Annual Average Inventory

EMAFAC2000 produces a number of seasonal inventories for different purposes. Seasonal adjustments in the model include ambient temperature, humidity and the Reid Vapor Pressure of dispensed fuel.

Episodic inventories are needed to assess worst case conditions for ozone, high ambient temperature and low relative humidity, and carbon monoxide, low ambient temperature and high relative humidity, in order to estimate how effective adopted or proposed emission reductions strategies will be in reducing peak concentrations of pollutants. EMFAC2000 produces both episodic and month specific inventories, however, an annual average inventory is best suited for assessing emission trends over time.

MVEI7G did not produce an annual average emissions inventory, rather ozone and carbon monoxide episodic estimates were weighted together for this purpose. A two thirds weighting for ozone and one third weighting for carbon monoxide was used in MVEI7G for all air basins with the exception of the South Coast, where a 7/12, 5/12 weighting was used for ozone and carbon monoxide, respectively. The weighting of episodic inventories may have led to an overestimation of annual average emissions.

In EMFAC2000, annual average inventories are derived by weighting each month of emissions for the year equally for a specific area. It is believed that this modification in methodology yields a more realistic basis for tracking emission reductions and assessing the cost of effectiveness of various strategies.

Section 4.10 CO_2 BASE EMISSION RATES AND FUEL CONSUMPTION

4.10.1 Introduction

This section details the PC, LDT and MDT gasoline and diesel carbon dioxide (CO2) base emission rates for the Unified Cycle (UC) and the Federal Test Procedure (FTP). Additionally, this memorandum details a methodology to determine fuel consumption from CO2 emissions. This fuel consumption is then utilized for the determination of lead (Pb) and oxides of sulfur (SOx) emissions.

4.10.2 Gasoline PC, LDT and MDT CO2

The analysis was conducted on data from surveillance and UC research test projects that included an FTP and a corresponding UC for each vehicle. The surveillance test projects included; 2S93C1, 2S95C1, and 2S97C1. Surveillance Project 2S97C1 was in progress during the analysis, so only data collected through March 11, 1999, were included. The research test projects included 2R9312, 2R9513, and 2R9811. Tests were also prescreened to determine if there was a corresponding UC for every FTP. Only baseline exhaust emission results were used for the analysis.

The data were split into three vehicle class groups, including light duty cars, light duty trucks, and medium duty vehicles. Standard vehicle class definitions were used.

Vehicles were then split into their corresponding technology and model year groups. The technology and model year groups are similar to those used in Section 4.7. Four technology groups were used including non-catalyst, carbureted, throttle body, and multi-point fuel injected. The carbureted technology group includes carbureted vehicles with a catalyst, while the non-catalyst carbureted equipped vehicles were assigned to the non-catalyst technology group.

Each technology group was further split into model year groups. The non-catalyst group contained only one model year group for vehicles less than or equal to the 1979 model year. The carbureted technology group includes model year group splits of 1975 to 1980, 1981 to 1985, and greater than or equal to 1986 model year. The throttle body technology group was split into three model year groups that included less than or equal to 1980, 1981 to 1984, and greater than or equal to 1985 model year. The fuel injection technology group was split into four model year groups that included less than or equal to 1980, 1981 to 1985, 1986 to 1992, and greater than or equal to 1993 model year.

The mean exhaust emission rates for CO_2 by vehicle class, technology group, and model year group, are shown in Table 4.10-1. The CO_2 exhaust emission rates have been determined for bags one, two and three of the FTP and for bags one and two of the UC. For each vehicle class, technology group, and model year group combination, the ratio of its CO_2 bag emission rates to the corresponding PC vehicle class bag emission rates were also determined. These ratios will be used to adjust the PC base emission rates (similar to "ratio of the standards" adjustments) to be consistent with how EMFAC2000 handles hydrocarbons (HC), carbon monoxide (CO) and oxides of nitrogen (NOx). Careful examination of Table 4.10-1 shows that for several of the LDT and MDV technology/model year groupings, insufficient data were available to determine meaningful mean FTP and UC emissions. For these groups, staff used their judgment as to the most appropriate ratio. Note, each Technology Group in Table 4.10-1 has a number associated with it (in parenthesis). These numbers are used in conjunction with Table 4.10-2 to map to EMFAC2000 technology groups. The ratios are applied to each regime.

4.10.3 Gasoline PC, LDT and MDT Fuel Consumption

Fuel consumption will be determined and output in the BURDEN module only, with units of gallons consumed per day. The determination can be simplified to the following equation:

Gallons/day = (0.273*CO2 TPD +0.429*CO TPD + 0.866*HC TPD)*375 [1] (4.10-1)

For a given calendar, class and technology group.

[1]Methodology for Estimating Emissions from On-Road Motor Vehicles, Vol. VI, CARB, 1996

Table 4.10-1. Gasoline CO_2 Base Exhaust Emission Rates.

Vehicle Class	Tech Group	Model Year Group	FTP Bag 1 CO_2 (g/mi)	FTP Bag 2 CO_2 (g/mi)	FTP Bag 3 CO_2 (g/mi)	UC Bag 1 CO_2 (g/mi)	UC Bag 2 CO_2 (g/mi)	Ratio FTP Bag 1 CO_2 (g/mi)	Ratio FTP Bag 2 CO_2 (g/mi)	Ratio FTP Bag 3 CO_2 (g/mi)	Ratio UC Bag 1 CO_2 (g/mi)	Ratio UC Bag 2 CO_2 (g/mi)

Table 4.10-2 EMFAC2000 Technology Groups

MAP Grp	Tech Grp	Model Yr		Description
10	1	<75	LDV	no AIR
10	2	<75	LDV	with AIR
10	3	75+	LDV	noncatalyst
7	4	75-76	LDV	OxCat with AIR
7	5	75-79	LDV	OxCat no AIR
8	6	80+	LDV	OxCat no AIR
7	7	77+	LDV	OxCat with AIR
7	8	77-79	LDV	TWC TBI/CARB
5	9	81-84	LDV	TWC TBI/CARB 0.7 Nox
6	10	85+	LDV	TWC TBI/CARB 0.7 Nox
4	11	77-80	LDV	TWC MPFI
1	12	81-85	LDV	TWC MPFI 0.7 NOx
2	13	86+	LDV	TWC MPFI 0.7 NOx
5	14	81+	LDV	TWC TBI/CARB 0.4 Nox
1	15	81+	LDV	TWC MPFI 0.4 NOx
7	16	1980	LDV	TWC TBI/CARB
6	17	93+	LDV	TWC TBI/CARB .25 HC
3	18	93+	LDV	TWC MPFI .25 HC
6	19	96+	LDV	TWC TBI/CRB .25 OBD2
3	20	96+	LDV	TWC MPFI .25HC OBD2
3	21	94-95	LDV	TLEV MPFI .25HC
3	22	96+	LDV	TLEV OBD2 GCL
3	23	96+	LDV	LEV OBD2 GCL CBC AFC
3	24	96+	LDV	ULEV OBD2 GCL CBC AFC
	25	ALL	ZEV	
3	26	96+	LDT	TWC MPFI OBD2 .7NOx
6	27	96+	LDT	TWC TBI/CARB OBD2

4.10.4 <u>Diesel PC, LDT and MDT CO_2</u>

MVEI7G did not have emissions estimates for CO_2, nor fuel consumption, for light-duty vehicles. To create CO_2 BERs, 138 light-to-medium duty vehicles from CARB's Surveillance data base were analyzed. The fleet was comprised of 29 pre-1981 vehicles, 89 1981-1983 vehicles, and 20 1984-1985 vehicles. There were an insufficient number of trucks to analyze separately, so the vehicles were collapsed into one class for analysis. Although these data were collected in the early 1980s, staff believe that these results are valid for vehicles operating currently, since staff did analyze the CO_2 data and found no deterioration with age or odometer. Additionally, since these data pre-date the LA92/UC cycle, it is assumed that the FTP and UC rates are equivalent (Table 4.10-3).

Table 4.10-3 - Diesel PC, LDT and MDT FTP/UC CO2 BERS (grams/mile)

		BAG 1		BAG 2		BAG 3	
CLASS	MY	ZM	DR	ZM	DR	ZM	DR
PC DSL CO2	1965-74	392.430	0.000	455.100	0.000	375.130	0.000
	1975-79	392.430	0.000	455.100	0.000	375.130	0.000
	1980	392.430	0.000	455.100	0.000	375.130	0.000
	1981-83	381.160	0.000	437.550	0.000	364.870	0.000
	1984-85	345.720	0.000	397.840	0.000	329.880	0.000
	1986	345.720	0.000	397.840	0.000	329.880	0.000
	1987-95	345.720	0.000	397.840	0.000	329.880	0.000
	1996+	345.720	0.000	397.840	0.000	329.880	0.000
LDT DSL CO2	1965-74	392.430	0.000	455.100	0.000	375.130	0.000
	1975-79	392.430	0.000	455.100	0.000	375.130	0.000
	1980	392.430	0.000	455.100	0.000	375.130	0.000
	1981-83	381.160	0.000	437.550	0.000	364.870	0.000
	1984-85	345.720	0.000	397.840	0.000	329.880	0.000
	1986	345.720	0.000	397.840	0.000	329.880	0.000
	1987-95	345.720	0.000	397.840	0.000	329.880	0.000
	1996+	345.720	0.000	397.840	0.000	329.880	0.000
MDT DSL CO2	1965-74	392.430	0.000	455.100	0.000	375.130	0.000
	1975-79	392.430	0.000	455.100	0.000	375.130	0.000
	1980	392.430	0.000	455.100	0.000	375.130	0.000
	1981-83	381.160	0.000	437.550	0.000	364.870	0.000
	1984-85	345.720	0.000	397.840	0.000	329.880	0.000
	1986	345.720	0.000	397.840	0.000	329.880	0.000
	1987-95	345.720	0.000	397.840	0.000	329.880	0.000
	1996+	345.720	0.000	397.840	0.000	329.880	0.000

4.10.5 Diesel PC, LDT and MDT Fuel Consumption

Due to the aforementioned uncertainties associated with the diesel CO2 BERs, a simplified version of equation 4.10-1 is more:

22.2 lbs CO2/gal fuel, or[2]

(2) Gallons/day = (CO2 TPD)*90

For a given calendar, class and technology group.

[2] American Automobile Manufacturers Association, International Fuel Survey, Summer 1998 Los Angeles

4.10.6 Pb and SOx Emissions

The Pb and SOx emissions are a function of the lead and sulfur content of the fuel, in combination with the fuel consumption. This methodology is carried over from MVEI7G.[3] Tables 4.10-4 and 4.10-5 give the Pb and SOx concentrations in the fuel:

TABLE 4.10-4 LEAD CONCENTRATION PER GALLON OF FUEL

CAL YEAR	GRAMS/GAL
1971	2.080
1972	1.959
1973	1.904
1974	1.956
1975	1.843
1979	1.120
1980	0.831
1981	0.697
1982	0.783
1983	0.738
1984	0.660
1985	0.332
1986	0.324
1987	0.260
1988	0.083
1991	0.080
1992+	0.000

[3] Methodology for Estimating Emissions from On-Road Motor Vehicles, Vol. VI, CARB, 1996

TABLE 4.10-5 SOx CONCENTRATION IN PPM BY WEIGHT

CAL.	STATEWIDE			SCAB		
YEAR	LEADED	UNLEADED	DIESEL	LEADED	UNLEADED	DIESEL
1975	610	380	2650	610	380	2650
1976	620	290	2340	620	290	2340
1978	350	190	3080	350	190	3080
1979	380	200	2850	380	200	2850
1980	330	210	2720	330	210	2720
1981	290	190	2800	290	190	2800
1982	310	210	2910	310	210	2910
1983	420	180	3150	420	180	3150
1984	360	250	3280	360	250	3280
1985	340	210	3000	340	210	1050
1986	400	220	3000	400	220	950
1987	400	220	3000	400	220	850
1988	400	220	3000	400	220	500
1989	400	220	3000	400	220	500
1990	400	220	3000	400	220	500
1991	151	151	3000	151	151	500
1992	151	151	3000	151	151	500
1993	151	151	500	151	151	500
1994	151	151	150	151	151	150
1995	151	151	140	151	151	130
1996-2002	22	22	140	20	20	130
2003+	15	15	130	20	20	130

SECTION 5.3 DIURNAL AND RESTING LOSS EMISSIONS

5.3.1 Introduction

While most hydrocarbons are emitted from the tailpipe of vehicles as the product of incomplete combustion, a significant amount of hydrocarbons emanate through evaporation, namely, hot soak, diurnal, resting and running loss emissions. Diurnal and resting loss emissions occur as a result of the vehicle's fuel heating and volatilizing as the ambient temperature rises or declines during the day. To reduce evaporative hydrocarbon emissions, vehicles are equipped with a canister containing activated charcoal to adsorb the vapors. When the vehicle is operated, the canister is purged with ambient air and the stored hydrocarbon is burned in the engine.

The diurnal emission factors in MVEI7g1.0c were developed in 1992 using data from Air Resources Board's past In-Use Vehicle Surveillance programs as well as Inspection and Maintenance projects. The diurnal basic emission rates were estimated by measuring hydrocarbon vapor from a vehicle during a compressed one-hour Sealed Housing Evaporative Determination (SHED) test. During this test, a heating blanket is placed in contact with the vehicle's fuel tank to heat the fuel from 60 to 84 F over a one-hour period, representing a temperature excursion that stationary vehicles may experience daily. The resting loss basic emission rates were based on limited 3-day and 8-day diurnal test data (SAE 901110).

Although the above methods attempt to quantify diurnal and resting loss emissions, the compressed nature of the test may not faithfully reproduce the real-time evaporative emission process and may, therefore, underestimate emissions. In other words, the one-hour condensed diurnal test may not generate the total diurnal and resting loss emissions from a 24-hour diurnal. Thus, there is a critical need to model diurnal and resting loss emissions using real-time data to improve the emissions inventory. In this study, diurnal and resting loss results were analyzed from four databases: ATL(A096-214 and A132-183), CRC and EPA. All data were collected under real-time conditions ranging from 24 hours to 72 hours with different combinations of fuel and temperature cycle. Additionally, the temperature profiles are for the ambient SHED temperature rather than the tank temperature (with a heating blanket).

5.3.2 Objectives

This analysis has the following objectives:

1. To develop the diurnal and resting loss basic emission rates as a function of ambient temperature and fuel RVP.
2. To develop the fuel and temperature correction factors.
3. To develop the multi-day correction factors for diurnal and resting loss emissions
4. To define evaporative emission regimes (normal, moderate, and liquid leaker) and develop regime growth rates for CARB and FI vehicles.

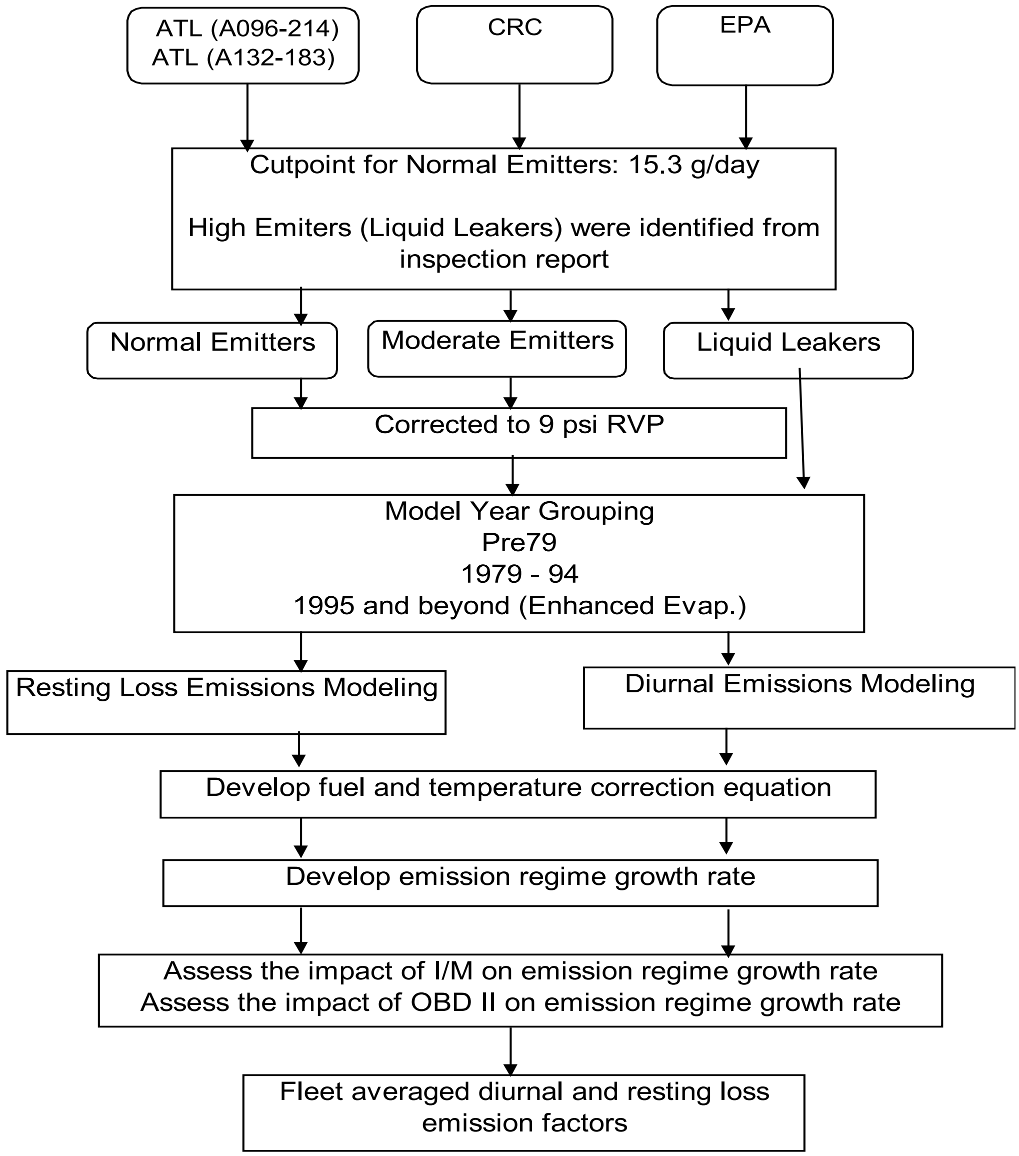


Figure 5.3-1. Flowchart of the methodology used in data analysis of diurna and resting loss emissions.

5.3.3 Methodology

Figure 5.3-1 outlines the methodology used for the analysis of diurnal and resting loss emissions. The four databases were combined into one. The resulting data are shown in Table 5.3-1a - 291 vehicles covering passenger cars and trucks with model years ranging from 1971 to 1995.

Table 5.3-1a. Distribution of vehicles' model years from four databases.

ATL096-214 (n=10)

Vehicle Type	Car	
Model Year	CARB	FI
73	1	0
76	1	0
78	1	0
79	1	0
83	1	0
85	1	0
86	0	1
87	0	1
90	0	2
Subtotal	6	4

ATL132-183 (n=11)

Vehicle Type	Car	
Model Year	CARB	FI
73	1	0
76	1	0
78	1	0
83	1	0
84	1	0
85	1	0
86	0	1
87	0	1
89	0	1
90	0	2
Subtotal	6	5

Combined Databases (n=291)

Vehicle Typ	Car		Truck	
Model Year	CARB	FI	CARB	FI
71	2	0	2	0
72	6	0	1	0
73	6	0	3	0
74	6	0	1	0
75	3	0	2	0
76	14	0	2	0
77	8	0	4	0
78	2	0	0	0
79	2	0	0	0
80	2	0	3	0
81	3	0	7	0
82	0	0	7	0
83	4	0	7	0
84	3	1	13	1
85	6	8	15	2
86	2	13	3	4
87	3	15	4	5
88	2	5	0	12
89	1	7	0	14
90	0	12	0	8
91	0	11	0	7
92	0	4	0	0
93	0	6	0	3
94	0	3	0	0
95	0	0	0	1
Total	75	85	74	57

CRC (n=151)

Vehicle Typ	Car		Truck	
Model Year	CARB	FI	CARB	FI
71	2	0	1	0
72	6	0	1	0
73	4	0	3	0
74	4	0	1	0
75	3	0	1	0
76	11	0	2	0
77	8	0	4	0
78	0	0	0	0
79	0	0	0	0
80	0	0	2	0
81	0	0	5	0
82	0	0	6	0
83	0	0	7	0
84	0	0	12	1
85	0	0	15	2
86	0	0	3	4
87	0	0	4	3
88	0	0	0	9
89	0	0	0	12
90	0	0	0	8
91	0	0	0	7
Subtotal	38	0	67	46

EPA (n=119)

Vehicle Typ	Car		Truck	
Model Year	CARB	FI	CARB	FI
71	0	0	1	0
72	0	0	0	0
73	0	0	0	0
74	2	0	0	0
75	0	0	1	0
76	1	0	0	0
77	0	0	0	0
78	0	0	0	0
79	1	0	0	0
80	2	0	1	0
81	3	0	2	0
82	0	0	1	0
83	2	0	0	0
84	2	1	1	0
85	4	8	0	0
86	2	11	0	0
87	3	13	0	2
88	2	5	0	3
89	1	6	0	2
90	0	8	0	0
91	0	11	0	0
92	0	4	0	0
93	0	6	0	3
94	0	3	0	0
95	0	0	0	1
Subtotal	25	78	7	11

Table 5.3-1b summarizes the fuel RVP and temperature cycles used in each database. With the exception of the CRC test program, most vehicles were tested over different temperature cycles using different fuels.

All vehicles were segregated into three emission regimes, namely; normal, moderate and liquid leakers. A liquid leaker was defined as a vehicle classified by its emission rate as a liquid leaker when undergoing visual inspection. Note that most of the liquid leakers were identified from the CRC study, which included a detailed inspection report on the condition of each vehicle.

Table 5.3-1b. Distribution of diurnal tests from four databases.

ATL096-214 (n=30)

Vehicle Type	Car	
RVP	9 psi	
Temp Range	CARB	FI
60 - 84 F	12	8
65 - 105 F	8	2

ATL132-183 (n=40)

Vehicle Type	Car							
RVP	6.6 psi		7.5 psi (ethanol)		7.6 psi		8.7 psi	
Temp Range	CARB	FI	CARB	FI	CARB	FI	CARB	F
65 - 105 F	6	5	2	4	7	5	6	[illegible]

CRC (n=151)

Vehicle Type	Car		Truck	
RVP	6.8 psi		6.8 psi	
Temp Range	CARB	FI	CARB	FI
72 - 96 F	38	0	67	46

EPA (n=560)

Vehicle Type	Car							
RVP	6.3 psi		6.7 psi		6.9 psi		9.0 psi	
Temp Range	CARB	FI	CARB	FI	CARB	FI	CARB	F
60 - 84 F	0	6	0	0	12	43	19	6
72 - 96 F	0	6	12	29	12	44	19	6
82 - 106 F	0	6	7	18	12	45	13	4

(cont'd)

Vehicle Type	Truck					
RVP	6.3 psi		6.9 psi		9.0 psi	
Temp Range	CARB	FI	CARB	FI	CARB	FI
60 - 84 F	0	0	0	2	7	11
72 - 96 F	7	9	0	2	7	11
82 - 106 F	8	9	0	2	0	4

Prior to establishing a cutpoint for normal and moderate emitters, a correlation equation was developed relating the one-hour condensed diurnal and the 24-hour real-time diurnal test (see Appendix 5.3-1). To be consistent with the cutpoint used in the hot soak analysis, the same 2 g/test (based on the one-hour condensed diurnal test) was selected to distinguish normal and moderate emitters. According to the correlation equation mentioned earlier, 2 g/test (one-hour) corresponds to 15.3 g/day. Therefore, vehicles were divided into normal and moderate emitters based on this 15.3 g/day cutpoint.

The domain of the database is described below:

- Fuel RVP (6.3 psi, 7.0 psi, 7.5 psi, 9.0 psi)
- Temperature cycles (60 – 84 F, 65 – 105 F, 72 – 96 F, and 82 – 106 F)
- Vehicle Types (Passenger Car and Light Duty Truck)
- Model Year Range (1971 to 1995)
- Fuel Delivery System (CARB, TBI, and PFI)
- Emission Status (Normal, Moderate and Liquid Leakers)

Since not all data were collected under the same temperature cycle and fuel RVP, the data were adjusted to a common RVP prior to analysis. To do so, the hourly average emissions were computed combining all temperature cycles at each fuel RVP (6.3 RVP, 7.0 RVP, 7.5 RVP and 9.0 RVP). The hourly average emissions were then normalized (treating the data at 9 RVP as unity). As a result, all hourly average emissions of various fuel RVPs were standardized to 9 RVP (liquid leakers are not assumed to be effected by RVP).

Model year grouping were based on the same model year split used in the hot soak analysis. Duncan's test was performed on the data and it was found that no statistical difference exists between: (1) car and truck and (2) TBI and PFI. As a result, car and truck were combined into a single category, and TBI and PFI data were combined into a single category, called Fuel Injection (FI).

Finally, the data were stratified into several categories according to emission status (normal, moderate and liquid leakers), fuel delivery system (FI and CARB), and model year group (Pre-79, 1979-94, and 1995 and beyond). Hourly average emissions were then computed for each stratum. (See Appendix 5.3-2.)

5.3.4 Diurnal and Resting Loss Basic Emission Rates

Diurnal emissions are defined as the evaporative emissions occuring when the ambient temperature rises. Figure 5.3-2a shows an example of how temperature cycle relates to hourly average emissions for a particular category (normal emitter, FI, and 1979-1994). As seen in this figure, hourly average emissions rise as the ambient temperature increases. Only the data corresponding to a rising ambient temperature were used for the diurnal emission analysis. In other words, the hourly average emissions from the four temperature cycles were used to develop a model using the ambient temperature as the independent variable. Several regression models were tried and it was concluded that a third order polynomial equation fit the data adequately.

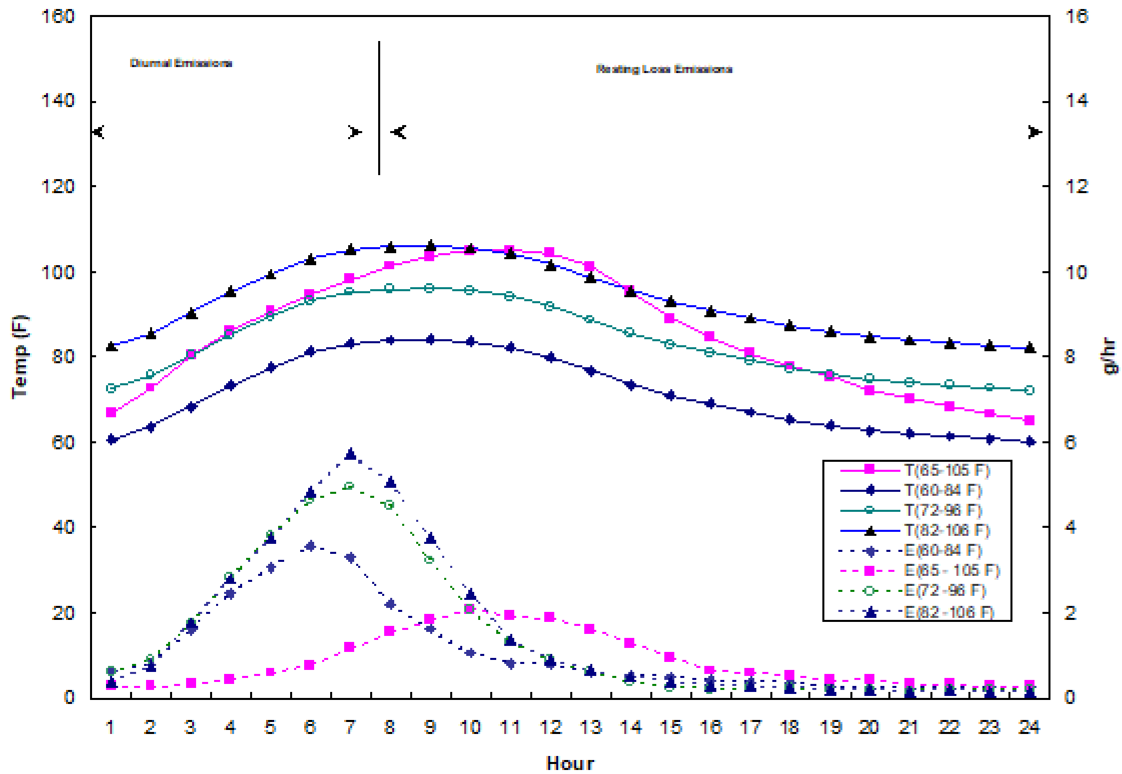


Figure 5.3-2a. Average hourly emission for the category: moderate emitters/FI/model year 1979-94.
T - Temperature E - Emissions

Resting loss emissions are defined as the evaporative emissions occuring when the ambient temperature (T) declines or remains constant. Only the data corresponding to the declining ambient temperature were used in the modeling of resting loss. Similar to diurnal emission, a third order polynomial equation was used. The general form of this polynomial equation is listed below.

$$\text{Diurnal or Resting Loss (g/hr)} = \alpha(T) + \beta(T)^2 + \chi(T)^3 + \text{Intercept} \qquad (5.3\text{-}1)$$

For normal and liquid leakers, it was assumed that diurnal or resting loss emissions rates increase from 55 F to 110 F and that diurnal and resting loss emissions fall to zero at 55 F or below. While a third order equation was used to predict diurnal and resting loss emission rates reasonably for the temperature range between 65 F to 110 F, a linear model was used to depict the emission rates between 55 F and 65 F for diurnal and resting loss. For liquid leaker, it was assumed that the diurnal and resting loss emissions rates increase from 40 F to 110 F. A third order equation was used to predict the diurnal and resting loss emission rates between 70 to 110 F and a linear model was used to depict the emission rates from 70 F to 40 F. Table 5.3-2a and 5.3-2b list the coefficients of the regression models for diurnal and resting loss emissions for the temperature ranges described above. Any diurnal or resting loss at a different fuel RVP should be adjusted by fuel and temperature correction factors

Table 5.3-2a Coefficients of the regression model for diurnal and evaporative emissions (fuel RVP = 9 psi)*.

Diurnal Evaporative Emission (g/hr)

Status	System	MY Group	Intercept	Temp	Temp²	Temp³	Conditions	Tech Group
Normal	CARB	Pre77	0.3702	-0.0220910	0.0003170		Ranges from 65 F to 110 F	1-3, 21, 22
	CARB	77+	1.3300	-0.0495310	0.0004930		Ranges from 65 F to 110 F	4,23,24
	FI	79-94	-3.6979	0.1310920	-0.0015340	0.0000066	Ranges from 65 F to 110 F	5-12, 25-32
	FI	Enhanced	-0.4230	0.0149969	-0.0001755	0.0000007	Ranges from 65 F to 110 F	13, 33
	FI	Zero Evap	-0.1058	0.0037492	-0.0000439	0.0000002	Ranges from 65 F to 110 F	14, 34
Moderate	CARB	Pre77	-65.1714	2.5978250	-0.0346650	0.0001590	Ranges from 65 F to 110 F	1-3, 21, 22
	CARB	77+	-40.4512	1.5929020	-0.0208880	0.0000952	Ranges from 65 F to 110 F	4,23,24
	FI	79-94	11.4632	-0.3342420	0.0026300		Ranges from 65 F to 110 F	5-12, 25-32
	FI	Enhanced	1.3114	-0.0382	0.0003009		Ranges from 65 F to 110 F	13, 33
	FI	Zero Evap	0.3278	-0.0096	0.0000752		Ranges from 65 F to 110 F	14, 34
High	All	All	25.0075	-0.6909750	0.0054520		Ranges from 70 F to 110 F	All

Resting Evaporative Emission (g/hr)

Status	System	MY Group	Intercept	Temp	Temp²	Temp³	Conditions	Tech Group
Normal	CARB	Pre77	2.6605	-0.0864800	0.0007370		Ranges from 65 F to 110 F	1-3, 21, 22
	CARB	77+	2.8687	-0.0870240	0.0006820		Ranges from 65 F to 110 F	4,23,24
	FI	79+	1.5166	-0.0459490	0.0003580		Ranges from 65 F to 110 F	5-12, 25-32
	FI	Enhanced	0.1735	-0.0052566	0.0000410		Ranges from 65 F to 110 F	13, 33
	FI	Zero Evap	0.0434	-0.0013141	0.0000102		Ranges from 65 F to 110 F	14, 34
Moderate	CARB	Pre77	8.0181	-0.2481270	0.0020160		Ranges from 65 F to 110 F	1-3, 21, 22
	CARB	77+	-37.7714	1.5544770	-0.0211460	0.0000960	Ranges from 65 F to 110 F	4,23,24
	FI	79+	-9.9635	0.4569720	-0.0070080	0.0000361	Ranges from 65 F to 110 F	5-12, 25-32
	FI	Enhanced	-1.1398	0.0522776	-0.0008017	0.0000041	Ranges from 65 F to 110 F	13, 33
	FI	Zero Evap	-0.2850	0.0130694	-0.0002004	0.0000010	Ranges from 65 F to 110 F	14, 34
High	All	All	16.9159	-0.4379580	0.0033520		Ranges from 70 F to 110 F	All

*The model is defined as:
Emission (g/hr) $= a*T + b*T^2 + c*T^3 +$ intercept

Table 5.3-2b. Coefficients of the linear model for diurnal and evaporative emissions (fuel RVP = 9 psi)*.

Diurnal Evaporative Emission (g/hr)

Status	System	MY Group	Temp	Conditions	Tech Group
Normal	CARB	Pre77	0.02736	Ranges from 65 F to 55 F	1-3, 21, 22
	CARB	77+	0.01934	Ranges from 65 F to 110 F	4,23,24
	FI	79+	0.01413	Ranges from 65 F to 110 F	5-12, 25-32
	FI	Enhanced	0.00162	Ranges from 65 F to 110 F	13, 33
	FI	Zero Evap	0.00040	Ranges from 65 F to 110 F	14, 34
Moderate	CARB	Pre77	0.08930	Ranges from 65 F to 55 F	1-3, 21, 22
	CARB	77+	0.09818	Ranges from 65 F to 55 F	4,23,24
	FI	79+	0.08493	Ranges from 65 F to 55 F	5-12, 25-32
	FI	Enhanced	0.00972	Ranges from 65 F to 55 F	13, 33
	FI	Zero Evap	0.00243	Ranges from 65 F to 55 F	14, 34
High	All	All	0.11180	Ranges from 70 F to 40 F	All

Resting Evaporative Emission (g/hr)

Status	System	MY Group	Temp	Conditions	Tech Group
Normal	CARB	Pre77	0.01531	Ranges from 65 F to 55 F	1-3, 21, 22
	CARB	77+	0.00936	Ranges from 65 F to 55 F	4,23,24
	FI	79-94	0.00424	Ranges from 65 F to 55 F	5-12, 25-32
	FI	Enhanced	0.00049	Ranges from 65 F to 55 F	13, 33
	FI	Zero Evap	0.00012	Ranges from 65 F to 55 F	14, 34
Moderate	CARB	Pre77	0.04075	Ranges from 65 F to 55 F	1-3, 21, 22
	CARB	77+	0.03046	Ranges from 65 F to 55 F	4,23,24
	FI	79-94	0.00341	Ranges from 65 F to 55 F	5-12, 25-32
	FI	Enhanced	0.00039	Ranges from 65 F to 55 F	13, 33
	FI	Zero Evap	0.00010	Ranges from 65 F to 55 F	14, 34
High**	All	All	0.08945	Ranges from 70 F to 40 F	All

*The linear model for normal and moderate emitters is defined as:
Emission (g/hr) = a* (T-55)

** The linear model for high emitters is defined as:
Emission (g/hr) = a* (T-40)

Figure 5.3-2b presents the estimated diurnal emissions for both moderate and normal emitters. As expected, the emission rates are higher for older vehicles. Figure 5.3-2c shows the estimated resting loss for both moderate and normal emitters. A similar trend showing higher emission rates for older vehicles was also observed. When comparing Figure 5.3-2b with 5.3-2c, it was found that the magnitude of emissions from the diurnal is higher than resting loss. Figure 5.3-2d shows the diurnal and resting losses for the liquid leakers. As expected, the liquid leaker has the highest hourly diurnal and resting loss emissions.

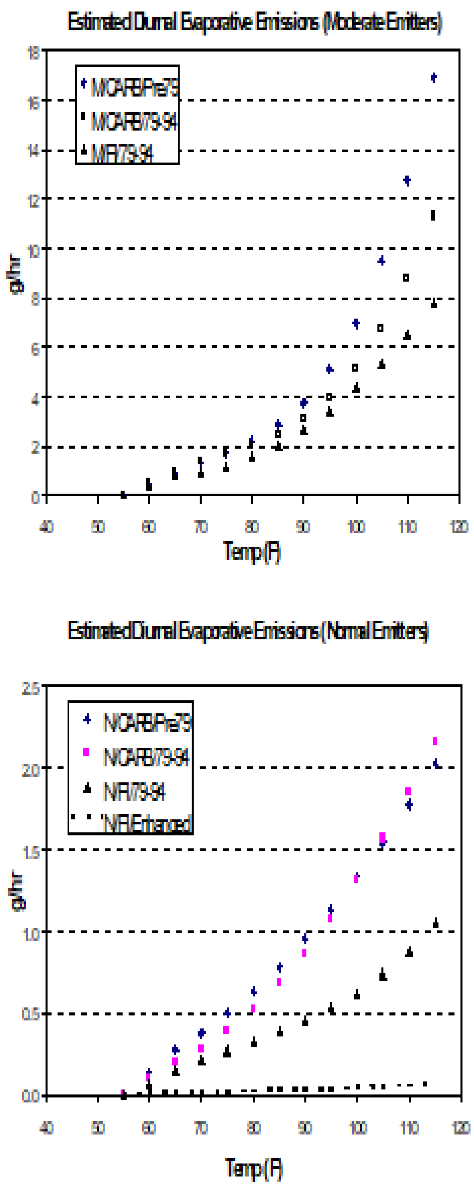


Figure x-2b. Relationship between estimated diurnal emissions and ambient temperature for normal and moderate emitters.

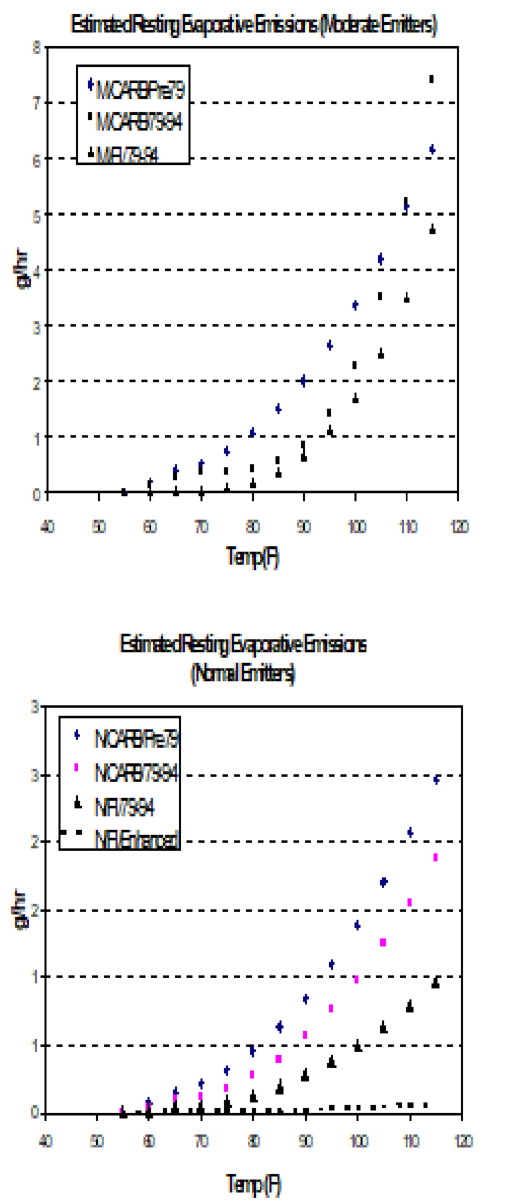


Figure x-2c. Relationship between estimated resting loss emissions and ambient temperature for moderate and normal emitters.

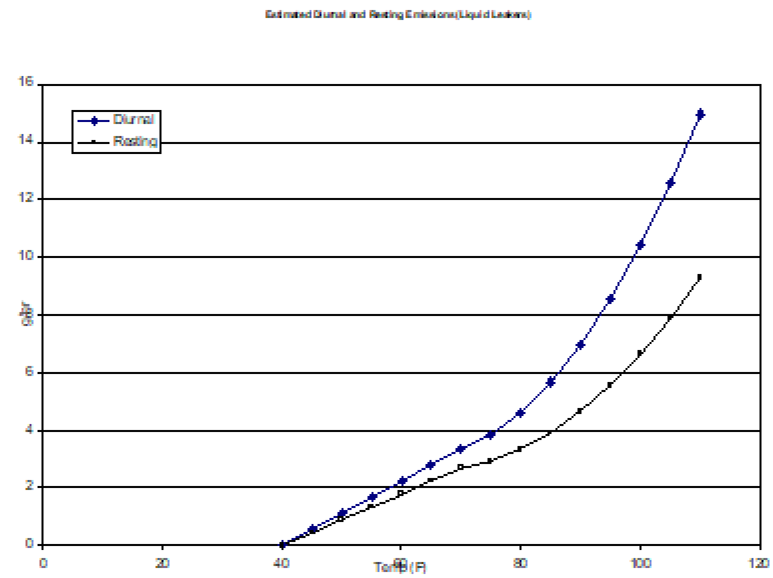


Figure 5.3-2d. Estimated diurnal and resting loss emissions with respect to ambient te
for liquid leakers

5.3.5 <u>Basic Emission Rate for model year 1995 and beyond (Enhanced Evaporative Emission Standards)</u>

The enhanced evaporative emission standards for passenger cars and trucks is 2 gram/test (based upon a three-day diurnal and a one-hour hot soak test), with the temperature ranging from 65 F to 105 F. Four enhanced evap vehicles were analyzed from CRC Project E-41, Real World Evaporative Testing of Late Model In-Use Vehicles, McClement, Hall and Strunck, October 1999. The mean emissions of these four vehicles are assumed to be representative of Normal emitting enhanced evap vehicles. To derive temperature based BERs for diurnal and resting losses for model years 1995+, diurnal and resting loss emission rates from the category (Normal/FI/ 79-94) were used as a basis for estimation. The BERs for the Normal/79-94 groups were reduced iteratively until the sum of the daily emissions equaled the mean emissions observed in E-41. The data from E-41 and the adjustment algorithm are given in Appendix 5.3-3.

5.3.6 <u>Estimation of Basic Emission Rate for Near-zero Evap Vehicles</u>

The basic emission rates for near-zero evap vehicles were estimated from the basic emission rates of enhanced evap vehicles. Similar to the methodology used to estimate BERs for enhanced evap vehicles, near-zero evap vehicles were assumed to emit like enhanced evap vehicles, but with emissions reduced by the ratio of the standards. For PCs, the ratio is 0.5/2.0= 0.25. The BERs for vehicle classes other than passenger vehicles were determined using the ratio of the standards (relative to PCs) as outlined below. These ratios are applied to Normal and Moderate emitters only.

Class Specific Scaling Factor

Class	Tech	Near-zero Evap Standards	Scalar (Ratio of Standards)
PC	Near-zero Evap	0.5	1
T1	Near-zero Evap	0.65	1.3
T2	Near-zero Evap	0.9	1.8
T3	Near-zero Evap	1	2
T4	Near-zero Evap	1	2
T5	Near-zero Evap	1	2
T6	Near-zero Evap	1	2
T7	Near-zero Evap	1	2
T8	Near-zero Evap	1	2

Phase-in Schedule

Near-zero evap vehicles are phased in as follows:

MY	% Near-zero
2004	40
2005	80
2006	100

5.3.7 Temperature and Fuel Correction Factor

The purpose of developing temperature and fuel correction factors is to adjust diurnal and resting loss emission factors to other fuel and temperature conditions. Diurnal or resting loss emissions tend to increase when the ambient temperature is higher. Likewise, diurnal or resting loss will rise if fuel RVP increases. To detect such a relationship, it is necessary to analyze a sample of vehicles undergoing the same temperature cycle at different fuel RVP levels.

The data used in this portion of the analysis is a subset of the EPA database. This subset contains 8 CARB and 18 FI vehicles that were tested over the 72-96 F temperature cycle both at 7 and 9 RVP. Hourly HC averages were computed for the temperature range between 72 to 96 F. As a result, we are able to discern the relationship of temperature and fuel RVP. Because of the small sample size, both CARB and FI vehicles were combined for the data analysis. Finally, a regression model was developed to depict the relationship as listed below.

$$f(T, RVP) = \alpha(T+15) + \beta(RVP) + \chi(T+15)(RVP) + Intercept \qquad (5.3\text{-}2)$$

where the domain of temperature (T) ranges from 55 to 110 F and RVP ranges from 6.5 to 13 psi.

Therefore, the temperature and fuel correction factor

$= f(T, RVP)/f(T, 9\ RVP)$

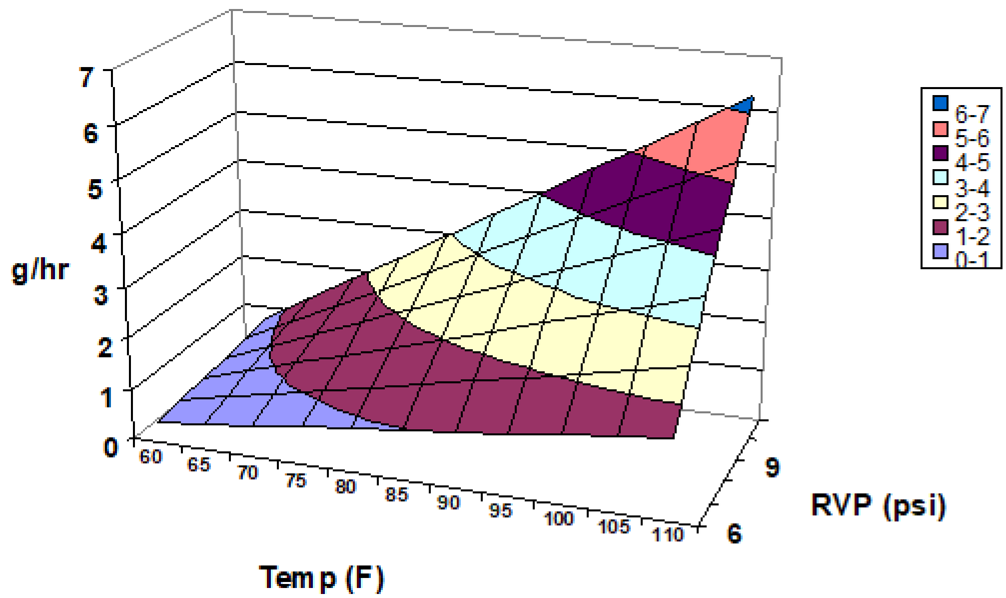


Figure 5.3-3. Relationship between ambient temperature and fuel RVP on diurnal and resting evaporative loss

Table 5.3-3. Coefficient for Temperature and Fuel Correction Equation

TEMP	FUEL	TEMPFUEL	INTERCEPT
A	B	C	D
0.0822	1.2607	0.0175	6.2162

f (T, RVP) = A*(T+15) + B*RVP + C*(T+15)*RVP + D (g/hr)

Temperature and Fuel Correction Factor = f(T, RVP)/f(T, 9)

where T and RVP ranges from 55 F to 110 F and 6.5 to 13 RVP respectively

Table 5.3-3 lists the coefficients of the above equation and Figure 3 graphically presents the temperature and fuel correction equation. As expected, emissions rise as temperature or RVP increases. The temperature and fuel correction factor is applicable to normals and moderates in FI and CARB categories.

