**	**Impala LS sedan**
Start one-year driving phase odometer	399	109	270	451	220	1343	347	545
Program miles 11/1/06 - 10/31/07	3738	17834	10782	6489	12283	16491	17819	11194
E85 refueling events	14	56	52	21	45	45	59	21
Chevron tanks	1	0	0	0	0	1	0	0
Phantom tanks	0	3	2	0	11	1	6	1
Gasoline refueling events	1	24	2	2	11	37	7	25
Total refueling events	15	80	54	23	56	82	66	46
Avg. miles/tank	249	223	200	282	219	201	270	243
Avg. gallons/tank	23.19	17.67	19.68	25.76	22.68	21.06	23.28	11.57
Max. miles/tank E85	397	374	314	365	303	498	362	309
Max. miles/tank gasoline	0	393	319	176	292	478	433	395
Max. gallons/tank	31.3	30.6	30.0	31.9	30.4	33.5	29.4	16.2
Gallons E85	336.035	956.23	1023.336	569.389	1020.693	1011.861	1372.685	245.405
Gallons gasoline	11.80	457.40	39.36	23.13	249.48	715.05	163.98	287.02
Miles on E85	3738	12305	10187	6195	9627	9820	15494	4923
Miles on gasoline	0	5529	595	294	2656	6671	2325	6271
Miles/gallon E85	11.12	12.87	9.95	10.88	9.43	9.70	11.29	20.06
Miles/gallon gasoline	0.00	12.09	15.12	12.71	10.65	9.33	14.18	21.85

Table L.3 E85 Fuel Economy (Uncorrected), Marysville Impala LS

						E85			
Equipment	**Start Date**	**End Date**	**Start Odometer**	**End Odometer**	**Net Miles**	**Refueling Events**	**Gallons**	**Fuel Economy (mpg)**	**Fuel Economy (GGE)**
7003352	6/5/2007	6/26/2007	13805	14927	1122	6	54.547		
	7/10/2007	8/2/2007	15450	16644	1194	6	46.073		
	8/29/2007	10/2/2007	17807	19083	1276	6	58.427		
Total					3592	18	159.047	22.58	30.77
7003357	11/27/2006	1/17/2007	5595	7327	1732	8	84.844		
	3/1/2007	5/1/2007	8926	10987	2061	10	99.237		
	6/27/2007	7/20/2007	12982	13850	868	5	42.488		
	7/27/2007	9/20/2007	14583	16506	1923	10	97.458		
	10/11/2007	10/31/2007	17249	18395	1146	5	53.151		
Total					7730	38	377.178	20.49	27.92
7003389	3/16/2007	4/5/2007	11775	12782	1007	5	51.335		
	4/26/2007	5/4/2007	13561	14235	674	4	33.034		
	6/7/2007	7/12/2007	15742	16957	1215	6	61.306		
	8/1/2007	8/27/2007	17587	18525	938	5	46.772		
	9/11/2007	9/17/2007	19569	20003	434	3	27.369		
Total					4268	23	219.816	19.42	26.46
7003390	4/3/2007	5/2/2007	6482	8332	1850	10	93.911		
	5/23/2007	6/20/2007	9467	11201	1734	9	86.029		
	7/25/2007	8/15/2007	12659	13886	1227	7	57.407		
	8/22/2007	10/3/2007	14151	16059	1908	11	96.408		
	10/22/2007	10/25/2007	16999	17377	378	3	25.106		
Total					7097	40	358.861	19.78	26.95
7003391	12/15/2006	1/3/2007	5409	5702	293	3	30.777		
	2/22/2007	8/14/2007	7320	14272	6952	39	397.224		
	8/17/2007	10/31/2007	14508	18818	4310	27	256.249		
Total					11555	69	684.250	16.89	23.01
7003392	12/20/2006	1/23/2007	9627	12333	2706	13	144.987		
	2/23/2007	4/6/2007	14363	16642	2279	13	110.927		