5.3.8 Multi-day Correction Factors

Cumulative emissions of HC may be different for day 2 and day 3 of vehicle soak. Therefore, there is a need to develop a correction factor to account for the changes in total emissions for day 2 as well as day 3 and beyond.

The data used for the multi-day correction factor analysis contains 101 vehicles tested at 9 psi over 72 hours. These vehicles were also tested over different temperature cycles; namely, 60 – 84 F, 65 – 105 F, 72 – 96 F, and 82 –106 F.

To develop multi-day correction factors, an analysis was performed to compare the cumulative HC emissions over 24 hours, 48 hours, and 72 hours, respectively. It was found that the temperature cycle has a minimal effect on the relative changes of cumulative HC emissions for day 1, day 2 and day 3 for both CARB and FI vehicles. In other words, there were no relative changes in cumulative HC for day 1, day 2, and day 3 when compared with various temperature cycles. Based upon certification data on low emitting data, it is assumed that near-zero evap vehicles will not have elevated emissions on the second and subsequent days.

On the other hand, the fuel-metering system appears to have a major impact on the multi-day correction factor. As shown in Figure 5.3-4, the hourly average emissions for CARB vehicles remain almost constant throughout three days whereas hourly average emissions for FI vehicles increase daily. Table 5.3-4 lists the multi-day correction factor for CARB and FI. Diurnal or resting loss for day 2 as well as day 3 and beyond can be estimated by multiplying the multi-day correction factor by the basic emission rates of day 1.

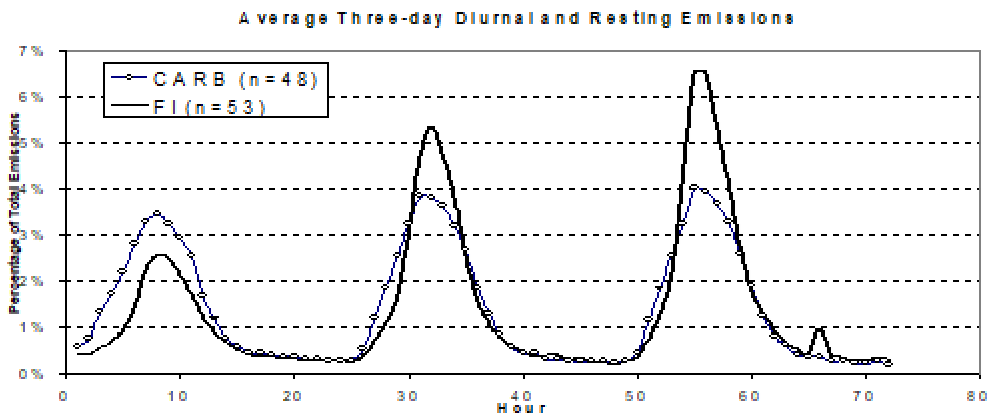


Figure 5.3-4. Normalized average three-day diurnal and resting evaporative loss based on 101 velcles at 9 psi RVP

Table 5.3-4. Multiple day Correction Factors at 9 psi RVP

System	Day 1	Day 2	Day 3 +
CARB	1	1.01	1.01
FI	1	1.53	1.86
Enhanced	1	1.00	1.00
Near Zero	1	1.00	1.00

5.3.9 Regime Growth Rates

The emission regime growth rates for CARB and FI were developed from the historical Air Resources Board condensed one-hour diurnal data, using 2g/test as the cutpoint for normal and moderate categories. For consistency, it was assumed that the EPA's assessment of the fraction of liquid leakers could be used for both CARB and FI vehicles.

Figure 5.3-5a and 5b present the regime growth rates of normal, moderate and liquid leakers for CARB and FI, respectively. The equations describing the regime growth pattern were also listed. As expected, CARB vehicles tend to attain moderate and liquid leaker categories faster than FI vehicles. Moreover, the percentage of liquid leakers for CARB is higher than FI, for any given age. In the event that the sum of fractions exceed 100%, the regimes are normalized.

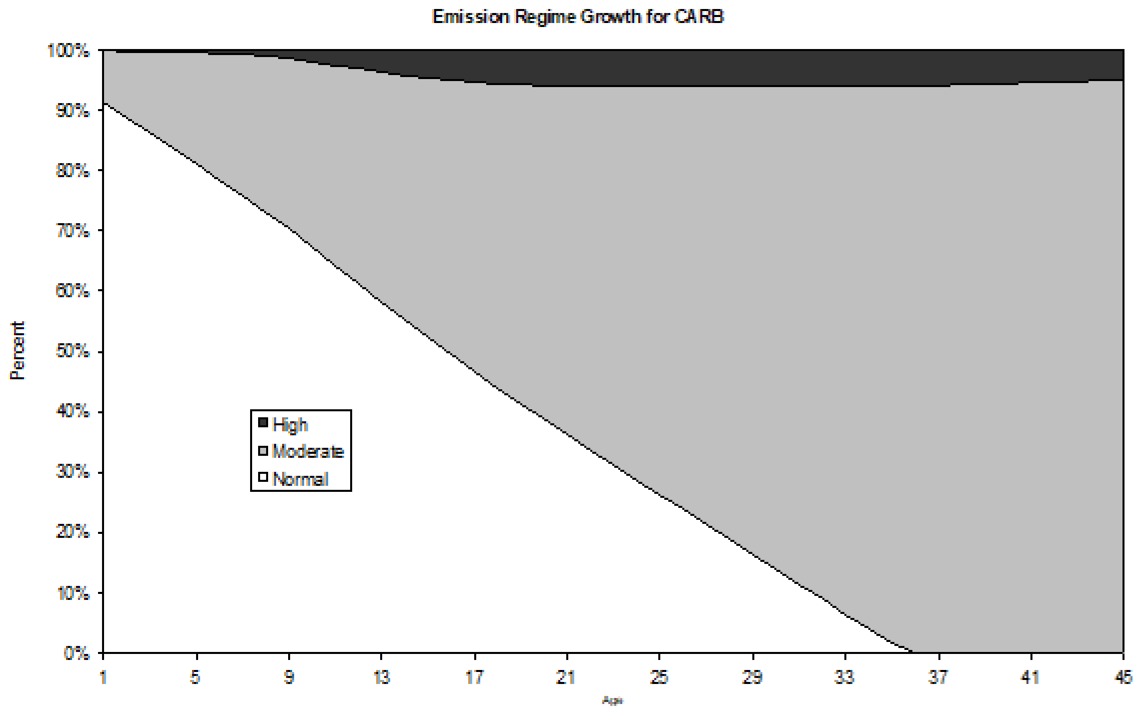


Figure 5.3-5a. Regime growth of normal, moderate, liquid leakers for CARB vehicles.

CARB	Equation
Normal	Fraction = 0.92 + -0.0259*Age
Moderate	Fraction = 0.085521 + 0.02468*(Age -1)
LL	Fraction = 0.06/(1+120*exp(-0.4*age))

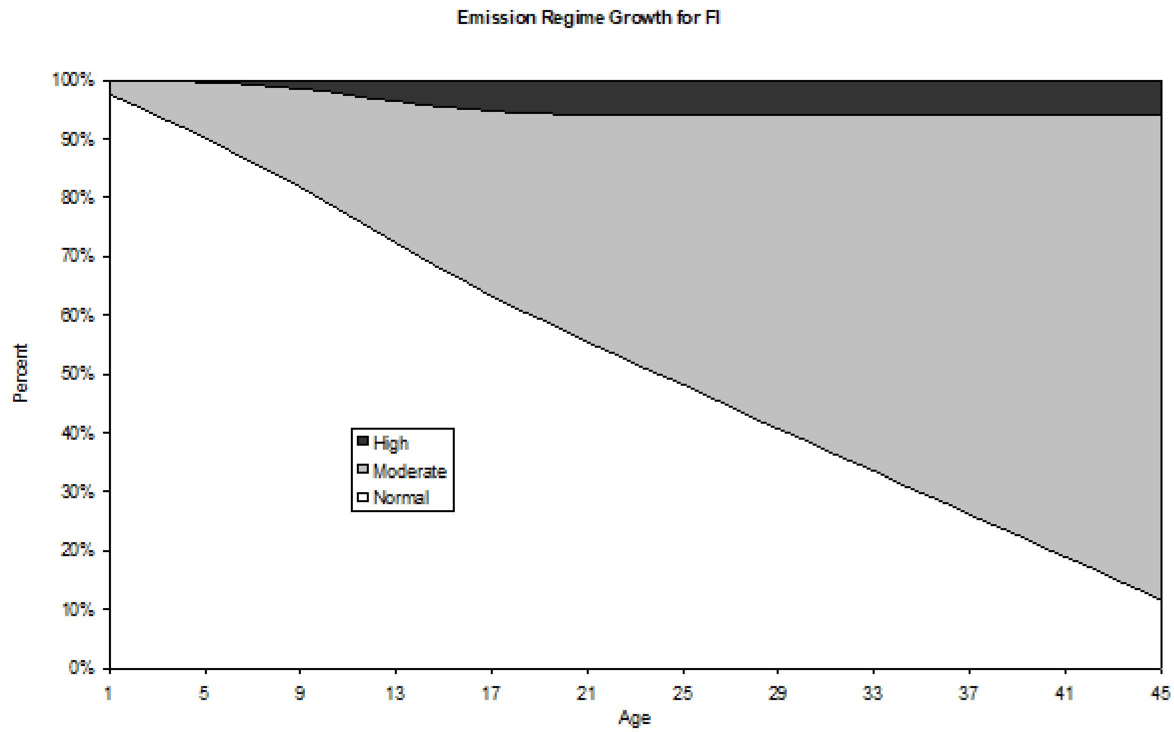


Figure 5.3-5b. Regime growth rate of normal, moderate, and liquid leakers for FI vehicles.

FI	Equation
Normal	Fraction = 0.975 + -0.0189*Age
Moderate	Fraction =0.0229 + 0.01821*(Age-1)
LL	Fraction = 0.06/(1+120*exp(-0.4*age))

As discussed in section 5.1, the growth of liquid leaking enhanced and near-zero fleets are assumed to be half of the FI growth rate.

5.3.10 I/M corrected Diurnal and Resting Loss Emission Factors

The California I/M program requires vehicles to undergo inspection biennially. Hence, we assume moderates will receive I/M benefit as some of the components causing high evaporative emissions are identified and repaired.

The average emission factor for normal emitters with respect to age is defined as follows:

Average EF for Normal Emitters in the Fleet ($EF_{\text{Ave Normal Emitters, Age}}$)
= Normal Emitter Growth Rate $_{\text{CARB}}$ *EF $_{\text{CARB}}$*CARB Vehicle Fraction +
Normal Emitter Growth Rate $_{\text{FI}}$*EF $_{\text{FI}}$*FI Vehicle Fraction
(5.3-3)

Similarly, the average emission factor for moderate emitters with respect to age is defined as follows:

Average EF for Moderate Emitters in the Fleet ($EF_{Ave\ Moderate\ Emitters,\ Age}$)
= Moderate Emitter Growth Rate $_{CARB}$ *EF $_{CARB}$*CARB Vehicle Fraction +
Moderate Emitter Growth Rate $_{FI}$*EF $_{FI}$*FI Vehicle Fraction

(5.3-4)

Average EF for Liquid Leakers in the Fleet ($EF_{Ave\ LL,\ Age}$)
= Liquid Leaker Growth Rate $_{CARB}$ *EF $_{CARB}$*CARB Vehicle Fraction +
Liquid Leaker Growth Rate $_{FI}$*EF $_{FI}$*FI Vehicle Fraction (5.3-5)

Because of the I/M program, there is an emission benefit for moderate emitters. In particular, vehicles subject to I//M and successful repair will change their status from moderate to normal emitters. Therefore, the moderate emitter growth rate for CARB and FI is adjusted accordingly.

Gas cap failure rates were well documented in a 1996 smog check study conducted by BAR. Therefore, gas cap failure rates were used to estimate the emission control failure rate in I/M. (See Appendix 5.3-4 for the methodology to estimate gas cap failure rate.)

It was assumed that the vehicles in the moderate emitter regime benefit from the I/M program. Specifically, vehicles in the moderate emitter category are identified and repaired, and will move to the normal emitter regime after repair. However, vehicles in the liquid leaker category were assumed not to be identified by I/M and thus will not change its emission regime size.

Fraction of moderate emitters moved to normal emitters per inspection period ($Rate_{Moderate\ to\ Normal}$)

= Identification Rate (ID %)*Incremental Gas Cap Failure Rate (IGC Fail)*Repair Efficiency (Repair %) (5.3-6)

Thus, adjusted moderate emitter growth rate for both CARB and FI per inspection period is as follows:
= Moderate Emitter Growth Rate - $Rate_{Moderate\ to\ Normal}$
(5.3-7)

Assuming the identification rate and repair efficiency is 95%, the new moderate emitter growth rate is thus given as follows:

New Moderate Emitter Growth Rate =
Moderate Emitter Growth Rate * (1- 0.95*gas cap failure rate) (5.3-8)

5.3.11 <u>Moderate Emitter Growth Rate and OBDII</u>

Because of the OBD II system, emissions control components are closely monitored and likely to be repaired once malfunctioning components are detected. Therefore, OBDII vehicles will be modeled by suppressing the formation of moderate emitters for the first seven years of a vehicle's life. As a result, the new moderate emitter growth rate for OBDII vehicles will be created by subtracting the fraction of moderate emitters for the first seven years, as presented below:

The adjusted moderate emitter regime growth

$$= 0.0229 + 0.01821*(Age-1) - 0.13216$$
$$= 0.01821*(Age-1) - 0.10916 \quad (5.3\text{-}9)$$

Note that if the fraction of moderate emitters becomes negative, it is considered zero. It was assumed that the regime growth rate for liquid leakers would remain unchanged as listed in Figure 5.3-5b. Therefore, the fraction of normal emitters is given as follows:

Fraction of Normal Emitters =
1 – Adjusted Fraction of Moderate Emitters – Fraction of Liquid Leakers

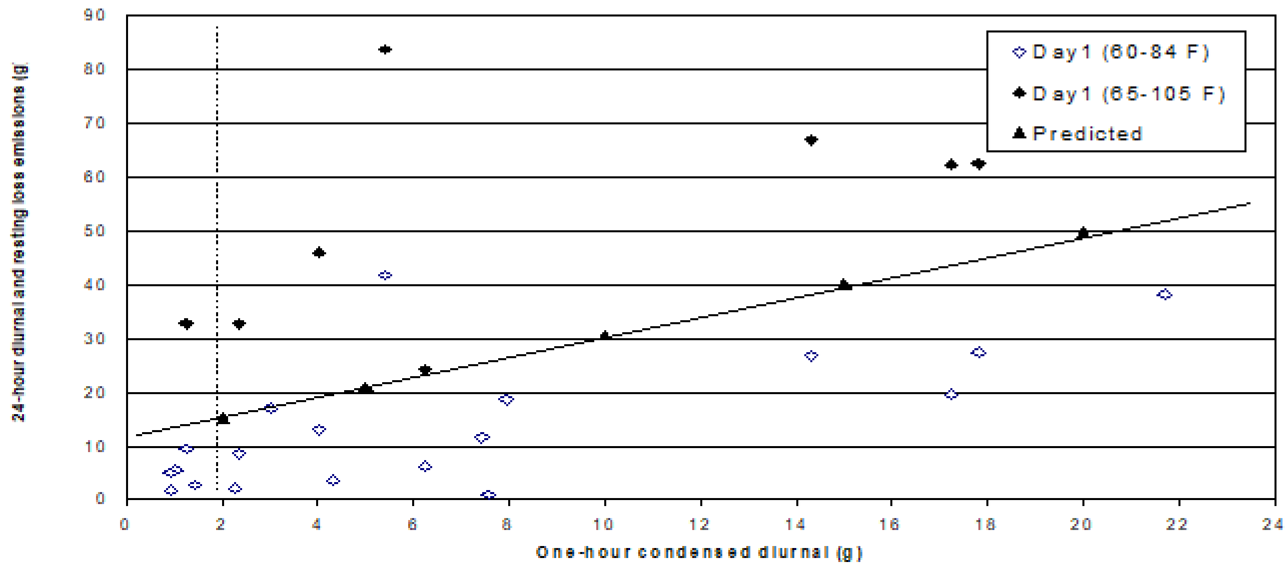
5.3.12 <u>Conclusions</u>

While this study attempts to model both diurnal and resting loss using ambient temperature as the driving force, there are limitations in modeling because of lack of data. Both diurnal and resting losses were modeled based on a defined temperature cycle; however, these cycles may not faithfully depict the temperature profile experienced by vehicles under various initial conditions. Furthermore, with the more stringent evaporative emission standards, newer vehicles are expected to have less evaporative emission. Diurnal and resting loss emission data from vehicles subject to the enhanced evaporative emission standards are needed.

Future studies should focus on the following issues:

(1) Vehicles of model year 1995 and beyond;
(2) The effect of time and initial temperature on diurnal and resting loss;
(3) Understanding the lag time between the peaks of emissions and ambient temperature;
(4) The impact of solar loading and wind on evaporative emissions; and
(5) Comparing the diurnal and resting loss emissions with the methodology used by the EPA.

Appendix 5.3-1. Correlation between one-hour condensed diurnal and the 24-hour test (9 psi RVP)



Correlation Equation:

24-hour test(g) = 11.4335 + 1.9195*(One-hour condensed diurnal)

The purpose of this analysis is to relate the one-hour condensed diurnal test to the diurnal and resting loss emissions over a 24-hour period. Thus, the corresponding 24-hour cutpoint can be estimated from the 2 g/hr one-hour condensed diurnal test, similar to the cutpoint used in the hot soak analysis. The data used in this correlation analysis came from the a study conducted by Automotive Testing Laboratories in 1994 (Contract No. A096-214). The conventional one-hour hot soak results were compared with 24-hour test data. There were two diurnal temperature profiles; namely, 60 to 84 F and 65 to 105 F. As expected, data from the temperature profile 65 to 105 F have a higher total emissions when compared to the 60 to 84 F profile. Nevertheless, the correlation is developed in order to estimate a cutpoint to distinguish between normal and moderate emitters.

Appendix 5.3-2. Hourly average emissions based on emission status, model year groupings, fuel delivery system, and temperature cycles.

Status	Normal			
MY Group	1979 - 1994			
System	CARB			
Number	25	4	58	8
Hour	60-84 F	65 - 105 F	72 -96 F	82 -106 F
1	0.188	0.575	0.232	0.388
2	0.218	0.557	0.245	0.437
3	0.318	0.657	0.399	0.543
4	0.428	0.729	0.598	0.855
5	0.551	0.726	0.851	1.053
6	0.750	0.810	1.123	1.275
7	0.858	0.875	1.348	1.536
8	0.837	1.024	1.286	1.406
9	0.721	0.954	1.063	1.391
10	0.638	1.110	0.843	0.901
11	0.513	0.999	0.615	0.886
12	0.425	0.765	0.470	0.672
13	0.380	0.575	0.410	0.602
14	0.274	0.449	0.332	0.410
15	0.209	0.290	0.275	0.307
16	0.163	0.175	0.189	0.265
17	0.151	0.107	0.184	0.252
18	0.132	0.076	0.170	0.211
19	0.127	0.095	0.149	0.187
20	0.112	0.095	0.136	0.246
21	0.115	0.039	0.118	0.150
22	0.098	0.085	0.124	0.193
23	0.104	0.037	0.116	0.190
24	0.105	0.038	0.121	0.200
Sum	8.856	12.960	11.850	14.766

Status	Normal			
MY Group	Pre79			
System	CARB			
Number	4	1	7	
Hour	60-84 F	65 - 105 F	72 -96 F	82 -106 F
1	0.325	0.210	0.364	
2	0.211	0.238	0.384	
3	0.358	0.267	0.532	
4	0.613	0.386	0.720	
5	0.679	0.490	0.931	
6	0.785	0.639	1.205	
7	0.820	0.833	1.530	
8	0.787	0.869	1.629	
9	0.774	1.044	1.466	
10	0.658	1.277	1.218	
11	0.505	1.273	0.951	
12	0.407	0.795	0.716	
13	0.334	0.755	0.651	
14	0.275	0.652	0.563	
15	0.330	0.425	0.537	
16	0.176	0.197	0.391	
17	0.217	0.183	0.417	
18	0.153	0.146	0.360	
19	0.166	0.135	0.366	
20	0.146	0.095	0.332	
21	0.102	0.088	0.294	
22	0.145	0.095	0.326	
23	0.141	0.026	0.306	
24	0.144	0.027	0.320	
Sum	9.707	12.456	17.694	

Status	Normal			
MY Group	1995 and beyond			
System	FI			
Number	1		2	1
Hour	60-84 F	65 - 105 F	72 -96 F	82 -106 F
1	0.050		0.080	0.090
2	0.040		0.079	0.112
3	0.040		0.091	0.144
4	0.060		0.109	0.203
5	0.080		0.145	0.256
6	0.090		0.166	0.314
7	0.100		0.215	0.365
8	0.100		0.220	0.347
9	0.100		0.207	0.293
10	0.100		0.193	0.254
11	0.110		0.155	0.156
12	0.090		0.144	0.152
13	0.080		0.126	0.111
14	0.070		0.107	0.105
15	0.060		0.091	0.081
16	0.050		0.059	0.071
17	0.050		0.073	0.067
18	0.040		0.059	0.047
19	0.040		0.054	0.057
20	0.040		0.048	0.047
21	0.030		0.049	0.049
22	0.030		0.050	0.060
23	0.030		0.043	0.046
24	0.030		0.044	0.048
Sum	1.590		2.540	3.080

Status	Normal			
MY Group	1979 - 1994			
System	FI			
Number	118	17	173	77
Hour	60-84 F	65 - 105 F	72 -96 F	82 -106 F
1	0.089	0.119	0.128	0.146
2	0.113	0.119	0.149	0.155
3	0.221	0.148	0.265	0.240
4	0.361	0.196	0.391	0.319
5	0.481	0.239	0.498	0.441
6	0.540	0.302	0.603	0.593
7	0.594	0.367	0.716	0.796
8	0.480	0.429	0.689	0.934
9	0.362	0.476	0.595	0.845
10	0.263	0.565	0.467	0.677
11	0.176	0.674	0.338	0.464
12	0.145	0.498	0.274	0.328
13	0.118	0.426	0.222	0.274
14	0.095	0.305	0.185	0.222
15	0.080	0.194	0.139	0.182
16	0.058	0.105	0.140	0.136
17	0.054	0.090	0.108	0.119
18	0.052	0.078	0.095	0.115
19	0.042	0.075	0.087	0.104
20	0.045	0.074	0.084	0.092
21	0.041	0.058	0.072	0.099
22	0.041	0.069	0.073	0.090
23	0.043	0.054	0.075	0.081
24	0.043	0.055	0.078	0.084
Sum	4.626	6.318	6.644	7.726

Appendix 5.3-3 - Enhanced Evap Vehicle

CRC Project E-41
World Evaporative Testing of Late Model In-Use Vehicles

	Veh #	Yr./Make/Model	24-hour DHB Grams
enh	E-41008	1997 Dodge Stratus 2.4L, PFI, 16.0 tank	0.38
enh	E-41020	1997 Plymouth Breeze 2.0L, PFI, 16.0 tank	0.59
enh	E-41027	1996 Dodge Caravan 2.4L, PFI, 20.0 tank	0.82
enh	E-41032	1996 Chevrolet S-10 4.3L, PFI, 19.0 tank	0.35
		mean enh	0.54

Spreadsheet to calculate enhanced evap vehicle reduction

Hour	Temp profile	ER 9RVP N/79-94	RVPCF 9-->7 RVP	ER 7RVP N/79-94	E41 Enhanced	
1	65.0	0.1548	0.6962	0.1077	0.0123	
2	68.6	0.2075	0.6611	0.1372	0.0157	
3	72.3	0.2557	0.6386	0.1633	0.0187	
4	75.9	0.3011	0.6229	0.1876	0.0215	
5	79.5	0.3457	0.6113	0.2114	0.0242	
6	83.2	0.3914	0.6025	0.2358	0.0270	
7	86.8	0.4401	0.5955	0.2621	0.0300	
8	90.5	0.4937	0.5898	0.2912	0.0333	
9	94.1	0.5541	0.5851	0.3242	0.0371	
10	97.7	0.6232	0.5811	0.3621	0.0414	
11	101.4	0.7028	0.5777	0.4060	0.0465	
12	105.0	0.7950	0.5748	0.4570	0.0523	
13	101.7	0.5454	0.5775	0.3150	0.0360	
14	98.3	0.4599	0.5805	0.2670	0.0306	
15	95.0	0.3824	0.5840	0.2233	0.0256	
16	91.7	0.3128	0.5881	0.1840	0.0211	
17	88.3	0.2512	0.5930	0.1489	0.0170	
18	85.0	0.1975	0.5988	0.1182	0.0135	
19	81.7	0.1518	0.6059	0.0920	0.0105	
20	78.3	0.1140	0.6148	0.0701	0.0080	
21	75.0	0.0842	0.6264	0.0527	0.0060	
22	71.7	0.0623	0.6418	0.0400	0.0046	
23	68.3	0.0484	0.6635	0.0321	0.0037	
24	65.0	0.0425	0.6962	0.0296	0.0034	factor = enh/(79-94)
		7.9176		4.7185	0.5400	0.1144

Appendix 5.3-2. (cont'd)

Status	Moderate			
MY Group	1979 - 1994			
System	CARB			
Number	11	11	32	23
Hour	60-84 F	65 - 105 F	72 -96 F	82 -106 F
1	0.705	0.681	0.795	0.960
2	0.825	0.961	0.924	1.193
3	1.639	1.866	1.583	2.119
4	2.509	2.839	2.285	3.277
5	3.162	3.636	3.164	4.589
6	3.689	4.517	4.031	6.239
7	3.703	5.203	4.404	6.984
8	3.046	5.350	4.005	6.355
9	2.282	5.825	3.100	4.701
10	1.614	5.497	2.144	3.209
11	1.133	4.279	1.469	2.062
12	0.823	3.159	0.995	1.382
13	0.703	2.196	0.869	1.014
14	0.630	1.582	0.680	0.789
15	0.480	1.240	0.551	0.647
16	0.357	0.652	0.429	0.433
17	0.353	0.661	0.381	0.439
18	0.341	0.667	0.339	0.392
19	0.276	0.602	0.306	0.333
20	0.263	0.436	0.290	0.318
21	0.252	0.286	0.274	0.245
22	0.237	0.339	0.226	0.253
23	0.211	0.295	0.246	0.233
24	0.214	0.302	0.253	0.240
Sum	30.316	56.572	34.036	48.015

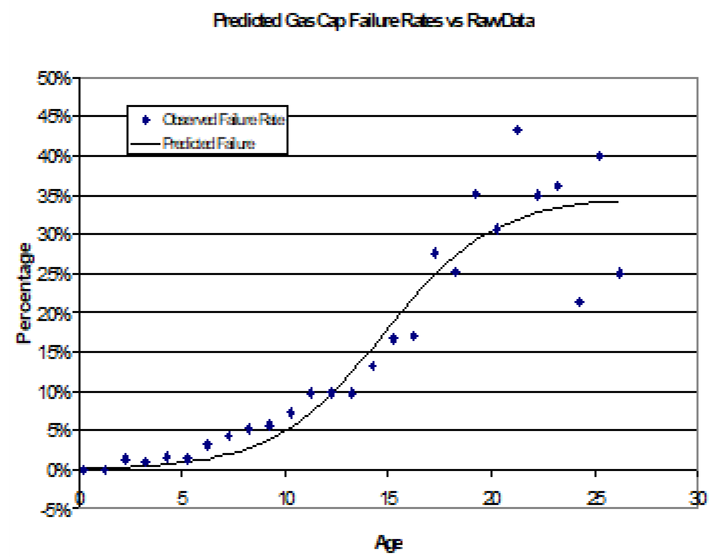
Status	Moderate			
MY Group	Pre79			
System	CARB			
Number	11	15	31	7
Hour	60-84 F	65 - 105 F	72 -96 F	82 -106 F
1	0.545	0.694	0.534	0.774
2	0.740	0.883	2.292	0.896
3	1.387	1.702	3.007	1.793
4	1.802	2.068	3.865	3.449
5	2.010	2.820	4.921	6.107
6	2.351	3.474	6.371	9.154
7	2.473	4.572	7.242	10.738
8	2.426	5.251	6.797	9.482
9	2.196	5.649	5.356	6.360
10	1.840	5.303	4.323	4.079
11	1.507	4.503	2.894	2.434
12	0.996	2.860	2.305	1.736
13	0.784	1.651	2.135	1.256
14	0.673	0.980	1.743	0.850
15	0.565	0.659	1.512	0.646
16	0.433	0.498	1.176	0.471
17	0.398	0.359	1.286	0.405
18	0.393	0.364	1.213	0.442
19	0.388	0.320	1.105	0.300
20	0.341	0.263	1.041	0.303
21	0.335	0.225	0.942	0.309
22	0.277	0.206	0.979	0.238
23	0.320	0.202	0.930	0.229
24	0.324	0.204	0.973	0.237
Sum	26.534	48.463	68.335	62.278

Status	Moderate			
MY Group	1979 - 1994			
System	FI			
Number	13	2	36	55
Hour	60-84 F	65 - 105 F	72 -96 F	82 -106 F
1	0.682	0.320	0.620	0.378
2	0.829	0.318	0.901	0.711
3	1.660	0.380	1.821	1.708
4	2.539	0.504	3.029	2.748
5	3.192	0.706	4.143	3.711
6	3.679	0.918	5.069	4.820
7	3.440	1.441	5.403	5.700
8	2.294	1.905	4.879	5.053
9	1.731	2.233	3.454	3.702
10	1.160	2.525	2.197	2.450
11	0.900	2.207	1.349	1.381
12	0.886	2.133	0.894	0.876
13	0.677	1.800	0.602	0.637
14	0.574	1.519	0.336	0.488
15	0.552	1.085	0.239	0.388
16	0.451	0.729	0.179	0.279
17	0.418	0.650	0.200	0.273
18	0.389	0.576	0.206	0.224
19	0.313	0.447	0.154	0.194
20	0.258	0.486	0.156	0.173
21	0.252	0.332	0.152	0.161
22	0.258	0.349	0.173	0.169
23	0.270	0.282	0.166	0.162
24	0.273	0.292	0.171	0.165
Sum	28.830	27.015	36.987	36.630

Status	High			
MY Group	All			
System	All			
Number	2		35	2
Hour	60-84 F	65 - 105 F	72 -96 F	82 -106 F
1	2.895		0.814571	3.75
2	3.095		3.887198	4.35486
3	4.015		4.491217	6.260341
4	4.915		5.457016	8.39
5	5.695		6.350595	10.2956
6	6.275		7.772331	13.65382
7	6.35		8.755185	11.59731
8	6.185		8.919793	12.67754
9	5.5		7.698219	9.868606
10	5.075		6.860281	8.372663
11	4.805		5.127289	7.315992
12	4.52		4.342946	5.650222
13	3.635		4.175853	5.534259
14	3.13		3.764295	4.396585
15	2.86		3.547298	3.88593
16	2.785		2.836253	3.935036
17	2.735		3.121084	3.736441
18	2.625		3.101931	3.578129
19	2.53		2.844746	3.637486
20	2.54		2.763386	3.620701
21	2.675		2.563845	3.679369
22	2.535		2.659463	3.71264
23	2.505		2.494234	3.457857
24	2.505		2.607179	3.549976
Sum	92.385		106.956	148.911

Appendix 5.3-4 Estimation of the gas cap failure rate from BAR's smog check data performed in Spring 1996.

MY	Age	Observed Failure Rate	Predicted Failure
70	26.25	25.0%	34.2%
71	25.25	40.0%	34.0%
72	24.25	21.4%	33.7%
73	23.25	36.1%	33.3%
74	22.25	35.0%	32.7%
75	21.25	43.3%	31.9%
76	20.25	30.6%	30.7%
77	19.25	35.1%	29.2%
78	18.25	25.2%	27.3%
79	17.25	27.6%	24.8%
80	16.25	17.1%	22.0%
81	15.25	16.7%	18.8%
82	14.25	13.2%	15.6%
83	13.25	9.7%	12.4%
84	12.25	9.8%	9.6%
85	11.25	9.7%	7.2%
86	10.25	7.3%	5.3%
87	9.25	5.6%	3.8%
88	8.25	5.2%	2.7%
89	7.25	4.3%	1.9%
90	6.25	3.2%	1.3%
91	5.25	1.4%	0.9%
92	4.25	1.6%	0.6%
93	3.25	1.0%	0.4%
94	2.25	1.3%	0.3%
95	1.25	na	0.2%
96	0.25	na	0.1%



Parameter	Value
K	0.347
No	0.00133
R	0.3758

Model
Y= K/(1+((K-No)/No)*EXP(-R*AGE))

Section 5.2 HOT SOAK EMISSIONS

5.2.1 <u>Introduction</u>

Hot soak emissions are comprised of fuel vapors emitted from a vehicle after the engine is turned off. The elevated engine temperature causes fuel vaporization from different sources such as fuel delivery lines, purge line to the canister, and gas cap. For carbureted (CARB) vehicles, the residual fuel in the carburetor bowl and intake manifold can vaporize and escape the evaporative control system. For vehicles with fuel injectors (FI), residual fuel may drip from the fuel injectors. In addition, external factors such as the ambient temperature and fuel Reid vapor pressure (RVP) also effect the rate of hot soak emissions.

The hot soak emission factors in MVEI7g1.0c were developed in 1992 using data from ARB's past vehicle surveillance programs, where vehicles were selected randomly for hot soak emissions testing. To refine the hot soak emission factors, it is imperative to update the methodology with the most current data. In particular, the introduction of enhanced evaporative testing and reformulated gasoline as well as improved evaporative emissions control technology may all contribute to lower evaporative emissions from new vehicles. Table 5.2-1 presents the changes in evaporative emission standards through the years.

Table 5.2-1. Evaporative Vehicle Emission Standards

Model Years	Standard (hot soak + diurnal)	Test Procedure
1972-1977	2 grams/test	Carbon Trap
1978-1979	6 grams/test	SHED
1980-1994	2 grams/test	SHED
1995 and beyond	2 grams/test	Enhanced Evap. Test
2004 and beyond	0.5 grams/test	Enhanced Evap. Test

Research on hot soak emissions is ongoing and several major studies have been conducted in the past few years. The data used in this analysis are from hot soak emission studies conducted by ARB, U.S. EPA, and the Auto/Oil study. It is anticipated that with updated data, a refined hot soak emission model can be developed.

5.2.2 <u>Objectives</u>

This analysis intends to achieve the following tasks:

1. Develop the emission profile based on minute-by-minute hot soak data.
2. Develop a new "cut-off" point for hot soak emissions and relate the one-hour conventional hot soak emissions to the newly defined hot soak interval.
3. Develop hot soak basic emission rates.
4. Develop emission regime growth rates.
5. Assess the impact of I/M and OBD II on hot soak emissions.

5.2.3 Methodology

The hot soak data analyzed in this study come from four databases: ARB's In-Use Vehicle Surveillance Projects conducted from 1976 to 1994, Auto/Oil Air Quality Improvement Research Program conducted in 1993, EPA's hot soak emissions test program conducted in 1995, and CRC E41. Prior to analysis, all data were separated into three categories; namely, normal, moderate, and liquid leakers. The cutpoint for normal and moderate emitters was established at 2 g/test and 1 g/test, for carbureted and fuel-injected vehicles respectively. A high liquid leaker is defined as a vehicle with a fuel leak and is identified from either the EPA or Auto/Oil inspection report. The average hot soak emissions are approximately 21 g/test from those vehicles leaking fuel.

Table 5.2-2 lists the distribution of model years with respect to emitter category from the three databases. As expected, there are more vehicles in the normal emitter category when compared to high emitters. The model years range from 1969 to 1997.

Table 5.2-2 Model year distributions of vehicles from four databases

	ARB		AUTO/OIL		EPA		CRC		
MY	CARB	FI	CARB	FI	FI	CARB	CARB	FI	Subtotal
69	1								1
70	17								17
71	27								27
72	27	1							28
73	25								25
74	31	1							32
75	75	2							77
76	91	4							95
77	58	4							62
78	129	7							136
79	107	17							124
80	132	19							151
81	109	18			4	1			132
82	98	13			4	1			116
83	67	23	12	4	6	2			114
84	56	32	17	8	4	2			119
85	30	32	4	18	5	4			93
86	19	20	11	22	9	12			93
87	12	12	7	32	10	15			88
88	5	15	6	29	2	13			70
89		11	4	22	3	19			59
90		6	0	34		16			56
91		4	1	35		21			61
92		3		26		10		13	52
93				4		4		12	20
94						10	1	12	23
95						1		4	5
96								6	6
97								2	2
								Total	1884

Though not all tests were performed under the same ambient temperature conditions and fuel RVP, all data were adjusted to 9 RVP and 75 F using fuel and temperature correction factors developed in section 5.2.4.

Figure 5.2-1 briefly outlines the methodology employed in this study. Prior to developing the hot soak emission factors, emissions profiles for normal, moderate, and liquid leakers were generated based on "real-time" modal data analysis. (See Appendix 5.2-A1 for detailed information on modal data analysis.) As a result, hot soak emissions were defined to end after 35 minutes. Consequently, the conventional one-hour hot soak data were adjusted to 35 minutes. The data were then stratified into model year and technology groupings prior to developing the hot soak basic emission rates.

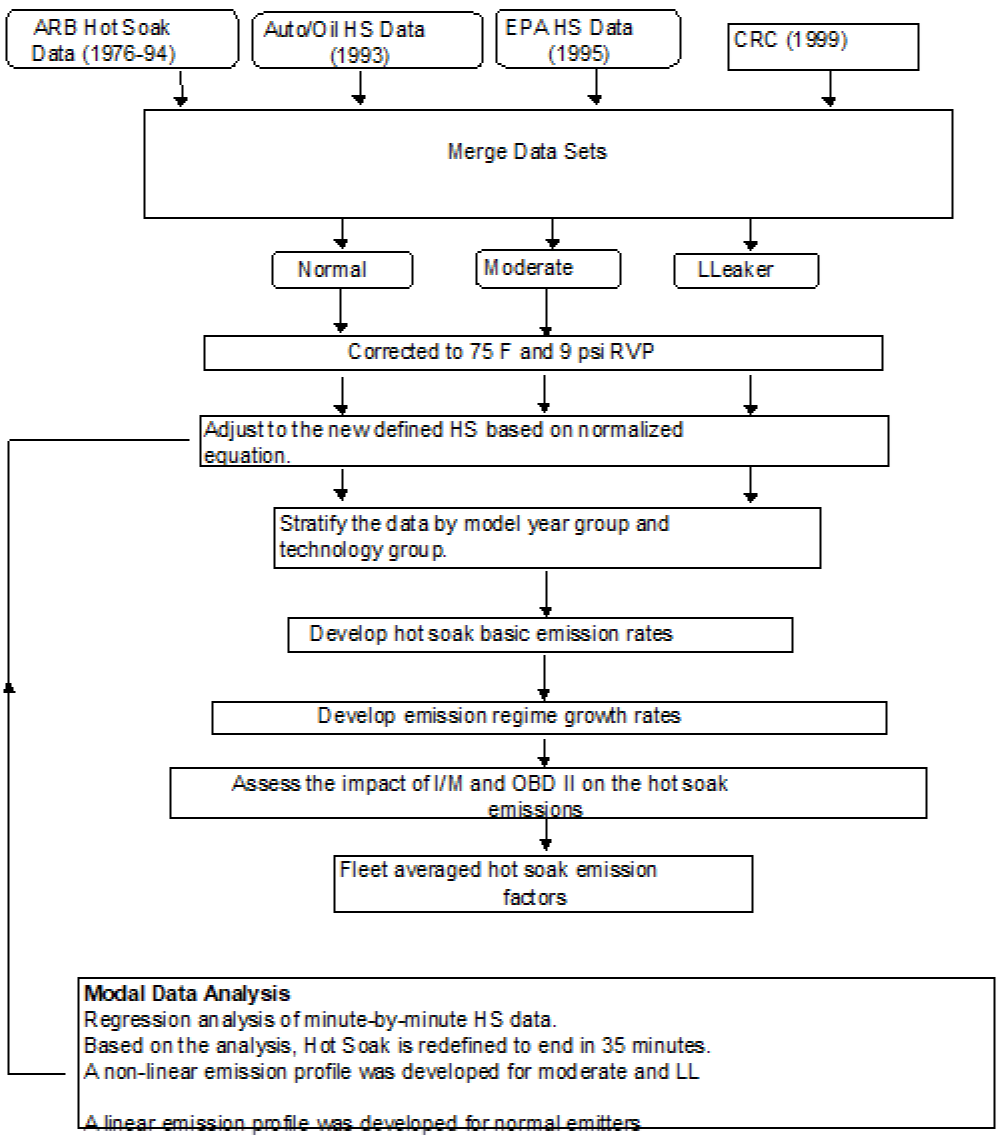


Figure 5.2-1. Flowchart of the methodology used for hot soak data analysis

5.2.4 Temperature and RVP Adjustments

In order to develop Temperature and RVP adjustment factors, 337 vehicle-temp-RVP test combinations were analyzed. These data are from USEPA testing primarily in Phoenix and South Bend. The complete data set is available in Appendix X-A2.

Table 5.2-3 gives the resulting equations and coefficients.

Table 5.2-3 Temperature and Fuel Correction Equations

FUELSYS	MYGROUP	INTERCEPT	NRVP	NTEMP
CARB	ALL	2.337071	0.241183	0.0239
FI	ALL	-0.480003	0.355518	0.063063

HS = exp(Intercept + NRVP*(RVP-9) + NTEMP*(T-75))

To become a true correction factor:

TEMP/RVPcf = HS(T, RVP)/HS(75, 9) =

[exp(Intercept + NRVP*(RVP-9) + NTEMP*(T-75))]/[exp(Intercept)] (5.2-1)

Insufficient data were available to segregate temperature and RVP effects by regime or model year. However, differences were observed for fuel delivery system.

5.2.5 Development of Hot Soak Basic Emission Rate (BER)

After adjusting the data to 9 RVP and 75 F, and further correcting to 35 minutes, the data were grouped by technology into CARB and FI (combining throttle-body injected and multi-port fuel-injected vehicles). The data were then stratified into the appropriate emission regimes, technology and model year groups. A normal carbureted vehicle was defined as being less than 2 grams/test. Normal fuel-injected vehicles were defined as less than 1 gram/test. A linear model was used to relate hot soak emissions to the age of the vehicle and is defined in the following equation:

Hot soak = α(age) + Intercept (5.2-2)

Age = CY - MY + 1 (5.2-3)

where CY = calendar year when the testing was conducted.
MY = model year of the vehicle.

Because of the uneven distribution of sample sizes, regression analyses were repeated by combining certain model year groups to obtain more meaningful and robust results. Since the data exhibit high variability, even the linear model may not depict the relationship adequately. Instead, average hot soak emission rates were used. Vehicles identified as liquid leakers were segregated from the moderate vehicles.

Table 5.2-4 lists the results of the analysis. As expected, emissions in the moderate emitter regime could be an order of magnitude higher than those in the normal emitter regime. The Age term was found not to be significantly different from zero. However, the model was programmed a linear function in case this changes with additional data. Because these technology groups are not exactly the same as the technology groups used in other aspects of the model, these technology groups are mapped to those of Appendix B.

Table 5.2-4 Hot Soak Basic Emission Rates at 75 F and 9 psi (g/35 minutes)

CARB

Status	Model Year Gp	n	Intercept	Age	Tech Group
Normal	Pre77	158	0.746	0.000	1-3, 21-23
	1977 +	469	0.531	0.000	4, 24
Moderate	Pre77	453	6.674	0.000	1-3, 21-23
	1977 +	188	6.305	0.000	4, 24
LL	All	19	21.340	0.000	1-4, 23-24

FI

Status	Model Year Gp	n	Intercept	Age	Tech Group
Normal	Pre79	41	0.322	0.000	5. 6, 25, 26
	79 - 85	150	0.209	0.000	7, 8, 26, 27
	86+	240	0.129	0.000	9,10,29,30 11,12,31,32
	Enhanced	6	0.038	0.000	13, 33
	Near Zero		0.010	0.000	14, 34
Moderate	Pre79	28	4.827	0.000	5. 6, 25, 26
	79 - 85	23	2.561	0.000	7, 8, 27
	86+	41	2.561	0.000	9,10,29,30 11,12,31,32
	Enhanced		0.761	0.000	13, 33
	Near Zero		0.199	0.000	14, 34
LL	All	See CARB	21.340	0.000	4-13, 24-33

5.2.6 Estimation of Basic Emission Rate for Near-zero Evap Vehicles

The basic emission rates for near-zero evap vehicles were estimated from the basic emission rates of enhanced evap vehicles. The BER of passenger cars were determined by taking the BER of enhanced evap vehicles and ratioing by the standards (2 grams and 0.5 grams respectively). The BER for other vehicle classes was determined by applying the ratio of the standards to the BER of passenger vehicles (PC) as outlined below. These ratios are applied to Normal and Moderate emitters only.

Class Specific Scaling Factor

Class	Tech	Near-zero Evap Standards	Scalar (Ratio of Standards)
PC	Near-zero Evap	0.5	1
T1	Near-zero Evap	0.65	1.3
T2	Near-zero Evap	0.9	1.8
T3	Near-zero Evap	1	2
T4	Near-zero Evap	1	2
T5	Near-zero Evap	1	2
T6	Near-zero Evap	1	2
T7	Near-zero Evap	1	2
T8	Near-zero Evap	1	2

Phase-in Schedule

Near-zero evap vehicles are phased in as follows:

MY	% Near-zero Evap
2004	40
2005	80
2006	100

5.2.7 Development of Emission Regime Growth Rate

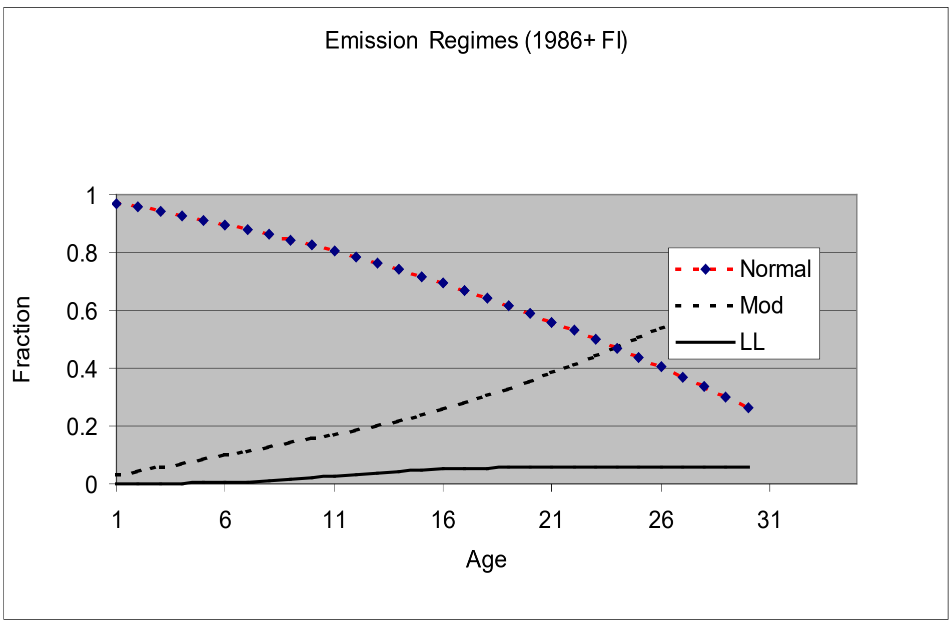
The emission regime growth rates were developed to estimate the overall emissions from vehicles per year, as the emission status of vehicles may change with respect to age. Normal and moderate emitter growth rates for CARB and FI were estimated using those cutpoints defined earlier. The following is the linear model relating growth rate to age.

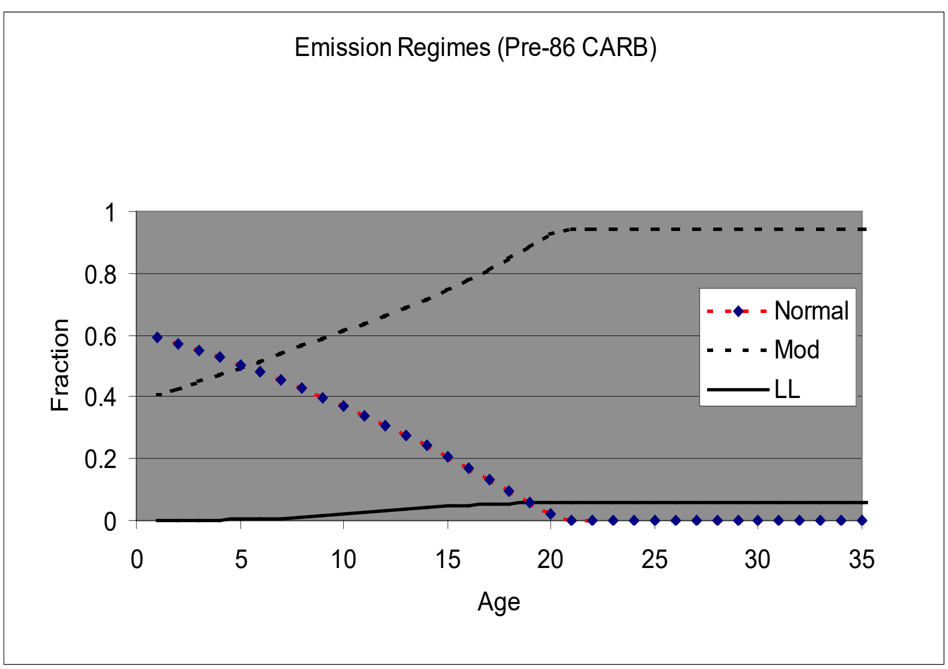
$$\text{Emission regime growth rate \%} = \alpha(\text{age}) + \text{Intercept} \qquad (5.2\text{-}4)$$

The regression is weighted by sample size for each age because of the uneven distribution of vehicles by age. On the other hand, the emission regime growth rate for high emitters was estimated based on EPA's assessment of liquid leakers. For reasons of consistency, it was assumed that the same liquid leaker growth rate be applicable to all technology groups for all evaporative processes.

Figure 5.2-2 presents the emission regime growth rates for 1986+ FI and pre-1986 CARB. As expected, as age progresses, more FI vehicles remain in the normal regime when compared to CARB. In the event the sum of fractions of moderate and high emitters exceed 100%, moderate and high regime growth rates are adjusted by normalizing their sum. The regime growth rates equations are summarized in Table 5.2-4.

Figure 5.2-2 Emission Regime Growth Rates





Liquid Leaker Fraction
The fraction of Liquid Leakers (LLfr) is defined in Section 5.1

Moderate Fraction
The Moderate fraction (MODfr) is defined as

MODfr = Intercept + a*Age+b*Age^2 (5.2-5)

Table 5.2-5a

FI

MYGROUP	Intercept	Age	Age^2	R Square	Tech Group
Pre86	0.1476	-0.0252	0.00302	0.5537	5-8, 25-28
86+	0.02048	0.01123	0.00042	0.5134	9-12, 29-32
OBDII	-0.05803	0.00535	0.00042		13, 14, 33, 34

Where OBDII is discussed in section 5.2.9

CARB

MYGROUP	Intercept	Age	Age2	R Square	Tech Group
Pre77	0.38645	0.0192	0.00053	0.8129	1-3, 21-22
77+	0.19822	-0.0104	0.00165	0.1035	4, 23-24

Normal Fraction

Table 5.2-5b

FI

MYGROUP	Intercept	Age	Age^2	R Square	Tech Group
Pre86	1.024448	-0.02953	0.0	0.344	5-8, 25-28
86+	0.993933	-0.01526	0.0	0.593	9-12, 29-32
OBDII	0.993933	-0.01526	0.0		13, 14, 33, 34

Where OBDII is discussed in section 5.2.9

CARB

MYGROUP	Intercept	Age	Age2	R Square	Tech Group
Pre77	0.645285	-0.02903	0.0	0.884	1-3, 21-22
77+	0.857149	-0.00957	0.0	0.073	4, 23-24

It is possible for the regimes to sum to more than 100%. If this occurs, a normalization process is employed to assure the sum adds to 100%.

5.2.8 Estimation of I/M corrected Hot Soak Emission Factors

The average emission factor for normal emitters with respect to age is defined as follows:

Average EF for Normal Emitters in the Fleet ($EF_{Ave\ Normal\ Emitters,\ Age}$)
= Normal Emitter Rate $_{CARB}$ *EF $_{CARB}$*CARB Vehicle Fraction +
Normal Emitter Rate $_{FI}$*EF $_{FI}$*FI Vehicle Fraction (5.2-6)

Similarly, the average emission factor for moderate and high emitters with respect to age is defined as follows:

Average EF for Moderate Emitters in the Fleet ($EF_{Ave\ Moderate\ Emitters,\ Age}$)
= Moderate Emitter Rate $_{CARB}$ *EF $_{CARB}$*CARB Vehicle Fraction +
Moderate Emitter Rate $_{FI}$*EF $_{FI}$*FI Vehicle Fraction (5.2-7)

Average EF for High Emitters in the Fleet ($EF_{Ave\ High\ Emitters,\ Age}$)
= High Emitter Rate $_{CARB}$ *EF $_{CARB}$*CARB Vehicle Fraction +
High Emitter Rate $_{FI}$*EF $_{FI}$*FI Vehicle Fraction (5.2-8)

Because of the I/M program, vehicles undergo smog check inspection biennially. Hence, we assume moderate emitters will receive I/M benefit as some of the components causing high hot soak emissions are identified and repaired. In particular, it is assumed that vehicles identified and successfully repaired will change their status from moderate to normal emitters. Therefore, the moderate emitter rate for CARB and FI would be adjusted accordingly.

Though there are many malfunctioning emission control components that could lead to excessive hot soak emissions, only gas cap checks are performed in I/M. Therefore, gas cap failure rates were used to estimate I/M benefits. Note that the data for gas cap failure rates are based on smog check testing conducted by the Bureau of Automotive Repair (BAR) in 1996. Appendix 5.2-4 lists the methodology for estimating gas cap failure rate.

Fraction of vehicles changed from moderate to normal emitters per inspection period ($Rate_{Moderate\ to\ Normal}$).
= Identification Rate (ID %)*Incremental Gas Cap Failure Rate (IGC Fail)*Repair Efficiency (Repair %) (5.2-9)

Thus, adjusted moderate emitter growth rate for both CARB and FI per inspection period is as follows:
= Moderate Emitter Growth Rate - $Rate_{Moderate\ to\ Normal}$
(5.2-10)

Assuming the identification rate and repair efficiency is 95%, and that the vehicle stays in the normal regime, the new moderate emitter growth rate is thus given as follows:

New Moderate Emitter Growth Rate = Moderate Emitter Growth Rate * (1-0.95* gas cap failure rate)

5.2.9 Moderate Emitter Growth Rate and OBD II

Emissions control components are closely monitored by the OBD II system and are likely to be repaired once malfunctioning components are detected. Therefore, the hot soak emissions of OBD II equipped vehicles will be modeled by suppressing the formation of moderate emitters for the first seven years of a vehicle's life. As a result, the new moderate emitter growth rate for OBD II vehicles will be corrected accordingly by subtracting the fraction of moderate emitters for the first seven years. As under I/M, it is assumed that OBDII will not detect Liquid Leakers.

To suppress the formation of moderates for the first 7 years, equation 5.2-5 is modified to:

$$Mfr = Intercept + a*(Age-7)+b*(Age-7)^2 = 0$$

And the coefficients are re-calculated.

It was assumed that the regime growth rate for the Liquid Leakers would remain unchanged. Therefore, the fraction of normal emitters is given as follows:

Fraction of Normal Emitters = 1 – Adjusted Fraction of Moderate Emitters – Fraction of Liquid Leakers

5.2.10 Partial Hot Soaks

Figure 5.2-A3 of Appendix 5.2-A1 is to be used to estimate the partial hot soak emissions for vehicles that do not complete the full 35 minute soak. Additionally, a certain fraction of the fleet take trips too short for the fuel temperature to reach levels necessary for hot soak emissions to occur. Staff believes this time is approximately 4 minutes, which is consistent with MOBILE6 ("Soak Length Activity Factors for Hot Soak Emissions", Report Number M6.FLT.004)

5.2.11 Conclusions

While this analysis represents a more up-to-date approach to modeling hot soak emissions, more data are needed to reflect the changes in the current evaporative emissions regulations. Note that in the previous hot soak analysis for MVEI7G, the definition of conforming and malperforming is based on the failure of emission control components. However, the current methodology stratifies the data into normal, moderate and high emitter categories based on cutpoints.

It is recommended that future evaporative studies put more emphasis on the design of the experimental methodology so that meaningful data will be collected to facilitate the analysis. Particularly, there is a need for hot soak emission data for newer model year vehicles. As the technology is changing, it is expected the projected hot soak emissions will decline as more advanced emission technology is introduced in future.

Appendix 5.2-A1 Modal Data Analysis

Previously, hot soaks were defined as lasting one hour because of the duration of the test. However, evidence has shown that hot soak emissions may end before one hour. In ARB's research project 2S95C1, minute-by-minute modal data were collected for 12 vehicles. As shown in Figure 5.2-A1, there are two distinctive trends of emission profiles. The first group is the normal emitters where emission rates remain almost constant throughout the entire hour. The second group is the moderate and high emitters where the hot soak emission rate tends to increase rapidly in the beginning and reach a plateau before the end of the one-hour test. Therefore, it is plausible to assume normal emitters exhibit a linear emission profile while the moderate and high emitters exhibit a non-linear emissions profile.

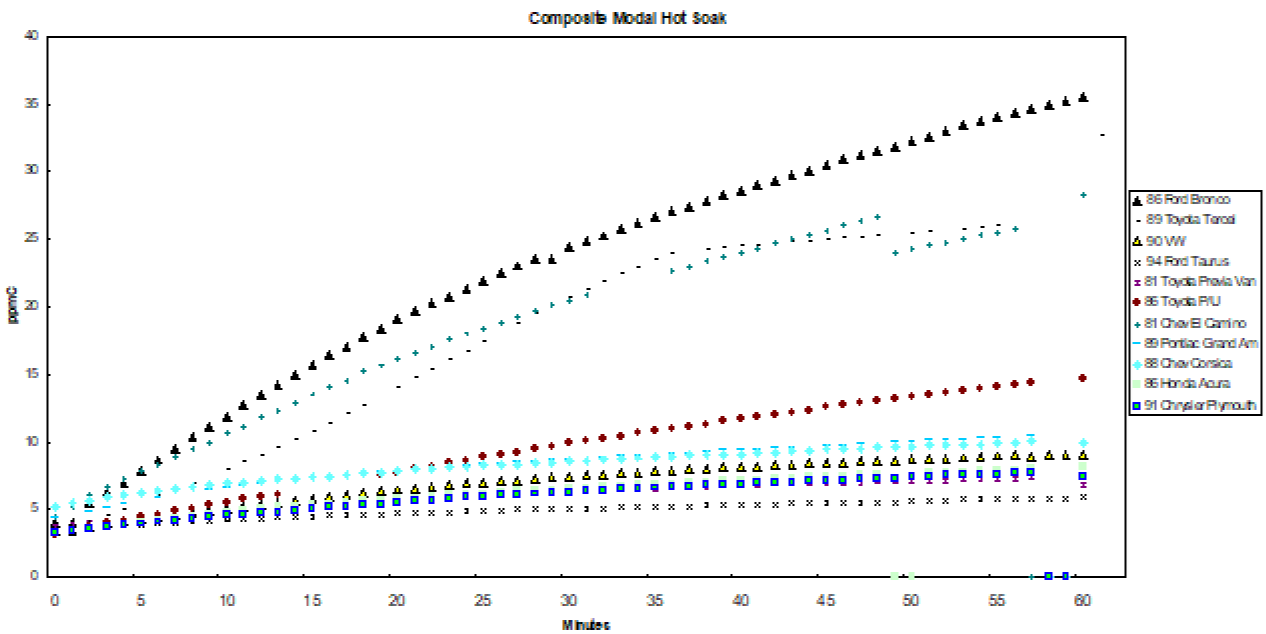


Figure 5.2-A2 presents both the linear and non-linear emission profiles normalized to 60 minutes. From a visual examination of the raw data, it was determined that hot soak emissions reach a plateau around 35 minutes. In other words, hot soak is redefined to end at 35 minutes. Because of this new definition, all of the historical hot soak data were adjusted to 35 minutes. As shown in Figure 5.2-A2, the newly defined hot soak for a normal emitter is 58% of the historical one-hour hot soak emissions while moderate and high emitters are 83% of the historical one-hour hot

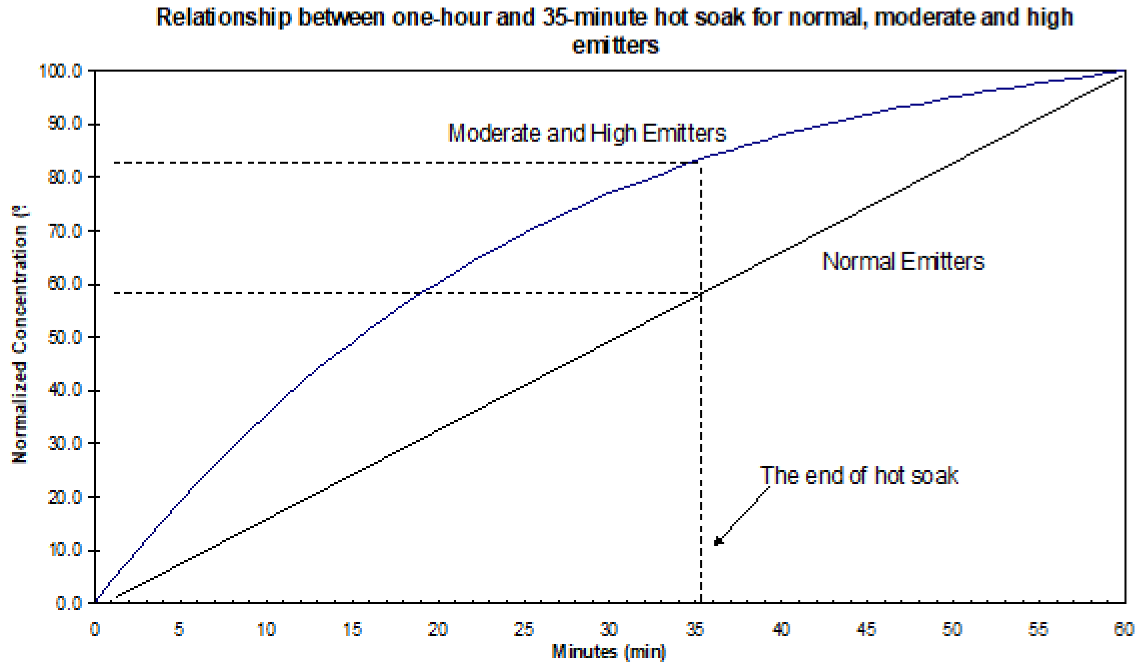


Figure 5.2-A2. New defined hot soak based on normalized one-hour hot soak profiles

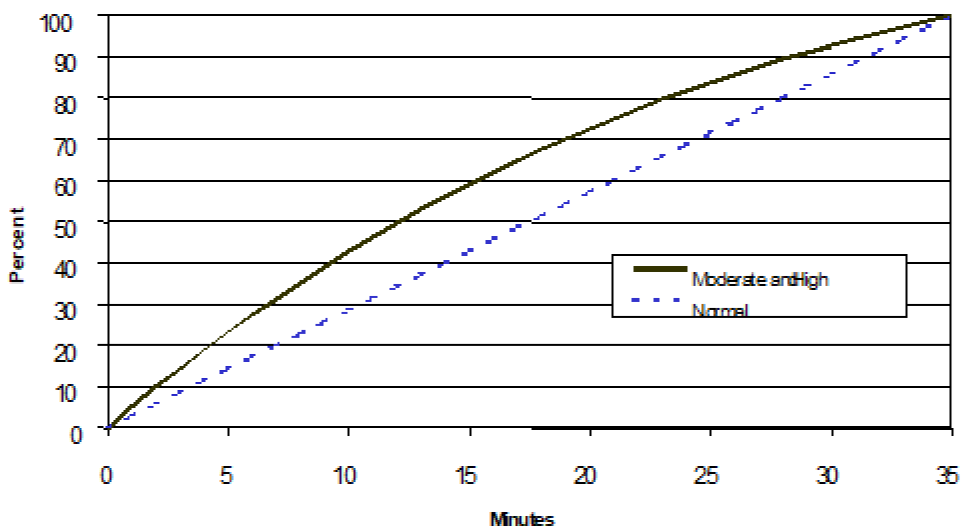


Figure 5.2-A3. Normalized emission profile for normal, moderate, and high

Normalized equation for normal emitters:
$Y(\%) = 2.857*(min)$

Normalized equation for moderate and high
$Y (\%) = 100\%*\{(1.244697*(min) - .020457*(min)^2 + 0.000159*(min)^3 - 0.000000437*(min)^4)/24.666\}$

soak emissions. Figure 5.2-A3 presents the normalized hot soak emission profile based on 35 minutes, allowing partial hot soaks to be estimated.

Appendix 5.2-A2 Temperature/RVP Database

PROJ	VEH	MY	MAKE	MODEL	VTYPE	FINJ	TEMP	RVP	HS_
0-07	266	93	Dodge	Shadow	LDV	PFI	105	6.2	0.75
0-07	266	93	Dodge	Shadow	LDV	PFI	105	6.9	0.13
0-07	266	93	Dodge	Shadow	LDV	PFI	80	6.2	0.13
0-07	266	93	Dodge	Shadow	LDV	PFI	80	8.9	0.11
0-07	266	93	Dodge	Shadow	LDV	PFI	80	6.8	0.08
0-07	266	93	Dodge	Shadow	LDV	PFI	95	6.8	0.22
0-07	266	93	Dodge	Shadow	LDV	PFI	95	8.8	0.12
0-07	266	93	Dodge	Shadow	LDV	PFI	95	6.2	0.08
0-07	267	91	Chevrolet	Beretta	LDV	PFI	105	8.9	65.50
0-07	267	91	Chevrolet	Beretta	LDV	PFI	105	6.9	34.29
0-07	267	91	Chevrolet	Beretta	LDV	PFI	105	6.3	22.73
0-07	267	91	Chevrolet	Beretta	LDV	PFI	80	8.9	12.12
0-07	267	91	Chevrolet	Beretta	LDV	PFI	80	6.8	10.87
0-07	267	91	Chevrolet	Beretta	LDV	PFI	80	6.2	4.32
0-07	267	91	Chevrolet	Beretta	LDV	PFI	95	8.9	24.43
0-07	267	91	Chevrolet	Beretta	LDV	PFI	95	6.8	13.40
0-07	267	91	Chevrolet	Beretta	LDV	PFI	95	6.2	12.62
0-07	268	91	Ford	Festiva	LDV	PFI	105	9.0	0.36
0-07	268	91	Ford	Festiva	LDV	PFI	105	6.3	0.24
0-07	268	91	Ford	Festiva	LDV	PFI	105	6.9	0.21
0-07	268	91	Ford	Festiva	LDV	PFI	80	6.2	0.17
0-07	268	91	Ford	Festiva	LDV	PFI	80	8.8	0.12
0-07	268	91	Ford	Festiva	LDV	PFI	80	6.8	0.11
0-07	268	91	Ford	Festiva	LDV	PFI	95	9.0	0.31
0-07	268	91	Ford	Festiva	LDV	PFI	95	6.9	0.17
0-07	268	91	Ford	Festiva	LDV	PFI	95	6.1	0.12
0-07	269	94	Hyundai	Excel	LDV	PFI	105	8.9	9.72
0-07	269	94	Hyundai	Excel	LDV	PFI	105	6.8	1.38
0-07	269	94	Hyundai	Excel	LDV	PFI	105	6.2	1.14
0-07	269	94	Hyundai	Excel	LDV	PFI	80	8.6	1.05
0-07	269	94	Hyundai	Excel	LDV	PFI	80	6.1	0.84
0-07	269	94	Hyundai	Excel	LDV	PFI	80	6.7	0.42
0-07	269	94	Hyundai	Excel	LDV	PFI	95	8.7	2.42
0-07	269	94	Hyundai	Excel	LDV	PFI	95	6.2	1.02
0-07	269	94	Hyundai	Excel	LDV	PFI	95	6.7	0.75
0-07	270	94	Chevrolet	Cavalier	LDV	PFI	105	8.8	88.35
0-07	270	94	Chevrolet	Cavalier	LDV	PFI	105	6.3	0.30
0-07	270	94	Chevrolet	Cavalier	LDV	PFI	105	6.8	0.29
0-07	270	94	Chevrolet	Cavalier	LDV	PFI	80	6.7	0.13
0-07	270	94	Chevrolet	Cavalier	LDV	PFI	80	6.2	0.12
0-07	270	94	Chevrolet	Cavalier	LDV	PFI	80	8.7	0.11
0-07	270	94	Chevrolet	Cavalier	LDV	PFI	95	8.7	0.35
0-07	270	94	Chevrolet	Cavalier	LDV	PFI	95	6.8	0.21
0-07	270	94	Chevrolet	Cavalier	LDV	PFI	95	6.2	0.19
0-07	271	91	Dodge	Shadow	LDV	TBI	105	8.8	38.68
0-07	271	91	Dodge	Shadow	LDV	TBI	105	6.8	11.02
0-07	271	91	Dodge	Shadow	LDV	TBI	105	6.1	5.61
0-07	271	91	Dodge	Shadow	LDV	TBI	80	6.5	2.91
0-07	271	91	Dodge	Shadow	LDV	TBI	80	6.2	2.41

0-07	271	91 Dodge	Shadow	LDV	TBI	80	8.8	0.83
0-07	271	91 Dodge	Shadow	LDV	TBI	95	8.7	20.53
0-07	271	91 Dodge	Shadow	LDV	TBI	95	6.7	7.28
0-07	271	91 Dodge	Shadow	LDV	TBI	95	6.2	4.39
0-11	372	88 Jeep	Cherokee	LDT	PFI	106	9.0	12.04
0-11	372	88 Jeep	Cherokee	LDT	PFI	106	6.3	1.07
0-11	372	88 Jeep	Cherokee	LDT	PFI	84	8.9	0.65
0-11	372	88 Jeep	Cherokee	LDT	PFI	96	8.9	1.74
0-11	372	88 Jeep	Cherokee	LDT	PFI	96	6.3	0.56
0-11	375	88 Ford	Ranger XLT	LDT	PFI	106	6.3	6.04
0-11	375	88 Ford	Ranger XLT	LDT	PFI	84	9.0	4.40
0-11	375	88 Ford	Ranger XLT	LDT	PFI	96	9.0	10.73
0-11	375	88 Ford	Ranger XLT	LDT	PFI	96	6.3	2.18
0-11	376	89 Ford	Aerostar	LDT	PFI	106	6.2	10.50
0-11	376	89 Ford	Aerostar	LDT	PFI	84	8.9	19.23
0-11	376	89 Ford	Aerostar	LDT	PFI	96	8.7	30.47
0-11	376	89 Ford	Aerostar	LDT	PFI	96	6.3	11.78
0-11	378	93 Chevrolet	Lumina APV	LDT	TBI	106	8.9	0.97
0-11	378	93 Chevrolet	Lumina APV	LDT	TBI	84	8.9	0.77
0-11	378	93 Chevrolet	Lumina APV	LDT	TBI	96	8.9	0.99
0-11	378	93 Chevrolet	Lumina APV	LDT	TBI	96	6.3	0.89
0-11	379	93 Chevrolet	S-10 Pickup	LDT	TBI	106	6.3	0.41
0-11	379	93 Chevrolet	S-10 Pickup	LDT	TBI	84	8.9	0.32
0-11	379	93 Chevrolet	S-10 Pickup	LDT	TBI	96	6.3	0.40
0-11	380	87 Chevrolet	Blazer 4x4	LDT	TBI	106	6.3	1.22
0-11	380	87 Chevrolet	Blazer 4x4	LDT	TBI	84	8.9	0.69
0-11	380	87 Chevrolet	Blazer 4x4	LDT	TBI	96	8.9	1.55
0-11	380	87 Chevrolet	Blazer 4x4	LDT	TBI	96	6.3	0.31
0-11	381	93 Mazda	B2600i	LDT	PFI	106	6.3	0.29
0-11	381	93 Mazda	B2600i	LDT	PFI	84	8.9	3.94
0-11	381	93 Mazda	B2600i	LDT	PFI	96	6.1	0.28
0-11	381	93 Mazda	B2600i	LDT	PFI	96	8.9	0.17
0-11	384	88 Chevrolet	S-10 Pickup	LDT	TBI	106	6.3	0.52
0-11	384	88 Chevrolet	S-10 Pickup	LDT	TBI	84	8.9	0.19
0-11	384	88 Chevrolet	S-10 Pickup	LDT	TBI	96	8.9	0.46
0-11	384	88 Chevrolet	S-10 Pickup	LDT	TBI	96	6.3	0.21

PHOE	5030	88 MAZDA	MX-6	LDV	PFI	105	9.0	33.26
PHOE	5030	88 MAZDA	MX-6	LDV	PFI	95	9.0	0.84
PHOE	5030	88 MAZDA	MX-6	LDV	PFI	80	9.0	0.33
PHOE	5030	88 MAZDA	MX-6	LDV	PFI	105	6.9	6.58
PHOE	5030	88 MAZDA	MX-6	LDV	PFI	95	6.9	1.05
PHOE	5030	88 MAZDA	MX-6	LDV	PFI	80	6.9	0.25
PHOE	5032	91 HONDA	CIVI	LDV	PFI	105	9.0	0.18
PHOE	5032	91 HONDA	CIVI	LDV	PFI	95	9.0	0.07
PHOE	5032	91 HONDA	CIVI	LDV	PFI	80	9.0	0.08
PHOE	5032	91 HONDA	CIVI	LDV	PFI	105	6.9	0.18
PHOE	5032	91 HONDA	CIVI	LDV	PFI	95	6.9	0.18
PHOE	5032	91 HONDA	CIVI	LDV	PFI	80	6.9	0.07
PHOE	5034	85 HONDA	PREL	LDV	NO	105	9.0	41.47
PHOE	5034	85 HONDA	PREL	LDV	NO	95	9.0	19.62
PHOE	5034	85 HONDA	PREL	LDV	NO	80	9.0	7.60
PHOE	5034	85 HONDA	PREL	LDV	NO	105	6.9	8.29
PHOE	5034	85 HONDA	PREL	LDV	NO	105	6.9	8.30
PHOE	5034	85 HONDA	PREL	LDV	NO	95	6.9	8.12
PHOE	5034	85 HONDA	PREL	LDV	NO	80	6.9	4.43
PHOE	5035	90 TOYOTA	CORO	LDV	PFI	105	9.0	48.86
PHOE	5035	90 TOYOTA	CORO	LDV	PFI	95	9.0	11.49
PHOE	5035	90 TOYOTA	CORO	LDV	PFI	80	9.0	5.92
PHOE	5035	90 TOYOTA	CORO	LDV	PFI	105	6.9	25.93
PHOE	5035	90 TOYOTA	CORO	LDV	PFI	95	6.9	6.80
PHOE	5035	90 TOYOTA	CORO	LDV	PFI	80	6.9	2.21
PHOE	5036	86 MAZDA	323	LDV	PFI	105	9.0	17.55
PHOE	5036	86 MAZDA	323	LDV	PFI	95	9.0	25.47
PHOE	5036	86 MAZDA	323	LDV	PFI	80	9.0	2.72
PHOE	5036	86 MAZDA	323	LDV	PFI	105	6.9	14.34
PHOE	5036	86 MAZDA	323	LDV	PFI	95	6.9	2.18
PHOE	5037	89 GMC	CELE	LDV	TBI	105	9.0	13.22
PHOE	5037	89 GMC	CELE	LDV	TBI	95	9.0	5.92
PHOE	5037	89 GMC	CELE	LDV	TBI	80	9.0	0.72
PHOE	5037	89 GMC	CELE	LDV	TBI	105	6.9	4.98
PHOE	5037	89 GMC	CELE	LDV	TBI	95	6.9	0.43
PHOE	5037	89 GMC	CELE	LDV	TBI	80	6.9	0.38
PHOE	5038	92 TOYOTA	CORO	LDV	PFI	105	9.0	7.39
PHOE	5038	92 TOYOTA	CORO	LDV	PFI	95	9.0	0.30
PHOE	5038	92 TOYOTA	CORO	LDV	PFI	80	9.0	0.15
PHOE	5038	92 TOYOTA	CORO	LDV	PFI	105	6.9	0.33
PHOE	5038	92 TOYOTA	CORO	LDV	PFI	95	6.9	0.23
PHOE	5039	86 OLDSMOBIL	DELT	LDV	PFI	105	9.0	14.85
PHOE	5039	86 OLDSMOBIL	DELT	LDV	PFI	95	9.0	6.86
PHOE	5039	86 OLDSMOBIL	DELT	LDV	PFI	80	9.0	2.91
PHOE	5039	86 OLDSMOBIL	DELT	LDV	PFI	105	6.9	15.68
PHOE	5039	86 OLDSMOBIL	DELT	LDV	PFI	95	6.9	1.89
PHOE	5039	86 OLDSMOBIL	DELT	LDV	PFI	80	6.9	1.21
PHOE	5040	90 CHEVROLET	CELE	LDV	PFI	105	9.0	34.10
PHOE	5040	90 CHEVROLET	CELE	LDV	PFI	95	9.0	23.73
PHOE	5040	90 CHEVROLET	CELE	LDV	PFI	80	9.0	0.34
PHOE	5040	90 CHEVROLET	CELE	LDV	PFI	105	6.9	11.94
PHOE	5040	90 CHEVROLET	CELE	LDV	PFI	95	6.9	12.92

PHOE	5040	90	CHEVROLET	CELE	LDV	PFI	80	6.9	0.23
PHOE	5041	86	LINCOLN	LINC	LDV	PFI	105	9.0	0.69
PHOE	5041	86	LINCOLN	LINC	LDV	PFI	95	9.0	0.35
PHOE	5041	86	LINCOLN	LINC	LDV	PFI	80	9.0	0.14
PHOE	5041	86	LINCOLN	LINC	LDV	PFI	105	6.9	0.29
PHOE	5041	86	LINCOLN	LINC	LDV	PFI	95	6.9	0.15
PHOE	5041	86	LINCOLN	LINC	LDV	PFI	80	6.9	0.08
PHOE	5042	87	MAZDA	323	LDV	PFI	105	9.0	14.95
PHOE	5042	87	MAZDA	323	LDV	PFI	95	9.0	7.24
PHOE	5042	87	MAZDA	323	LDV	PFI	80	9.0	0.17
PHOE	5042	87	MAZDA	323	LDV	PFI	105	6.9	0.75
PHOE	5042	87	MAZDA	323	LDV	PFI	95	6.9	2.42
PHOE	5042	87	MAZDA	323	LDV	PFI	80	6.9	0.15
PHOE	5043	89	MAZDA	323	LDV	PFI	105	9.0	9.19
PHOE	5043	89	MAZDA	323	LDV	PFI	95	9.0	0.74
PHOE	5043	89	MAZDA	323	LDV	PFI	80	9.0	0.19
PHOE	5043	89	MAZDA	323	LDV	PFI	105	6.9	6.93
PHOE	5043	89	MAZDA	323	LDV	PFI	95	6.9	0.34
PHOE	5043	89	MAZDA	323	LDV	PFI	80	6.9	0.09
PHOE	5044	93	DODGE	DYNA	LDV	PFI	105	9.0	16.86
PHOE	5044	93	DODGE	DYNA	LDV	PFI	95	9.0	20.63
PHOE	5044	93	DODGE	DYNA	LDV	PFI	80	9.0	0.19
PHOE	5044	93	DODGE	DYNA	LDV	PFI	105	6.9	0.14
PHOE	5044	93	DODGE	DYNA	LDV	PFI	95	6.9	0.18
PHOE	5044	93	DODGE	DYNA	LDV	PFI	80	6.9	0.11
PHOE	5045	90	HONDA	CIVI	LDV	TBI	105	9.0	41.40
PHOE	5045	90	HONDA	CIVI	LDV	TBI	95	9.0	13.59
PHOE	5045	90	HONDA	CIVI	LDV	TBI	80	9.0	0.15
PHOE	5045	90	HONDA	CIVI	LDV	TBI	105	6.9	0.37
PHOE	5045	90	HONDA	CIVI	LDV	TBI	95	6.9	0.26
PHOE	5045	90	HONDA	CIVI	LDV	TBI	80	6.9	0.12
PHOE	5047	91	TOYOTA	TERC	LDV	PFI	105	9.0	0.30
PHOE	5047	91	TOYOTA	TERC	LDV	PFI	95	9.0	0.56
PHOE	5047	91	TOYOTA	TERC	LDV	PFI	80	9.0	0.12
PHOE	5047	91	TOYOTA	TERC	LDV	PFI	105	6.9	0.43
PHOE	5047	91	TOYOTA	TERC	LDV	PFI	95	6.9	0.24
PHOE	5047	91	TOYOTA	TERC	LDV	PFI	80	6.9	0.15
PHOE	5049	87	PONTIAC	GRAN	LDV	TBI	105	9.0	20.63
PHOE	5049	87	PONTIAC	GRAN	LDV	TBI	95	9.0	9.51
PHOE	5049	87	PONTIAC	GRAN	LDV	TBI	80	9.0	2.32
PHOE	5049	87	PONTIAC	GRAN	LDV	TBI	105	6.9	3.66
PHOE	5049	87	PONTIAC	GRAN	LDV	TBI	95	6.9	1.85
PHOE	5049	87	PONTIAC	GRAN	LDV	TBI	80	6.9	0.41
PHOE	5050	89	PONTIAC	6000	LDV	TBI	105	9.0	8.85
PHOE	5050	89	PONTIAC	6000	LDV	TBI	95	9.0	15.32
PHOE	5050	89	PONTIAC	6000	LDV	TBI	80	9.0	0.18
PHOE	5050	89	PONTIAC	6000	LDV	TBI	105	6.9	7.97
PHOE	5050	89	PONTIAC	6000	LDV	TBI	95	6.9	0.32
PHOE	5050	89	PONTIAC	6000	LDV	TBI	80	6.9	0.28
PHOE	5051	88	CHEVROLET	CAVA	LDV	TBI	105	9.0	4.95
PHOE	5051	88	CHEVROLET	CAVA	LDV	TBI	95	9.0	0.48
PHOE	5051	88	CHEVROLET	CAVA	LDV	TBI	80	9.0	0.26

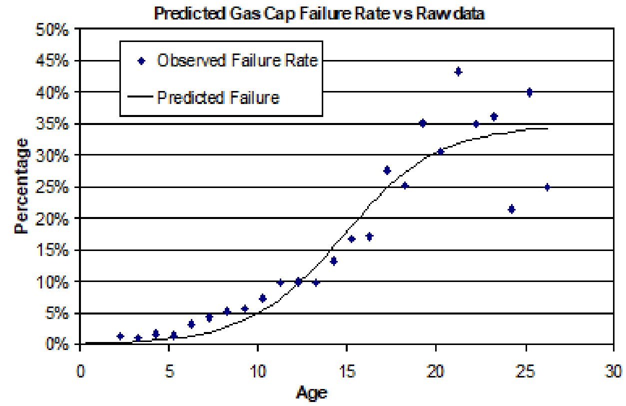
PHOE	5051	88	CHEVROLET	CAVA	LDV	TBI	105	6.9	0.52
PHOE	5051	88	CHEVROLET	CAVA	LDV	TBI	95	6.9	0.45
PHOE	5051	88	CHEVROLET	CAVA	LDV	TBI	80	6.9	0.36
PHOE	5052	92	SATURN	SATU	LDV	PFI	105	9.0	1.44
PHOE	5052	92	SATURN	SATU	LDV	PFI	95	9.0	0.77
PHOE	5052	92	SATURN	SATU	LDV	PFI	80	9.0	0.54
PHOE	5052	92	SATURN	SATU	LDV	PFI	105	6.9	1.60
PHOE	5052	92	SATURN	SATU	LDV	PFI	95	6.9	1.32
PHOE	5052	92	SATURN	SATU	LDV	PFI	80	6.9	1.19
PHOE	5054	86	BUICK	SOME	LDV	TBI	105	9.0	16.82
PHOE	5054	86	BUICK	SOME	LDV	TBI	95	9.0	2.01
PHOE	5054	86	BUICK	SOME	LDV	TBI	80	9.0	1.05
PHOE	5054	86	BUICK	SOME	LDV	TBI	105	6.9	2.63
PHOE	5054	86	BUICK	SOME	LDV	TBI	95	6.9	1.37
PHOE	5054	86	BUICK	SOME	LDV	TBI	80	6.9	0.84
PHOE	5055	89	BUICK	RIVI	LDV	PFI	105	9.0	56.43
PHOE	5055	89	BUICK	RIVI	LDV	PFI	95	9.0	11.91
PHOE	5055	89	BUICK	RIVI	LDV	PFI	80	9.0	2.56
PHOE	5055	89	BUICK	RIVI	LDV	PFI	105	6.9	6.97
PHOE	5057	81	PONTIAC	LEMA	LDV	NO	105	9.0	34.94
PHOE	5057	81	PONTIAC	LEMA	LDV	NO	95	9.0	17.90
PHOE	5057	81	PONTIAC	LEMA	LDV	NO	80	9.0	11.57
PHOE	5057	81	PONTIAC	LEMA	LDV	NO	95	6.9	11.85
PHOE	5057	81	PONTIAC	LEMA	LDV	NO	80	6.9	9.05
PHOE	5057	81	PONTIAC	LEMA	LDV	NO	105	6.9	15.18
PHOE	5058	81	CHEVROLET	MONT	LDV	NO	105	9.0	60.82
PHOE	5058	81	CHEVROLET	MONT	LDV	NO	95	9.0	25.55
PHOE	5058	81	CHEVROLET	MONT	LDV	NO	80	9.0	15.81
PHOE	5058	81	CHEVROLET	MONT	LDV	NO	105	6.9	21.02
PHOE	5058	81	CHEVROLET	MONT	LDV	NO	80	6.9	17.25
PHOE	5058	81	CHEVROLET	MONT	LDV	NO	95	6.9	17.25
PHOE	5061	79	CHEVROLET	CAPR	LDV	NO	105	9.0	13.78
PHOE	5061	79	CHEVROLET	CAPR	LDV	NO	95	9.0	15.53
PHOE	5061	79	CHEVROLET	CAPR	LDV	NO	80	9.0	11.03
PHOE	5061	79	CHEVROLET	CAPR	LDV	NO	105	6.9	10.63
PHOE	5061	79	CHEVROLET	CAPR	LDV	NO	95	6.9	6.82
PHOE	5061	79	CHEVROLET	CAPR	LDV	NO	80	6.9	7.58
PHOE	5066	93	DODGE	SHAD	LDV	TBI	105	9.0	88.07
PHOE	5066	93	DODGE	SHAD	LDV	TBI	95	9.0	88.07
PHOE	5066	93	DODGE	SHAD	LDV	TBI	80	9.0	0.10
PHOE	5066	93	DODGE	SHAD	LDV	TBI	105	6.9	0.13
PHOE	5066	93	DODGE	SHAD	LDV	TBI	95	6.9	0.22
PHOE	5066	93	DODGE	SHAD	LDV	TBI	80	6.9	0.08
PHOE	5066	93	DODGE	SHAD	LDV	TBI	105	6.3	0.75
PHOE	5066	93	DODGE	SHAD	LDV	TBI	95	6.3	0.08
PHOE	5066	93	DODGE	SHAD	LDV	TBI	80	6.3	0.09
PHOE	5067	91	CHEVROLET	BERE	LDV	PFI	105	9.0	65.13
PHOE	5067	91	CHEVROLET	BERE	LDV	PFI	95	9.0	24.28
PHOE	5067	91	CHEVROLET	BERE	LDV	PFI	80	9.0	12.09
PHOE	5067	91	CHEVROLET	BERE	LDV	PFI	105	6.9	34.12
PHOE	5067	91	CHEVROLET	BERE	LDV	PFI	95	6.9	13.33
PHOE	5067	91	CHEVROLET	BERE	LDV	PFI	80	6.9	10.83

PHOE	5067	91 CHEVROLET	BERE	LDV	PFI	105	6.3	22.62
PHOE	5067	91 CHEVROLET	BERE	LDV	PFI	95	6.3	12.55
PHOE	5067	91 CHEVROLET	BERE	LDV	PFI	80	6.3	4.30
PHOE	5068	91 FORD	FEST	LDV	PFI	105	9.0	0.25
PHOE	5068	91 FORD	FEST	LDV	PFI	95	9.0	0.31
PHOE	5068	91 FORD	FEST	LDV	PFI	80	9.0	0.12
PHOE	5068	91 FORD	FEST	LDV	PFI	105	6.9	0.21
PHOE	5068	91 FORD	FEST	LDV	PFI	95	6.9	0.17
PHOE	5068	91 FORD	FEST	LDV	PFI	80	6.9	0.11
PHOE	5068	91 FORD	FEST	LDV	PFI	105	6.3	0.24
PHOE	5068	91 FORD	FEST	LDV	PFI	95	6.3	0.12
PHOE	5068	91 FORD	FEST	LDV	PFI	80	6.3	0.17
PHOE	5069	94 HYUNDAI	EXCE	LDV	PFI	105	9.0	9.66
PHOE	5069	94 HYUNDAI	EXCE	LDV	PFI	95	9.0	2.41
PHOE	5069	94 HYUNDAI	EXCE	LDV	PFI	80	9.0	1.05
PHOE	5069	94 HYUNDAI	EXCE	LDV	PFI	105	6.9	1.37
PHOE	5069	94 HYUNDAI	EXCE	LDV	PFI	95	6.9	0.74
PHOE	5069	94 HYUNDAI	EXCE	LDV	PFI	80	6.9	0.42
PHOE	5069	94 HYUNDAI	EXCE	LDV	PFI	105	6.3	1.13
PHOE	5069	94 HYUNDAI	EXCE	LDV	PFI	95	6.3	1.01
PHOE	5069	94 HYUNDAI	EXCE	LDV	PFI	80	6.3	0.84
PHOE	5071	91 DODGE	SHAD	LDV	TBI	105	9.0	38.48
PHOE	5071	91 DODGE	SHAD	LDV	TBI	95	9.0	20.41
PHOE	5071	91 DODGE	SHAD	LDV	TBI	80	9.0	8.29
PHOE	5071	91 DODGE	SHAD	LDV	TBI	105	6.9	10.97
PHOE	5071	91 DODGE	SHAD	LDV	TBI	95	6.9	7.25
PHOE	5071	91 DODGE	SHAD	LDV	TBI	80	6.9	2.89
PHOE	5071	91 DODGE	SHAD	LDV	TBI	105	6.3	5.58
PHOE	5071	91 DODGE	SHAD	LDV	TBI	95	6.3	4.30
PHOE	5071	91 DODGE	SHAD	LDV	TBI	80	6.3	2.39
PHOE	5072	88 JEEP	CHER	LDV	PFI	105	9.0	53.89
PHOE	5072	88 JEEP	CHER	LDV	PFI	95	9.0	1.74
PHOE	5072	88 JEEP	CHER	LDV	PFI	80	9.0	0.64
PHOE	5072	88 JEEP	CHER	LDV	PFI	105	6.3	1.06
PHOE	5072	88 JEEP	CHER	LDV	PFI	95	6.3	0.55
PHOE	5073	84 DODGE	RAM	LDT	NO	95	9.0	8.94
PHOE	5073	84 DODGE	RAM	LDT	NO	80	9.0	13.03
PHOE	5073	84 DODGE	RAM	LDT	NO	105	6.3	13.93
PHOE	5073	84 DODGE	RAM	LDT	NO	95	6.3	10.75
PHOE	5077	80 FORD	RANG	LDT	NO	95	9.0	15.96
PHOE	5077	80 FORD	RANG	LDT	NO	105	6.3	6.12
PHOE	5077	80 FORD	RANG	LDT	NO	95	6.3	6.92
PHOE	5077	80 FORD	RANG	LDT	NO	80	9.0	5.88
PHOE	5079	93 CHEVROLET	PICK	LDT	TBI	95	9.0	0.40
PHOE	5079	93 CHEVROLET	PICK	LDT	TBI	80	9.0	0.32
PHOE	5079	93 CHEVROLET	PICK	LDT	TBI	105	6.3	0.41
PHOE	5079	93 CHEVROLET	PICK	LDT	TBI	95	6.3	0.40
SBEN	5003	85 BUICK	PARK	LDV	PFI	105	9.0	14.64
SBEN	5003	85 BUICK	PARK	LDV	PFI	95	9.0	17.45
SBEN	5003	85 BUICK	PARK	LDV	PFI	80	9.0	9.65
SBEN	5003	85 BUICK	PARK	LDV	PFI	105	6.9	13.15
SBEN	5003	85 BUICK	PARK	LDV	PFI	95	6.9	8.51

SBEN	5003	85	BUICK	PARK	LDV	PFI	80	6.9	5.87
SBEN	5009	85	TOYOTA	SUPE	LDV	PFI	105	9.0	1.13
SBEN	5009	85	TOYOTA	SUPE	LDV	PFI	95	9.0	1.25
SBEN	5009	85	TOYOTA	SUPE	LDV	PFI	80	9.0	1.08
SBEN	5009	85	TOYOTA	SUPE	LDV	PFI	105	6.9	0.65
SBEN	5009	85	TOYOTA	SUPE	LDV	PFI	95	6.9	1.34
SBEN	5009	85	TOYOTA	SUPE	LDV	PFI	80	6.9	0.26
SBEN	5010	85	FORD	TEMP	LDV	TBI	105	9.0	3.55
SBEN	5010	85	FORD	TEMP	LDV	TBI	95	9.0	0.40
SBEN	5010	85	FORD	TEMP	LDV	TBI	80	9.0	0.95
SBEN	5010	85	FORD	TEMP	LDV	TBI	105	6.9	0.48
SBEN	5010	85	FORD	TEMP	LDV	TBI	95	6.9	0.56
SBEN	5010	85	FORD	TEMP	LDV	TBI	80	6.9	0.36
SBEN	5012	87	FORD	TAUR	LDV	PFI	105	9.0	2.43
SBEN	5012	87	FORD	TAUR	LDV	PFI	95	9.0	1.79
SBEN	5012	87	FORD	TAUR	LDV	PFI	80	9.0	3.92
SBEN	5012	87	FORD	TAUR	LDV	PFI	105	6.9	5.51
SBEN	5012	87	FORD	TAUR	LDV	PFI	95	6.9	3.73
SBEN	5012	87	FORD	TAUR	LDV	PFI	80	6.9	3.72
SBEN	5013	89	CHEVROLET	ASTR	LDT	TBI	105	9.0	1.02
SBEN	5013	89	CHEVROLET	ASTR	LDT	TBI	95	9.0	0.69
SBEN	5013	89	CHEVROLET	ASTR	LDT	TBI	80	9.0	0.31
SBEN	5013	89	CHEVROLET	ASTR	LDT	TBI	105	6.9	0.64
SBEN	5013	89	CHEVROLET	ASTR	LDT	TBI	95	6.9	0.41
SBEN	5013	89	CHEVROLET	ASTR	LDT	TBI	80	6.9	0.48
SBEN	5014	85	NISSAN	300	LDV	PFI	105	9.0	5.89
SBEN	5014	85	NISSAN	300	LDV	PFI	95	9.0	3.17
SBEN	5014	85	NISSAN	300	LDV	PFI	80	9.0	4.45
SBEN	5014	85	NISSAN	300	LDV	PFI	105	6.9	4.85
SBEN	5014	85	NISSAN	300	LDV	PFI	95	6.9	5.58
SBEN	5014	85	NISSAN	300	LDV	PFI	80	6.9	1.38
SBEN	5015	85	NISSAN	300	LDV	PFI	105	9.0	1.28
SBEN	5015	85	NISSAN	300	LDV	PFI	95	9.0	0.91
SBEN	5015	85	NISSAN	300	LDV	PFI	80	9.0	0.92
SBEN	5015	85	NISSAN	300	LDV	PFI	105	6.9	0.93
SBEN	5015	85	NISSAN	300	LDV	PFI	95	6.9	0.88
SBEN	5015	85	NISSAN	300	LDV	PFI	80	6.9	0.56
SBEN	5016	87	VOLVO	740	LDV	PFI	105	9.0	1.35
SBEN	5016	87	VOLVO	740	LDV	PFI	95	9.0	0.96
SBEN	5016	87	VOLVO	740	LDV	PFI	80	9.0	0.74
SBEN	5016	87	VOLVO	740	LDV	PFI	105	6.9	1.11
SBEN	5016	87	VOLVO	740	LDV	PFI	95	6.9	0.77
SBEN	5016	87	VOLVO	740	LDV	PFI	80	6.9	0.63

Appendix 5.2-4. Estimation of the gas cap failure rate from BAR's smog check data performed in Spring 1996.