Table L.3 E85 Fuel Economy (Uncorrected), Marysville Impala LS

						E85			
Equipment	**Start Date**	**End Date**	**Start Odometer**	**End Odometer**	**Net Miles**	**Refueling Events**	**Gallons**	**Fuel Economy (mpg)**	**Fuel Economy (GGE)**
	5/4/2007	5/15/2007	18680	19588	908	4	38.313		
	9/18/2007	9/28/2007	25823	26560	737	3	35.949		
Total					6630	33	330.176	20.08	27.36
7003393	12/8/2006	1/24/2007	734	1697	963	6	50.759		
	2/1/2007	3/6/2007	2043	3352	1309	9	72.795		
	3/22/2007	6/5/2007	4549	7250	2701	21	144.119		
	6/13/2007	10/12/2007	7879	12264	4385	30	240.873		
Total					9358	66	508.546	18.40	25.07
7003394	12/15/2006	1/22/2007	4415	5035	620	3	30.004		
	5/17/2007	6/26/2007	10624	12070	1446	7	67.840		
	7/12/2007	8/8/2007	12763	13912	1149	5	50.339		
	8/16/2007	9/18/2007	14260	15416	1156	6	58.219		
	10/3/2007	10/29/2007	16058	16893	835	4	38.013		
Total					5206	25	244.415	21.30	29.02
7003395	12/20/2006	1/9/2007	1174	1669	495	3	23.627		
	3/15/2007	4/10/2007	4993	6336	1343	7	64.809		
	5/7/2007	6/12/2007	7849	9234	1385	7	70.385		
	7/5/2007	7/11/2007	10337	10868	531	3	17.367		
	8/23/2007	9/24/2007	14736	16097	1361	7	64.931		
	10/2/2007	10/26/2007	16856	18532	1676	8	82.574		
Total					6791	35	323.693	20.98	28.59
7003396	4/6/2007	5/10/2007	11750	13416	1666	8	81.481		
	6/19/2007	8/14/2007	14786	17891	3105	16	142.884		
	8/21/2007	9/19/2007	18265	19699	1434	10	71.272		
	9/27/2007	10/29/2007	19980	21420	1440	9	71.539		
Total					7645	43	367.176	20.82	28.37
7003397	1/25/2007	2/7/2007	1115	1988	873	4	43.991		
	3/19/2007	6/11/2007	3601	7503	3902	18	187.862		

Table L.3 E85 Fuel Economy (Uncorrected), Marysville Impala LS

						E85			
Equipment	**Start Date**	**End Date**	**Start Odometer**	**End Odometer**	**Net Miles**	**Refueling Events**	**Gallons**	**Fuel Economy (mpg)**	**Fuel Economy (GGE)**
	6/20/2007	7/27/2007	8041	9445	1404	6	69.514		
	9/11/2007	10/30/2007	10900	12799	1899	12	87.334		
Total					8078	40	388.701	20.78	28.32
7003398	12/22/2006	3/22/2007	3640	4950	1310	6	70.463		
	4/4/2007	10/31/2007	5740	9285	3545	16	176.083		
Total					4855	22	246.546	19.69	26.83
7003399	4/20/2007	5/10/2007	10120	11454	1334	7	64.478		
	6/18/2007	8/3/2007	13852	16518	2666	15	134.676		
	9/29/2007	10/30/2007	18620	19853	1233	7	57.948		
Total					5233	29	257.102	20.35	27.73
7003401	12/1/2006	1/19/2007	88	2297	2209	8	85.183		
	3/9/2007	4/2/2007	4074	5160	1086	5	51.584		
	4/25/2007	5/17/2007	6741	7607	866	5	44.053		
	6/25/2007	7/10/2007	9826	10482	656	4	33.729		
	8/17/2007	9/12/2007	11910	12804	894	5	48.516		
	9/27/2007	10/26/2007	13405	15165	1760	9	86.590		
Total					7471	36	349.655	21.37	29.11
7003402	3/1/2007	3/8/2007	11219	11500	281	3	24.073		
	3/14/2007	4/5/2007	12085	13375	1290	8	63.254		
	4/30/2007	5/23/2007	14665	16241	1576	8	79.072		
	7/11/2007	8/27/2007	18697	20940	2243	12	111.766		
	9/26/2007	10/25/2007	22981	24128	1147	8	56.760		
Total					6537	39	334.925	19.52	26.59
Total					**102,046**	**556**	**5,150.087**	**19.81**	**27.00**