MY	Age	Observed Failure Rate	Predicted Failure
70	26.25	25.0%	34.2%
71	25.25	40.0%	34.0%
72	24.25	21.4%	33.7%
73	23.25	36.1%	33.3%
74	22.25	35.0%	32.7%
75	21.25	43.3%	31.9%
76	20.25	30.6%	30.7%
77	19.25	35.1%	29.2%
78	18.25	25.2%	27.3%
79	17.25	27.6%	24.8%
80	16.25	17.1%	22.0%
81	15.25	16.7%	18.8%
82	14.25	13.2%	15.6%
83	13.25	9.7%	12.4%
84	12.25	9.8%	9.6%
85	11.25	9.7%	7.2%
86	10.25	7.3%	5.3%
87	9.25	5.6%	3.8%
88	8.25	5.2%	2.7%
89	7.25	4.3%	1.9%
90	6.25	3.2%	1.3%
91	5.25	1.4%	0.9%
92	4.25	1.6%	0.6%
93	3.25	1.0%	0.4%
94	2.25	1.3%	0.3%
95	1.25	na	0.2%
96	0.25	na	0.1%



Parameter	Value
K	0.347
No	0.0013
R	0.3758

Model
Y(%) = K/(1+((K-No)/No)*EXP(-R*AGE))

Note that the incremental gas cap failure rate is defined as the difference between gas cap failure percentage between two consecutive ages.

Section 12.0 MEXICAN VEHICLES

This section discusses Mexican vehicle activity and emissions in San Diego and Imperial Counties. Mexican vehicles will be modeled into four new technology groups.

12.1 Introduction

Emissions from Mexican vehicles may account for a significant portion of the mobile source inventory in the U.S./Mexico border region. To characterize the fleet crossing into California and to estimate the contribution of these vehicles, activity and emissions data from various sources will be used in developing a mobile source inventory for this region.

The U.S. Customs Service surveys the number of Mexican vehicles entering California annually. This data was used to estimate the population of Mexican plated vehicles operating in California.

In addition, Colorado State University has collected data on approximately 200 vehicles that originated from Juarez and entered into the El Paso region. The Texas Natural Resource Conservation Commission contracted with Mantech Environmental to conduct IM240 tests on these vehicles, and the emissions collected were evaluated to estimate the emissions of Mexican vehicles crossing the border. By utilizing the Juarez fleet, the assumption is made these vehicles are representative of all Mexican vehicles that enter California. The average emission rates for each pollutant were compared to the average emissions for the same technology groups of California cars tested in the 1994 ARB Inspection and Maintenance Pilot Program. Therefore, it is suggested that emissions from Mexican vehicles can be modeled using existing CALIMFAC technology groups adjusted by the ratios of the means of their emissions.

12.2 Activity

The U.S. Customs Service monitors and gathers statistics on the number of vehicles entering California annually. Additionally, the U.S. Customs Service monitors the fraction of the fleet with Mexican plates. The total number of vehicles arriving in fiscal year 1995 is multiplied by the percentage of Mexican cars to approximate annual Mexican vehicle crossings.

Andrade is the smallest of the five crossings from Mexico to California and is located in southeast Imperial County. The fleet is composed of 24.0 percent Mexican plated vehicles, and the number of Mexican passenger cars entering California from Mexico is estimated to be 126,753 annually.

Calexico is also located in Imperial County. The fleet includes 40.7 percent Mexican passenger vehicles. The annual number of Mexican passenger cars entering Calexico is approximately 2,982,623.

Otay Mesa is located in southwestern San Diego County. The fleet crossing the border consists of about 28.7 percent Mexican passenger vehicles, or about 1,317,769 annually.

San Ysidro is in the extreme southwestern corner of San Diego County. This is the most active U.S. Customs border station. The fleet distribution was found to be 25.1 percent Mexican, and the annual traffic is approximately 3,472,262 Mexican passenger cars.

Tecate is in central San Diego County. The passenger vehicles crossing the border were 28.6 percent Mexican. The annual number of Mexican plated cars entering California is estimated at 298,021.

12.3 Emissions

To determine the current and future technology mix, the light-duty Juarez fleet was disaggregated (after the U.S. and Canadian vehicles were removed from the dataset) into four technology groups: (1) carbureted, no catalyst (CN); (2) carbureted, oxidation catalyst (CO_x); (3) carbureted, three-way catalyst (CT_w); and (4) fuel injected, three-way catalyst (FT_w).

Table 12-1 presents the technology group/model year matrix with each year normalized to 100 percent. The registration distribution was then determined by renormalizing the sum of all model years to unity (Table 12-2). The average HC, CO and NO_x emission rates from IM240 tests were calculated for each technology group.

Approximately 600 vehicles from the ARB's I/M pilot program were evaluated. Medium-duty trucks and vehicles with thermal reactors were removed from the dataset since these vehicle types were not identified in the Juarez fleet. The vehicles were classified into the same four technology groups described earlier, and the average IM240 emissions were calculated for each pollutant.

12.4 Results

Most of the Mexican vehicles crossing northbound into California go through the San Diego County border stations. Table 12-3 shows the activity estimates of Mexican vehicles traveling northbound through the five crossings.

The adjustment factor for Mexican vehicles was determined by dividing the average Mexican emissions reading by the corresponding pilot program average reading for the same pollutant:

$$\text{adjustment factor} = \frac{\text{avg. emissions for Mexican vehs}}{\text{avg. emissions for I/M pilot program vehs}}$$

The adjustment factors are shown in Table 12-4, and these factors were applied to CALIMFAC technology groups 1, 7, 10 and 13. The following four technology groups were created for Mexican vehicles with the same regime growth rates:

Tech Group 40 (= Tech 1, noncat/no air)

Tech Group 41 (= Tech7, oxycat/air)
Tech Group 42 (= Tech 10, TBI/carb)
Tech Group 43 (=Tech 13, MPFI/0.7NO_x)

Table 12-1. Technology Classification of Mexican Fleet.

Model Year	Carbureted, No Catalyst (CN)	Carbureted, Oxidization Catalyst (CO_x)	Carbureted, Three-way Catalyst (CT_w)	Fuel injected, Three-way Catalyst (FT_w)
pre-63	100%			
63	100%			
64	100%			
65	100%			
66	100%			
67	100%			
68	100%			
69	100%			
70	100%			
71	100%			
72	100%			
73	100%			
74	100%			
75	33%	67%		
76	33%	67%		
77	33%	67%		
78	15%	85%		
79	15%	85%		
80		92%	8%	
81		42%	46%	12%
82		42%	46%	12%
83		32%	47%	21%
84		32%	47%	21%
85		10%	38%	52%
86		7%	38%	55%
87			20%	80%
88				100%
89				100%
90				100%
91				100%
92				100%
93				100%
94				100%

Table 12-2. Registration Distribution of Mexican Vehicles for 1995.

Model Year	Carbureted, No Catalyst (CN)	Carbureted, Oxidation Catalyst (CO_x)	Carbureted, Three-way Catalyst (CT_w)	Fuel injected, Three-way Catalyst (FT_w)	Age Distribution
pre-63	0.56%	0.00%	0.00%	0.00%	0.56%
63	0.56%	0.00%	0.00%	0.00%	0.56%
64	0.56%	0.00%	0.00%	0.00%	0.56%
65	0.56%	0.00%	0.00%	0.00%	0.56%
66	0.56%	0.00%	0.00%	0.00%	0.56%
67	0.56%	0.00%	0.00%	0.00%	0.56%
68	0.56%	0.00%	0.00%	0.00%	0.56%
69	0.56%	0.00%	0.00%	0.00%	0.56%
70	0.56%	0.00%	0.00%	0.00%	0.56%
71	2.23%	0.00%	0.00%	0.00%	2.23%
72	0.56%	0.00%	0.00%	0.00%	0.56%
73	1.12%	0.00%	0.00%	0.00%	1.12%
74	1.12%	0.00%	0.00%	0.00%	1.12%
75	0.56%	1.12%	0.00%	0.00%	1.68%
76	0.56%	1.12%	0.00%	0.00%	1.68%
77	0.56%	1.12%	0.00%	0.00%	1.68%
78	1.12%	6.70%	0.00%	0.00%	7.82%
79	1.12%	6.70%	0.00%	0.00%	7.82%
80	0.00%	6.15%	0.56%	0.00%	6.70%
81	0.00%	3.07%	3.35%	0.84%	7.26%
82	0.00%	3.07%	3.35%	0.84%	7.26%
83	0.00%	3.07%	4.47%	1.96%	9.50%
84	0.00%	3.07%	4.47%	1.96%	9.50%
85	0.00%	0.56%	2.23%	3.07%	5.87%
86	0.00%	0.56%	2.23%	3.07%	5.87%
87	0.00%	0.00%	1.12%	4.47%	5.59%
88	0.00%	0.00%	0.00%	5.03%	5.03%
89	0.00%	0.00%	0.00%	2.23%	2.23%
90	0.00%	0.00%	0.00%	1.68%	1.68%
91	0.00%	0.00%	0.00%	0.56%	0.70%
92	0.00%	0.00%	0.00%	0.56%	0.70%
93	0.00%	0.00%	0.00%	1.12%	0.70%
94	0.00%	0.00%	0.00%	0.56%	0.70%

Table 12-3. Mexican Vehicle Activity Estimates.

BORDER STATION	MEX LDV (per day)
IMPERIAL	
ANDRADE	347
CALEXICO	8,172
TOTAL	8,519
SAN DIEGO	
OTAY MESA	3,610
SAN YSIDRO	9,513
TECATE	816
TOTAL	13,939

Table 12-4. Emissions Adjustment Factors.

	HC (g/mi)	CO (g/mi)	NO_x (g/mi)
I/M PILOT PROGRAM EMISSION AVERAGES			
CARB/NONCAT	5.551	49.036	3.326
CARB/OXY	4.905	42.057	2.862
CARB/TWC	1.803	28.295	1.675
FI/TWC	0.715	8.511	1.059
JUAREZ FLEET EMISSION AVERAGES			
CARB/NONCAT	6.644	74.075	2.131
CARB/OXY	5.899	87.047	1.763
CARB/TWC	5.336	101.033	1.497
FI/TWC	2.771	30.885	2.140
ADJUSTMENT FACTORS			
CARB/NONCAT	1.197	1.511	0.641
CARB/OXY	1.202	2.070	0.616
CARB/TWC	2.959	3.571	0.894
FI/TWC	3.874	3.629	2.021

Table 12-4, however, does not account for the differences in mileage accumulation between California and Mexican vehicles. The odometer readings for the Juarez fleet were found to be unreliable, and curve-fitting odometer with respect to age resulted in regression relationships that were not statistically significant. Consequently, reported odometer values were not used in this analysis.

12.5 <u>Discussion</u>

Comparing the average pollutant levels of HC and CO by technology classification, the Mexican vehicles appear to have consistently higher emissions than U.S. vehicles. For NO_x, however, the reverse is true. The lower NO_x trend may indicate that the Juarez vehicles run rich, and they may have defective emission control components. It is speculated that the higher emission levels seen in the Juarez fleet are due to a high percentage of poisoned catalysts caused by misfueling. The vehicle technologies in the Juarez fleet were found to lag behind those in the U.S. by about two to three years, e.g., 1979 Juarez vehicles would have a technology mix similar to 1977 U.S. vehicles. This model year "lag" assumption may not be the same at the California/Mexico border as the data collected by CSU is limited to the Juarez/El Paso region and reflects that particular border crossing fleet.

To obtain a more complete emissions inventory, future studies should include information on model year, emission rates, fuels, control technologies, and odometer readings to differentiate between California and Frontera fleet characteristics. License plate readers should be set up at each inspection station during different months of the year to note any differences between summer and winter fleet compositions.

12.6 <u>Conclusion</u>

Mexican vehicle activity and emission rates have been incorporated into EMFAC2000. Table 12-2 shows technology fractions by age, as well as model year/age registration distribution. Table 12-3 was used to assess the Mexican vehicle population operating in Imperial and San Diego counties.

It is assumed that Mexican vehicles take the same number of trips per day as vehicles in San Diego and Imperial counties. Fuel effects in the model are assumed to be the same as for San Diego and Imperial counties. Additionally, the number of starts, soak times, speed distribution, and mileage accrual rates are assumed to be the same as for California vehicles of the same vintage.

Mexican vehicles are modeled as a distinct vehicle class so that Mexican vehicle-specific activity data can be input at a later date. Finally, Table 12-4 was used to develop Mexican vehicle technology groups from existing CALIMFAC technology groups.

12.6.1 Mexican Trucks

Mexican trucks are also modeled in EMFAC2000 and are assumed to comprise of Heavy-Duty Diesel trucks with the same age distribution and technology fraction splits as California Certified Diesel trucks in San Diego and Imperial Counties. Mexican trucks are assumed to emit at the same rate as California trucks up to calendar year 2000. Mexican truck standards are listed in Table 12-5. The number of truck border crossings is based on a U.S. General Accounting Office (GAO/RCED-97-68) report, which states that approximately 2,000 and 650 trucks cross daily at Otay Mesa (San Diego County) and Calexico (Imperial County), respectively.

Table 12-5. Diesel Engines in Vehicles with Net Weight Greater Than 8485.4 lbs.

Model Year	Emissions Standards (g/brake*hp*hr)			
	HC	CO	NO_x	PM
1993	1.3	15.5	5.0	0.25
1994-1997				
Heavy heavy urban buses	1.3	15.5	5.0	0.07
Medium-heavy, light and other urban buses	1.3	15.5	5.0	0.10
1998+				
Heavy heavy urban buses	1.3	15.5	4.0*	0.05
Medium-heavy, light and other urban buses	1.3	15.5	4.0	0.10

*This standard is subject to revision according to U.S. EPA requirements, however, the standard will not exceed 5.0.

Section 4.11 ON-ROAD MOTORCYCLE ACTIVITY, TECHNOLOGY GROUPS, AND EMISSION RATES

4.11.1 Introduction

The on-road motorcycle (MC) activity and emission data have not been significantly revised since early 1980s. However, over the past two decades MC emission characteristics have changed considerably. ARB staff believe that several factors have had impact on the emission inventory of MCs. First, technologies for controlling motorcycle emissions have been continuously evolving, undoubtedly leading to changes in motorcycle emissions. Second, the compositions of motor vehicle fuels have been modified considerably over time, directly affecting the emissions from all motor vehicles. Third, although the in-use fleet includes a sizable fraction of older MCs, EMFAC7G still assumes no motorcycles older than 7 years. Finally, driving behaviors, which have been found to affect the exhaust emissions of motor vehicles, are significantly different today than many years ago.

To adequately address the changes in MC emissions in EMFAC2000, ARB staff reviewed MC activity and emission data gathered from a number of sources, including emission test results from a recent ARB motorcycle surveillance program. This section describes the analysis of the available MC activity and emission data. The first part of the section discusses MC activity data; the second part examines MC emission data and addresses MC technology groups and basic emission rates.

4.11.2 <u>On-Road Motorcycle Activity Data</u>

The following MC activity data were updated or re-calculated using data from several sources:

- accrual rate and cumulative mileage;
- population (POP) and age distribution;
- vehicle mile traveled (VMT).

The accrual rate for MCs was estimated using mileage accrual data from the Motorcycle Industry Council's (MIC) survey[1]. The survey contains mileage accrual rates for MCs ages 1 through 15. The 15 data points were found to be best fit by the following model:

$$\text{Accrual Rate} = 4{,}104 * \exp(-0.0654 * \text{Age}), \quad R^2 = 0.99 \qquad (4.11\text{-}1)$$

Equation 4.11-1 was used to calculate the accrual rates for MCs with ages 1 through 45. The cumulative mileage for MCs with age *i* is the sum of accrual rates for MCs with ages 1 through *i*.

The MC population was obtained from the Department of Motor Vehicle (DMV) annual vehicle registration reports, which provide the number of motor vehicles registered in each county of California. The MC age distribution was determined from the DMV's 1998 registration data.

[1] Survey of Motorcycle Ownership and Usage, MIC, 1990.

The MC daily VMT for a given year was estimated from the MC POP and accrual rate using the following equation:

$$VMT = \Sigma \, (POP_i * \text{Accrual Rate}_i), \quad i = 1 \text{ to } 45 \qquad (4.11\text{-}2)$$

Calculated results for MC accrual rate, cumulative mileage, and age distribution are given in Appendix 4.11-A.

4.11.3 On-Road Motorcycle Technology Groups

Emissions Data from On-Road Motorcycle Surveillance Programs

In 1978 and 1980, the ARB conducted MC Surveillance Testing Programs I and II (MCSTP I and II) to gather emissions data on in-use MCs[2]. Twenty-one uncontrolled MCs were tested in MCSTP I and 40 uncontrolled and controlled MCs in MCSTP II. In 1998, ARB initiated another testing program, Surveillance Testing of Motorcycles for Emissions (MCSTP98), to update the MC emissions inventory.

Note that while all MCs in MCSTP I and II were tested over the Federal Test Procedure (FTP) for HC, CO, and NOx emission levels, all tests in MCSTP98 for the three pollutants were performed over the Unified Cycle (UC). In addition, CO_2 emissions were also measured in MCSTP98.

Since the emission data used in EMFAC2000 are based on the UC, the FTP composite results from MCSTP I and II must be converted to UC bag-specific emission rates. As a result, 26 of the MCs from MCSTP98 were also tested over both the UC and FTP cycle. From this data, a correlation between the FTP and UC emission rates were established (Table 4.11-1). Note that CO_2 emissions were not measured in MCSTP I and II and therefore no FTP-UC correlation calculation was performed for CO_2.

Table 4.11-1. Correlation between FTP and UC Composite Emissions for On-Road Motorcycles.

Pollutant	Correlation	R^2
HC	$HC_{UC} = 0.8648\ HC_{FTP} + 0.2732$	0.97
CO	$CO_{UC} = 0.9860\ CO_{FTP} + 2.0344$	0.92
NOx	$NOx_{UC} = 1.4978\ NOx_{FTP} + 0.0648$	0.82

[2] Final Report of the Motorcycle Surveillance Test Program, First Series, ARB, 1980; Test Report of the Motorcycle Surveillance Test Program, Series 2, ARB, 1981.

With the FTP-UC correlation, the FTP composite results from MCSTP I and II were first converted to UC composite rates and then partitioned into Bags 1, 2, and 3 using the following equations:

$$ER_{com} = 0.109ER_{B1} + 0.782ER_{B2} + 0.109ER_{B3} \quad (4.11\text{-}3)$$
$$ER_{B1} / ER_{B2} = A \quad (4.11\text{-}4)$$
$$ER_{B1} / ER_{B3} = B \quad (4.11\text{-}5)$$

where ER_{com} is the UC composite emission rate, and ER_{B1}, ER_{B2}, and ER_{B3} are the emission rates of UC Bag 1, 2, and 3, respectively. The UC Bag 1 to UC Bag 2 ratio and UC Bag 1 to UC Bag 3 ratio were estimated from the UC bag results obtained in MCSTP98. The values of A and B for HC, CO, and NOx are given in Table 4.11-2.

Table 4.11-2. UC Bag 1/UC Bag 2 and UC Bag 1/UC Bag 3 Ratios.

	Bag 1/Bag 2 (A)	Bag 1/Bag 3 (B)
HC	0.438	0.624
CO	0.778	0.849
NOx	1.374	0.902

On-Road Motorcycle Technology Group

Technology Group Identification

The identification of MC technology groups (tech groups) was based on the emissions data from ARB's surveillance testing programs and a consideration of the past, current, and future MC exhaust and evaporative emission standards. The MC exhaust emission standards are summarized in Table 4.11-3.

Evaporative emissions of Class I and II MCs (50-279 cc) were first controlled in 1983 under a 6.0 g/test standard, which was subsequently revised to 2.0 g/test in 1985. The same evaporative standards were also applicable to Class III (280 cc and over) MCs but with a one-year delay (i.e., 6.0 g/test for 1984-85 and 2.0 for 1986 and later). In order to incorporate the evaporative emission standards into the MC tech groups, it was assumed that MCs built before 1985 had to meet the 6.0 g/test standard and those built in 1985 and later, the 2.0 g/test standard.

A statistical analysis of testing data pooled from the three ARB surveillance programs suggested that four MC tech groups could be distinguished on the basis of technology: 1) those with a two-stroke engine; 2) those built before 1978; 3) those built since 1978 equipped with a carburetor; and 4) those with the same technology as (3) but with their emission control systems tampered.

Lack of test data precluded any analysis of motorcycles with fuel injection and catalyst technologies. It was, however, recognized that these technologies had been in use since mid-1990s and the impending implementation of new emission standards in 2004 and 2008 (Table

4.11-3) called for a high percentage of such technologies. As a result, additional tech groups were identified for MCs equipped with fuel injection, catalyst, or both.

Table 4.11-3. On-Road Motorcycle Exhaust Emission Standards.

Year	Displacement (cc)	HC (g/km)	CO (g/km)
1978-79	50-169	5.0	17
	170-749	X*	17
	750 and over	14.0	17
1980-81	50 and over	5.0	12
1982-84	50-279	1.0	12
	280 and over	2.5	12
1985-87	50-279	1.0	12
	280 and over	1.4	12
1988-03	50-279	1.0	12
	280-699	1.0	12
	700 and over	1.4	12
2004-07	50-279	1.0	12
	280-699	1.0	12
	700 and over	1.4**	12
2008 and later	50-279	1.0	12
	280-699	1.0	12
	700 and over	0.8**	12

* X = 5.0 + 0.0155 (D – 170), where D = engine displacement.

** Standards applicable to HC+NOx emissions.

A total of 18 MC tech groups were established:

1. All Two-Stroke Carbureted (All-CARB2S);
2. Pre-78 Four-Stroke Carbureted (Pre-78CARB4S);
3. 78-79 Four-Stroke Carbureted (78-79CARB4S);
4. 80-81 Four-Stroke Carbureted (80-81CARB4S);
5. 82-84 Four-Stroke Carbureted (82-84CARB4S);
6. 85-87 Four-Stroke Carbureted (85-87CARB4S);
7. 88-03 Four-Stroke Carbureted (88-03CARB4S);
8. 88-03 Four-Stroke Fuel Injected (88-03FI4S);
9. 88-03 Four-Stroke Carbureted/Catalyst (88-03CARB/CAT4S);
10. 88-03 Four-Stroke Fuel Injected-Catalyst (04-07FI/CAT4S);
11. 04-07 Four-Stroke Carbureted (04-07CARB4S);

12. 04-07 Four-Stroke Fuel Injected (04-07FI4S);
13. 04-07 Four-Stroke Carbureted/Catalyst (04-07CARB/CAT4S);
14. 03-07 Four-Stroke Fuel Injected/Catalyst (04-07FI/CAT4S);
15. 08+ Four-Stroke Carbureted (08+CARB4S);
16. 08+ Four-Stroke Fuel Injected (08+FI4S);
17. 08+ Four-Stroke Carbureted/Catalyst (08+CARB/CAT4S);
18. 08+ Four-Stroke Fuel Injected/Catalyst (08+FI/CAT4S).

The following provides a brief description of the 18 tech groups. The emission rates for these groups will be discussed in the section that follows.

<u>All-CARB2S Group</u>

Emission testing data show that two-stroke MCs have distinctively higher emission rates than uncontrolled four-stroke MCs. Thus, two-stroke MCs of all model years are collected in this technology group.

<u>Pre-78CARB4S Group</u>

All MCs were uncontrolled prior to 1978. Therefore, all four-stroke MCs built before 1978 are placed in one technology group.

<u>78+CARB4S Group</u>

Motorcycles were first controlled for their emissions in 1978 and over the next two decades there have been amendments to the original standards. Thus, controlled MCs equipped with carburetors are divided into 7 technology groups corresponding to the different emission standards (see Table 4.11-3): 1978-79, 1980-81, 1982-84, 1985-87, 1988-2003, 2004-07, and 2008 and later.

<u>88+FI4S Group</u>

Although fuel injection was used occasionally on MCs prior to 1994, it was not until that year that a consistent application of this technology in MCs occurred. According to ARB MC certification reports, over the last few years fuel-injected units have been steadily rising from 2% to around 10% of the annual production. It is projected that the application of this technology will remain at its current level for the next few years and then increase significantly with the implementation of Tier 1 standards in 2004 and Tier 2 in 2008. Accordingly, fuel-injected MCs are divided into three groups: *88-03FI4S*, *04-07FI4S*, and *08+FI4S*.

<u>88+CARB/CAT4S Group</u>

Motorcycles with catalysts began to appear on the market during the 1994 model year. Although both oxidation and three-way catalysts are being offered on selected models, MCs equipped with oxidation catalysts dominate the sales (>90% oxidation vs. <10% three-way). The total sales of catalyst-equipped MCs have been fairly constant at about 20% and it is projected that the percentage of Carbureted catalyst-equipped MCs is likely to remain at current levels. Similar to the fuel-injection groups, MCs with a carburetor-catalyst control system are divided into three groups: *88-03CARB/CAT4S*, *04-07CARB/CAT4S*, and *08+CARB/CAT4S*.

<u>88+FI/CAT4S Group</u>

Motorcycles equipped with both fuel injectors and catalysts first entered the market in 1994. Over the last 5 years, the percentage of fuel-injected and catalyst-equipped MCs has remained small at 4-5% of the total sales. However, such a control system is generally considered to be crucial in achieving California's two-tier MC emission standards, in particular for the 2008 Tier 2 standards (see Table 4.11-3). All MCs with a fuel injection-catalyst control system are further divided into three groups: *88-03FI/CAT4S*, *04-07FI/CAT4S*, and *08+FI/CAT4S*.

<u>Fractions of Technology Groups for Years 1960 to 2020</u>

The fractions of MCs of different tech groups (technology fractions) for model years from 1960 to 2020 were estimated using data from ARB certification reports, manufacturers' production reports, and ARB staff's future year projections. The results are given in Appendix 4.11-B.

4.11.4 On-Road Motorcycle Emission Rates

UC-Based Exhaust Emission Rate for On-Road Motorcycles

The UC-based basic emission rates (BER, which includes a zero-mile, ZM, emission rate and a deterioration rate, DR) for the 18 tech groups, are listed in Appendix 4.11-C. In Appendix 4.11-D the FTP-based basic emission rates for the 18 tech groups are also provided.

For each of the 18 groups, two sets of BERs are given: one for non-tampered MCs and one for tampered. The overall BER for a given tech group is calculated as follows:

$$BER_X = (1-f)\, BER_{X/NT} + f\, BER_{X/T} \qquad (4.11\text{-}6)$$

where BER_X is the overall emission rate for tech group x; $BER_{X/NT}$ and $BER_{X/T}$ are, respectively, the rates for the non-tampered and tampered MCs in tech group x; and *f* is the tampering rate for tech group x. The tampering rate is specific to both model year and tech group. A tampering rate of 0.34, which is the rate found by MIC in its 1990 and 1998 motorcycle owner surveys[3], is assumed for all 18 tech groups and all model years.

Only one set of BERs for CO_2 is given for each tech group. An examination of test data showed that tampered and non-tampered MCs in each tech group were statistically indistinguishable in terms of their CO_2 emission levels. Thus, for each tech group the CO_2 BER was calculated using the CO_2 results from both tampered and non-tampered MCs.

For each tech group, HC, CO, NOx, and CO_2 emission data from the three ARB surveillance programs (MCSTP I&II and MCSTP98) were pooled and then plotted as a function of odometer readings. For each plot, attempt was made to see if a statistically significant line exist. A regression line would provide a ZM emission rate and a DR. In the cases where no meaningful

[3] Letter from Pamela Amette, MIC Vice President, to James Ryden, ARB Office of Legal Affairs, August 14, 1998.

regression line could be found, the average of all data points were used as the ZM emission rate and a zero DR was assumed.

Table 4.11-4 summarizes the emission data used for estimating HC, CO, NOx, or CO_2 BERs for each of the tech groups.

Table 4.11-4. Emission Data Base Used for Estimating Basic Emission Rates of On-Road Motorcycle Technology Groups.

<table>
<tr><th rowspan="3">Technology Group</th><th colspan="3">No. of Data Points Used in BER Calculation</th></tr>
<tr><th colspan="2">HC/CO/NOx</th><th>CO_2</th></tr>
<tr><td>MCSTP I & II</td><td>MCSTP98</td><td>MCSTP98</td></tr>
<tr><td>All-CARB2S</td><td>4</td><td>1</td><td>1</td></tr>
<tr><td>Pre-78CARB4S</td><td>25</td><td>10</td><td>10</td></tr>
<tr><td>78-79CARB4S (Non-Tampered)</td><td>21</td><td>3</td><td>4</td></tr>
<tr><td>80-81CARB4S (Non-Tampered)</td><td>1</td><td>6</td><td>10</td></tr>
<tr><td>82-84CARB4S (Non-Tampered)</td><td></td><td>9</td><td>11</td></tr>
<tr><td>85-87CARB4S (Non-Tampered)</td><td></td><td>8</td><td>12</td></tr>
<tr><td>88-03CARB4S (Non-Tampered)</td><td></td><td>28</td><td rowspan="2">33</td></tr>
<tr><td>04-07CARB4S, 08+CARB4S (Non-Tampered)</td><td></td><td>See text</td></tr>
<tr><td>78-79CARB4S, 80-81CARB4S, 82-84CARB4S, 85-87CARB4S, 88-03CARB4S, 04-07CARB4S, 08+CARB4S</td><td>6</td><td>9</td><td>See text</td></tr>
<tr><td>88-03FI4S, 04-07FI4S, 08+FI4S (Non-Tampered)</td><td></td><td>See text</td><td rowspan="2">1</td></tr>
<tr><td>88-03FI4S, 04-07FI4S, 08+FI4S (Tampered)</td><td></td><td>1</td></tr>
<tr><td>88-03CARB/CAT4S, 04-07CARB/CAT4S, 08+CARB/CAT4S (Non-Tampered)</td><td></td><td>2</td><td rowspan="2">4</td></tr>
<tr><td>88-03CARB/CAT4S, 04-07CARB/CAT4S, 08+CARB/CAT4S (Tampered)</td><td></td><td>2</td></tr>
<tr><td>88-03FI/CAT4S (Non-Tampered)</td><td></td><td>2</td><td rowspan="2">2</td></tr>
<tr><td>88-03FI/CAT4S (Tampered)</td><td></td><td>See text</td></tr>
<tr><td>04-07FI/CAT4S, 08+FI/CAT4S (Non-Tampered and Tampered)</td><td></td><td>See text</td><td>See text</td></tr>
</table>

Emissions data were not available for several tech groups (noted in Table 4.11-4 under "See text"). The BERs for these groups, which were obtained differently from the procedures outlined above, are discussed below.

<u>04-07CARB4S and 08+CARB4S Groups (Non-Tampered)</u>

Since the 1998 MC emission regulation recognizes the likely continuing marketing of carburetor-equipped MCs after the implementation of Tier 1 (2004) and Tier 2 (2008) standards, the BERs for *88-03CARB4S* group were assumed to be applicable to non-tampered MCs in *04-07CARB4S* and *08+CARB4S* groups.

<u>78+CARB4S Groups (Tampered)</u>

Among the 91 1978+ carburetor-equipped MCs in the pooled data set used for estimating emission rates, six were identified during vehicle inspection as being tampered. In addition, nine of the test vehicles have Bag 2 HC emissions over 6 g/mile and are clearly outside the cluster formed by the majority of the data points. These 15 MCs were collectively treated as "tampered" and their average emissions were assumed to be applicable to all 78+ carburetor groups.

The BER of CO_2 for each of the groups was assumed to be the same as that of its corresponding non-tampered group (non-tampered *78-79CARB4S* group and tampered *78-79CARB4S* group).

<u>88-03FI4S, 04-07FI4S, and 08+FI4S Groups (Non-Tampered and Tampered)</u>

No emission test data was available for fuel-injected non-catalyst MCs. As a result, for non-tampered MCs in these three groups the BERs for HC, CO, and NOx were assumed to be the same as those for non-tampered *88-03CARB4S* groups. The BERs of HC, CO, and NOx for the tampered MCs in these three groups were based on the test result of a fuel-injected 1985 Honda test in MCSTP98. Although no tampering was reported during its inspection, this Honda exhibited high HC and CO emissions during the test. The BER of CO_2 for both non-tampered and tampered MCs in these groups were also based on the test result of this 1985 Honda.

<u>88-03FI/CAT4S Group (Tampered)</u>

For MCs in this group, the BERs of HC, CO, and NOx estimated for tampered MCs in *88-03CARB/CAT4S* group were used and the BER of CO_2 was assumed to be the same as that for the non-tampered MCs in this group.

<u>04-07FI/CAT4S and 08+FI/CAT4S Groups (Non-Tampered and Tampered)</u>

The BERs of HC, CO, and NOx for non-tampered MCs in these two groups were assumed to be the same as the BERs used in the emission inventory evaluations for 1998 California MC emission control regulation (the scenario used for estimating emissions benefit for the regulation calls for 60% of the 2008 and later MCs to be equipped with fuel-injection and catalyst system to attain 0.4 g/km HC+NOx emissions in order for the entire fleet to meet the Tier 2 standard, 0.8 g/km HC+NOx). Calculation of the 1998 regulation BERs assumed that fuel-injection/catalyst system of a non-tampered 2008 and later MCs would deteriorate 30% in HC and 10% in NOx controls over 30,000 km (its useful life span) and would emit 0.4 g/km HC+NOx at 30,000 km. These assumptions are based on emission data for on-road passenger cars.

The BERs of HC, CO, and NOx for tampered MCs in these two groups were assumed to be the same as the BER for tampered MCs in *88-03FI4S* group.

The BERs of CO_2 for both non-tampered and tampered MCs in the group were assumed to be the same as that estimated for *88-03FI/CAT4S* group.

Evaporative Emissions: Diurnal and Hot-Soak Emission Rates

Ten MCs from MCSTP98 were tested for diurnal and hot-soak evaporative emissions using the Sealed Housing Evaporative Determination (SHED) method. The ten MCs are divided into two model-year groups: Pre-1985 and 1985 and later. The Pre-1985 group consists of two 1981 MCs and the other group has eight MCs ranging from 1985 to 1999 model years. For each of the two groups, the SHED results were averaged and used as the diurnal and hot-soak emission rates for Pre-1985 and 1985 and later model year MCs (Table 4.11-5).

Table 4.11-5. On-Road Motorcycle Evaporative Emission Rates.

	Diurnal (g/event)	**Hot Soak** (g/35min)
Pre-1985	6.515	1.397
1985 and Later	2.392	0.806

4.11.5 On-Road Motorcycle Emission Correction Factors

Temperature, Speed, and Fuel Correction Factors

The temperature, speed, and fuel correction factors (TCF, SCF, and FCF) are used in inventory models to correct for the effects of non-standard speeds, temperatures, and fuels on the UC-based emission rates. In EMFAC2000, the TCF, SCF, and FCF for MCs are the same as those used for light-duty vehicles (LDV) with similar emission control technologies. A complete discussion of these correction factors is given in Section 6.1-6.3 of this document. Table 4.11-6 provides the equivalent LDV tech groups for the 18 MC tech groups for the purpose of applying LDV correction factors to MCs.

Start Correction Factor

Start Correction Factors (StCF) are used in the emissions inventory model to adjust the basic UC based Bag1 emission rates to model start emissions for real-world driving conditions. Following the definition for passenger cars (Section Z), the StCF for MCs is defined as:

StCF = (CE100/UCBag1) / (ERUCBag1) (4.11-7) where $CE_{100/UCBag1}$ is the cumulative emissions within the first 100 seconds of Bag 1 of the UC (grams); ER_{UCBag1} is the emission rate of the UC (g/mi).

Table 4.11-6. Equivalent Light-Duty Vehicle Technology Groups.

MC Technology Groups		LDV Technology Groups	
Tech Group	**Description**	**Tech Group**	**Description**
1	All CARB 2S	3	75+ LDV NCAT
2	Pre-78 CARB 4S	3	75+ LDV NCAT
3	78-79 CARB 4S	3	75+ LDV NCAT
4	80-81 CARB 4S	3	75+ LDV NCAT
5	82-84 CARB 4S	3	75+ LDV NCAT
6	85-87 CARB 4S	3	75+ LDV NCAT
7	88-03 CARB 4S	3	75+ LDV NCAT
8	88-03 FI 4S	3	75+ LDV NCAT
9	88-03 CARB/CAT 4S	6	80+ OxCAT No AIR
10	88-03 FI/CAT 4S	11	77-80 TWC MPFI
11	04-07 CARB 4S	3	75+ LDV NCAT
12	04-07 FI 4S	3	75+ LDV NCAT
13	04-07 CARB/CAT 4S	6	80+ OxCAT No AIR
14	04-07 FI/CAT 4S	11	77-80 TWC MPFI
15	08+ CARB 4S	3	75+ LDV NCAT
16	08+ FI 4S	3	75+ LDV NCAT
17	08+ CARB/CAT 4S	6	80+ OxCAT No AIR
18	08+ FI/CAT 4S	11	77-80 TWC MPFI

The UC modal (second-by-second) emission data from 11 MCs tested in MCSTP98 were used to calculate the StCFs for non-catalyst MCs according to Equation 4.11-7. No UC modal data was available for catalyst-equipped MCs. However, FTP modal data were collected for a 1997 Harley-Davidson both with and without its catalyst. From this FTP-based modal data two StCFs (representing cases with and without catalyst) were calculated and their ratio was then used to estimate the UC-based StCFs for catalyst-equipped MCs from the UC-based non-catalyst StCFs. Table 4.11-7 shows the calculated StCFs for MCs with and without catalyst control system.

Table 4.11-7. Start Correction Factor for On-Road Motorcycles (mile).

Pollutant	Non-Catalyst	Catalyst*
HC	0.387	0.653
CO	0.420	0.618

NOx	0.087	0.195
* Calculated from the values for Non-Catalyst MCs.		

4.11.6 Recommendations

In the future, staff should consider emissions testing of fuel-injected MCs equipped with and without a catalyst. Staff has assumed that MCs are driven in a manner similar to passenger cars and hence characterized by UC-based emission rates. Staff would like to collect real-world activity data to evaluate the driving behavior of MCs. Staff would also like to derive MC-specific TCF, SCF, and FCF.

Appendix 4.11-A. Annual Mileage Accrual Rate, Cumulative Mileage, and Population Distribution for On-Road Motorcycles			
Age	Accrual Rate (mi/year)	Cumulative Mileage	Population
45	216	57,331	1,417
44	231	57,102	251
43	247	56,857	325
42	263	56,596	296
41	281	56,317	364
40	300	56,019	366
39	320	55,701	323
38	342	55,362	395
37	365	55,000	395
36	390	54,613	584
35	416	54,200	794
34	444	53,759	919
33	474	53,288	1,820
32	506	52,786	2,903
31	540	52,249	4,521
30	577	51,677	7,214
29	616	51,065	7,200
28	658	50,413	7,788
27	702	49,716	8,741
26	749	48,972	9,097
25	800	48,178	11,089
24	854	47,330	7,954
23	912	46,425	6,766
22	974	45,458	10,138
21	1,039	44,427	11,670
20	1,110	43,325	14,339
19	1,185	42,150	19,310
18	1,265	40,894	31,259
17	1,350	39,554	29,508
16	1,441	38,124	21,563
15	1,539	36,596	41,797
14	1,643	34,966	45,910
13	1,754	33,225	34,183
12	1,872	31,366	20,088
11	1,999	29,382	22,362
10	2,134	27,264	18,846
9	2,278	25,003	17,177
8	2,432	22,588	15,016
7	2,596	20,011	16,029
6	2,772	17,260	16,932
5	2,959	14,322	16,294
4	3,159	11,186	22,082
3	3,373	7,838	17,391
2	3,601	4,264	1,407
1	3,844	961	37

Appendix 4.11-B. Technology Group Fractions for On-Road Motorcycles

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Model Year	Two-Stroke	Pre-78	78-79 Carb	80-81 Carb	82-84 Carb	85-87 Carb	88-03 Carb	88-03 FI	88-03 Carb+Cat	88-03 FI+Cat	03-08 Carb	03-08 FI	03-08 Carb+Cat	03-08 FI+Cat	08+ Carb	08+ FI	08+ Carb+Cat	08+ FI+Cat	
1960	0.500	0.500																	1.000
1961	0.500	0.500																	1.000
1962	0.500	0.500																	1.000
1963	0.500	0.500																	1.000
1964	0.500	0.500																	1.000
1965	0.500	0.500																	1.000
1966	0.500	0.500																	1.000
1967	0.500	0.500																	1.000
1968	0.500	0.500																	1.000
1969	0.500	0.500																	1.000
1970	0.500	0.500																	1.000
1971	0.070	0.930																	1.000
1972	0.070	0.930																	1.000
1973	0.070	0.930																	1.000
1974	0.070	0.930																	1.000
1975	0.070	0.930																	1.000
1976	0.070	0.930																	1.000
1977	0.070	0.930																	1.000
1978			1.000																1.000
1979			1.000																1.000
1980				1.000															1.000
1981				1.000															1.000
1982					1.000														1.000
1983					1.000														1.000
1984					1.000														1.000
1985						1.000													1.000
1986						1.000													1.000
1987						1.000													1.000
1988							1.000												1.000
1989							1.000												1.000
1990							1.000												1.000
1991							1.000												1.000

Appendix 4.11-B (continued)																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Model Year	Two-Stroke	Pre-78	78-79 Carb	80-81 Carb	82-84 Carb	85-87 Carb	88-03 Carb	88-03 FI	88-03 Carb+Cat	88-03 FI+Cat	03-08 Carb	03-08 FI	03-08 Carb+Cat	03-08 FI+Cat	08+ Carb	08+ FI	08+ Carb+Cat	08+ FI+Cat	
1992							1.000												1.000
1993							1.000												1.000
1994							0.980	0.005		0.015									1.000
1995							0.740	0.010	0.220	0.030									1.000
1996							0.735	0.045	0.180	0.040									1.000
1997							0.720	0.060	0.180	0.040									1.000
1998							0.720	0.060	0.180	0.040									1.000
1999							0.720	0.060	0.180	0.040									1.000
2000							0.720	0.060	0.180	0.040									1.000
2001							0.720	0.060	0.180	0.040									1.000
2002							0.720	0.060	0.180	0.040									1.000
2003							0.720	0.060	0.180	0.040									1.000
2004											0.560	0.260	0.140	0.040					1.000
2005											0.560	0.260	0.140	0.040					1.000
2006											0.560	0.260	0.140	0.040					1.000
2007											0.560	0.260	0.140	0.040					1.000
2008															0.224	0.104	0.056	0.616	1.000
2009															0.224	0.104	0.056	0.616	1.000
2010															0.224	0.104	0.056	0.616	1.000
2011															0.224	0.104	0.056	0.616	1.000
2012															0.224	0.104	0.056	0.616	1.000
2013															0.224	0.104	0.056	0.616	1.000
2014															0.224	0.104	0.056	0.616	1.000
2015															0.224	0.104	0.056	0.616	1.000
2016															0.224	0.104	0.056	0.616	1.000
2017															0.224	0.104	0.056	0.616	1.000
2018															0.224	0.104	0.056	0.616	1.000
2019															0.224	0.104	0.056	0.616	1.000
2020															0.224	0.104	0.056	0.616	1.000

Appendix 4.11-C. UC-Based Basic Emission Rate for On-Road Motorcycles								
	UC BAG 1 HC				UC BAG 2 HC			
	NON TAMPERED		TAMPERED		NON TAMPERED		TAMPERED	
TECH GROUP	ZME	DR	ZME	DR	ZME	DR	ZME	DR
	g/mi	g/mi/10kmi	g/mi	g/mi/10kmi	g/mi	g/mi/10kmi	g/mi	g/mi/10kmi
(1) Two-Stroke	56.9910	0.0000	--	--	14.6780	0.0000	--	--
(2) Pre-78	9.9657	0.0000	--	--	4.3501	0.0000	--	--
(3) 78-79Carb	8.8903	0.0000	20.6765	0.0000	3.0120	0.0000	7.8651	0.0000
(4) 80-81Carb	7.1570	0.0000	20.6765	0.0000	2.4847	0.0000	7.8651	0.0000
(5) 82-84Carb	9.4022	0.0000	20.6765	0.0000	2.2781	0.0000	7.8651	0.0000
(6) 85-87Carb	6.5444	0.0000	20.6765	0.0000	2.4214	0.0000	7.8651	0.0000
(7) 88-03Carb	3.7937	0.0000	20.6765	0.0000	1.8884	0.0000	7.8651	0.0000
(8) 88-03FI	3.7937	0.0000	12.2860	0.0000	1.8884	0.0000	7.0080	0.0000
(9) 88-03Carb+Cat	5.2960	0.0000	11.3790	0.0000	0.8380	0.0000	5.2940	0.0000
(10) 88-03FI+Cat	5.2960	0.0000	12.2860	0.0000	0.8380	0.0000	7.0080	0.0000
(11) 03-08Carb	3.7937	0.0000	20.6765	0.0000	1.8884	0.0000	7.8651	0.0000
(12) 03-08FI	3.7937	0.0000	12.2860	0.0000	1.8884	0.0000	7.0080	0.0000
(13) 03-08Carb+Cat	5.2960	0.0000	11.3790	0.0000	0.8380	0.0000	5.2940	0.0000
(14) 03-08FI+Cat	1.4000	0.0932	12.2860	0.0000	0.6132	0.0408	7.0080	0.0000
(15) 08+Carb	3.7937	0.0000	20.6765	0.0000	1.8884	0.0000	7.8651	0.0000
(16) 08+FI	3.7937	0.0000	12.2860	0.0000	1.8884	0.0000	7.0080	0.0000
(17) 08+Carb+Cat	5.2960	0.0000	11.3790	0.0000	0.8380	0.0000	5.2940	0.0000
(18) 08+FI+Cat	1.4000	0.0932	12.2860	0.0000	0.6132	0.0408	7.0080	0.0000

Appendix 4.11-C (continued)								
	UC BAG 1 CO				UC BAG 2 CO			
	NON TAMPERED		TAMPERED		NON TAMPERED		TAMPERED	
TECH GROUP	ZME	DR	ZME	DR	ZME	DR	ZME	DR
	g/mi	g/mi/10kmi	g/mi	g/mi/10kmi	g/mi	g/mi/10kmi	g/mi	g/mi/10kmi
(1) Two-Stroke	68.8010	0.0000	--	--	53.5270	0.0000	--	--
(2) Pre-78	63.2569	0.0000	--	--	49.1300	0.0000	--	--
(3) 78-79Carb	42.1417	0.0000	70.9200	0.0000	29.6058	0.0000	49.6093	0.0000
(4) 80-81Carb	34.7414	0.0000	70.9200	0.0000	26.9886	0.0000	49.6093	0.0000
(5) 82-84Carb	32.9578	0.0000	70.9200	0.0000	19.7378	0.0000	49.6093	0.0000
(6) 85-87Carb	35.0413	0.0000	70.9200	0.0000	21.5838	0.0000	49.6093	0.0000
(7) 88-03Carb	30.5482	0.0000	70.9200	0.0000	21.6196	0.0000	49.6093	0.0000
(8) 88-03FI	30.5482	0.0000	48.8450	0.0000	21.6196	0.0000	21.2050	0.0000
(9) 88-03Carb+Cat	36.5000	0.0000	66.6627	0.0000	9.4520	0.0000	47.2247	0.0000
(10) 88-03FI+Cat	36.5000	0.0000	48.8450	0.0000	9.4520	0.0000	21.2050	0.0000
(11) 03-08Carb	30.5482	0.0000	70.9200	0.0000	21.6196	0.0000	49.6093	0.0000
(12) 03-08FI	30.5482	0.0000	48.8450	0.0000	21.6196	0.0000	21.2050	0.0000
(13) 03-08Carb+Cat	36.5000	0.0000	66.6627	0.0000	9.4520	0.0000	47.2247	0.0000
(14) 03-08FI+Cat	11.7309	0.7821	48.8450	0.0000	6.1654	0.4110	21.2050	0.0000
(15) 08+Carb	30.5482	0.0000	70.9200	0.0000	21.6196	0.0000	49.6093	0.0000
(16) 08+FI	30.5482	0.0000	48.8450	0.0000	21.6196	0.0000	21.2050	0.0000
(17) 08+Carb+Cat	36.5000	0.0000	66.6627	0.0000	9.4520	0.0000	47.2247	0.0000
(18) 08+FI+Cat	11.7309	0.7821	48.8450	0.0000	6.1654	0.4110	21.2050	0.0000

Appendix 4.11-C (continued)								
	UC BAG 1 NOx				UC BAG 2 NOx			
	NON TAMPERED		TAMPERED		NON TAMPERED		TAMPERED	
TECH GROUP	ZME	DR	ZME	DR	ZME	DR	ZME	DR
	g/mi	g/mi/10kmi	g/mi	g/mi/10kmi	g/mi	g/mi/10kmi	g/mi	g/mi/10kmi
(1) Two-Stroke	0.0900	0.0000	--	--	0.1240	0.0000	--	--
(2) Pre-78	0.5759	0.0000	--	--	0.7655	0.0000	--	--
(3) 78-79Carb	0.8499	0.0000	0.8863	0.0000	1.1382	0.0000	0.9789	0.0000
(4) 80-81Carb	1.1706	0.0000	0.8863	0.0000	1.3957	0.0000	0.9789	0.0000
(5) 82-84Carb	0.9741	0.0000	0.8863	0.0000	1.3086	0.0000	0.9789	0.0000
(6) 85-87Carb	1.0979	0.0000	0.8863	0.0000	1.2134	0.0000	0.9789	0.0000
(7) 88-03Carb	0.8465	0.0000	0.8863	0.0000	1.0118	0.0000	0.9789	0.0000
(8) 88-03FI	0.8465	0.0000	1.6023	0.0000	1.0118	0.0000	1.8790	0.0000
(9) 88-03Carb+Cat	0.7760	0.0000	1.1410	0.0000	0.9520	0.0000	1.4210	0.0000
(10) 88-03FI+Cat	0.7760	0.0000	1.6023	0.0000	0.9520	0.0000	1.8790	0.0000
(11) 03-08Carb	0.8465	0.0000	0.8863	0.0000	1.0118	0.0000	0.9789	0.0000
(12) 03-08FI	0.8465	0.0000	1.6023	0.0000	1.0118	0.0000	1.8790	0.0000
(13) 03-08Carb+Cat	0.7760	0.0000	1.1410	0.0000	0.9520	0.0000	1.4210	0.0000
(14) 03-08FI+Cat	0.3833	0.0255	1.6023	0.0000	0.5266	0.0351	1.8790	0.0000
(15) 08+Carb	0.8465	0.0000	0.8863	0.0000	1.0118	0.0000	0.9789	0.0000
(16) 08+FI	0.8465	0.0000	1.6023	0.0000	1.0118	0.0000	1.8790	0.0000
(17) 08+Carb+Cat	0.7760	0.0000	1.1410	0.0000	0.9520	0.0000	1.4210	0.0000
(18) 08+FI+Cat	0.3833	0.0255	1.6023	0.0000	0.5266	0.0351	1.8790	0.0000

Appendix 4.11-C (continued)								
	UC BAG 1 CO_2				UC BAG 1 CO_2			
	NON TAMPERED		TAMPERED		NON TAMPERED		TAMPERED	
TECH GROUP	ZME	DR	ZME	DR	ZME	DR	ZME	DR
	g/mi	g/mi/10kmi	g/mi	g/mi/10kmi	g/mi	g/mi/10kmi	g/mi	g/mi/10kmi
(1) Two-Stroke	109	0.0	--	--	53.8	0.0	--	--
(2) Pre-78	138	0.0	--	--	103	0.0	--	--
(3) 78-79Carb	218	0.0	218	0.0	156	0.0	156	0.0
(4) 80-81Carb	216	0.0	216	0.0	147	0.0	147	0.0
(5) 82-84Carb	237	0.0	237	0.0	161	0.0	161	0.0
(6) 85-87Carb	246	0.0	246	0.0	163	0.0	163	0.0
(7) 88-03Carb	227	0.0	227	0.0	152	0.0	152	0.0
(8) 88-03FI	297	0.0	297	0.0	204	0.0	204	0.0
(9) 88-03Carb+Cat	239	0.0	239	0.0	162	0.0	162	0.0
(10) 88-03FI+Cat	242	0.0	242	0.0	197	0.0	197	0.0
(11) 03-08Carb	227	0.0	227	0.0	152	0.0	152	0.0
(12) 03-08FI	297	0.0	297	0.0	204	0.0	204	0.0
(13) 03-08Carb+Cat	239	0.0	239	0.0	162	0.0	162	0.0
(14) 03-08FI+Cat	242	0.1	242	0.0	197	0.0	197	0.0
(15) 08+Carb	227	0.0	227	0.0	152	0.0	152	0.0
(16) 08+FI	297	0.0	297	0.0	204	0.0	204	0.0
(17) 08+Carb+Cat	239	0.0	239	0.0	162	0.0	162	0.0
(18) 08+FI+Cat	242	0.1	242	0.0	197	0.0	197	0.0

Appendix 4.11-C (continued)								
	UC BAG 1 PM				UC BAG 2 PM			
	NON TAMPERED		TAMPERED		NON TAMPERED		TAMPERED	
TECH GROUP	ZME	DR	ZME	DR	ZME	DR	ZME	DR
	g/mi	g/mi/10kmi	g/mi	g/mi/10kmi	g/mi	g/mi/10kmi	g/mi	g/mi/10kmi
(1) Two-Stroke	0.3300	0.0000	--	--	0.3300	0.0000	--	--
(2) Pre-78	0.0460	0.0000	--	--	0.0460	0.0000	--	--
(3) 78-79Carb	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000
(4) 80-81Carb	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000
(5) 82-84Carb	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000
(6) 85-87Carb	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000
(7) 88-03Carb	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000
(8) 88-03FI	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000
(9) 88-03Carb+Cat	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000
(10) 88-03FI+Cat	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000
(11) 03-08Carb	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000
(12) 03-08FI	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000
(13) 03-08Carb+Cat	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000
(14) 03-08FI+Cat	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000
(15) 08+Carb	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000
(16) 08+FI	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000
(17) 08+Carb+Cat	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000
(18) 08+FI+Cat	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000	0.0460	0.0000

Appendix 4.11-D. FTP-Based Basic Emission Rate for On-Road Motorcycles								
	FTP BAG 1 HC				FTP BAG 2 HC			
	NON TAMPERED		TAMPERED		NON TAMPERED		TAMPERED	
TECH GROUP	ZME	DR	ZME	DR	ZME	DR	ZME	DR
	g/mi	g/mi/10kmi	g/mi	g/mi/10kmi	g/mi	g/mi/10kmi	g/mi	g/mi/10kmi
(1) Two-Stroke	28.040	0.0000	--	--	17.687	0.0000	--	--
(2) Pre-78	4.9031	0.0000	--	--	5.2419	0.0000	--	--
(3) 78-79Carb	4.3740	0.0000	10.1728	0.0000	3.6295	0.0000	9.4774	0.0000
(4) 80-81Carb	3.5212	0.0000	10.1728	0.0000	2.9941	0.0000	9.4774	0.0000
(5) 82-84Carb	4.6259	0.0000	10.1728	0.0000	2.7451	0.0000	9.4774	0.0000
(6) 85-87Carb	3.2198	0.0000	10.1728	0.0000	2.9178	0.0000	9.4774	0.0000
(7) 88-03Carb	1.8665	0.0000	10.1728	0.0000	2.2755	0.0000	9.4774	0.0000
(8) 88-03FI	1.8665	0.0000	6.0447	0.0000	2.2755	0.0000	8.4446	0.0000
(9) 88-03Carb+Cat	2.6056	0.0000	5.5985	0.0000	1.0098	0.0000	6.3793	0.0000
(10) 88-03FI+Cat	2.6056	0.0000	6.0447	0.0000	1.0098	0.0000	8.4446	0.0000
(11) 03-08Carb	1.8665	0.0000	10.1728	0.0000	2.2755	0.0000	9.4774	0.0000
(12) 03-08FI	1.8665	0.0000	6.0447	0.0000	2.2755	0.0000	8.4446	0.0000
(13) 03-08Carb+Cat	2.6056	0.0000	5.5985	0.0000	1.0098	0.0000	6.3793	0.0000
(14) 03-08FI+Cat	0.6000	0.0932	6.0447	0.0000	0.7546	0.0408	8.4446	0.0000
(15) 08+Carb	1.8665	0.0000	10.1728	0.0000	2.2755	0.0000	9.4774	0.0000
(16) 08+FI	1.8665	0.0000	6.0447	0.0000	2.2755	0.0000	8.4446	0.0000
(17) 08+Carb+Cat	2.6056	0.0000	5.5985	0.0000	1.0098	0.0000	6.3793	0.0000
(18) 08+FI+Cat	0.6000	0.0932	6.0447	0.0000	0.7546	0.0408	8.4446	0.0000

Appendix 4.11-D (continued)								
	FTP BAG 1 CO				FTP BAG 2 CO			
	NON TAMPERED		TAMPERED		NON TAMPERED		TAMPERED	
TECH GROUP	ZME	DR	ZME	DR	ZME	DR	ZME	DR
	g/mi	g/mi/10kmi	g/mi	g/mi/10kmi	g/mi	g/mi/10kmi	g/mi	g/mi/10kmi
(1) Two-Stroke	45.340	0.000	--	--	52.831	0.000	--	--
(2) Pre-78	41.686	0.000	--	--	48.491	0.000	--	--
(3) 78-79Carb	27.771	0.000	46.736	0.000	29.221	0.000	48.964	0.000
(4) 80-81Carb	22.895	0.000	46.736	0.000	26.638	0.000	48.964	0.000
(5) 82-84Carb	21.719	0.000	46.736	0.000	19.481	0.000	48.964	0.000
(6) 85-87Carb	23.092	0.000	46.736	0.000	21.303	0.000	48.964	0.000
(7) 88-03Carb	20.131	0.000	46.736	0.000	21.339	0.000	48.964	0.000
(8) 88-03FI	20.131	0.000	32.189	0.000	21.339	0.000	20.929	0.000
(9) 88-03Carb+Cat	24.054	0.000	43.931	0.000	9.329	0.000	46.611	0.000
(10) 88-03FI+Cat	24.054	0.000	32.189	0.000	9.329	0.000	20.929	0.000
(11) 03-08Carb	20.131	0.000	46.736	0.000	21.339	0.000	48.964	0.000
(12) 03-08FI	20.131	0.000	32.189	0.000	21.339	0.000	20.929	0.000
(13) 03-08Carb+Cat	24.054	0.000	43.931	0.000	9.329	0.000	46.611	0.000
(14) 03-08FI+Cat	7.2306	0.7821	32.189	0.000	6.075	0.411	20.929	0.000
(15) 08+Carb	20.131	0.000	46.736	0.000	21.339	0.000	48.964	0.000
(16) 08+FI	20.131	0.000	32.189	0.000	21.339	0.000	20.929	0.000
(17) 08+Carb+Cat	24.054	0.000	43.931	0.000	9.3291	0.0000	46.611	0.000
(18) 08+FI+Cat	7.2306	0.7821	32.189	0.000	6.0753	0.4110	20.929	0.000

Appendix 4.11-D (continued)								
	FTP BAG 1 NOx				FTP BAG 2 NOx			
	NON TAMPERED		TAMPERED		NON TAMPERED		TAMPERED	
TECH GROUP	ZME	DR	ZME	DR	ZME	DR	ZME	DR
	g/mi	g/mi/10kmi	g/mi	g/mi/10kmi	g/mi	g/mi/10kmi	g/mi	g/mi/10kmi
(1) Two-Stroke	0.0938	0.0000	--	--	0.0408	0.0000	--	--
(2) Pre-78	0.6001	0.0000	--	--	0.2518	0.0000	--	--
(3) 78-79Carb	0.8856	0.0000	0.9235	0.0000	0.3745	0.0000	0.3221	0.0000
(4) 80-81Carb	1.2198	0.0000	0.9235	0.0000	0.4592	0.0000	0.3221	0.0000
(5) 82-84Carb	1.0150	0.0000	0.9235	0.0000	0.4305	0.0000	0.3221	0.0000
(6) 85-87Carb	1.1440	0.0000	0.9235	0.0000	0.3992	0.0000	0.3221	0.0000
(7) 88-03Carb	0.8821	0.0000	0.9235	0.0000	0.3329	0.0000	0.3221	0.0000
(8) 88-03FI	0.8821	0.0000	1.6696	0.0000	0.3329	0.0000	0.6182	0.0000
(9) 88-03Carb+Cat	0.8086	0.0000	1.1889	0.0000	0.3132	0.0000	0.4675	0.0000
(10) 88-03FI+Cat	0.8086	0.0000	1.6696	0.0000	0.3132	0.0000	0.6182	0.0000
(11) 03-08Carb	0.8821	0.0000	0.9235	0.0000	0.3329	0.0000	0.3221	0.0000
(12) 03-08FI	0.8821	0.0000	1.6696	0.0000	0.3329	0.0000	0.6182	0.0000
(13) 03-08Carb+Cat	0.8086	0.0000	1.1889	0.0000	0.3132	0.0000	0.4675	0.0000
(14) 03-08FI+Cat	0.4182	0.0255	1.6696	0.0000	0.1471	0.0351	0.6182	0.0000
(15) 08+Carb	0.8821	0.0000	0.9235	0.0000	0.3329	0.0000	0.3221	0.0000
(16) 08+FI	0.8821	0.0000	1.6696	0.0000	0.3329	0.0000	0.6182	0.0000
(17) 08+Carb+Cat	0.8086	0.0000	1.1889	0.0000	0.3132	0.0000	0.4675	0.0000
(18) 08+FI+Cat	0.4182	0.0255	1.6696	0.0000	0.1471	0.0351	0.6182	0.0000

Appendix 4.11-D (continued)								
	FTP BAG 1 CO_2				FTP BAG 1 CO_2			
	NON TAMPERED		TAMPERED		NON TAMPERED		TAMPERED	
TECH GROUP	ZME	DR	ZME	DR	ZME	DR	ZME	DR
	g/mi	g/mi/10kmi	g/mi	g/mi/10kmi	g/mi	g/mi/10kmi	g/mi	g/mi/10kmi
(1) Two-Stroke	80.4	0.0	--	--	57.1	0.0	--	--
(2) Pre-78	101.8	0.0	--	--	109.4	0.0	--	--
(3) 78-79Carb	160.9	0.0	160.9	0.0	165.7	0.0	165.7	0.0
(4) 80-81Carb	159.4	0.0	159.4	0.0	156.1	0.0	156.1	0.0
(5) 82-84Carb	174.9	0.0	174.9	0.0	171.0	0.0	171.0	0.0
(6) 85-87Carb	181.5	0.0	181.5	0.0	173.1	0.0	173.1	0.0
(7) 88-03Carb	167.5	0.0	167.5	0.0	161.4	0.0	161.4	0.0
(8) 88-03FI	219.2	0.0	219.2	0.0	216.6	0.0	216.6	0.0
(9) 88-03Carb+Cat	176.4	0.0	176.4	0.0	172.0	0.0	172.0	0.0
(10) 88-03FI+Cat	178.6	0.0	178.6	0.0	209.2	0.0	209.2	0.0
(11) 03-08Carb	167.5	0.0	167.5	0.0	161.4	0.0	161.4	0.0
(12) 03-08FI	219.2	0.0	219.2	0.0	216.6	0.0	216.6	0.0
(13) 03-08Carb+Cat	176.4	0.0	176.4	0.0	172.0	0.0	172.0	0.0
(14) 03-08FI+Cat	178.6	0.0	178.6	0.0	209.2	0.0	209.2	0.0
(15) 08+Carb	167.5	0.0	167.5	0.0	161.4	0.0	161.4	0.0
(16) 08+FI	219.2	0.0	219.2	0.0	216.6	0.0	216.6	0.0
(17) 08+Carb+Cat	176.4	0.0	176.4	0.0	172.0	0.0	172.0	0.0
(18) 08+FI+Cat	178.6	0.0	178.6	0.0	209.2	0.0	209.2	0.0

Section 13.0 QUANTIFICATION OF CHANGES IN EMISSIONS

This section presents various comparisons of emission estimates as calculated by MVEI7G and EMFAC2000. These comparisons explain which factors, i.e., changes in population estimates, vehicle miles traveled, basic emission rates or other correction factors, account for changes in emission estimates between MVEI7G and EMFAC2000. These comparisons are made for summer (ozone) inventories for the South Coast Air Basin (SCAB) for calendar years 1980-2010, in five year increments.

13.1 Baseline Comparisons

Figures 13-1, 13-2, 13-3 and 13-4 show comparisons of the total running exhaust TOG, CO, NOx and PM emissions in tons per day, respectively. Each figure shows the percent change in VMT and pollutant relative to MVEI7G estimates. These figures show that there are large increases in running exhaust emissions attributable to changes in vehicle activity (population, mileage accrual), basic emission rates, speed/cycle correction factors, effectiveness of previous I/M programs and the inclusion of relative humidity NOx correction factors, and air conditioning correction factors.

Figure 13-1 Comparison of Total TOG Running Exhaust (tpd)

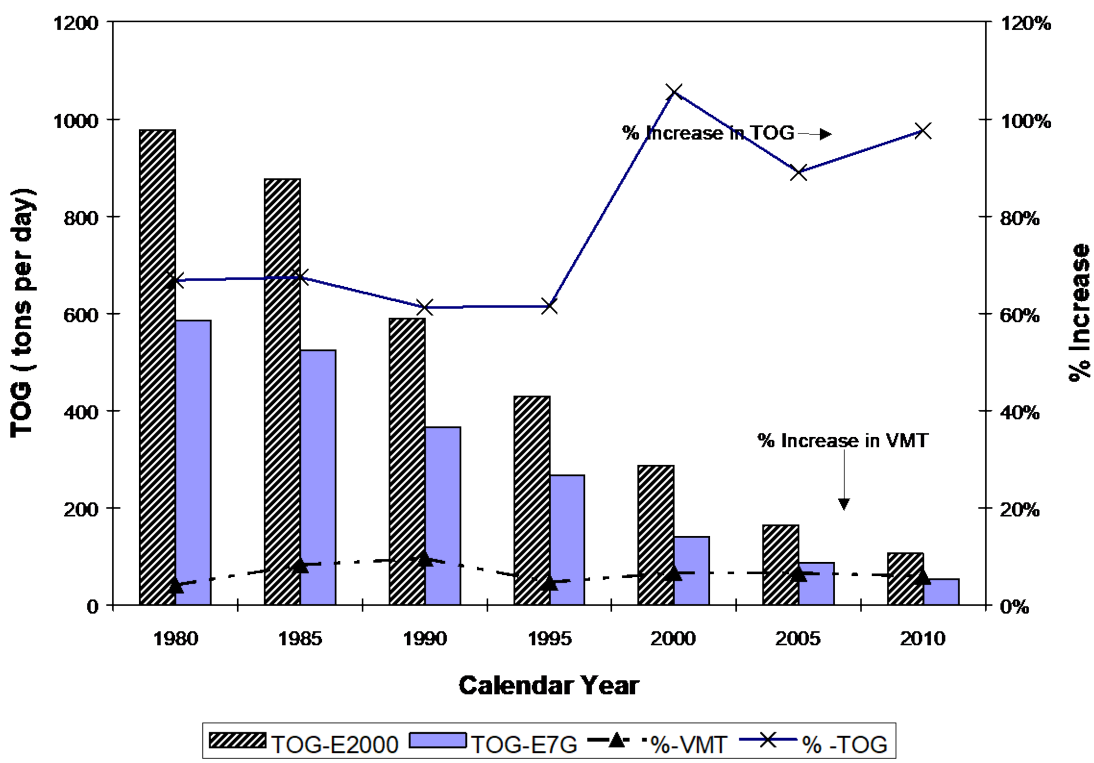


Figure 13-2 Comparison of Total CO Exhaust (tpd)

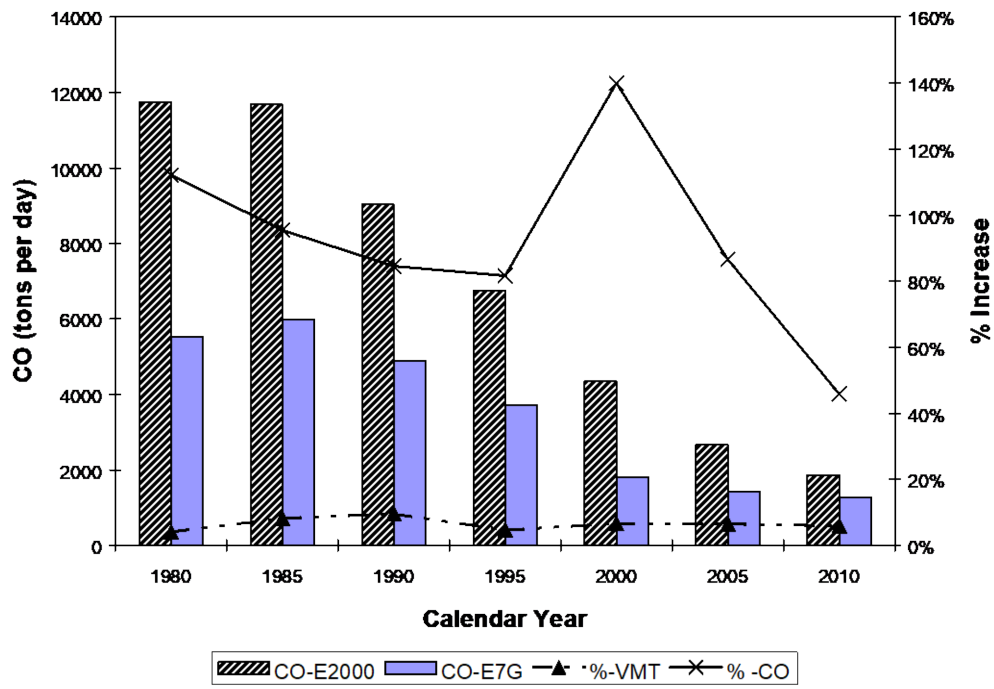


Figure 13-3 Comparison of Total NOx Exhaust (tpd)

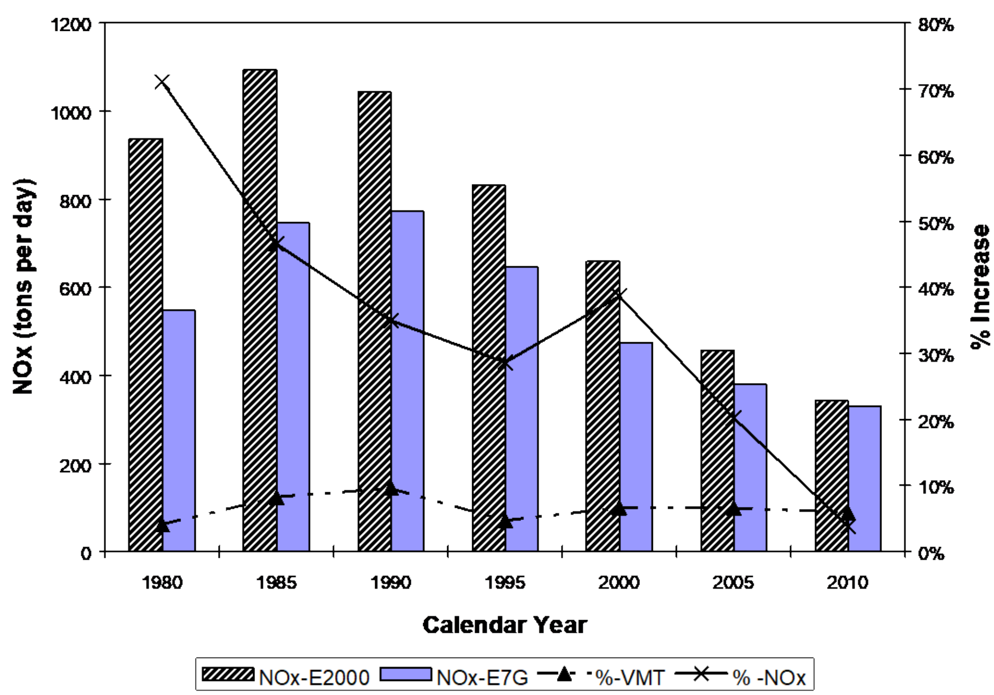
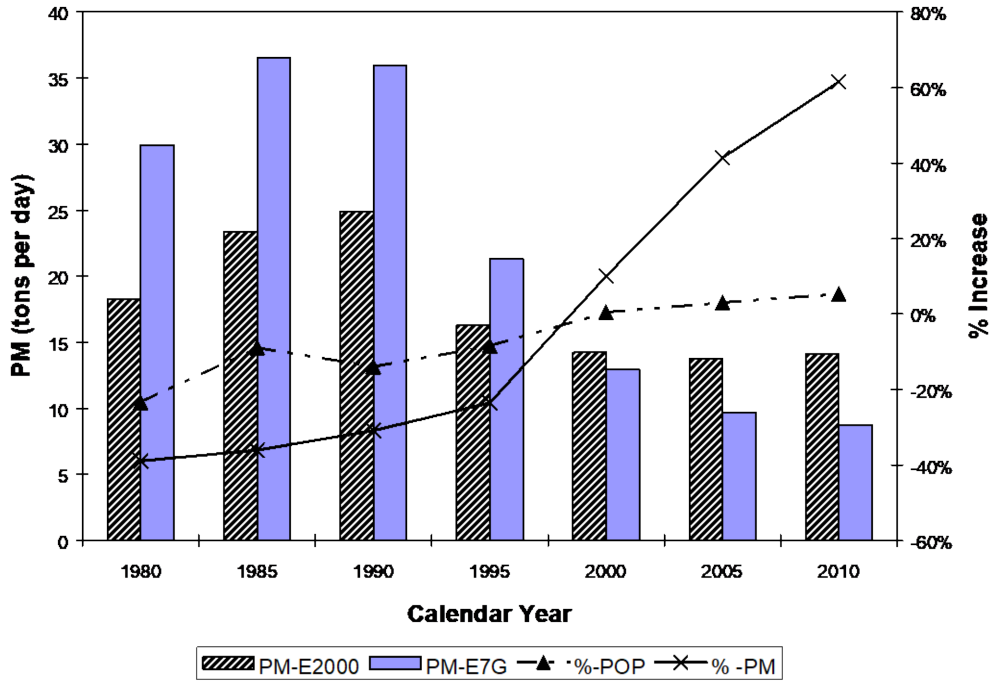


Figure 13-4 Comparison of Total PM Exhaust (tpd)



Figures 13-5, 13-6, 13-7, 13-8 show the total running exhaust TOG, CO, NOx and PM emissions in grams per mile, respectively. These comparisons partially mitigate the differences in vehicle activity between EMFAC2000 and MVEI7G, however, these comparisons do not reflect differences in the average age of the composite vehicle between the models. The redistribution of vehicles in EMFAC2000 results in an increase of the average age of the fleet. Section 7.2[1] details how the average of the fleet has changed between MVEI7G and EMFAC2000.

Figure 13-5 shows that TOG increases by 47 to 93 percent over MVEI7G's estimates. Figure 13-6 shows that CO increases by 38 to 125 percent. For both TOG and CO the change in the percentages by calendar also reflect differences in how fleet wide emissions are dropping in each model. Figure 13-7 shows that NOx changes by –2 to 64 percent. The EMFAC2000 model predicts a higher inventory for NOx for pre 2005 calendar years, however, the NOx is basically the same as MVEI7G for CY 2010. Figure 13-8 shows that PM changes between –41 to 53 percent. MVEI7G estimates for PM are higher that EMFAC2000 estimates for pre 2000 calendar years. However, the MVEI7G PM estimates decrease at a much faster rate than EMFAC2000, hence the increase in PM estimates for 2000 and later calendar years.

[1] Section 7.2 County-Specific Vehicle Age Distribution and Population Matrices

Figure 13-5 Comparison of Total TOG Running Exhaust (g/mi)

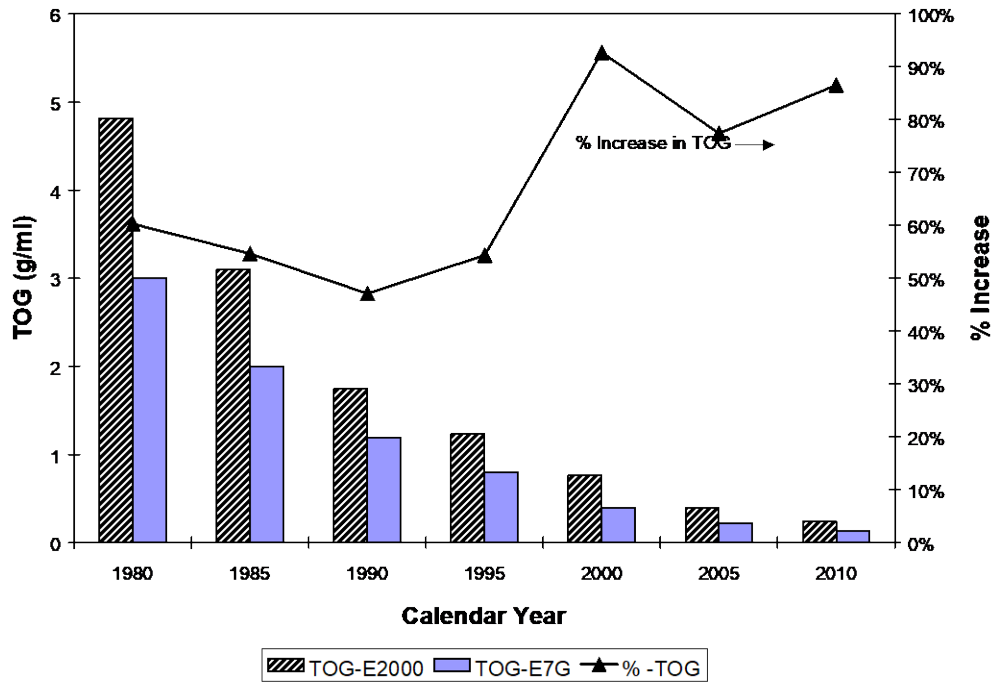


Figure 13-6 Comparison of Total CO Emissions (g/mi)

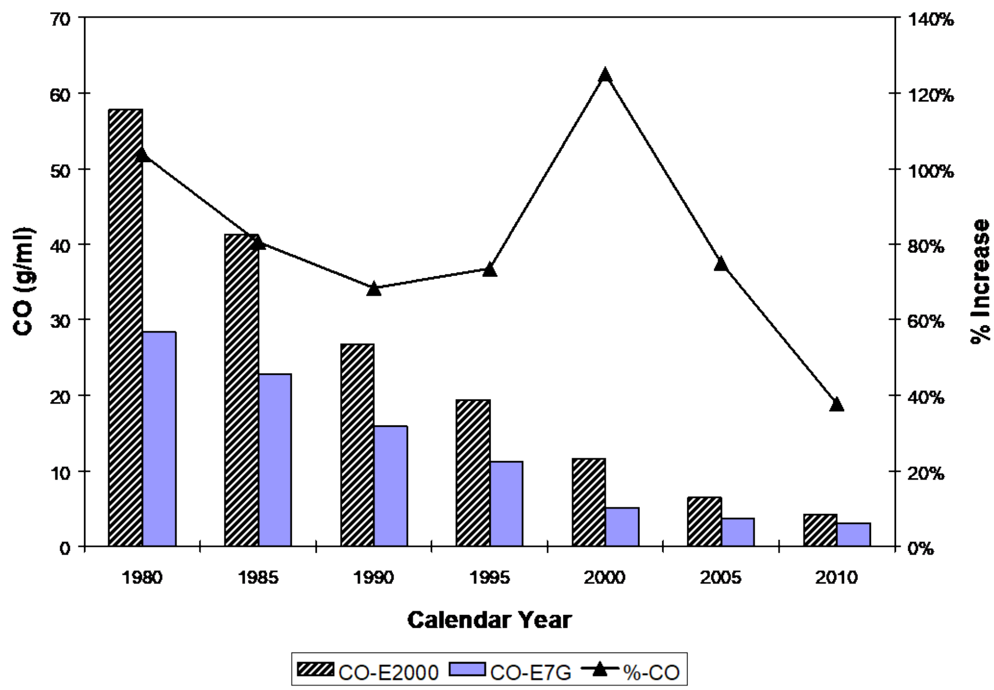


Figure 13-7 Comparison of Total NOx-Exhaust (g/mi)

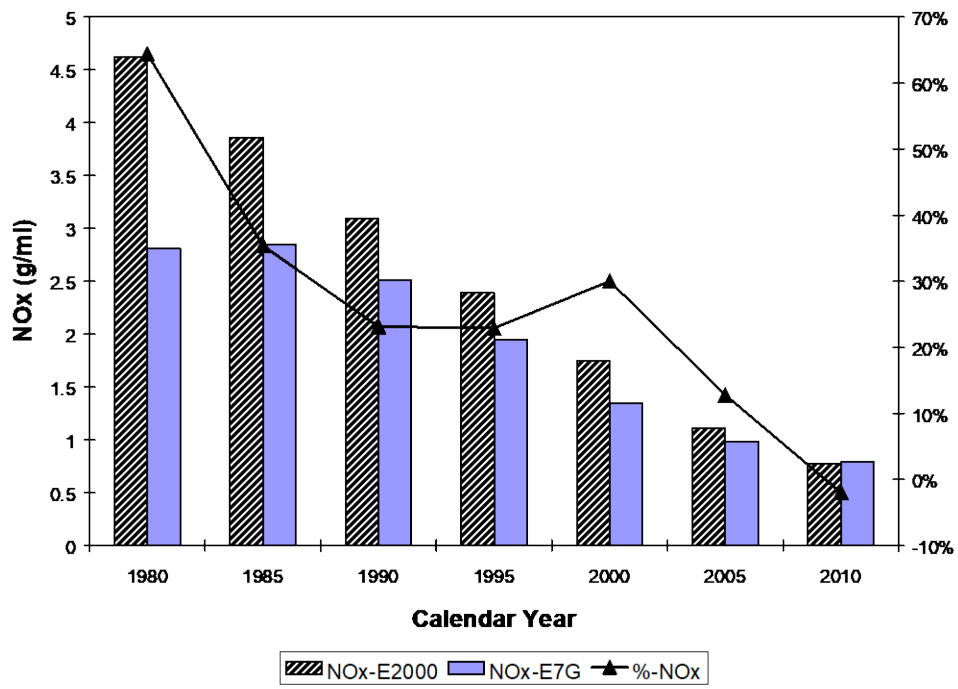
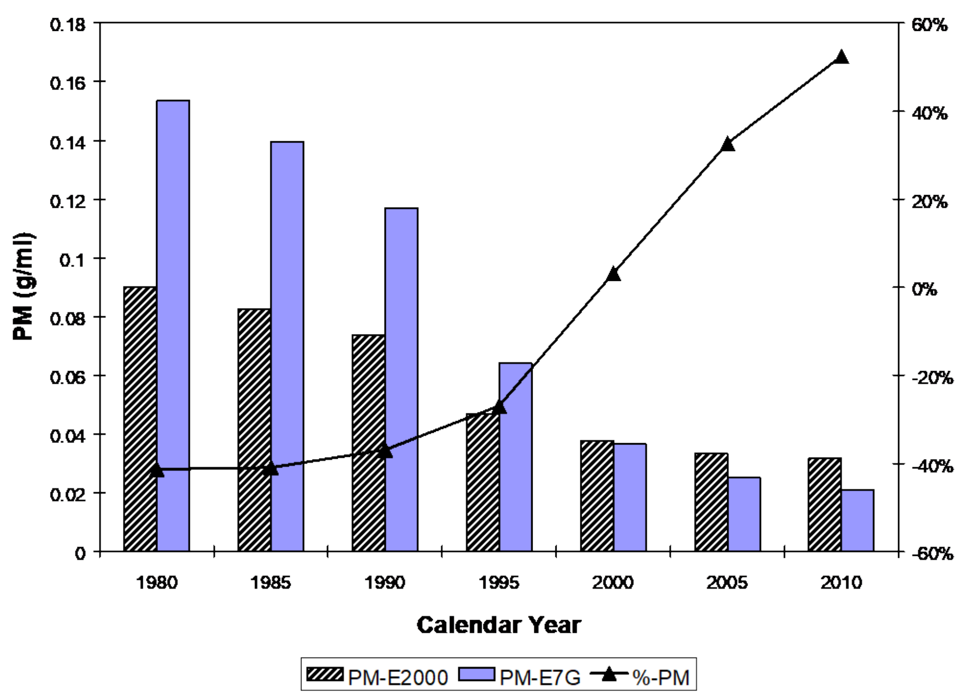


Figure 13-8 Comparison of Total PM-Exhaust (g/mi)



13.2 Comparisons with No Correction Factors

In the following comparisons the MVEI7G was run assuming that there was no changes in the fuel correction factors (due to the introduction of Phase 1 and Phase 2 fuel) and that there is no inspection and maintenance program. The EMFAC2000 program was also run under similar conditions. Both models only include the effect of temperature on emissions, and emission estimates are on an FTP basis. This comparison insulates the emission comparisons from the effect of other correction factors, and shows the change in basic emission rates between the models. Figures 13-9, 13-10, 13-11and 13-12 show the running exhaust tons per day comparisons between MVEI7G and EMFAC2000 for TOG, CO, NOx and PM, respectively. Each figure shows the percent change in VMT and pollutant over MVEI7G's estimates. Figures 13-13, 13-14, 13-15, 13-16, show the gram per mile comparisons between EMFAC2000 and MVEI7G for TOG, CO, NOx and PM, respectively.