Table L.4 Gasoline Fuel Economy (Uncorrected), Marysville Impala LS

Equipment	Start Date	End Date	Start Odometer	End Odometer	Net Miles	Gasoline		
						Refueling Events	Gallons	Fuel Economy (mpg)
7003352	10/25/2007	10/26/2007	20688	20693	5	1	0.95	
Total					5	1	0.95	5.28
7003357								
Total					0	0	0.00	
7003389	5/14/2007	5/16/2007	14627	14812	185	1	7.46	
	9/20/2007	9/25/2007	20335	20497	162	1	6.37	
Total					347	2	13.82	25.10
7003390	6/21/2007	6/22/2007	11362	11508	146	1	5.58	
Total					146	1	5.58	26.15
7003391								
Total					0	0	0.00	
7003392								
Total					0	0	0.00	
7003393	6/6/2007	6/7/2007	7433	7737	304	1	6.90	
Total					304	1	6.90	44.05
7003394	6/30/2007	7/9/2007	12386	12578	192	1	6.73	
	9/21/2007	9/27/2007	15761	15971	210	1	11.90	
Total					402	2	18.63	21.58
7003395	4/27/2007	5/1/2007	7245	7575	330	1	13.06	
	6/13/2007	6/19/2007	9426	9547	121	1	4.49	
	7/17/2007	7/19/2007	11020	11302	282	1	13.97	
	7/27/2007	8/3/2007	12000	12556	556	2	18.67	
	8/14/2007	8/16/2007	13833	14077	244	1	9.61	
Total					1533	6	59.80	25.64

Table L.4 Gasoline Fuel Economy (Uncorrected), Marysville Impala LS

Equipment	Start Date	End Date	Start Odometer	End Odometer	Net Miles	Gasoline		
						Refueling Events	Gallons	Fuel Economy (mpg)
7003396								
Total					0	0	0.00	
7003397								
Total					0	0	0.00	
7003398								
Total					0	0	0.00	
7003399	5/12/2007	5/18/2007	11755	12045	290	1	11.65	
Total					290	1	11.65	24.89
7003401	5/24/2007	5/30/2007	8090	8640	550	2	25.63	
Total					550	2	25.63	21.46
7003402	6/22/2007	6/25/2007	17898	18174	276	1	10.23	
Total					276	1	10.23	26.98
Total					**3,853**	**17**	**153.19**	**25.15**

Table L.5 E85 Fuel Economy (Uncorrected), Oakland Impala LS

						E85			
Equipment	**Start Date**	**End Date**	**Start Odometer**	**End Odometer**	**Net Miles**	**Refueling Events**	**Gallons**	**Fuel Economy (mpg)**	**Fuel Economy (GGE)**
7003480	11/21/2006	5/21/2007	6003	18215	12212	55	691.432		
	8/14/2007	8/24/2007	23217	23928	711	3	41.920		
Total					12923	58	733.352	17.62	24.01
7003482	1/3/2007	1/24/2007	5801	6852	1051	5	53.563		
	5/11/2007	5/29/2007	12318	13140	822	5	43.446		
	7/3/2007	7/21/2007	14187	14830	643	3	32.338		
	8/3/2007	8/27/2007	15581	16730	1149	6	58.813		
	9/14/2007	9/27/2007	17816	18457	641	3	34.565		
	10/9/2007	10/23/2007	18886	19713	827	5	40.535		
Total					5133	27	263.260	19.50	26.57
7003497	11/29/2006	1/2/2007	5288	6681	1393	6	73.080		
	2/8/2007	3/19/2007	9070	10442	1372	6	73.862		
	5/10/2007	5/22/2007	13483	14120	637	3	35.066		
	8/24/2007	9/11/2007	18225	19081	856	4	44.588		
Total					4258	19	226.596	18.79	25.60
7003499	11/30/2006	12/19/2006	5156	5963	807	4	53.639		
	4/19/2007	5/3/2007	11488	12196	708	3	42.893		
	6/25/2007	8/3/2007	14698	15825	1127	5	71.259		
	9/25/2007	10/17/2007	17676	18659	983	4	58.712		
Total					3625	16	226.503	16.00	21.81
7003500	11/29/2006	12/28/2006	5804	7950	2146	9	104.909		
	1/9/2007	1/22/2007	8590	9299	709	4	35.249		
	5/14/2007	5/23/2007	16444	17200	756	3	36.290		
	9/19/2007	10/15/2007	23865	25087	1222	5	60.200		
Total					4833	21	236.648	20.42	27.83
7003504	12/15/2006	1/29/2007	3557	6191	2634	13	145.652		
	3/9/2007	3/27/2007	7597	8525	928	5	55.648		
	4/4/2007	5/10/2007	9152	11626	2474	12	138.654		