Figure 13.9 Comparison of Total TOG Exhaust (tpd)

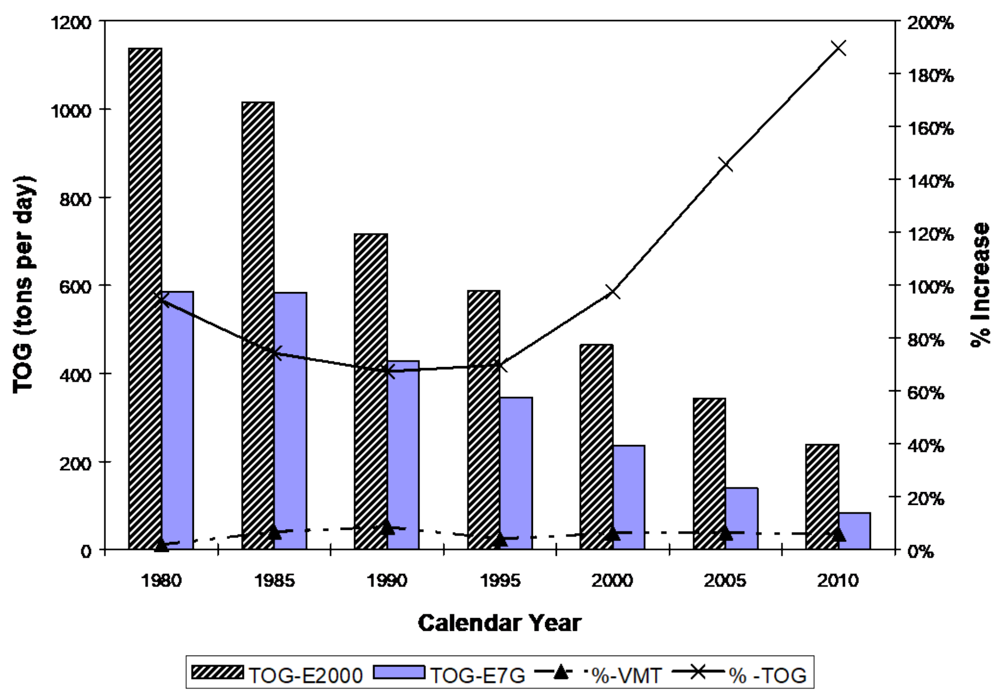


Figure 13-10 Comparison of Total CO Exhaust (tpd)

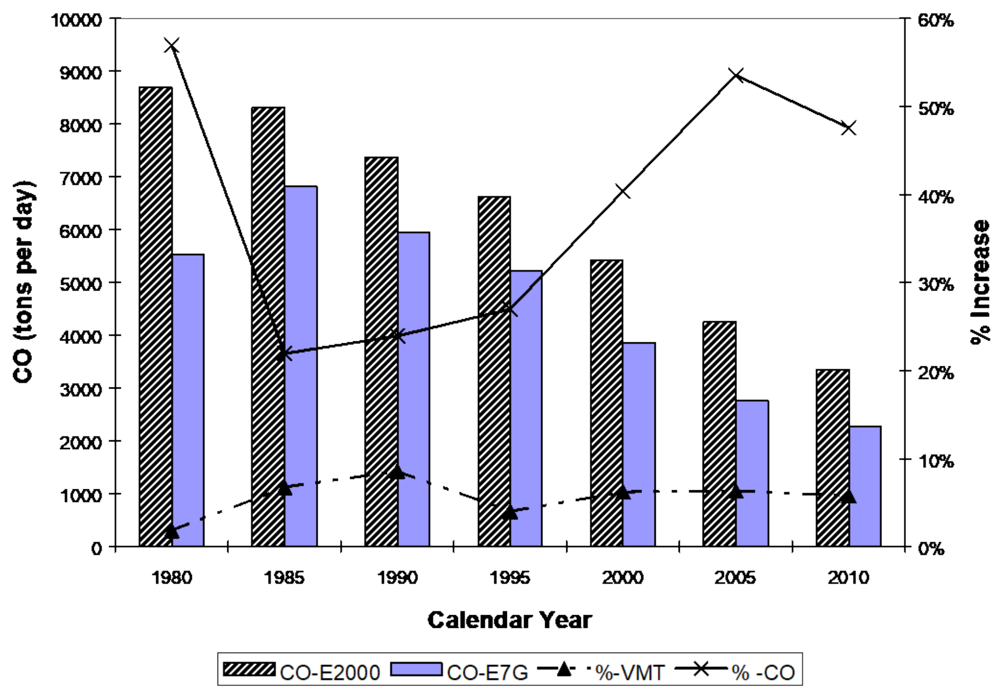


Figure 13-11 Comparison of Total NOx Exhaust (tpd)

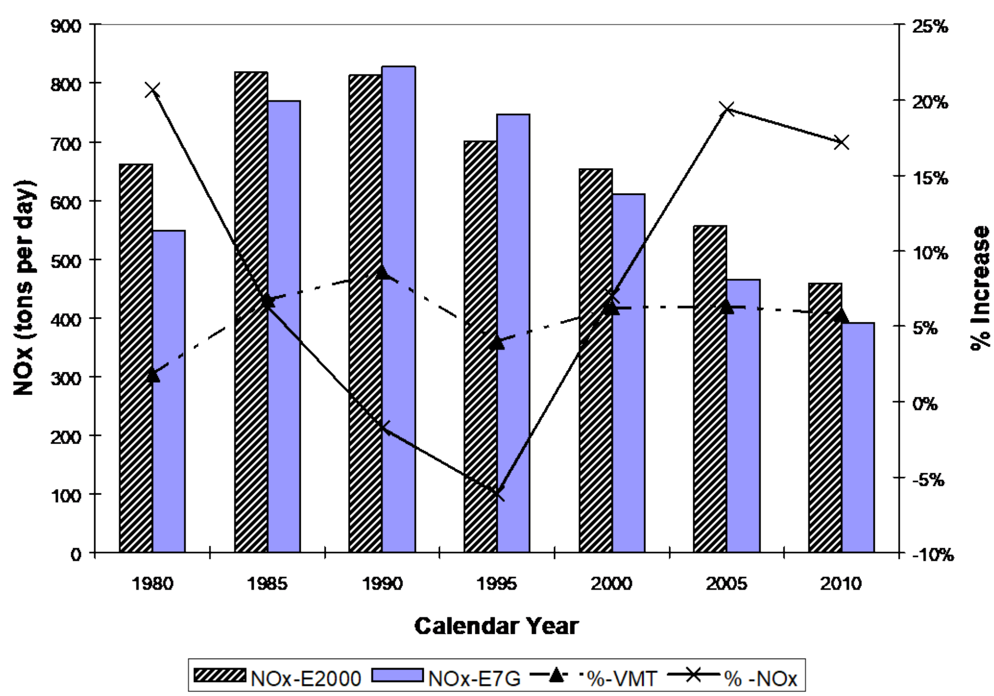


Figure 13-12 Comparison of Total PM Exhaust (tpd)

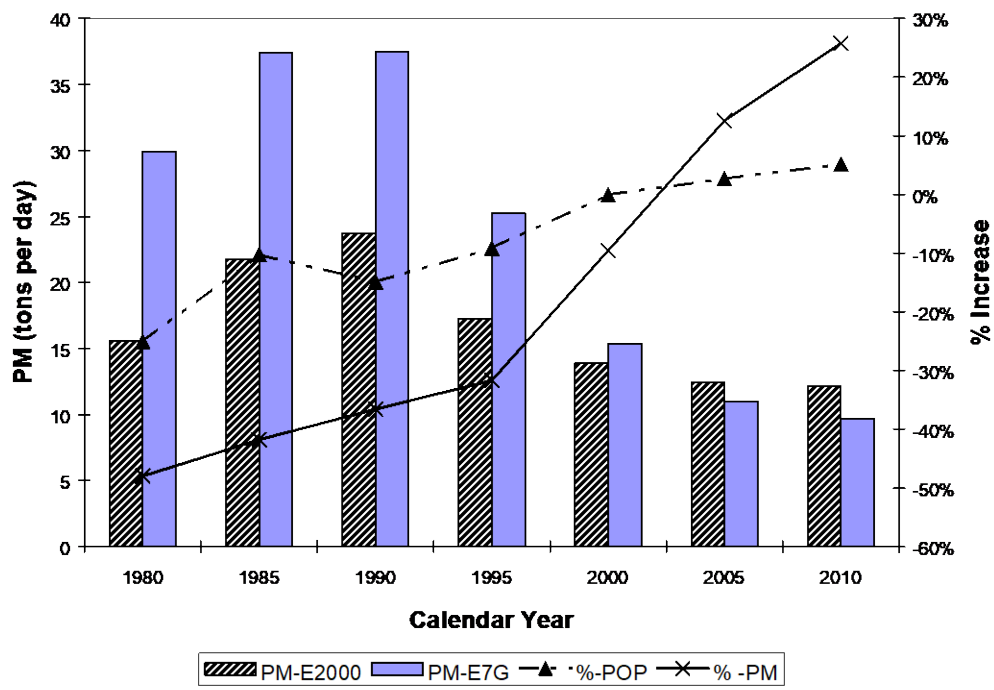


Figure 13-13 Comparison of Total TOG (g/mi)

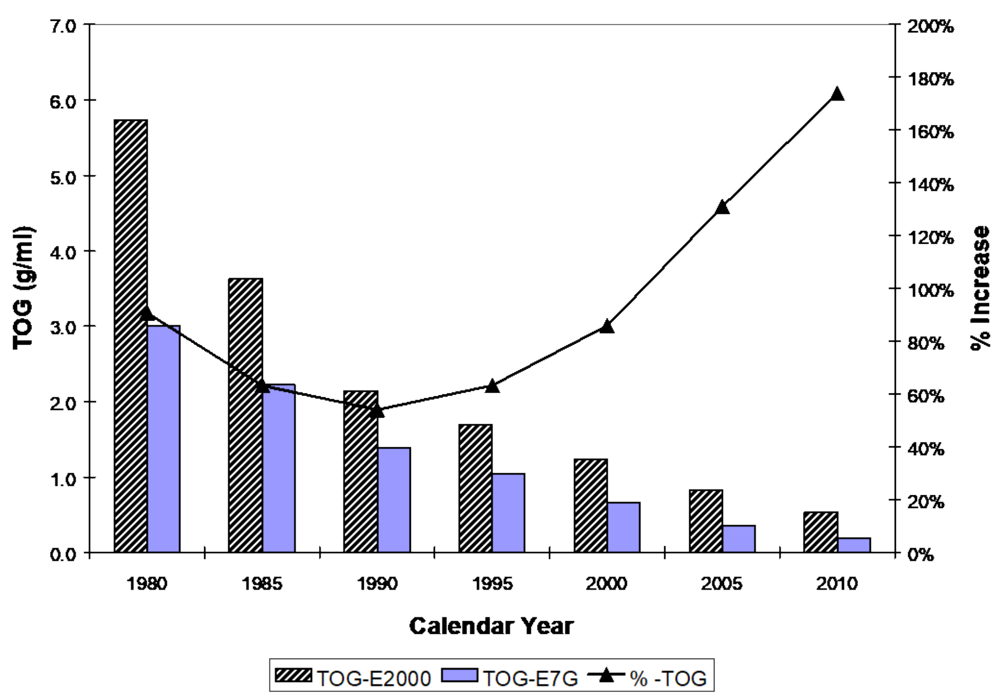


Figure 13-14 Comparison of Total CO Exhaust (g/mi)

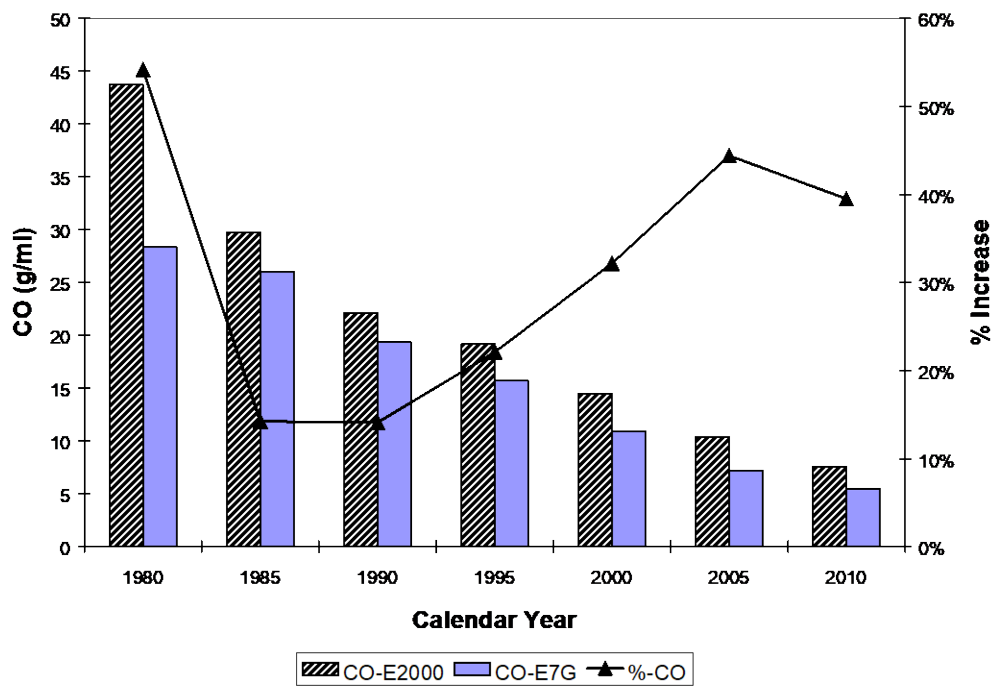


Figure 13-15 Comparison of Total NOx Exhaust (g/mi)

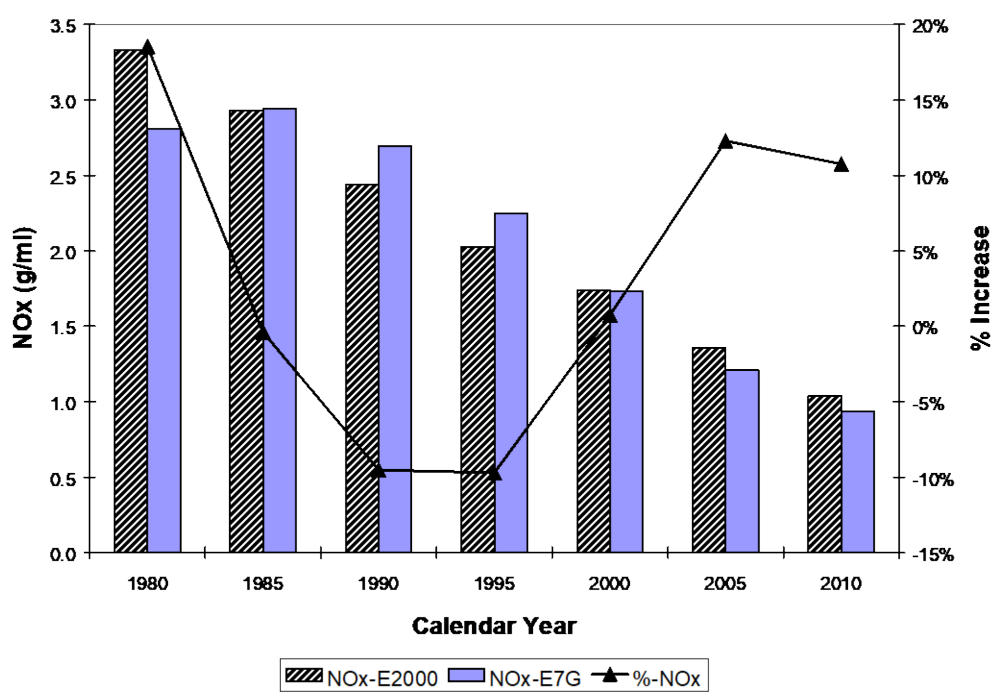
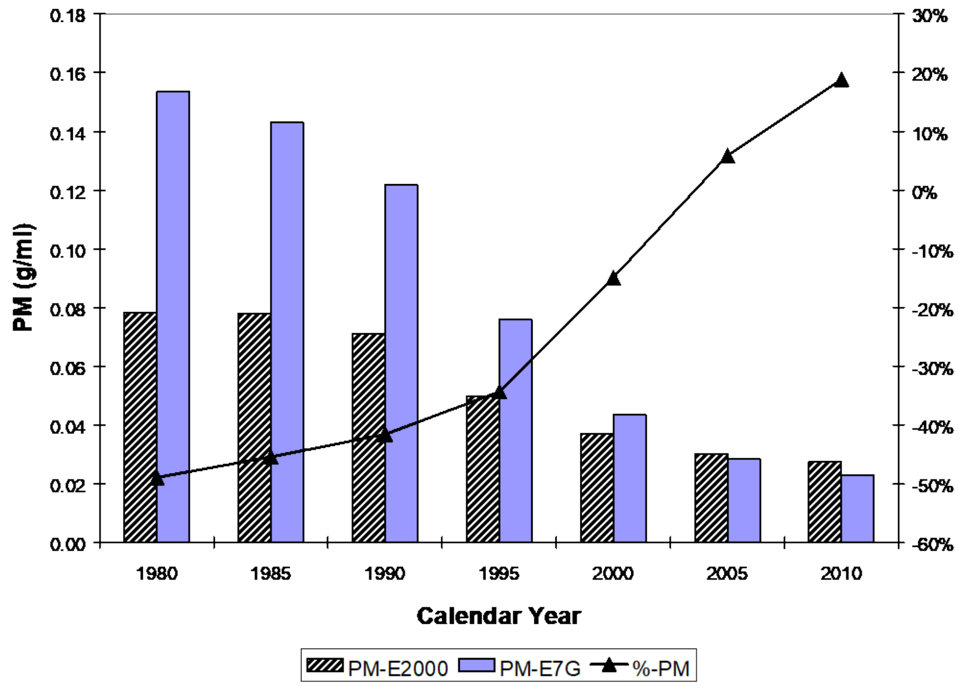


Figure 13-16 Comparison of Total PM Exhaust (g/mi)



13.3 Effect of Chronically Unregistered Vehicles

Chronically unregistered vehicles are 0.57% of the overall vehicle population (see Section 7.2) in any given calendar year. Figures 13-17, 13-18, 13-19 and 13-20 show the effect of chronically unregistered vehicles on the total running exhaust emissions of TOG, CO, NOx and PM, respectively. Accounting for unregistered vehicles increases the inventory by approximately 1-2 percent.

Figure13-17 Effect of Chronically Unregistered Vehicles On Total TOG Running Exhaust Emissions

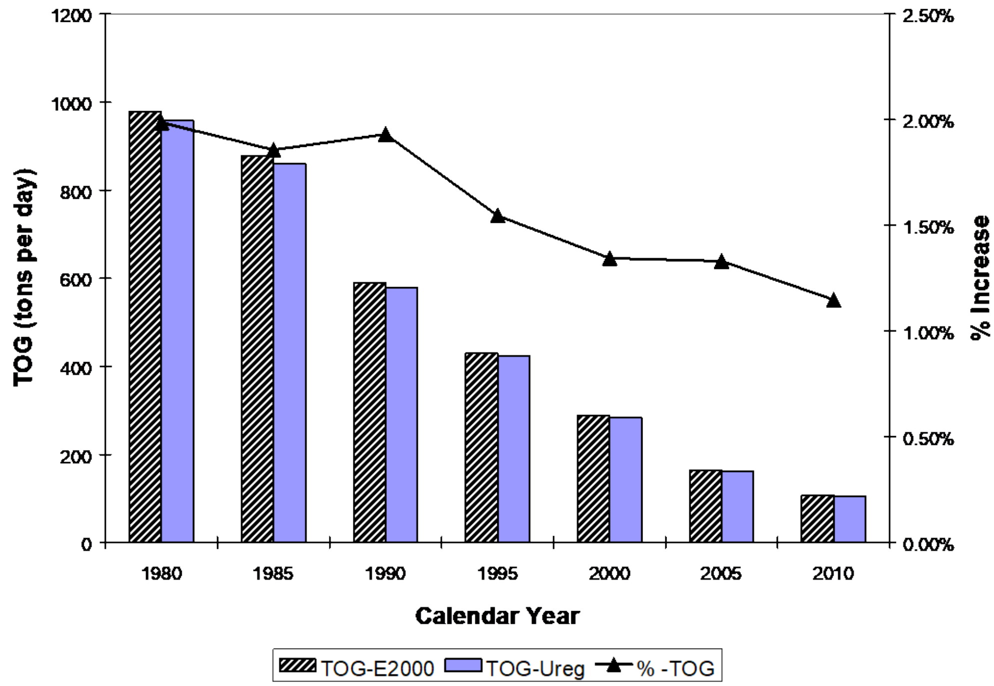


Figure 13-18 Effect of Unregistered Vehicles on Total CO Running Exhaust Emissions

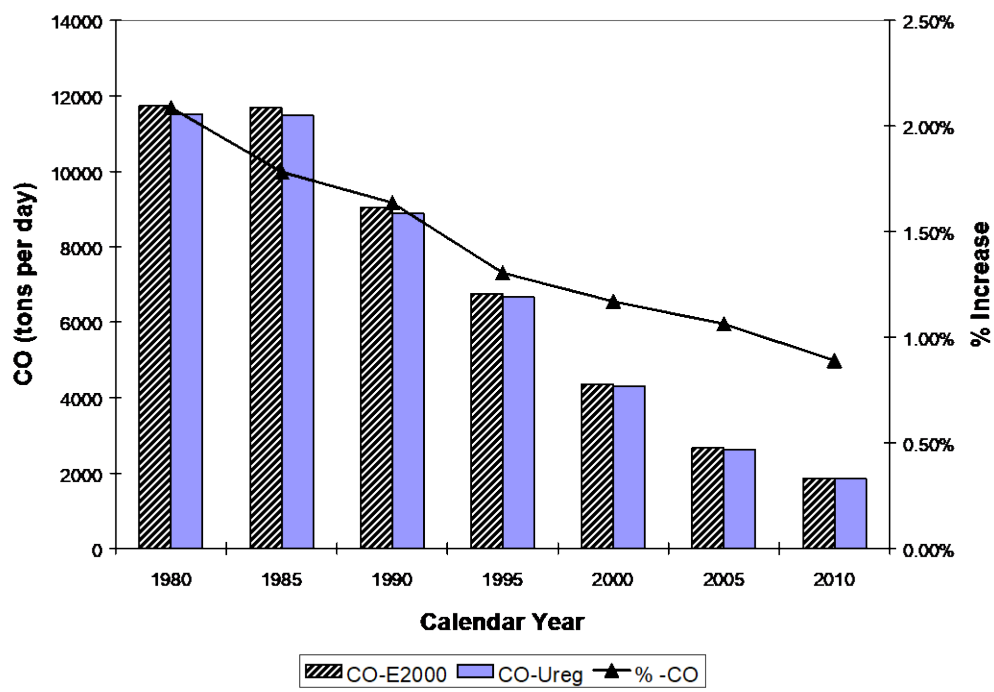


Figure 13-19 Effect of Unregistered Vehicles on Total NOx Running Exhaust Emissions

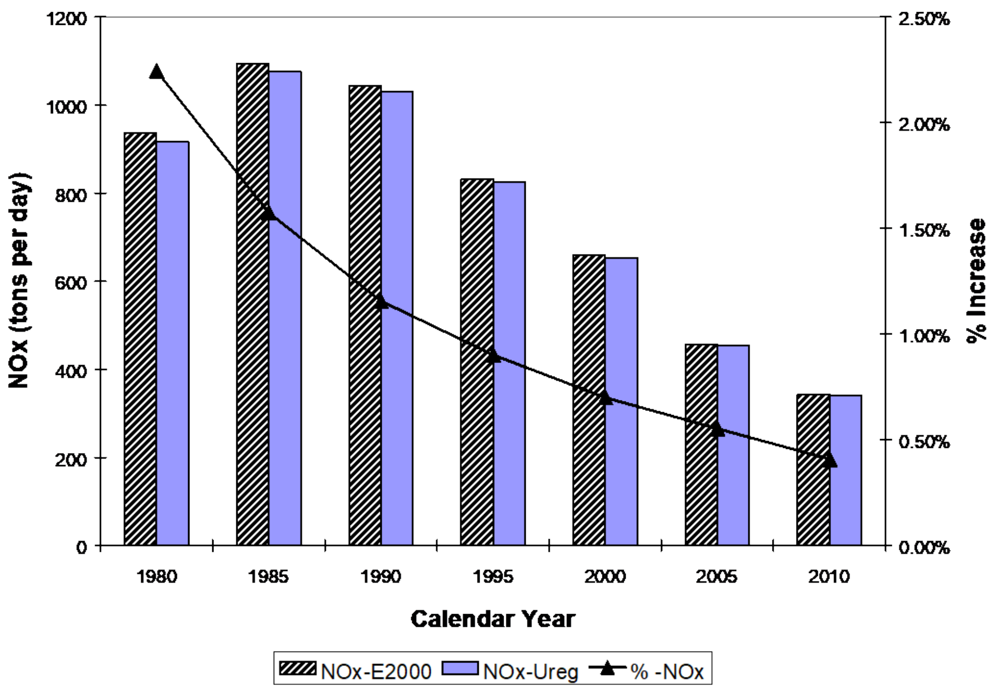
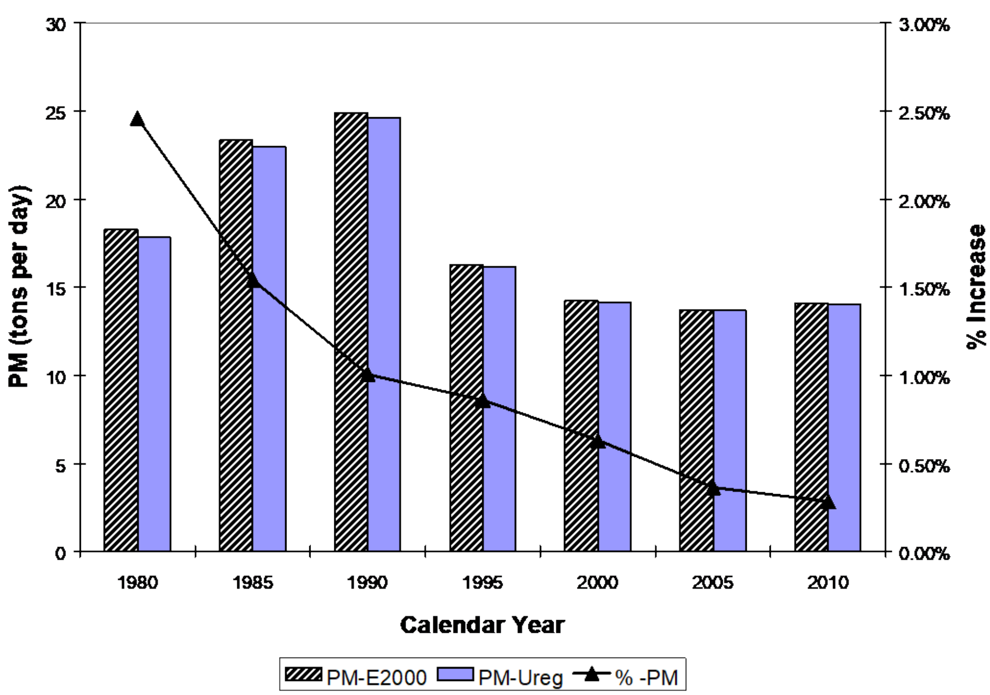


Figure 13-20 Effect of Unregistered Vehicles on Total PM Running Exhaust Emissions

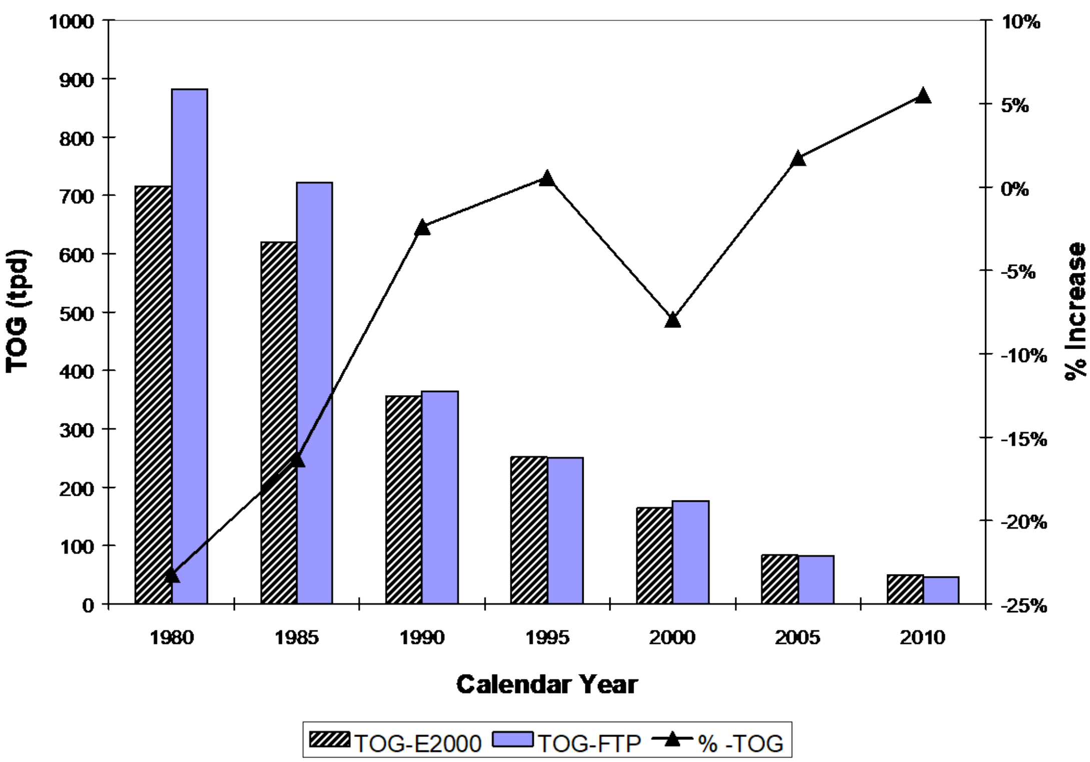


13.4 <u>FTP Versus UC based Cycle Correction Factors</u>

In the MVEI7G model, the basic emission rates were based on the FTP driving cycle. To adjust for more contemporary driving, these rates were adjusted to a UC basis using cycle correction factors. In EMFAC2000, the basic emission rates are on a UC basis. These rates are then adjusted with respect to speed using the new UC based cycle correction factors[2]. Figures 13-21, 13-22, 13-23, 13-24 show the percent change in TOG, CO, NOx and PM running exhaust emissions from gasoline fueled passenger cars, respectively, by changing from an FTP based model to a UC based model.

Figures 13-25, 13-26, 13-27, and 13-28 show the impact of the speed or new cycle correction factors on TOG, CO, NOx and PM emissions, respectively. The basic effect of the UC-based cycle/speed correction factors is to increase TOG emissions by 17 percent. The effect of speed/cycle correction factors on CO emissions diminishes with time, resulting in an increase of 2 percent in calendar year 2010. The speed/cycle correction factors increase NOx emissions by 3 to 5 percent.

Figure 13-21 <u>Comparison of UC Vs FTP Factors-TOG Exhaust PC Gas</u>



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[2] Section 6.2 Cycle correction Factors

Figure 13-22 Comparison of UC Vs FTP Factors- CO Exhaust PC-gas

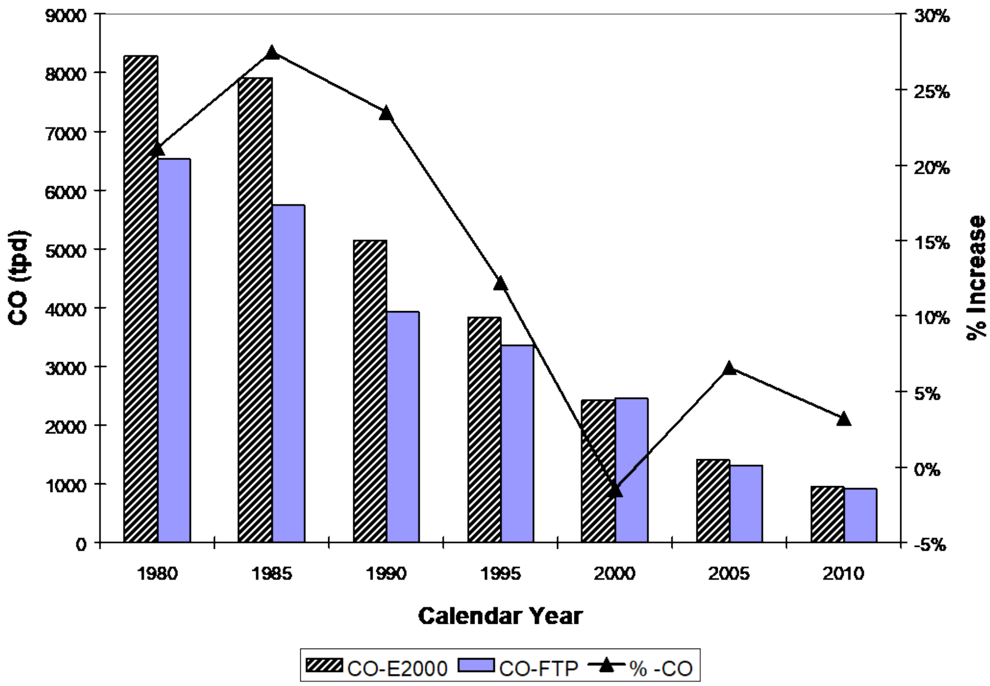


Figure 13-23 Comparison of UC Vs FTP Factors-NOx Exhaust PC gas

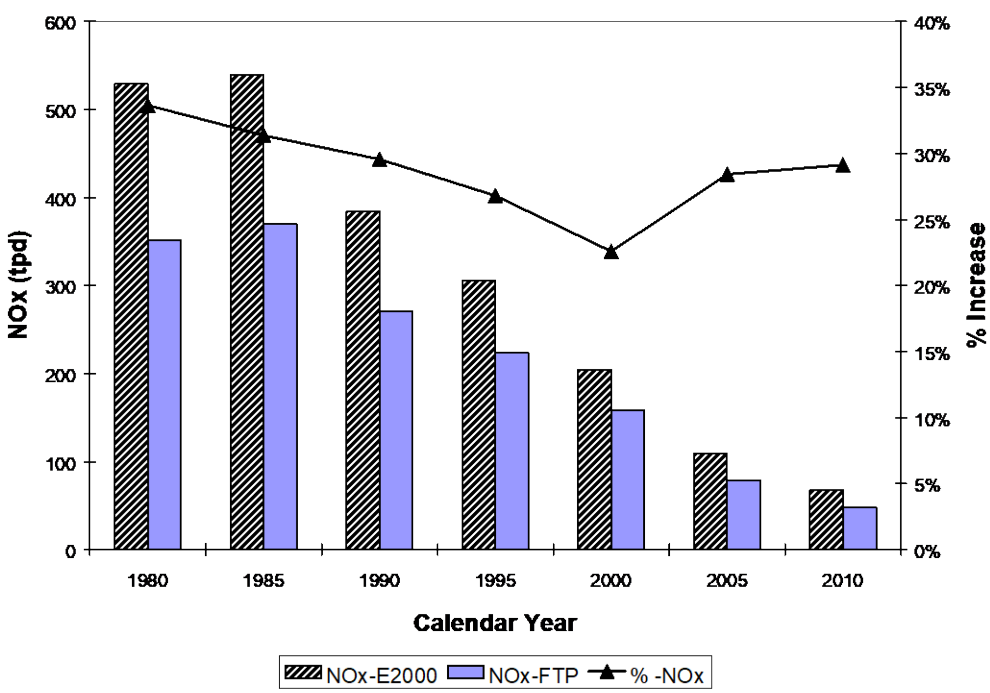


Figure 13-24 Comparison of UC Vs FTP Factors-Total Exhaust PM PC gas

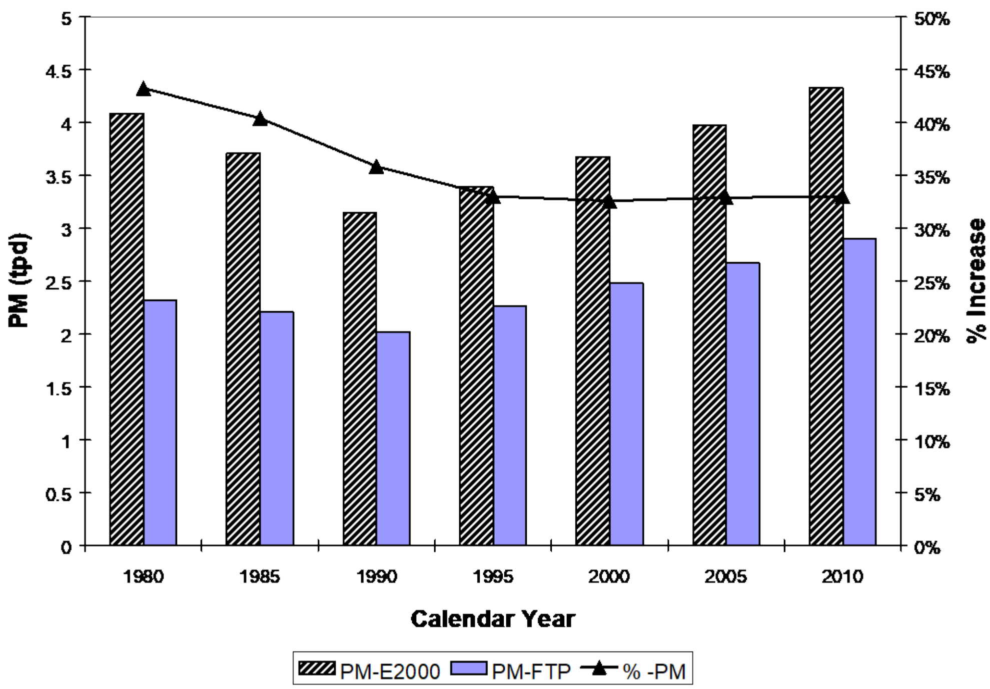


Figure 13-25 Effect of Speed on Total TOG Exhaust PC-Gas

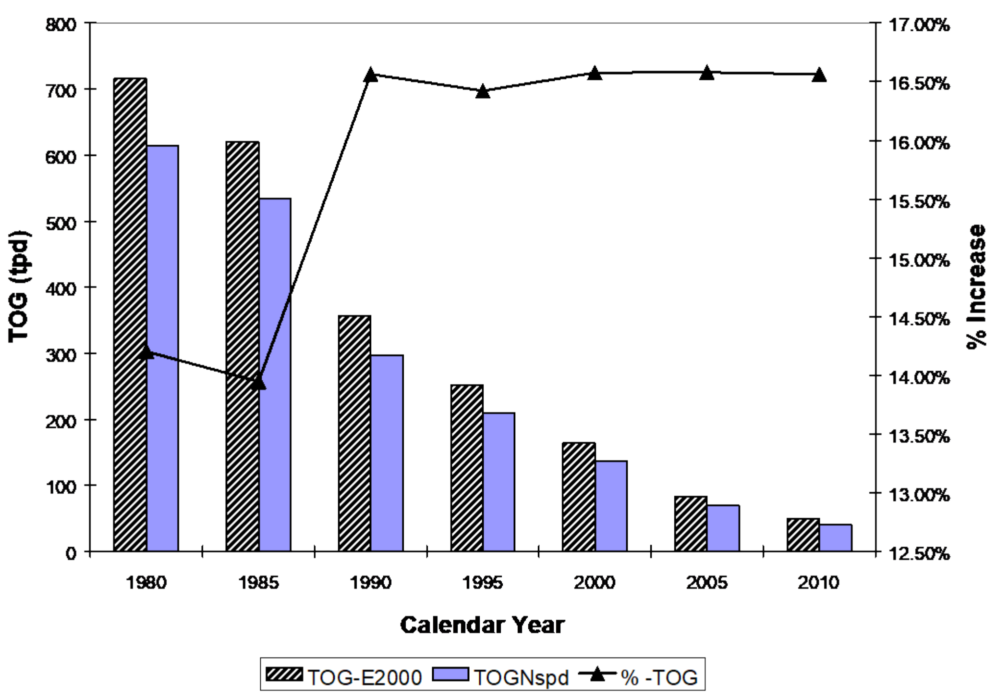


Figure 13-26 Effect of Speed on Total CO Exhaust PC-Gas

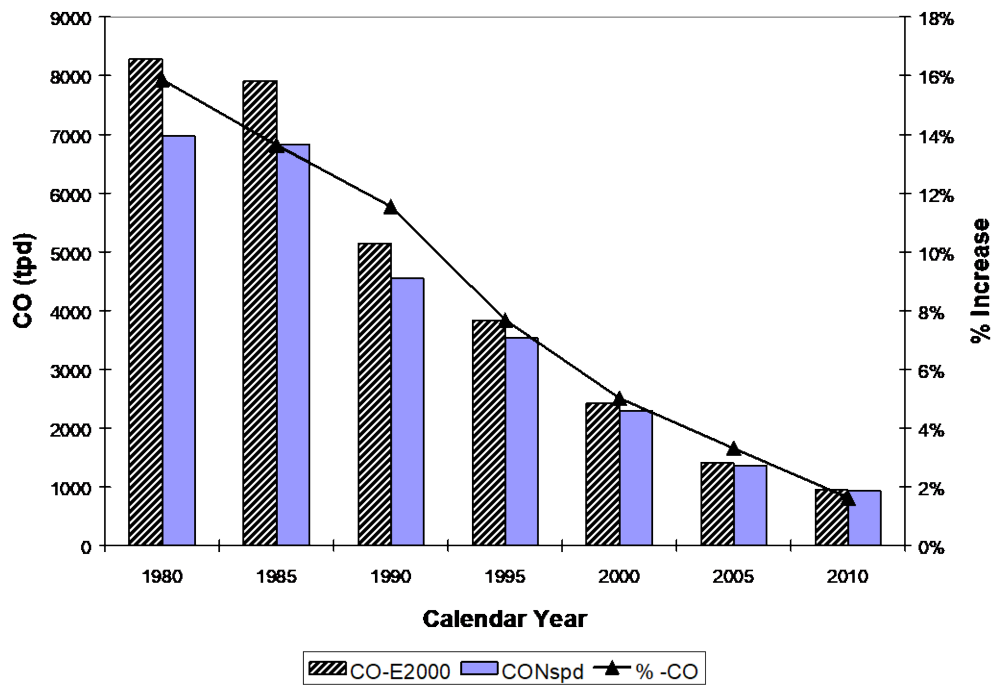


Figure 13-27 Effect of Speed on Total NOx Exhaust PC-Gas

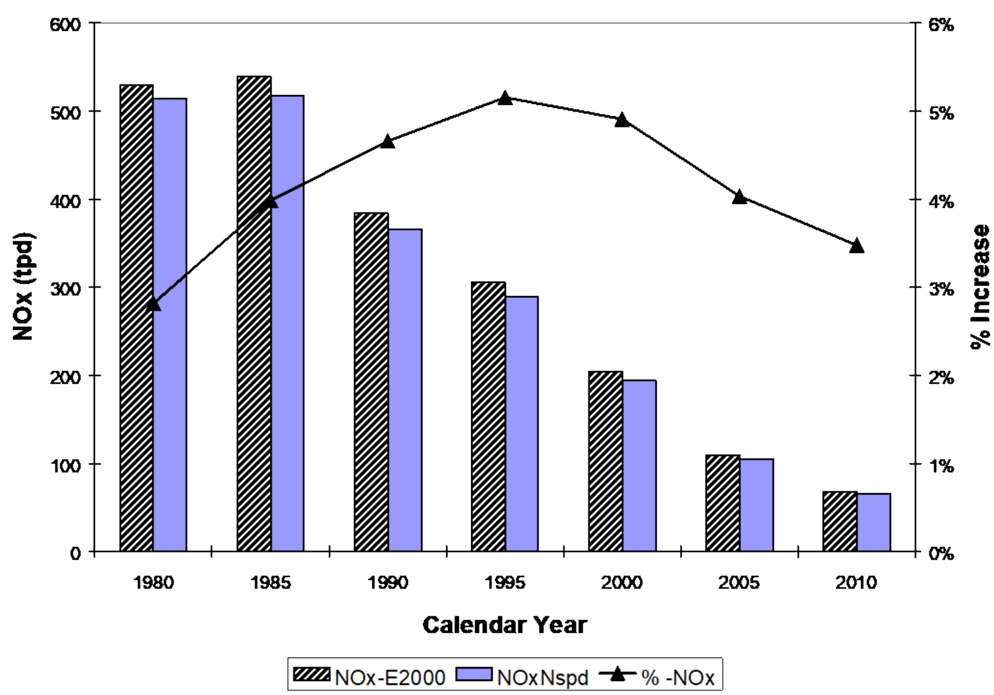
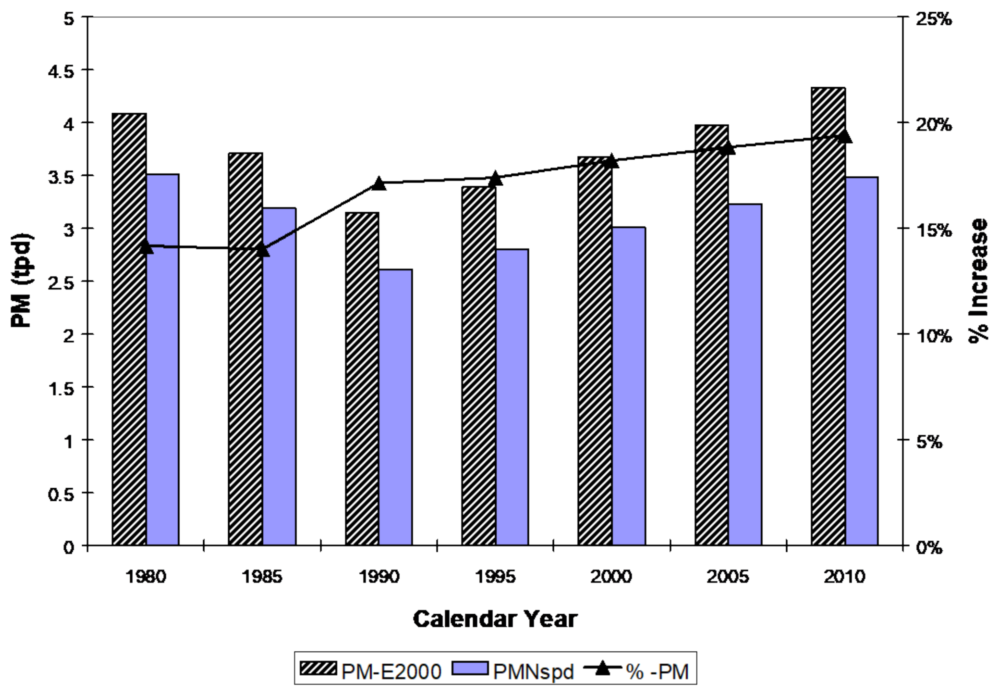


Figure 13-28 Effect of Speed on Total Exhaust PM from PC-Gas



13.5 Effect of Fuel Correction Factors

Fuel correction factors are used to model the effect of Phase 1 and Phase 2 gasoline and clean diesel fuel regulations on the motor vehicles emissions inventory[3]. The Phase 1 and Phase 2 gasoline fuel regulations limiting fuel RVP and aromatic content took effect in calendar years 1992 and 1996, respectively. Figures 13-29, 13-30, 13-31 and 13-32 show the effect of fuel correction factors impacts for TOG, CO, NOx and PM emissions, respectively.

The large NOx reduction from 1980-1990 is attributed to the early introduction of clean diesel fuel in the SCAB, which reduced emissions from diesel vehicles. Diesel vehicles certified after 1995 receive no emission reduction from the use of the cleaner fuel because these vehicles were allowed to certify using clean fuel. The NOx reductions after 1995 can be attributed to the introduction of Phase 1 and Phase 2 fuel that lowered the emissions of gasoline fueled vehicles. Figure 13-32 also shows a reduction in the PM inventory for calendar years 1985 and 1990 associated with the early introduction of clean diesel in SCAB.

An error in the fuel correction factors exists in the MVEI7G model that lead to an overestimation of the CO benefits from Phase 2 fuel. This error has been corrected in EMFAC2000. Figure 13-33 shows the impact from revising the CO fuel correction factors.

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[3] Section 6.3 Fuel Correction Factors

Figure 13-29 Effect of FCFs on Total TOG Exhaust From All Vehicles

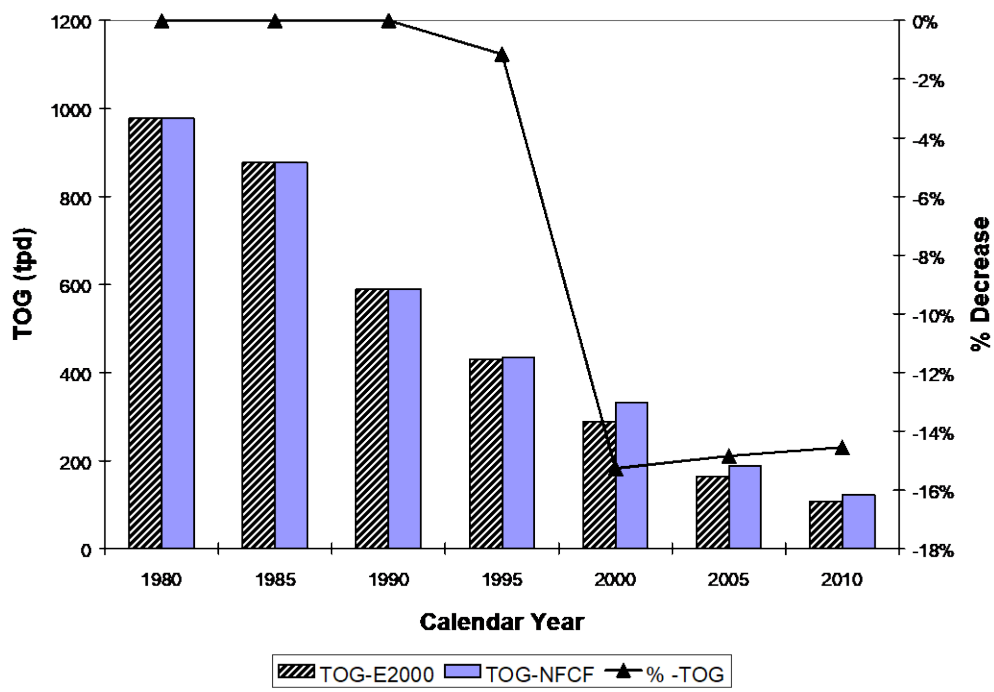


Figure 13-30 Effect of FCF on Total CO Exhaust From Vehicle

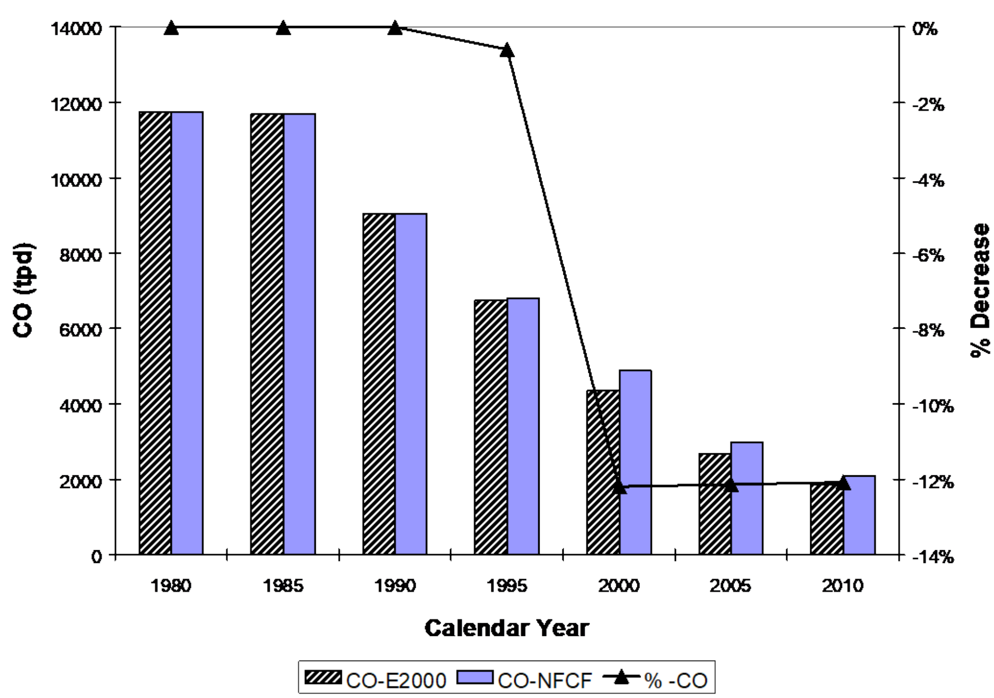


Figure 13-31 Effect of FCF on Total NOx Exhaust From Vehicles

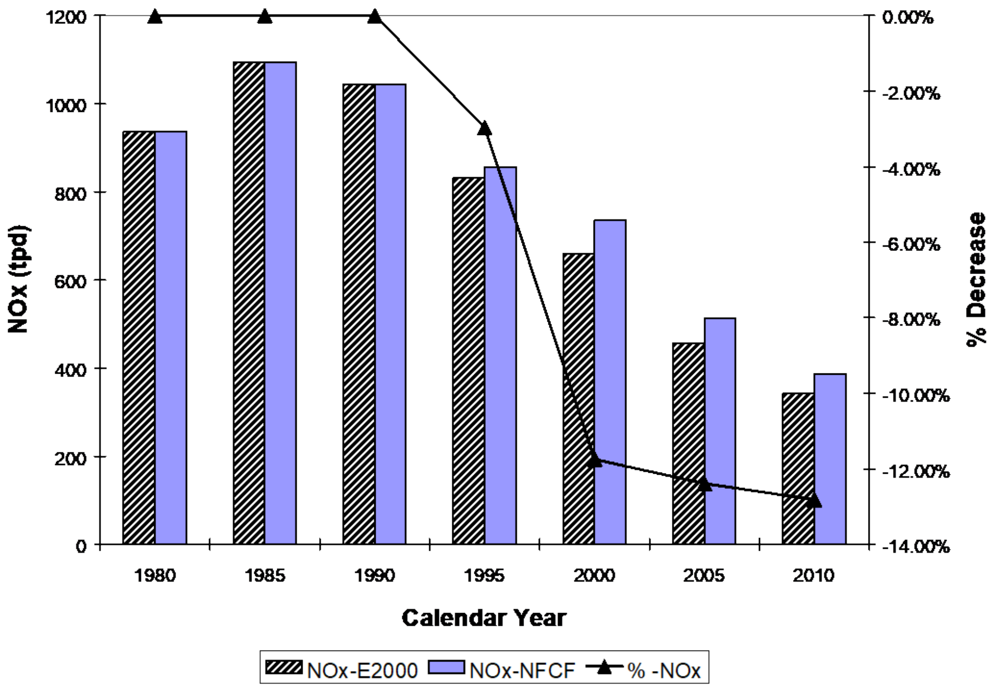


Figure 13-32 Effect of FCF on Total Exhaust PM From All Vehicles

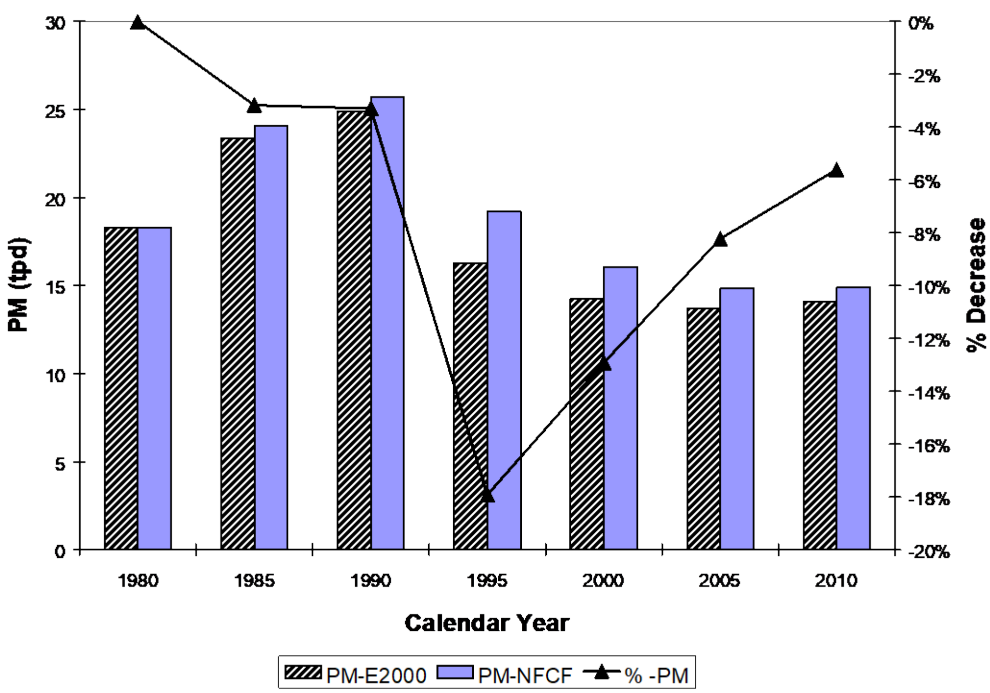
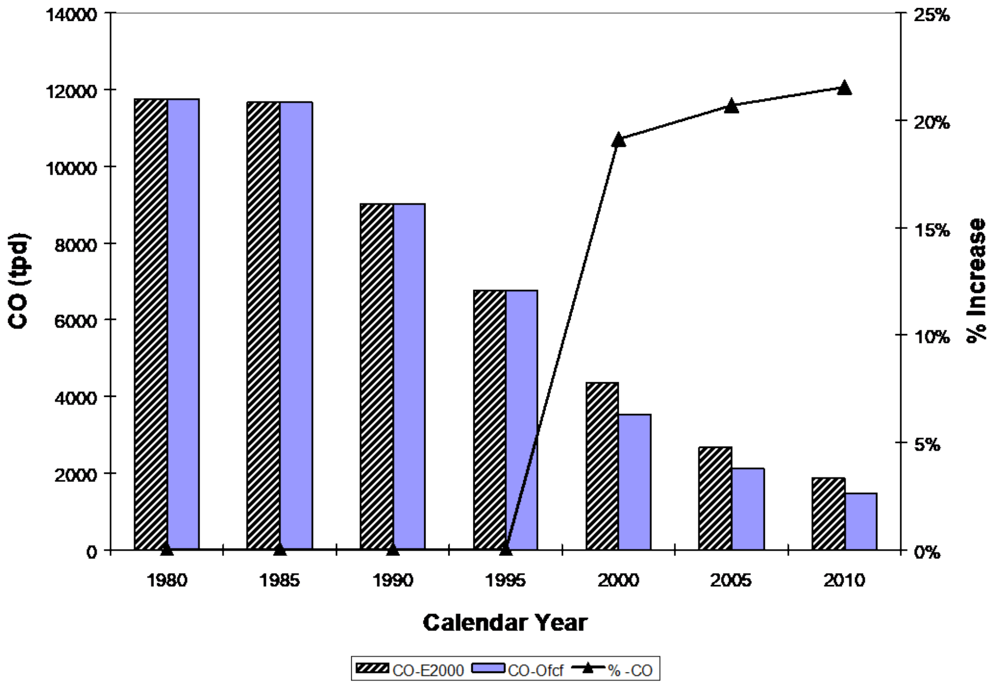


Figure 13-33 Comparison of the Old Vs. New FCFs For CO on Exhaust Emissions



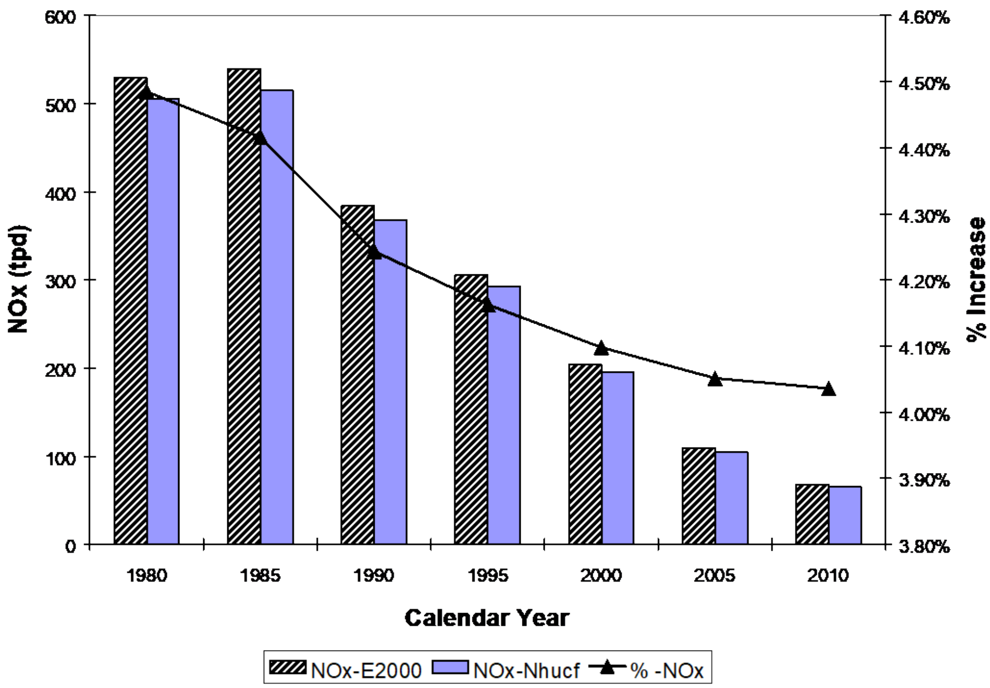
13.6 Humidity Correction Factor

During standardized emission tests such the FTP or UC, NOx emissions are adjusted to a standard humidity level of 75 grains of water per pound of dry air. However, the relative humidity levels throughout the state vary by county, month, and hour of the day. The impact of high relative humidity is to lower combustion temperatures and decrease NOx formation. Conversely, low relative humidity increases NOx formation in comparison to standardized testing.

A relative humidity correction factor was introduced in EMFAC2000 to account for the changes in the NOx basic emission rates as a function of relative humidity[4]. Figure 13-34 shows the effect of this factor on the inventory of gasoline fueled passenger cars. This factor increases the running exhaust NOx emissions by approximately 4.5 percent.

[4] Section 6.5 NOx Emission Rates and Humidity

Figure 13-34 Effect of Humidity Correction Factors on NOx Exhaust -PC gas



13.7 Effect of Air Conditioning

The effect of air conditioning usage increases the load on the engine. This increase in load results in higher running exhaust emissions. In EMFAC2000, the effects of air conditioning are modeled as a correction factor to the basic emission rates[5]. The magnitude of this correction factor is dependent on the heat index, which is a function of the ambient temperature and relative humidity.

Figure 13-35 shows that air conditioning usage increases TOG running exhaust emissions from gasoline fueled passenger cars by 2.5 to 3.8 percent. Figures 13-36 and 13-37 show that air conditioning usage increases CO and NOx emissions by 5.6 to 8.9 percent and 0.5 to 0.7 percent, respectively. Figures 13-35, 13-36 and 13-37 show that the A/C effect increases for future calendar years. This is because newer, lower emitting vehicles are effected more than current, in-use vehicles.

[5] Section 6.4 Development of Air Conditioning Emission Factors

Figure 13-35 <u>Effect of Air Conditioning on TOG Exhaust From PC Gas</u>

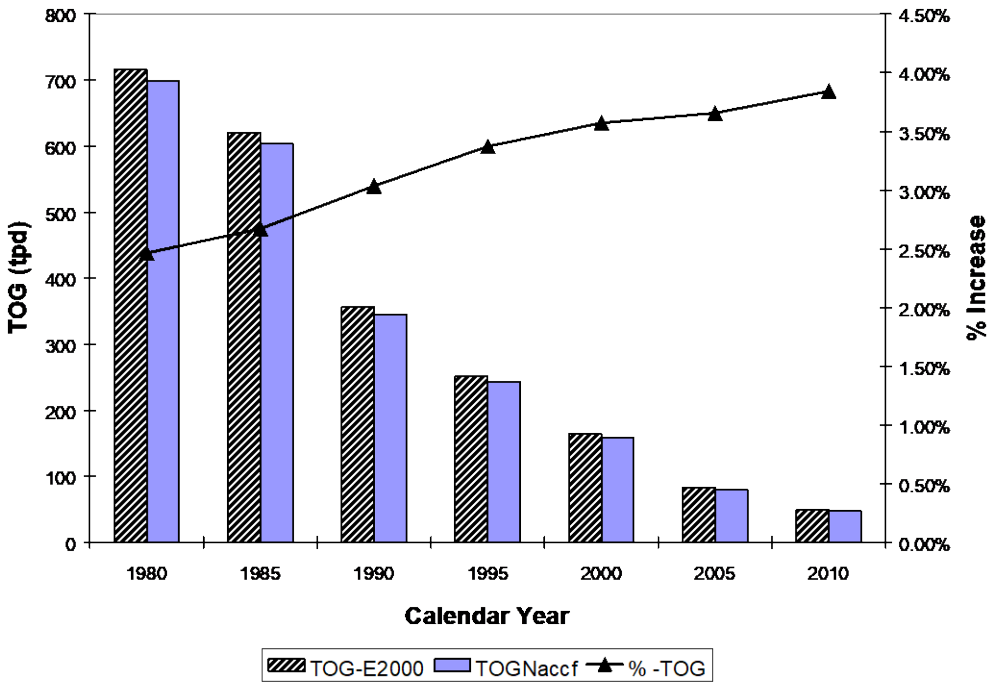


Figure 13-36 <u>Effect of Air Conditioning on CO Exhaust from PC gas</u>

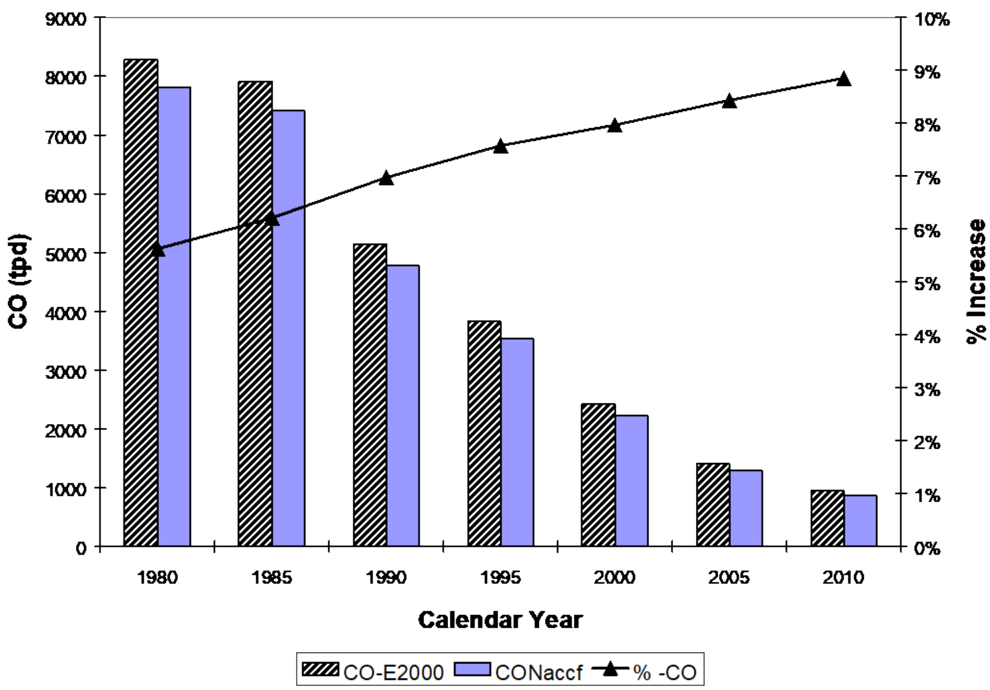
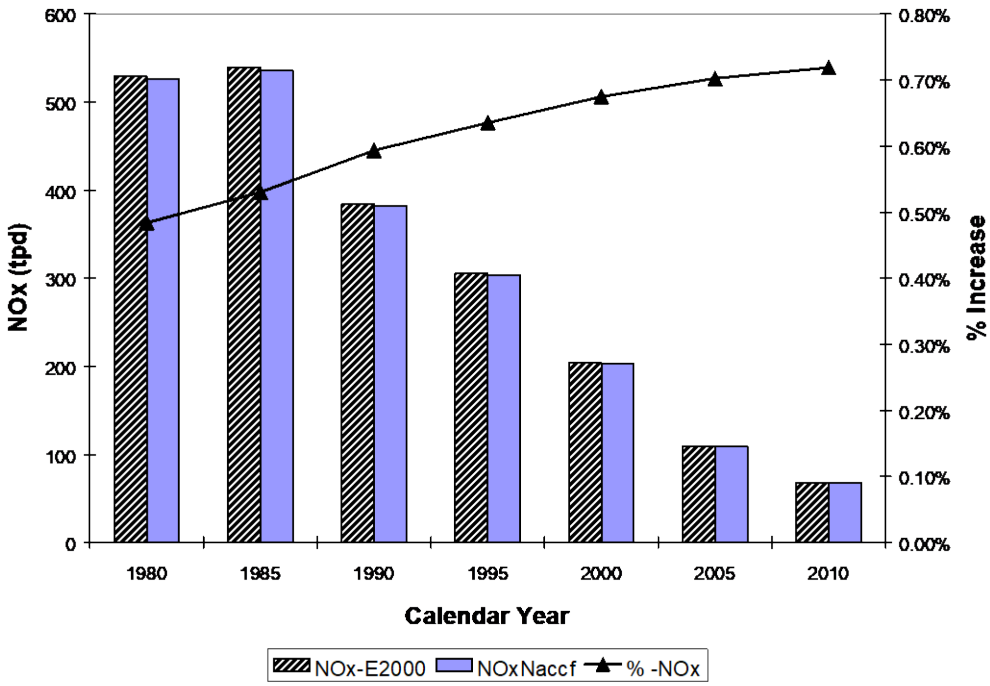


Figure 13-37 Effect of Air Conditioning on NOx Exhaust from PC gas



13.8 Effect of Liquid Leakers on Evaporative Emissions

In EMFAC2000, the percentage of the fleet that is comprised of high emitters, or liquid leakers, is based on the U.S. EPA's liquid leaker fraction[6]. The percentage of liquid leakers and their emissions contribution is important in that these vehicles may not be detected by the vehicle's on-board diagnostic (OBDII) system. The OBDII system was designed to detect vapor leaks, not liquid leaks, hence the relative emissions contribution from these vehicles is likely to increase as more stringent standards are phased in.

Figures 13-38, 13-39, 13-40 and 13-41 show the impact of liquid leakers on the diurnal, hot soak, running loss and resting loss emissions, respectively, from gasoline fueled passenger cars. The impact of liquid leakers is less (approximately 20 percent) in the early calendar years (1980-90) because the magnitude of the emissions is high. However, with the phase in of the enhanced evaporative standards and near zero standards the impact of liquid leakers increases for 1995 and later calendar years. The percentage of liquid leakers varies from 0% of the fleet of new vehicles to approximately 5% by age 15. Figures 13-38 to 13-41 show that approximately 20 to 50 percent of all evaporative emissions are attributable to liquid leakers.

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[6] Section 5.1 Methodology Used in Estimating Running Loss Emissions

Figure 13-38 **Effect of Liquid Leakers on Diurnal Emissions from PC gas**

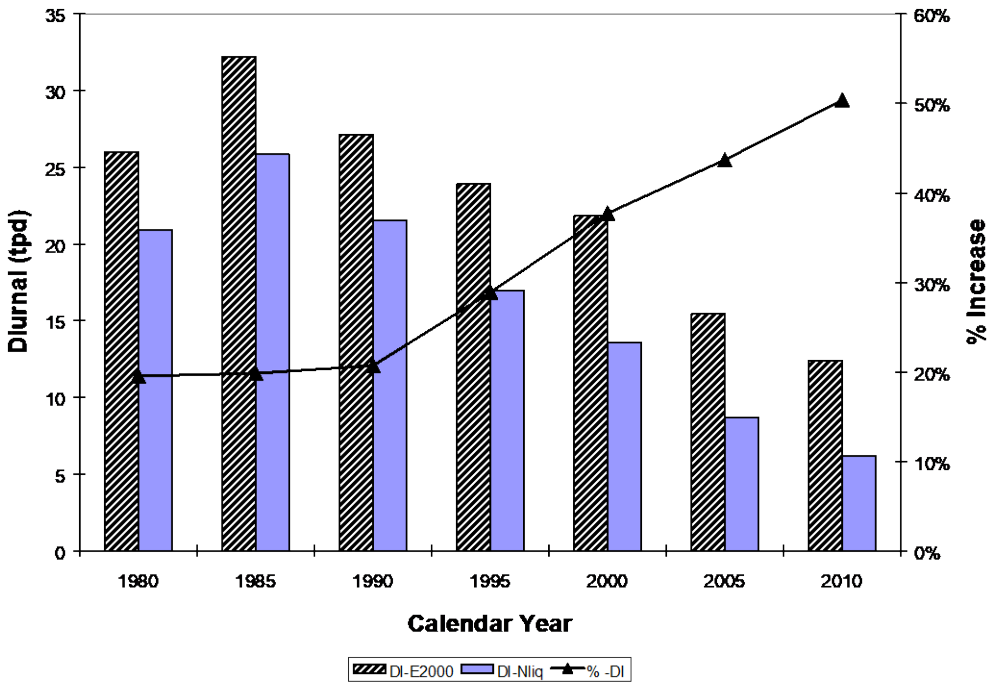


Figure 13-39 **Effect of Liquid Leakers on Hot Soak Emissions from PC gas**

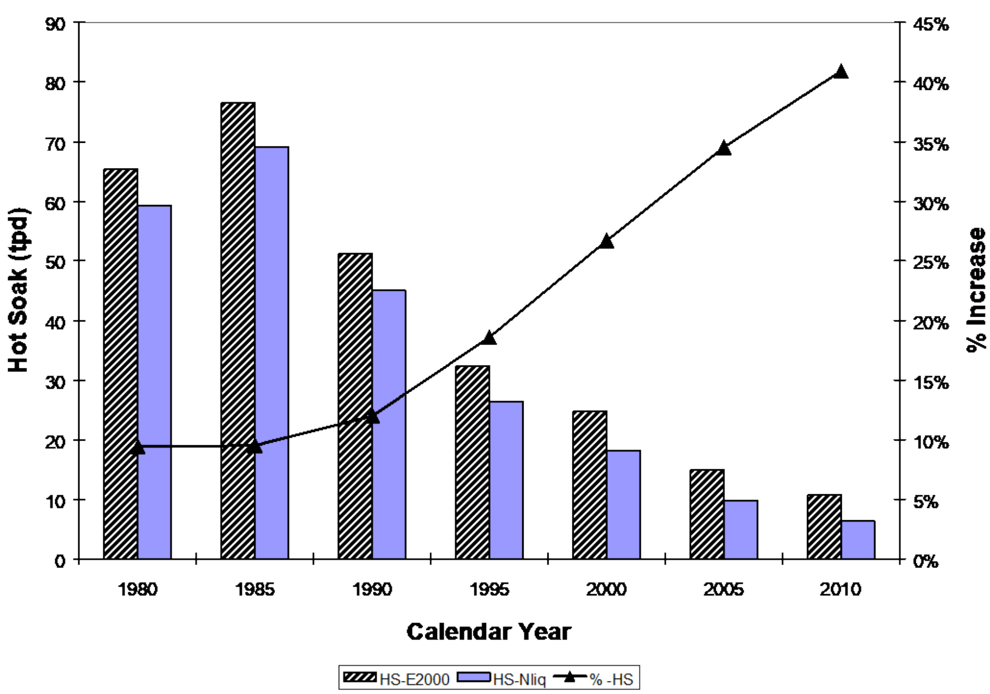


Figure 13-40 **Effect of Liquid Leakers on Running Loss Emissions from PC gas**

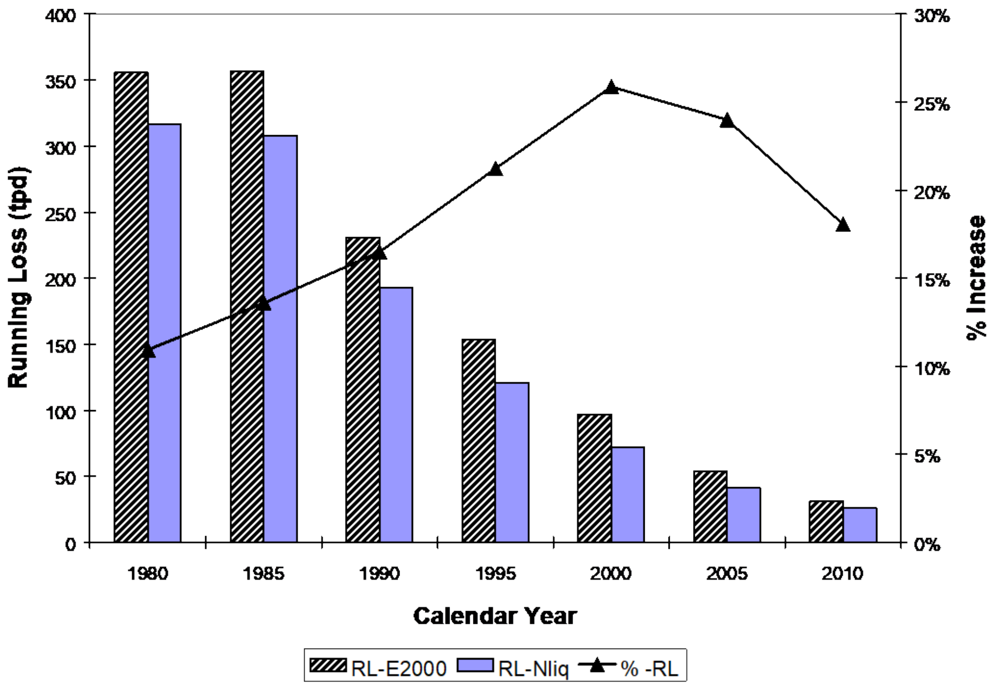
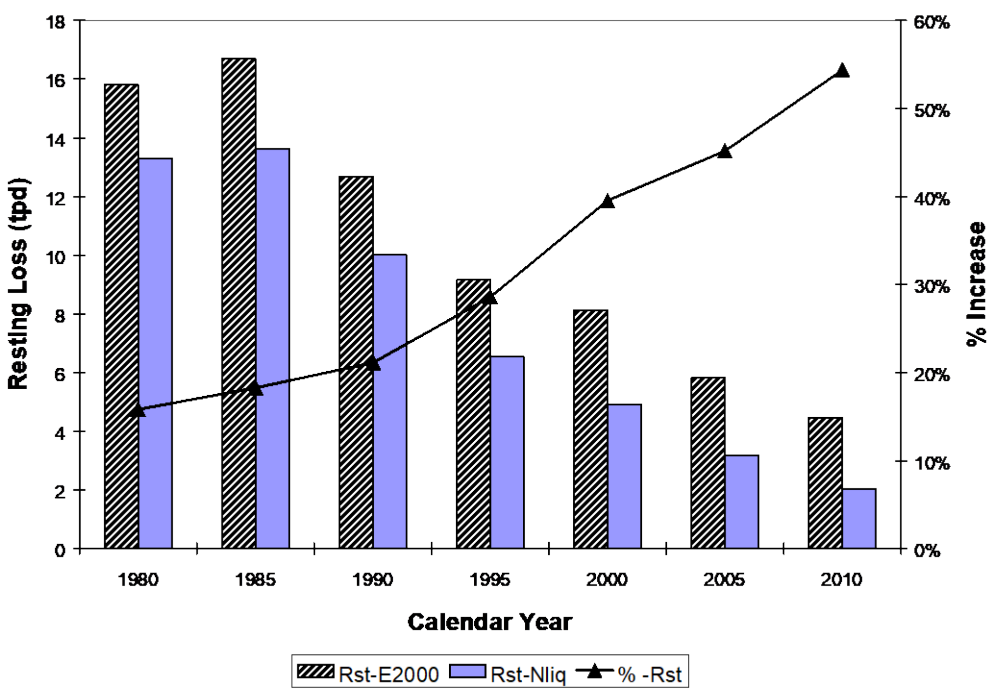


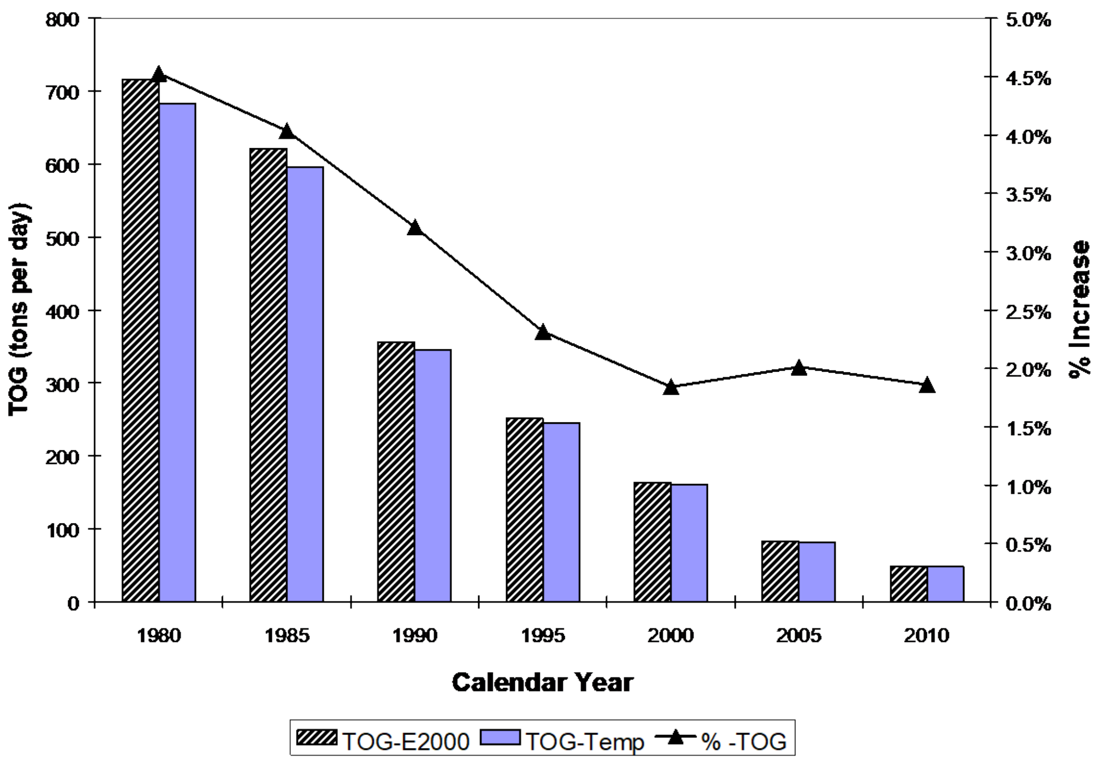
Figure 13-41 **Effect of Liquid Leakers on Resting loss Emissions from PC Gas**



13.9 Effect of Temperature Correction Factors

Figures 13-42, 13-43 and 13-44 show the effect of temperature corrections[7] on the running exhaust TOG, CO and NOx emissions, respectively, from gasoline fueled passenger cars. The effect of temperature correction increases emissions by 1-7% depending upon pollutant. Figures 13-45, 13-46 and 13-47 show the effect of temperature corrections on starting emissions of TOG, CO, and NOx emissions, respectively. Figures L1-L6 show that the effect of temperature corrections diminishes for future calendar years implying that emissions from newer technology vehicles are less sensitive to changes in ambient temperatures

Figure 13-42 Effect of Temperature Corrections on TOG Running Exhaust Emissions From PC-gas



[7] Section 6.1 Technology Specific Temperature Correction Factors.

Figure 13-43 Effect of Temperature Corrections on CO Running Exhaust Emissions From PC-gas

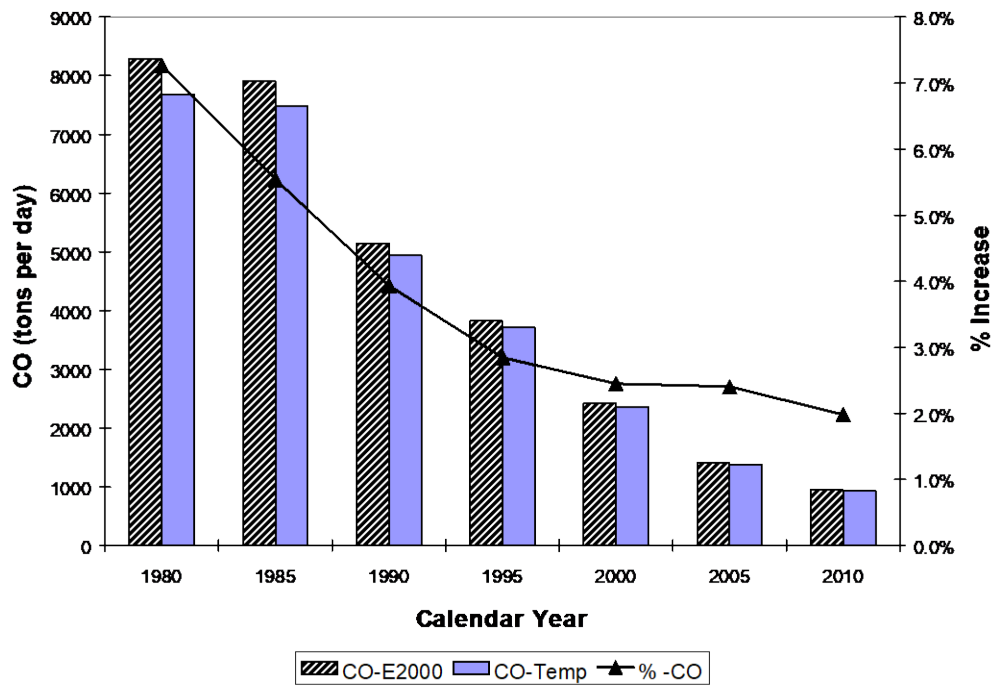


Figure 13-44 Effect of Temperature Corrections on NOx Running Exhaust Emissions From PC-gas

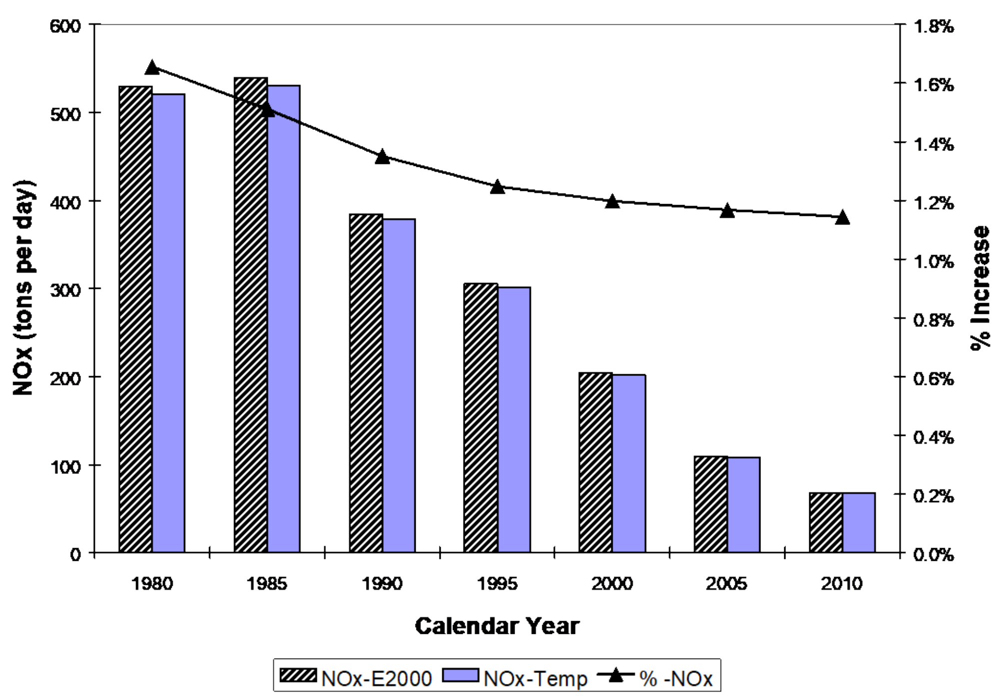


Figure 13-45 Effect of Temperature Corrections on TOG Starting Emissions From PC-gas

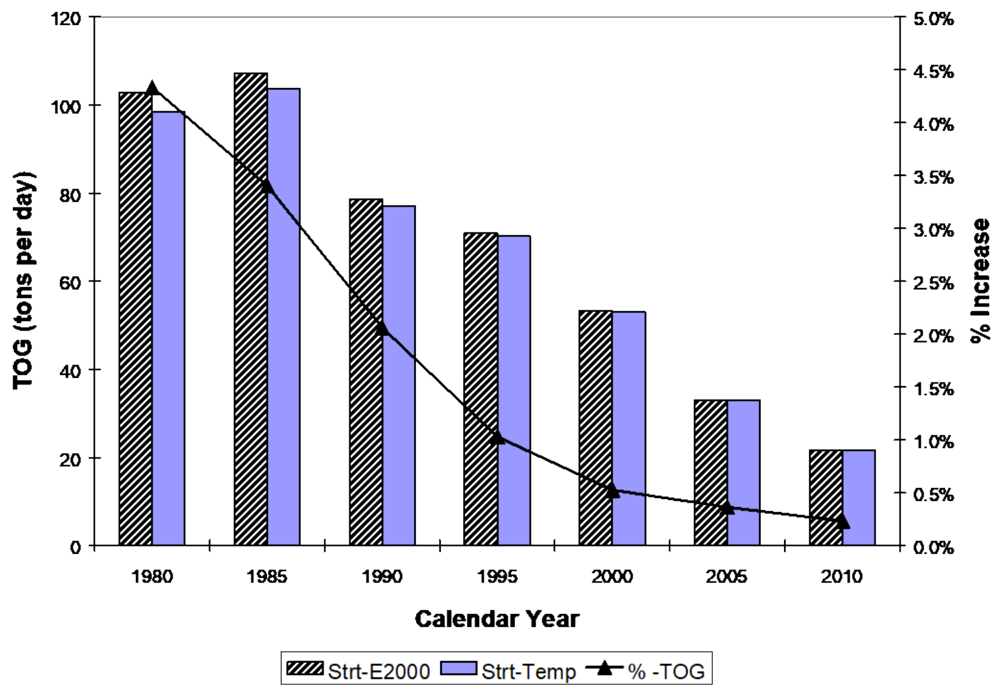


Figure 13-46 Effect of Temperature Corrections on CO Starting Emissions From PC-gas

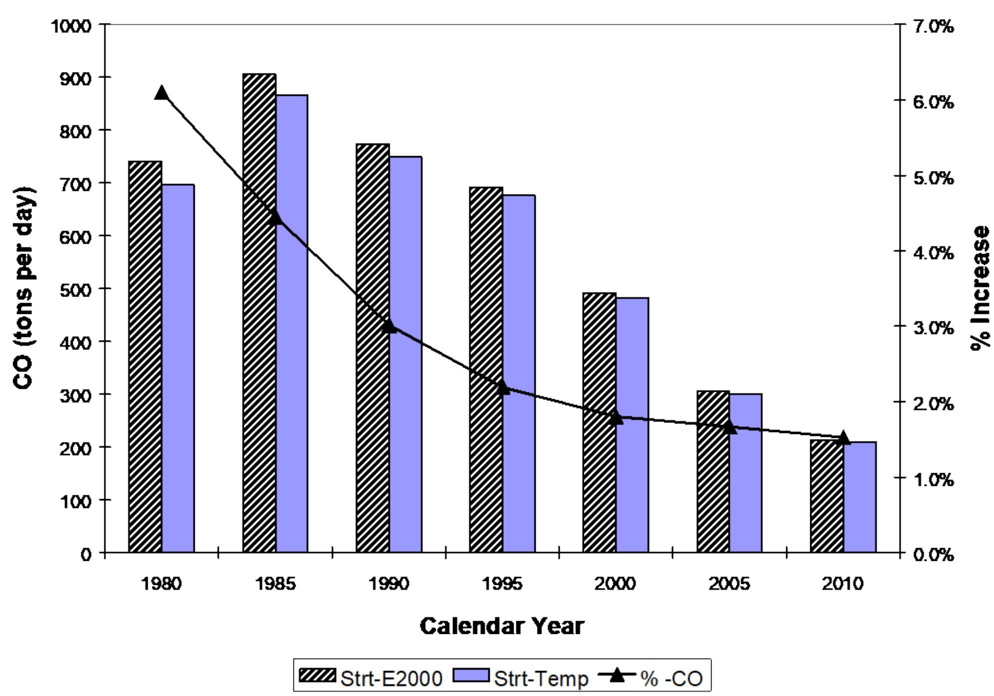
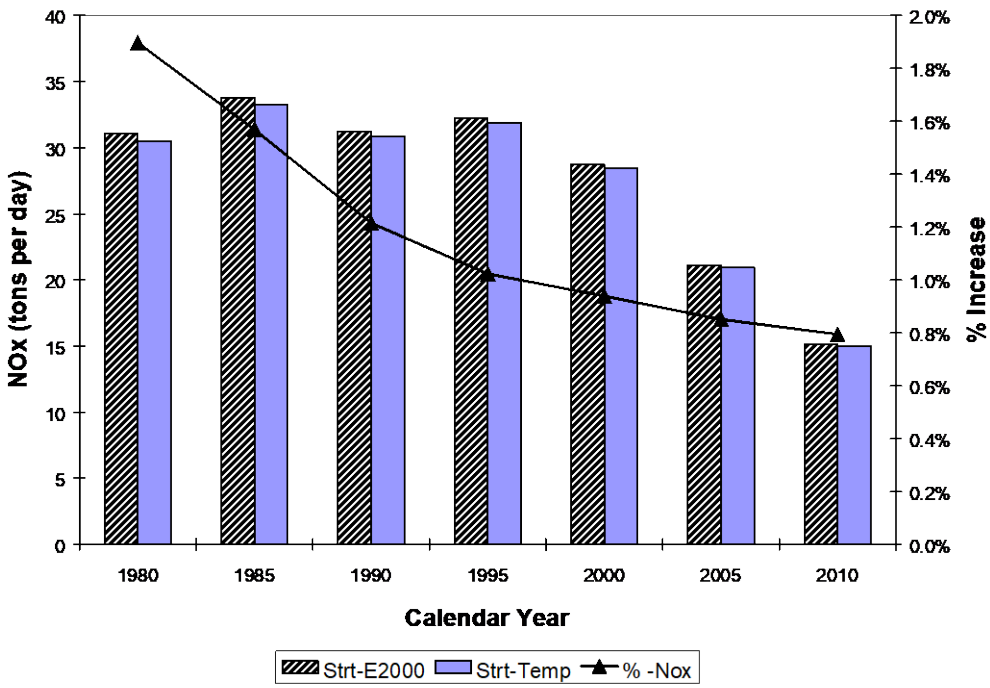


Figure 13-47 **Effect of Temperature Corrections on NOx Starting Emissions From PC-gas**



13.10 Effect of Inspection and Maintenance

Gasoline fueled vehicles (PCs, LDTs and MDVs) operating in the SCAB have been subject to three different I/M programs. The first program, implemented in 1984, required vehicles to be tested over a no load idle test. Failing vehicles were to be repaired within a $50 cost limit. This program was revised in 1990, requiring vehicles to be tested over both a low, and high speed idle (2500 rpm) tests. In addition, sliding repair cost limits were introduced with a $50 limit for older cars increasing to $300 for newer cars. The program was again revised in 1996[8] requiring vehicles in enhanced areas to be tested on a dynamometer using the acceleration simulation mode (ASM) test. The repair cost limit was increased to $450 for all vehicles.