Table L.5 E85 Fuel Economy (Uncorrected), Oakland Impala LS

						E85			
Equipment	**Start Date**	**End Date**	**Start Odometer**	**End Odometer**	**Net Miles**	**Refueling Events**	**Gallons**	**Fuel Economy (mpg)**	**Fuel Economy (GGE)**
	8/22/2007	10/30/2007	17256	21503	4247	24	243.737		
Total					10283	54	583.691	17.62	24.00
7003505	12/15/2006	2/7/2007	2241	3290	1049	5	57.183		
	7/13/2007	7/27/2007	14808	15600	792	3	37.295		
	9/13/2007	9/20/2007	19927	20520	593	3	28.545		
Total					2434	11	123.023	19.78	26.96
7003506	11/16/2006	1/26/2007	5680	9671	3991	15	193.563		
	2/13/2007	5/23/2007	10603	16820	6217	22	304.091		
	6/29/2007	7/24/2007	18899	20561	1662	7	82.512		
	8/8/2007	10/29/2007	21247	27448	6201	24	316.213		
Total					18071	68	896.379	20.16	27.47
7003510	12/1/2006	1/29/2007	5943	8484	2541	10	126.740		
	2/20/2007	2/23/2007	9463	10022	559	3	27.554		
	3/13/2007	4/18/2007	10720	12119	1399	6	65.599		
Total					4499	19	219.893	20.46	27.88
7003514	3/6/2007	5/9/2007	11487	13161	1674	10	106.519		
	9/11/2007	9/19/2007	19585	20741	1156	4	47.097		
	10/16/2007	10/31/2007	24283	25857	1574	5	63.701		
Total					4404	19	217.317	20.27	27.61
7003516	1/10/2007	1/31/2007	1308	1762	454	2	29.073		
	4/30/2007	5/17/2007	2996	3476	480	2	29.665		
Total					934	4	58.738	15.90	21.67
7003517	11/22/2006	4/4/2007	473	3535	3062	15	188.143		
	4/24/2007	5/15/2007	4243	5148	905	4	57.216		
	9/20/2007	10/18/2007	7918	8652	734	3	43.762		
Total					4701	22	289.121	16.26	22.15

Table L.5 E85 Fuel Economy (Uncorrected), Oakland Impala LS

						E85			
Equipment	**Start Date**	**End Date**	**Start Odometer**	**End Odometer**	**Net Miles**	**Refueling Events**	**Gallons**	**Fuel Economy (mpg)**	**Fuel Economy (GGE)**
7003580	12/5/2006	12/11/2006	1836	2312	476	2	25.191		
	7/17/2007	9/27/2007	10330	11739	1409	6	86.798		
Total					1885	8	111.989	16.83	22.93
Total					**77,983**	**346**	**4,186.510**	**18.63**	**25.38**

Table L.6 Gasoline Fuel Economy (Uncorrected), Oakland Impala LS

Equipment	Start Date	End Date	Start Odometer	End Odometer	Net Miles	Gasoline		
						Refueling Events	Gallons	Fuel Economy (mpg)
7003480	6/5/2007	7/31/2007	18948	22132	3184	11	133.61	
	9/27/2007	10/23/2007	25928	27676	1748	6	74.48	
Total					4932	17	208.09	23.70
7003482	6/4/2007	6/27/2007	13386	14013	627	3	26.28	
	7/26/2007	7/31/2007	15087	15324	237	1	9.92	
Total					864	4	36.20	23.87
7003497	6/17/2007	7/9/2007	15017	16301	1284	4	52.58	
Total					1284	4	52.58	24.42
7003499	5/11/2007	6/18/2007	12682	14328	1646	5	70.18	
	8/17/2007	8/27/2007	16136	16534	398	1	12.33	
Total					2044	6	82.51	24.77
7003500	6/13/2007	6/28/2007	18388	19465	1077	3	39.84	
Total					1077	3	39.84	27.03
7003504	11/20/2006	12/12/2006	2555	3321	766	3	33.80	
	2/16/2007	3/7/2007	6900	7409	509	2	21.17	
Total					1275	5	54.96	23.20
7003505	4/27/2007	4/30/2007	9025	9280	255	1	10.01	
	5/9/2007	5/17/2007	10225	11187	962	3	35.27	
Total					1217	4	45.28	26.88
7003506	5/30/2007	6/8/2007	17173	17489	316	1	12.25	
Total					316	1	12.25	25.80
7003510								
Total					0	0	0.00	
7003514	12/6/2006	12/20/2006	4308	5720	1412	5	60.43	

Table L.6 Gasoline Fuel Economy (Uncorrected), Oakland Impala LS

Equipment	Start Date	End Date	Start Odometer	End Odometer	Net Miles	Gasoline		
						Refueling Events	Gallons	Fuel Economy (mpg)
Total					1412	5	60.43	23.37
7003516	5/22/2007	6/7/2007	3733	4192	459	2	20.98	
Total					459	2	20.98	21.88
7003517	5/24/2007	6/12/2007	5458	5779	321	1	13.37	
Total					321	1	13.37	24.01
7003580	5/21/2007	5/29/2007	8917	9179	262	1	9.20	
Total					262	1	9.20	28.48
Total					**15,463**	**53**	**635.68**	**24.32**

Table L.7 E85 Fuel Economy (Uncorrected), Oakland C1500 Silverado

						E85			
Equipment	**Start Date**	**End Date**	**Start Odometer**	**End Odometer**	**Net Miles**	**Refueling Events**	**Gallons**	**Fuel Economy (mpg)**	**Fuel Economy (GGE)**
7003475	12/4/2006	3/12/2007	1736	4051	2315	12	232.506		
	4/5/2007	6/5/2007	4618	6374	1756	11	169.980		
	7/9/2007	10/18/2007	6774	8955	2181	11	185.562		
Total					6252	34	588.048	10.63	14.49
7003476	12/5/2006	5/31/2007	1745	9732	7987	27	637.576		
	6/29/2007	7/23/2007	11819	13311	1492	5	123.887		
	7/31/2007	10/31/2007	13915	19885	5970	19	490.464		
Total					15449	51	1251.927	12.34	16.81
7003477	11/22/2006	12/26/2006	489	1479	990	4	91.532		
	1/24/2007	6/22/2007	2138	4889	2751	12	256.683		
	6/29/2007	10/25/2007	5390	7850	2460	12	205.195		
Total					6201	28	553.410	11.21	15.27
7003478	11/29/2006	3/26/2007	773	3878	3105	9	211.827		
	4/6/2007	6/22/2007	4331	7419	3088	9	198.254		
	7/3/2007	10/29/2007	7840	11794	3954	12	292.582		
Total					10147	30	702.663	14.44	19.68
7003479	12/19/2006	1/9/2007	416	1139	723	2	33.806		
	1/26/2007	10/31/2007	1990	6555	4565	15	370.703		
Total					5288	17	404.509	13.07	17.81
7003481	12/6/2006	6/6/2007	2799	5353	2554	12	243.033		
Total					2554	12	243.033	10.51	14.32
7003508	1/11/2007	10/26/2007	4570	10374	5804	18	526.320		
Total					5804	18	526.320	11.03	15.03
7003511	12/7/2006	6/5/2007	677	4654	3977	18	378.298		
	6/25/2007	7/24/2007	5135	5755	620	3	62.280		
Total					4597	21	440.578	10.43	14.22

Table L.7 E85 Fuel Economy (Uncorrected), Oakland C1500 Silverado

						E85			
Equipment	**Start Date**	**End Date**	**Start Odometer**	**End Odometer**	**Net Miles**	**Refueling Events**	**Gallons**	**Fuel Economy (mpg)**	**Fuel Economy (GGE)**
7003512	12/5/2006	1/31/2007	895	1766	871	5	94.464		
	3/1/2007	5/31/2007	2275	3814	1539	7	157.947		
	6/25/2007	7/23/2007	4289	4786	497	2	51.517		
	9/14/2007	10/26/2007	5314	5820	506	2	51.533		
Total					3413	16	355.461	9.60	13.08
7003523	12/6/2006	10/25/2007	1203	9775	8572	26	682.241		
Total					8572	26	682.241	12.56	17.12
7003524	6/7/2007	10/29/2007	1559	2260	701	2	50.038		
Total					701	2	50.038	14.01	19.09
7003526	12/7/2006	5/14/2007	2868	6639	3771	15	312.712		
	8/27/2007	10/23/2007	10325	12950	2625	10	213.034		
Total					6396	25	525.746	12.17	16.58
Total					**75,374**	**280**	**6,323.974**	**11.92**	**16.24**

Table L.8 Gasoline Fuel Economy (Uncorrected), Oakland C1500 Silverado

Equipment	Start Date	End Date	Start Odometer	End Odometer	Net Miles	Gasoline		
						Refueling Events	Gallons	Fuel Economy (mpg)
7003475								
Total					0	0	0.00	
7003476	5/31/2007	6/7/2007	9746	10226	480	2	44.23	
Total					480	2	44.23	10.85
7003477								
Total					0	0	0.00	
7003478								
Total					0	0	0.00	
7003479								
Total					0	0	0.00	
7003481								
Total					0	0	0.00	
7003508								
Total					0	0	0.00	
7003511	10/2/2007	10/15/2007	7551	7895	344	1	26.19	
Total					344	1	26.19	13.13
7003512								
Total					0	0	0.00	
7003523								
Total					0	0	0.00	
7003524								
Total					0	0	0.00	

Table L.8 Gasoline Fuel Economy (Uncorrected), Oakland C1500 Silverado

Equipment	Start Date	End Date	Start Odometer	End Odometer	Net Miles	Gasoline		
						Refueling Events	Gallons	Fuel Economy (mpg)
7003526								
Total					0	0	0.00	
Total					**824**	**3**	**70.42**	**11.70**

Table L.9 E85 Fuel Economy (Uncorrected), Oakland K1500 Silverado

						E85			
Equipment	**Start Date**	**End Date**	**Start Odometer**	**End Odometer**	**Net Miles**	**Refueling Events**	**Gallons**	**Fuel Economy (mpg)**	**Fuel Economy (GGE)**
7003527	12/1/2006	12/13/2006	1137	2058	921	3	78.111		
	1/9/2007	1/31/2007	3580	4538	958	3	79.191		
	4/18/2007	6/6/2007	6823	9176	2353	7	198.223		
	7/11/2007	10/30/2007	10658	14890	4232	12	354.769		
Total					8464	25	710.294	11.92	16.24
7003528	11/28/2006	1/11/2007	1014	3260	2246	8	196.905		
	3/5/2007	3/13/2007	5748	6300	552	2	47.540		
	8/16/2007	10/25/2007	16565	17647	1082	3	71.796		
Total					3880	13	316.241	12.27	16.72
7003529	2/6/2007	10/29/2007	1075	4338	3263	10	285.102		
Total					3263	10	285.102	11.45	15.59
7003530	2/9/2007	10/18/2007	1021	4137	3116	12	284.459		
Total					3116	12	284.459	10.95	14.93
7003531	12/5/2006	1/24/2007	775	2706	1931	12	171.240		
	2/9/2007	3/8/2007	3590	4417	827	4	78.282		
	3/27/2007	4/11/2007	4977	5775	798	3	66.239		
	4/17/2007	6/1/2007	6285	8160	1875	9	169.801		
	9/17/2007	9/24/2007	14530	15250	720	3	61.310		
	10/1/2007	10/19/2007	15600	16830	1230	4	101.356		
	10/24/2007	10/30/2007	17550	17943	393	2	40.439		
Total					7774	37	688.667	11.29	15.38
7003532	12/5/2006	6/4/2007	486	6475	5989	31	518.552		
	6/12/2007	8/22/2007	7026	8340	1314	7	160.800		
	8/31/2007	10/16/2007	9001	10888	1887	8	203.215		
Total					9190	46	882.567	10.41	14.19
7003533	12/6/2006	5/15/2007	787	4072	3285	12	281.933		
	6/11/2007	7/26/2007	4571	5569	998	3	72.110		

Table L.9 E85 Fuel Economy (Uncorrected), Oakland K1500 Silverado

						E85			
Equipment	**Start Date**	**End Date**	**Start Odometer**	**End Odometer**	**Net Miles**	**Refueling Events**	**Gallons**	**Fuel Economy (mpg)**	**Fuel Economy (GGE)**
	8/14/2007	10/15/2007	6052	6940	888	3	88.454		
Total					5171	18	442.497	11.69	15.92
7003536	2/21/2007	5/30/2007	420	3560	3140	16	333.813		
	6/9/2007	6/16/2007	4400	5500	1100	6	128.893		
	7/5/2007	7/19/2007	6950	9000	2050	9	222.593		
	7/31/2007	8/11/2007	10200	11500	1300	5	131.593		
Total					7590	36	816.892	9.29	12.66
7003537	12/12/2006	12/19/2006	1343	1794	451	2	47.084		
	3/6/2007	4/3/2007	5811	6696	885	4	90.762		
	5/3/2007	5/15/2007	8810	9360	550	2	59.318		
	7/11/2007	7/21/2007	11993	12657	664	2	61.781		
	10/9/2007	10/22/2007	16014	16511	497	3	54.296		
Total					3047	13	313.241	9.73	13.25
7003538	11/21/2006	11/24/2006	944	4495	3551	13	320.108		
	2/2/2007	2/13/2007	5361	6511	1150	4	94.560		
	2/26/2007	3/19/2007	7286	8740	1454	6	126.894		
	3/26/2007	5/18/2007	9452	11998	2546	10	236.163		
	6/26/2007	7/17/2007	13873	14606	733	3	74.556		
	8/3/2007	10/31/2007	15484	18166	2682	10	261.866		
Total					12116	46	1114.147	10.87	14.82
Total					**63,611**	**256**	**5,854.107**	**10.87**	**14.81**

Table L.10 Gasoline Fuel Economy (Uncorrected), Oakland K1500 Silverado

Equipment	Start Date	End Date	Start Odometer	End Odometer	Net Miles	Gasoline		
						Refueling Events	Gallons	Fuel Economy (mpg)
7003527								
Total					0	0	0.00	
7003528	5/14/2007	5/15/2007	9848	9972	124	1	21.60	
	5/30/2007	6/5/2007	10833	11134	301	2	38.82	
	6/21/2007	6/26/2007	12520	12882	362	2	33.64	
	7/12/2007	7/13/2007	13967	14096	129	1	23.71	
Total					916	6	117.77	7.78
7003529								
Total					0	0	0.00	
7003530								
Total					0	0	0.00	
7003531	6/28/2007	7/5/2007	9530	10065	535	3	48.43	
	7/31/2007	8/6/2007	11520	12011	491	2	35.66	
Total					1026	5	84.09	12.20
7003532								
Total					0	0	0.00	
7003533								
Total					0	0	0.00	
7003536								
Total					0	0	0.00	
7003537	4/24/2007	4/26/2007	8200	8500	300	2	32.24	
	5/21/2007	5/23/2007	9670	9860	190	1	24.36	
	6/27/2007	7/2/2007	11412	11630	218	2	52.96	
	7/31/2007	8/16/2007	13064	13815	751	2	61.07	
	8/14/2007	8/16/2007			0			

Table L.10 Gasoline Fuel Economy (Uncorrected), Oakland K1500 Silverado

Equipment	Start Date	End Date	Start Odometer	End Odometer	Net Miles	Gasoline		
						Refueling Events	Gallons	Fuel Economy (mpg)
Total					1459	7	170.63	8.55
7003538								
Total					0	0	0.00	
Total					**3,401**	**18**	**372.50**	**9.13**

APPENDIX M

ARB EXECUTIVE ORDERS FOR GM FFVS SELECTED FOR VEHICLE EMISSIONS TESTING

APPENDIX N

SAYBOLT LP LAB REPORTS FOR DETAILED HYDROCARBON ANALYSES OF 50/50 BLEND FUEL USED IN VEHICLE EMISSIONS TESTING ARB VEHICLE EMISSIONS TESTING SUMMARY TABLES

APPENDIX O

VEHICLE EMISSIONS TESTING SUMMARY TABLES

APPENDIX P

COMPOSITIONAL ANALYSIS OF TWO SOURCES OF E85