The I&M program lowers vehicle deterioration by requiring failing vehicles to be repaired to acceptable levels. Figure 13-48 shows the I&M emission benefits, determined from MVEI7G, for TOG emissions from passenger cars operating in SCAB. The figure shows the emission estimates for vehicles subject to three I&M programs (1984,1990 and 1996), two I/M programs (1984 and 1990), the 1984 I/M program only, and no I/M program. The MVEI7G model predicted that the TOG emission benefits from the 1984 program, 1984 & 1990 program, and all three programs were 16%, 22 % and 24%,

[8] The enhanced I&M Program was implemented in 1998, however, it is anticipated that the full implementation, using more stringent standards to fail vehicles, will commence in the 2001 calendar year.

respectively, in 2010 compared to the no I/M baseline. Figures 13-49 and 13-50 show the I/M benefits for CO and NOx, respectively.

Figure 13-48 <u>IM Program Benefits For Total TOG From All Gasoline Vehicles - MVEI7G</u>

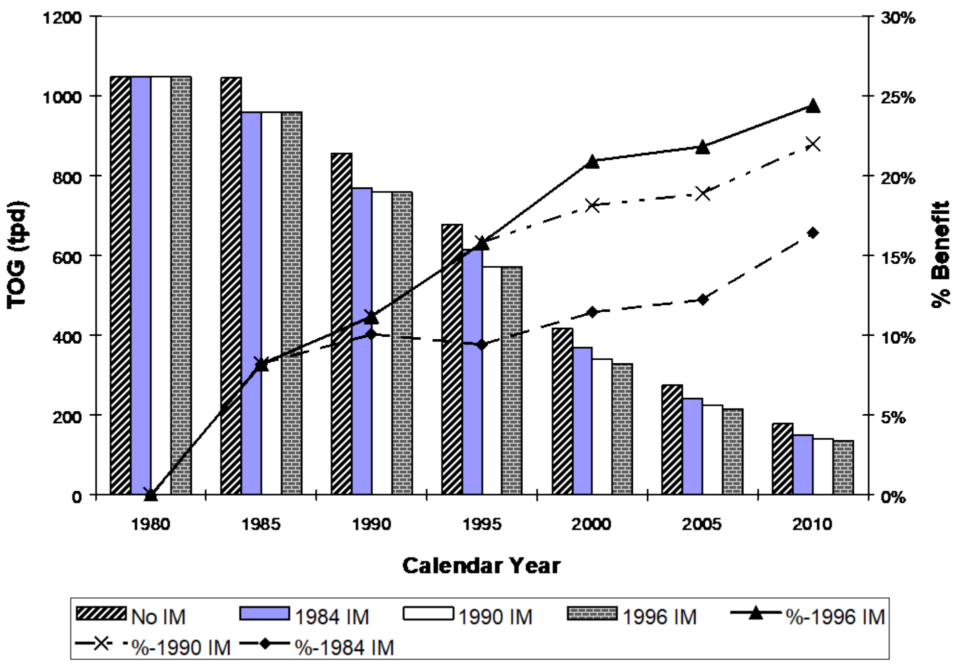


Figure 13-49 <u>IM Program Benefits for Total CO From All Gasoline Vehicles - MVEI7G</u>

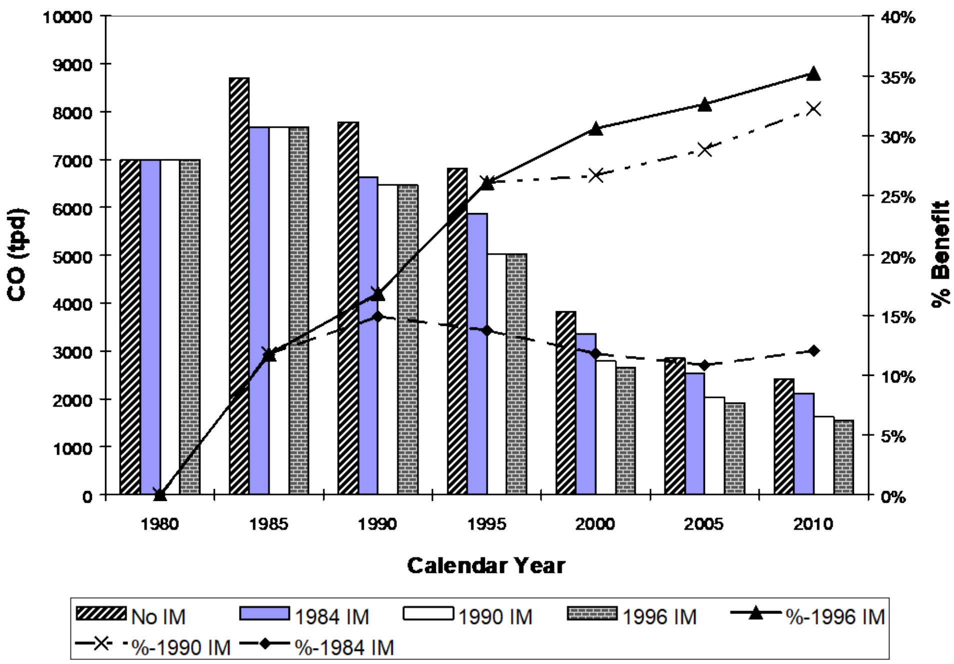
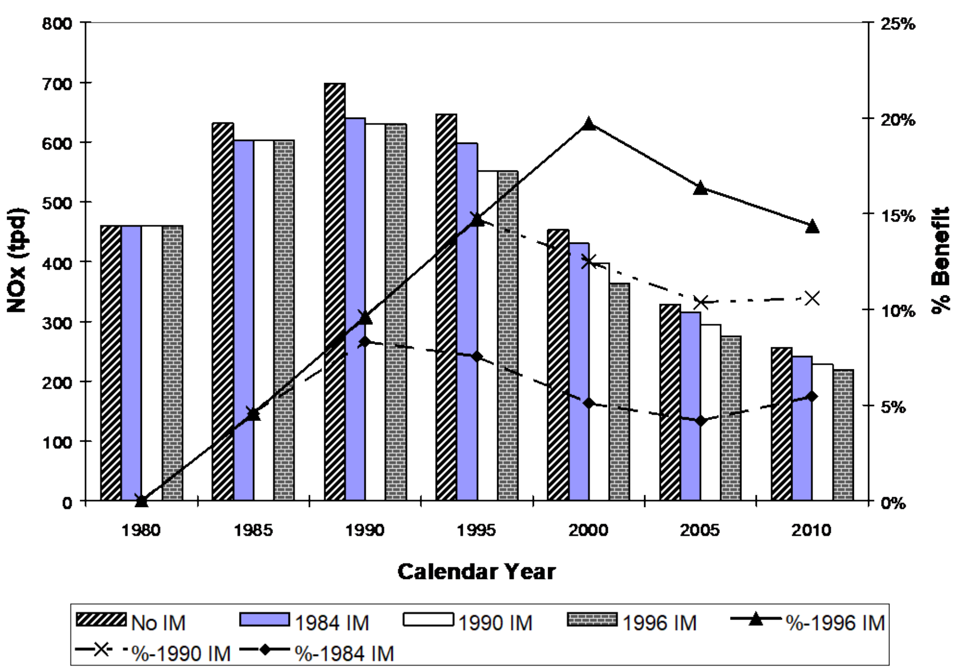


Figure 13-50 <u>IM Program Benefits for Total NOx From All Gasoline Vehicles - MVEI7G</u>



In EMFAC2000, it is assumed that the enhanced program utilizing ARB's suggested ASM cut-points will be implemented by the year 2001. Figure 13-51 shows the effect of I/M programs on total TOG (evaporative + exhaust) emissions from passenger cars in the SCAB. Figure 13-51 shows that program improvements made in the 1990 I/M program did result in further emission reductions compared to the 1984 program. The emission benefits from the 1984 and 1990 I/M programs increase for 2005 and later calendar years, due to the greater number of OBDII equipped vehicles. Figure 13-52 and 13-56 shows the emission benefits from I&M programs on the CO and NOx emissions, respectively. Table 13-1 shows the incremental tons per day reductions achieved by various I&M programs in the SCAB.

Table 13-1 Incremental Emission Reduction From Successive I&M Programs in the SCAB for Calendar Year 2010

2010	Total TOG	Incremental Redux-TOG	Total CO	Incremental Redux-CO	Total NOx	Incremental Redux-NOx
NO-IM	195.51	0.00	1642.25	0.00	135.75	0.00
1984	178.80	16.71	1478.06	164.19	117.80	17.95
1990	172.02	6.78	1420.98	57.08	114.60	3.20
Enhanced	130.30	41.72	1163.34	257.64	83.25	31.35

Figure 13-51 IM Program Benefits For Total TOG From All Gasoline Vehicles - EMFAC2000

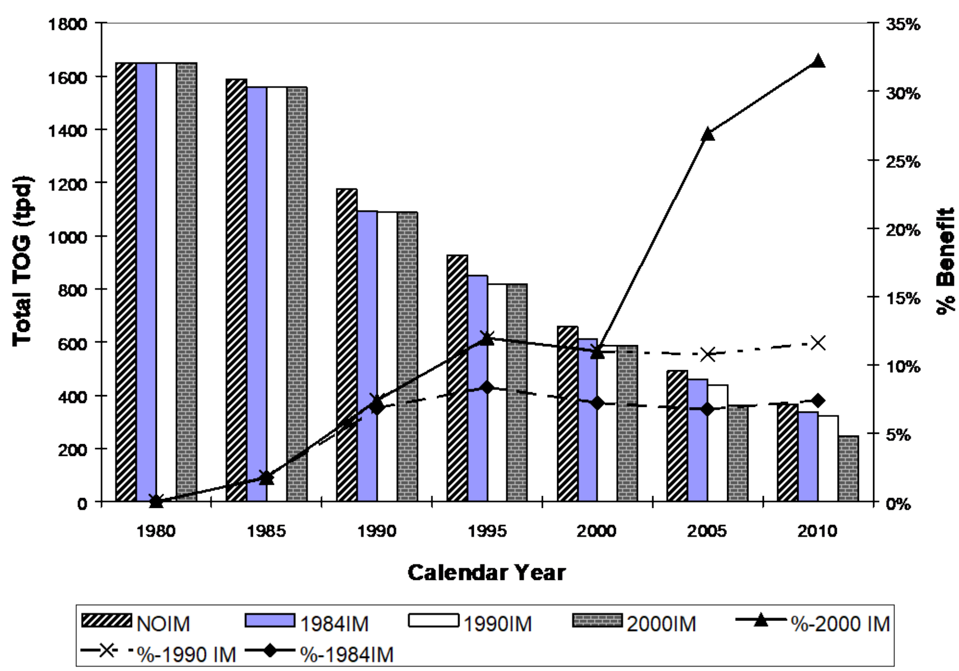


Figure 13-52 IM Program Benefits for Total CO From All Gasoline Vehicles - EMFAC2000

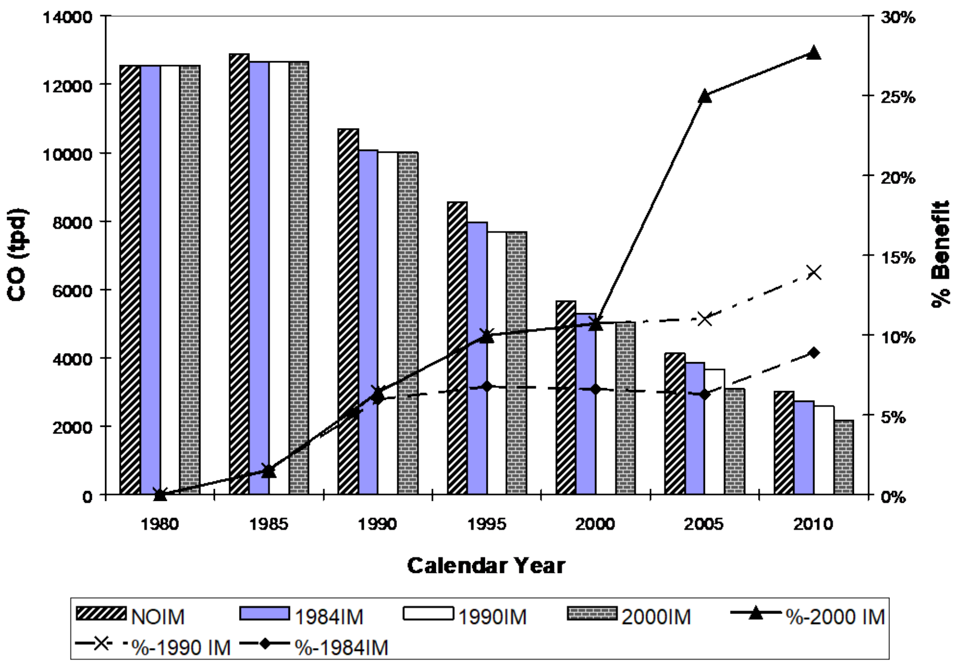
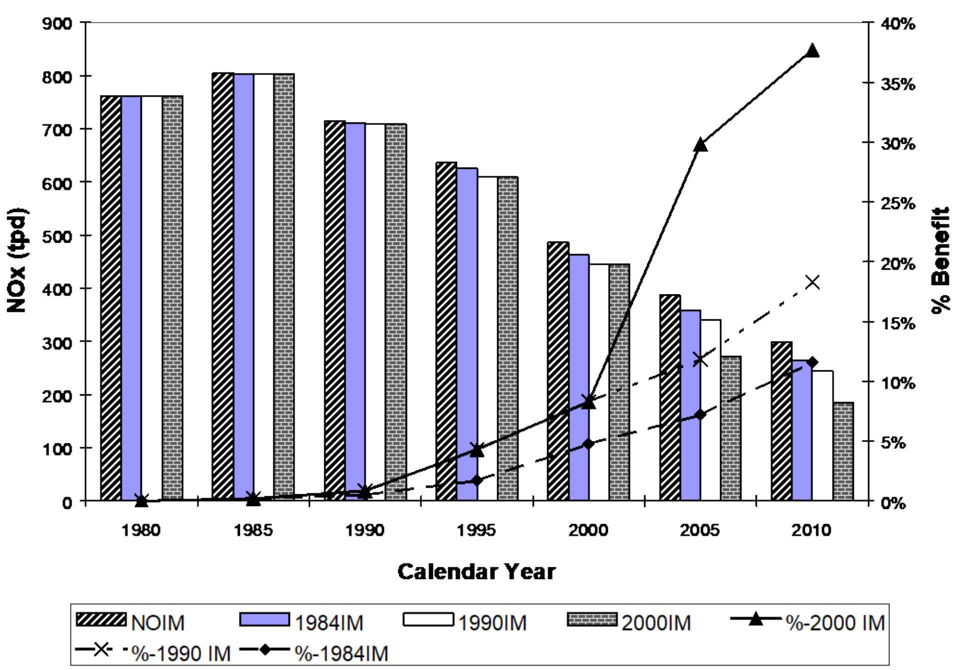


Figure 13-53 IM Program Benefits for Total NOx From All Gasoline Vehicles - EMFAC2000



13.11 Summation of the Incremental Increases in Emissions

Table 13-2 shows which process contributed to the overall increase in emissions relative to MVEI7G. This table shows that for calendar year 1980, the HC, CO, NOx and PM10 emissions increased by 179.5%, 232.5%, 203.9% and 51.19%, respectively, relatively to MVEI7G. The increase in HC emissions is made up a 111.8% increase basic emission rates, 2% increase due to unregistered vehicles, 20% reduction from moving to a UC based model, and a 2% increase due to AC effect. In calendar year 2000 there are no reductions associated with changes in fuel or I&M. The 2010 calendar year inventory reflects the introduction of Phase 1 and Phase 2 fuels, and implementation of I&M programs. Inclusion of these programs into the incremental effects analysis leads to differences between the compounded results and the actual differrences between the model.

Table 13-2 Quantification of the Incremental Increases for Gasoline Fueled PCs

Passenger cars-gas Tons per day	1980 HC	1980 CO	1980 NOx	1980 PM		2000 HC	2000 CO	2000 NOx	2000 PM
BERs/Vehicle age & mileage	211.84%	169.95%	125.61%	28.29%		194.01%	128.83%	94.51%	233.33%
Unregistered Vehicles	102.10%	102.23%	102.34%	102.25%		101.76%	101.51%	101.24%	100.82%
FTP to UC changes	81.15%	126.81%	150.73%	176.29%		92.65%	98.55%	129.18%	148.39%
Changes in FCFs	100.00%	100.00%	100.00%	100.00%		103.17%	127.84%	95.52%	100.00%
Air Conditioning	102.53%	105.96%	100.49%	100.00%		103.71%	108.66%	100.68%	100.00%
Humidity	100.00%	100.00%	104.70%	100.00%		100.00%	100.00%	104.27%	100.00%
Compounded	179.95%	233.46%	203.85%	50.99%		195.72%	179.03%	123.94%	349.08%
Difference from Baseline	179.55%	232.56%	203.91%	51.19%		207.15%	227.17%	143.86%	331.53%

Section 5.1 METHODOLOGY USED IN ESTIMATING RUNNING LOSS EMISSIONS

This section details how the running loss emissions were estimated for gasoline fueled vehicles.

5.1.1 Introduction

Hydrocarbon emissions that emanate from sources other than the vehicle tailpipe, while the engine is on, are referred to as running loss emissions. When the engine is on, leaks in the fuel delivery system or evaporative control system can lead to vapor losses. In general, running loss emissions vary with trip length, the size of any fuel leaks, fuel temperature and volatility, and the condition of the evaporative control system. In MVEI7G, running loss emissions were estimated by determining the average gram per mile rate as measured over three LA-4 cycles. This rate was then adjusted for speed (using running loss speed correction factors), temperature, and fuel volatility as indicated by the Reid Vapor Pressure (RVP). In EMFAC2000, this methodology has been revised to account for the fact that running loss emissions increase with trip length. Longer trips result in more work being performed on the fuel, which increases the fuel temperature, resulting in increased vapor losses.

5.1.2 Methodology

The running loss emission rates are based on a project conducted by the Coordinating Research Council (CRC) during which 150 conforming and 30 malperforming vehicles were tested. The vehicles were tested over a single LA-4 cycle using a 6.6 RVP fuel at an ambient temperature of 95°F. The emissions were recorded modally in one-minute increments for a period of 25 minutes. The malperforming vehicle data set contained vehicles identified as either needing repair or having emissions that were an order of magnitude higher than other vehicles in the same class. In some instances, these vehicles emitted 200-300 grams per test. Fourteen vehicles were removed from the conforming vehicle data set and placed in the malperforming vehicle data set. Tables 5.1-1 and 5.1-2 show the distribution of vehicles by fuel metering system and vehicle type in the conforming and malperforming vehicle data sets, respectively.

Table 5.1-1 Conforming Vehicles

	CARB	PFI	TBI	Total
Car	45	26	8	79
Truck	45	7	5	57
Total	90	33	13	136

Table 5.1-2 Malperforming Vehicles

	CARB	PFI	TBI	Total
Car	20	2	4	26
Truck	15	3	0	18
Total	35	5	4	44

5.1.3 Basic Emission Rates

Three statistical tests (t-test, non-parametric t-test and an analysis of variance) were performed using Statistical Analysis Software (SAS) to determine if the running loss emissions vary by vehicle type. The results of the t-test, which assumes a normal distribution in the data, indicated that the variance in the car and truck emissions is not the same and cannot occur purely by chance. The non-parametric t-test does not assume normality in the data and compares the median emission values from cars and trucks. This test also indicated that the variation in median values couldn't occur by chance alone indicating the need to split the data set into cars and trucks. The analysis of variance compares the variance between cars and trucks to the variance within cars or trucks to calculate an "F" value. A high F value indicates that there is a difference between cars and trucks. Since the number of cars and trucks was not the same, an analysis of variance using PROC GLM was used for unbalanced data sets. The results from this test also indicated that cars and trucks have significantly different running loss emissions. Based on the three tests above, it was determined that cars and trucks should be modeled separately.

Similar analyses were also performed to determine if running loss emissions vary by fuel metering system, i.e. carburetor, throttle body injection (TBI) or port fuel injection (PFI) system. An analysis of variance (using GLM with a Duncan test) indicated that TBI and PFI have similar emissions and that these emissions are different from those of carbureted vehicles. This result was true for both cars and trucks. Hence, carbureted vehicles were modeled separately than PFI/TBI vehicles.

Additional analyses were performed on vehicles within each vehicle type/fuel metering system to see if vehicles with similar average emissions could be grouped into model year groups. Results from the Duncan test within the analysis of variance indicated that carbureted cars can be grouped into 71-76 and 77-90 model year groups, and that carbureted trucks can be grouped into 71-79 and 80-90 model year groups. The analysis indicated that these groupings were not appropriate for either TBI/PFI cars or trucks.

Similar analyses were also performed on malperforming vehicles. The malperforming vehicles were split into two emission regimes to distinguish between deteriorated vehicles (moderate emitters) and high emitters. It is important to note that the magnitude of emissions from moderate and high emitters changes by technology group. For example, a high emitting pre-1970 carbureted vehicle has an emission rate 20 times greater than a high emitting fuel-injected vehicle.

Table 5.1-3 shows the modeled running loss regression coefficients by vehicle type, fuel metering system, and emissions regime. The general form of the running loss equation is:

$$Tot\_HC = A + B*time + C*time^2 + D*Odometer + E*Age \quad \textbf{(5.1-1)}$$

Where:
Tot_HC is the cumulative running loss emissions in grams.
Time is the engine time-on in minutes.

Odometer is the total mileage accrued by the vehicle.
Age = (calendar year – (model year+1)).

Table 5.1-3 <u>Running Loss Regression Coefficients</u>

				Intercept	Time	$Time^2$	Odometer	Age	
Vehicle Type	Fuel System	Model Yr. Group	Emission Regime	A	B	C	D	E	R-Square
Car/Truck	Carb	Pre-1970	Normal	0.0000000	1.1135000	0	0	0	0.95
			Moderate	0.0000000	1.0850832		0	0	0.74
			High	0.0000000	7.4541372	0	0	0	0.69
Car	Carb	1970-76	Normal	-1.2473406	0.1520645	0	0.000006589	0	0.30
			Moderate	0.0000000	1.0850832		0	0	0.74
			High	0.0000000	7.4541372	0	0	0	0.69
Car	Carb	1977+	Normal	-0.3820283	0.0726256	0	0.000001874	0	0.26
			Moderate	0.0000000	0.0000000	0.03324	0	0	0.58
			High	0.0000000	7.4541372	0	0	0	0.69
Car	TBI/PFI	All Pre-	Normal	-0.1115497	0.0223147	0	0	0.00800653	0.36
		Enhanced	Moderate	-0.1294396	0.1113702	0	0	0	0.74
		Evap	High	-1.4894734	0.6072166	0	0	0	0.76
Car	TBI/PFI	Enhanced	Normal	-0.0430068	0.0086032	0	0	0.00308684	
		Evap(1)	Moderate	-0.0499041	0.0429376	0	0	0	
			High	-1.4894734	0.6072166	0	0	0	
Truck	Carb	Pre-1980	Normal	-1.16413581	0.09926223	0	0.000006450	0	0.37
			Moderate	-4.08642138	0.49482703	0	0	0.13630326	0.68
			High	0	1.71089551	0	0	0	0.82
Truck	Carb	1980+	Normal	-0.30136997	0.0716051	0	0.000001091	0	0.34
			Moderate	-13.45972	0.4778018	0	0	0.95829205	0.67
			High	0	1.71089551	0	0	0	0.82
Truck	TBI/PFI	All	Normal	-0.18308557	0.00961453	0	0	0.0213216	0.59
			Moderate	-2.08792222	0	0.00688	0	0.27679645	0.73
			High	-1.48947344	0.60721658	0	0	0	0.76
Truck	TBI/PFI	Enhanced	Normal	-0.15803071	0.00829881	0	0	0.01840379	
		Evap(1)	Moderate	-1.80219466	0	0.00594	0	0.23891747	
			High	-1.48947344	0.60721658	0	0	0	

(1) Appendix 5.1-A details how the emission rates were derived for vehicles subject to the enhanced evaporative standards.
(2) There were no high emitters present in the fuel-injected truck data set. Staff assumed that this rate is the same as that for fuel-injected cars.

The following assumptions were also used in determining the running loss emission rates:

1. The data set analyzed did not contain pre-1970 high emitting vehicles. Staff assumed that this group of vehicles would have the same emission rates as those high emitting vehicles in the 1970-76 model year group.
2. The data set did not contain high emitting fuel-injected trucks. It was assumed that this emission rate is similar to high emitting fuel-injected passenger cars.
3. Appendix 5.1-A shows how the running loss emission rates were derived for vehicles certified to the enhanced evaporative running loss standard of 0.05 grams per mile. The basic premise in estimating the enhanced evaporative emission rates is that these vehicles will meet the standard at 100,000 miles or at 9-years of age when tested at 105°F using 7.0 RVP fuel.

5.1.4 <u>Calendar Year Specific Emissions</u>

In order to estimate the running loss emissions inventory for any given calendar year, the emissions from each technology group are weighted by the model year specific technology group fractions. Table 5.1-4 shows which technology groups are present in any given model year. This table shows the main technology groups that affect running loss emissions, however, the recent adoption of the near zero evaporative emissions standard for hot soak and diurnal emissions may also indirectly effect running loss emissions even though the running loss standard was not changed. Staff believes that changes made to the evaporative control system to meet this standard may also lower running loss emissions. However, it is difficult to quantify the reduction in running loss emissions without actual test data. Table 5.1-5 shows the model year technology fractions assumed for gasoline fueled heavy-duty trucks.

Table 5.1-4 <u>Model Year Specific Technology Fractions by Vehicle Class</u>

	Technology Fractions For Passenger Cars						
Year	Carb	TBI	PFI	Enh_TBI	Enh_PFI	Zero_Evap_PFI	Zev
2008	0.00					90.00	10.00
2007	0.00					90.00	10.00
2006	0.00					90.00	10.00
2005	0.00				18.00	72.00	10.00
2004	0.00				54.00	36.00	10.00
2003	0.00				90.00		10.00
2002	0.00				100.00		
2001	0.00			0.00	100.00		
2000	0.00			0.00	100.00		
1999	0.00			1.20	98.80		
1998	0.00	0.00	0.00	2.40	97.60		
1997	0.00	1.80	48.20	1.80	48.20		
1996	0.00	2.80	67.20	1.20	28.80		
1995	0.00	3.78	86.22	0.42	9.58		
1994	0.00	11.40	88.60				
1993	0.00	28.20	71.80				
1992	0.00	28.20	71.80				
1991	0.00	28.20	71.80				
1990	0.00	28.20	71.80				
1989	0.00	32.00	68.00				
1988	21.90	21.90	56.20				
1987	25.75	25.75	48.50				
1986	29.80	29.80	40.40				
1985	33.90	33.90	32.20				
1984	39.50	38.00	22.50				
1983	46.70	32.30	21.00				
1982	51.50	33.40	15.10				
1981	52.00	33.50	14.50				
1980	62.60	24.70	12.70				
1979	91.50	3.50	5.00				
1978	96.50	1.50	2.00				
1977	98.00	0.00	2.00				
<=1976	100.00	0.00	0.00				

	Technology Fractions For Light-Duty Trucks (T1)						
M_Year	Carb	TBI	PFI	Enh_TBI	Enh_PFI	Zero_Evap_PFI	Zev
2008						90.00	10.00
2007						90.00	10.00
2006					0.00	90.00	10.00
2005					18.00	72.00	10.00
2004	0.00				54.00	36.00	10.00
2003	0.00			0.00	90.00		10.00
2002	0.00			0.00	100.00		
2001	0.00			0.00	100.00		
2000	0.00			0.00	100.00		
1999	0.00	0.00	0.00	5.10	94.90		
1998	0.00	0.00	0.00	10.60	89.40		
1997	0.00	8.05	41.95	8.05	41.95		
1996	0.00	12.39	57.61	5.31	24.69		
1995	0.00	21.60	68.40	2.40	7.60		
1994	0.00	25.40	74.60				
1993	0.00	28.20	71.80				
1992	0.00	28.20	71.80				
1991	0.00	32.10	67.90				
1990	0.00	43.80	56.20				
1989	0.00	51.50	48.50				
1988	25.60	25.60	48.80				
1987	33.75	31.95	34.30				
1986	37.60	34.30	28.10				
1985	43.50	38.70	17.80				
1984	53.05	39.35	7.60				
1983	53.65	44.75	1.60				
1982	65.70	30.80	3.50				
1981	76.40	22.50	1.10				
1980	96.30	3.70	0.00				
1979	96.30	3.70	0.00				
1978	100.00	0.00	0.00				
1977	100.00	0.00	0.00				
<=1976	100.00	0.00	0.00				

Table 5.1-4 <u>(continued)</u>

Technology Fractions For Light-Duty Trucks (T2)						
M_Year	Carb	TBI	PFI	Enh_TBI	Enh_PFI	Zero_Evap_PFI
2008						100.00
2007						100.00
2006						100.00
2005					20.00	80.00
2004	0.00				60.00	40.00
2003	0.00				100.00	
2002	0.00				100.00	
2001	0.00			0.00	100.00	
2000	0.00			0.00	100.00	
1999	0.00	0.00	0.00	5.10	94.90	
1998	0.00	0.00	0.00	10.60	89.40	
1997	0.00	8.05	41.95	8.05	41.95	
1996	0.00	12.39	57.61	5.31	24.69	
1995	0.00	21.60	68.40	2.40	7.60	
1994	0.00	25.40	74.60			
1993	0.00	28.20	71.80			
1992	0.00	28.20	71.80			
1991	0.00	32.10	67.90			
1990	21.90	21.90	56.20			
1989	25.75	25.75	48.50			
1988	25.60	25.60	48.80			
1987	33.75	31.95	34.30			
1986	37.60	34.30	28.10			
1985	43.50	38.70	17.80			
1984	53.05	39.35	7.60			
1983	53.65	44.75	1.60			
1982	65.70	30.80	3.50			
1981	76.40	22.50	1.10			
1980	96.30	3.70	0.00			
1979	96.30	3.70	0.00			
1978	100.00	0.00	0.00			
1977	100.00	0.00	0.00			
<=1976	100.00	0.00	0.00			

Technology Fractions For Medium-Duty Trucks (T3)						
M_Year	Carb	TBI	PFI	Enh_TBI	Enh_PFI	Zero_Evap_PFI
2008						100.00
2007						100.00
2006						100.00
2005					20.00	80.00
2004	0.00				60.00	40.00
2003	0.00				100.00	
2002	0.00				100.00	
2001	0.00				100.00	
2000	0.00				100.00	
1999	0.00	0.00			100.00	
1998	0.00	0.00	0.00	0.00	100.00	
1997	0.00	0.00	50.00	0.00	50.00	
1996	0.00	19.74	50.26	8.46	21.54	
1995	0.00	25.38	64.62	2.82	7.18	
1994	0.00	28.20	71.80			
1993	0.00	32.10	67.90			
1992	0.00	43.80	56.20			
1991	0.00	51.50	48.50			
1990	24.30	24.30	51.40			
1989	31.90	30.20	37.90			
1988	30.05	30.05	39.90			
1987	23.90	23.90	52.20			
1986	34.90	34.90	30.20			
1985	44.00	44.00	12.00			
1984	50.00	50.00	0.00			
1983	76.90	23.10	0.00			
1982	97.50	2.50	0.00			
1981	99.00	1.00	0.00			
1980	100.00	0.00	0.00			
1979	100.00	0.00	0.00			
1978	100.00	0.00	0.00			
1977	100.00	0.00	0.00			
<=1976	100.00	0.00	0.00			

Table 5.1-5 Technology Fractions for Gasoline Fueled Heavy-Duty Trucks

5.1.5 Regime Growth Rates

	Technology Fractions For T4, T5, T6, T7 and T8 gas fueled vehicles					
M_Year	Carb	TBI	PFI	Enh_TBI	Enh_PFI	Zero_Evap_PFI
2008						100.00
2007						100.00
2006						100.00
2005					20.00	80.00
2004	0.00				60.00	40.00
2003	0.00				100.00	
2002	0.00				100.00	
2001	0.00				100.00	
2000	0.00				100.00	
1999	0.00	0.00			100.00	
1998	0.00	0.00	0.00	0.00	100.00	
1997	0.00	0.00	50.00	0.00	50.00	
1996	0.00	19.74	50.26	8.46	21.54	
1995	0.00	25.38	64.62	2.82	7.18	
1994	0.00	28.20	71.80			
1993	0.00	32.10	67.90			
1992	0.00	43.80	56.20			
1991	0.00	51.50	48.50			
1990	100.00	0.00	0.00			
1989	100.00	0.00	0.00			
1988	100.00	0.00	0.00			
1987	100.00	0.00	0.00			
1986	100.00	0.00	0.00			
1985	100.00	0.00	0.00			
1984	100.00	0.00	0.00			
1983	100.00	0.00	0.00			
1982	100.00	0.00	0.00			
1981	100.00	0.00	0.00			
1980	100.00	0.00	0.00			
1979	100.00	0.00	0.00			
1978	100.00	0.00	0.00			
1977	100.00	0.00	0.00			
<=1976	100.00	0.00	0.00			

A composite emissions rate is calculated by weighting the regime specific emission rates by the fraction of normal, moderate and high emitting vehicles within each technology group. To calculate the regime specific populations by technology group and vehicle odometer, staff analyzed a data set containing tests from projects performed by the USEPA, CARB and the CRC. The CRC data was also used in developing the emission rates. However, this data set was combined with the historical running loss data to increase the amount and diversity of the data used in developing the regime growth rates.

The regime specific populations by vehicle age were determined by analyzing vehicles that were tested using 9.0 RVP fuel and at 95°F. The vehicles were then classified into emission regimes by comparing the total emissions to the predicted emission levels or regime boundaries. The regime boundaries were defined as:

Normal: Vehicles with emissions less than or equal to the upper 95% confidence level (CL) for normal emitters.
Moderates: Vehicles with emissions between the lower 95% CL for highs and the upper 95% CL for normal emitters.
Highs: Vehicles with emissions greater than or equal to the lower 95% CL for highs for vehicles identified as highs.

Ideally, each technology group should have its own set of regime specific growth rates. However, due to a lack of data the regime growth rates were only developed for carbureted and fuel-injected vehicles. Tables 5.1-6 and 5.1-7 show the number of carbureted and fuel-injected vehicles classified as normal, moderate and high emitting by vehicle age, respectively.

Table 5.1-6 shows that between 2-5% of the carbureted vehicles are high emitting. This agrees well with USEPA's[1] estimates for the frequency of liquid leakers, which predicts approximately 5% of the vehicles as being high emitters. In comparison, table 5.1-7 indicates that approximately 32% of the fuel-injected vehicles were high emitting. Upon closer inspection, staff found that vehicles tested by CARB had a higher percentage of vehicles in the high emission regime then those tested by the USEPA. This larger percentage of highs could either result from a recruitment bias or that in earlier technology fuel-injected vehicles; the pressurized fuel system caused more leaks to develop in the evaporative control system. Assuming the former hypothesis to be true, vehicles tested by CARB were excluded in the development of regime growth rates. Ideally, the regime specific populations should be based on random testing of vehicles over a test that is a good indicator of the magnitude of the running loss emissions.

[1] Evaporative Emissions of Gross Liquid Leakers in MOBILE6, by Larry Landman, Draft, Document Number M6.EVP.009 dated June 20, 1999

Table 5.1-6 Distribution of Carbureted Vehicles by Emissions Regime

Age	High	Modr	Norm	Total
2	0	1	0	1
3	0	1	3	4
4	2	8	14	24
5	0	4	8	12
6	0	35	29	64
7	0	10	8	18
8	3	28	10	41
9	0	8	2	10
10	0	26	5	31
11	0	4	3	7
12	0	7	9	16
13	1	15	5	21
14	1	8	8	17
15	0	5	2	7
16	0	7	2	9
17	0	2	2	4
18	0	4	4	8
19	0	4	2	6
20	1	3	7	11
21	0	10	5	15
22	0	3	7	10
23	0	17	6	23
24	0	3	2	5
25	2	3	5	10
26	0	3	5	8
Total	10	219	153	382

Percent of Vehicles by Average Age					
Age Grp	Ave Age	Number	Norm	Modr	High
2-5	4.15	41	0.61	0.34	0.05
6-10	7.55	164	0.33	0.65	0.02
11-15	13.01	68	0.40	0.57	0.03
16-20	18.16	38	0.45	0.53	0.03
21-25	22.76	63	0.40	0.57	0.03

Table 5.1-7 <u>Distribution of Fuel-Injected Vehicles by Emissions Regime</u>

Age	High	Modr	Norm	Total
2	27	56	18	101
3	51	65	38	154
4	14	50	35	99
5	32	33	12	77
6	31	33	10	74
7	23	24	3	50
8	9	15	3	27
9	0	0	3	3
10	9	5	8	22
11	0	1	2	3
12	0	0	3	3
13	0	2	0	2
14	0	0	1	1
Total	196	284	136	616

Percent of Vehicles by Average Age					
Age Grp	Ave Age	Number	Norm	Modr	High
2-4	2.99	262	0.35	0.65	0.00
5-7	5.87	115	0.22	0.78	0.00
8-10	8.90	34	0.41	0.59	0.00
11-13	11.88	8	0.63	0.38	0.00

The fraction of high emitting fuel-injected vehicles is based on USEPA's estimates for the frequency of liquid leakers. This assessment is based on data collected from the CRC running loss study. Vehicles with emissions greater than 7 grams per mile (six vehicles) were classified as gross liquid leakers. Table 5.1-8 shows the frequency of gross liquid leakers as a function of vehicle age. A logistic function was then developed to match these data points. This equation (5.1-2) predicts the percent of liquid leakers as function of vehicle age.

Fraction of Gross Liquid Leakers = 0.06 / (1 + 120*EXP(-0.4*AGE)) **(5.1-2)**

Table 5.1-8 <u>Frequency of Liquid Leakers</u>

Vehicle Age (yr.)	Sample Size	Frequency (%)
8.84	50	2.00
14.24	39	5.13
22.48	61	4.92

The calculation of regime growth rates is problematic since the number of vehicles in each odometer bin is not the same. To calculate the regime growth rates, the percentage of vehicles in each regime were weighted by the number of vehicles in each age group. This provides more weight where there is more data. Table 5.1-9 shows the regime growth rates by fuel delivery system. The general form of the equation is:

F_reg = A + B * Age **(5.1-3)**

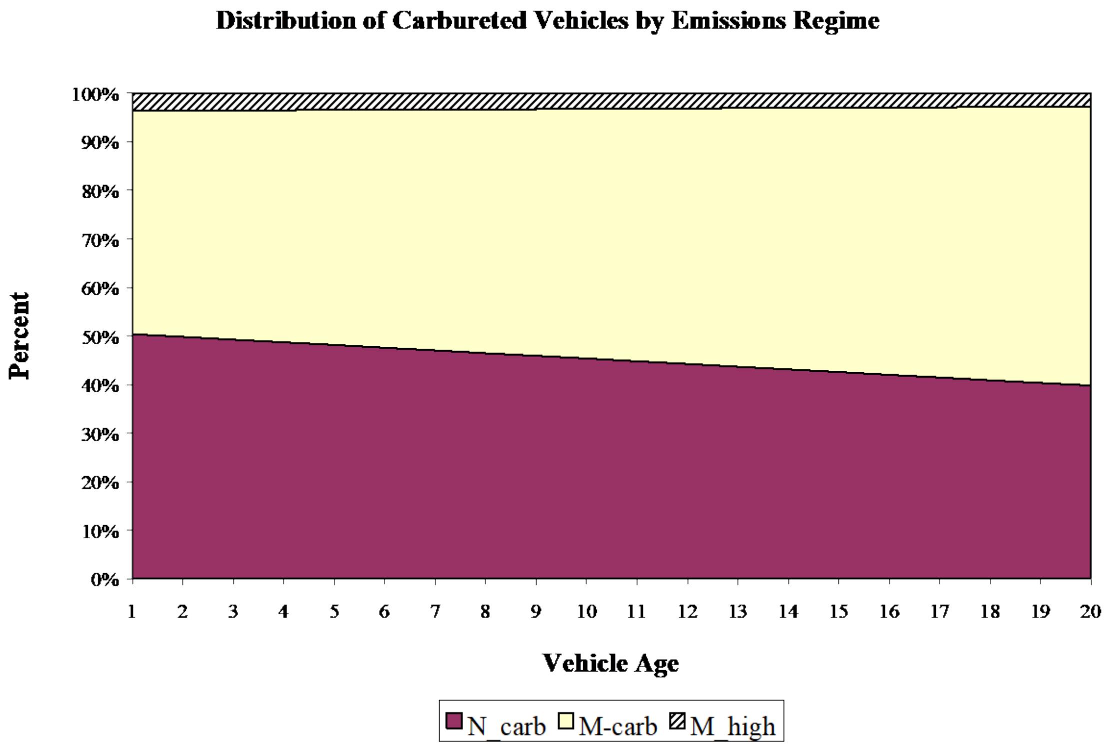
Where:
F_reg is the fraction of vehicles in a given regime
A & B are the regression coefficients

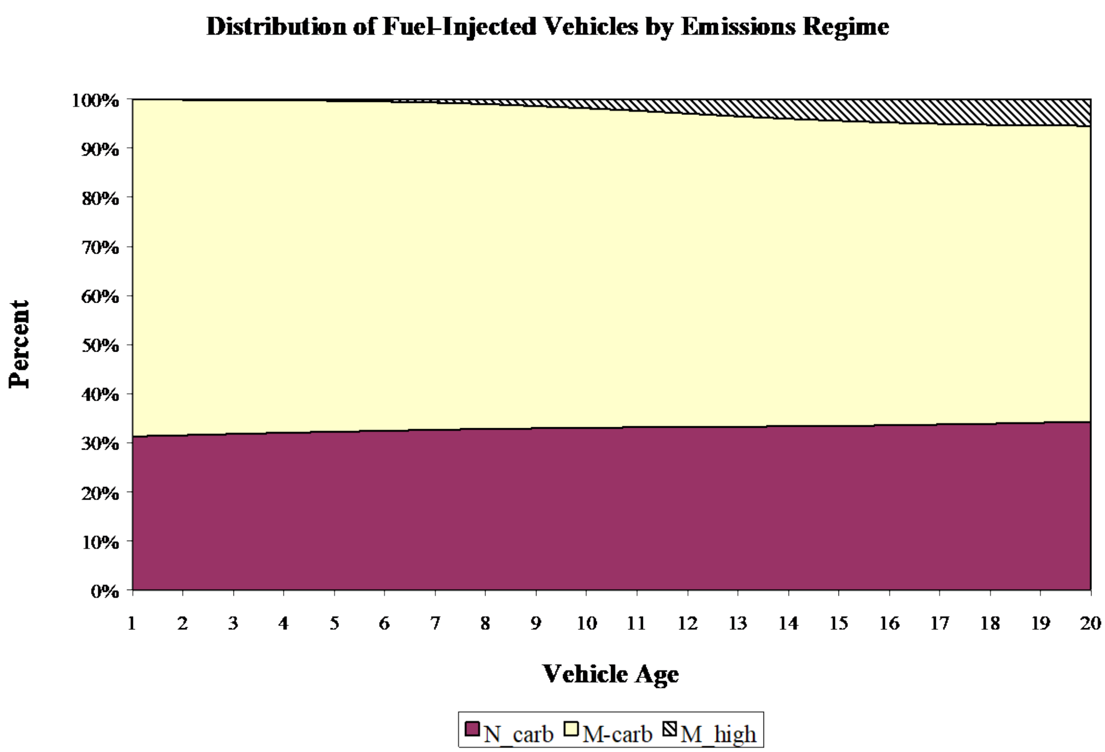
Table 5.1-9 Regime Growth Rates by Fuel Delivery System

Fuel-System	Regime	A	B
Carbureted	Normal	0.509180	-0.005575
	Moderate	0.453626	0.006032
	High	0.036762	-0.000454
Fuel-Injected	Normal	0.310268	0.002625
	Moderate	0.689731	-0.002625
	High	0.06/(1+120*EXP(-0.4*AGE))	
Fuel-Injected	Normal	0.310268	0.002625
OBD2	Moderate	-0.101911	0.014559
	High	0.03/(1+120*EXP(-0.4*AGE))	
Fuel-Injected	Normal	0.310268	0.002625
Near Zero Vehs	Moderate	-0.101911	0.014559
OBD2	High	0.03/(1+120*EXP(-0.4*AGE))	

Figure 5.1-1 shows the distribution of vehicles as a function of vehicle age and by fuel metering system.

Figure 5.1-1 Regime Growth Rates as a Function of Fuel-Delivery System





5.1.5.1 Regime Growth Rates for OBDII Equipped Vehicles

Beginning with the 1996 model year passenger cars, light and medium duty trucks are required to be equipped with an On-Board Diagnostic II (OBDII) system. This system is designed to identify malfunctions that increase emissions by 1.5 times the standard, and illuminate the malfunction indicator light. The OBDII system also stores a fault code identifying the malfunction. Beginning in 1996, the OBDII system on vehicles certified to the enhanced evaporative standard is required to perform a check that will detect vapor leaks from holes greater than 1 millimeter in size. In addition, the system also performs a functional check of the purge valve. The OBDII system is only required to perform a functional check of the purge valve for vehicles not certified to the enhanced evaporative standard. These checks will ensure that malfunctions in the evaporative control system are promptly identified, however, when this repair occurs is dependent upon the consumer. Staff has assumed:

1. There is no growth of moderates for the first 70,000 miles since these vehicles would be immediately repaired under manufacturer warranty. After 70,000 miles the population of moderates would increase. This assumption is based on Table 5.1-10, which shows the number of vehicles with liquid and vapor leaks in the malperforming vehicle data set. The majority of fuel-injected vehicles had vapor leaks with one exception that had a leaking fuel injector. Staff believes that the leaking injector and other vapor leaks would have been identified by the OBDII system.
2. During a smog check, the OBDII system will identify 95 percent of the vehicles in the moderate emissions regime.
3. Vehicles upon repair will migrate to the normal emissions regime. This assumes that the repair correction efficiency is 100 percent. This is based on the fact that the mechanic has to perform a correct repair in order to deactivate the malfunction indicator light.

Please note the OBDII system as designed can only detect vapor leaks, not liquid leaks. However, staff has assumed that by identifying the vapor leaks it will preclude liquid leaks from occurring.

Table 5.1-10 <u>Number of Vehicles with Liquid and Vapor Leaks by Emissions Regime</u>

Fuel-System	Liquid	Vapor
Carbureted	19	16
Fuel-Injected	1	8

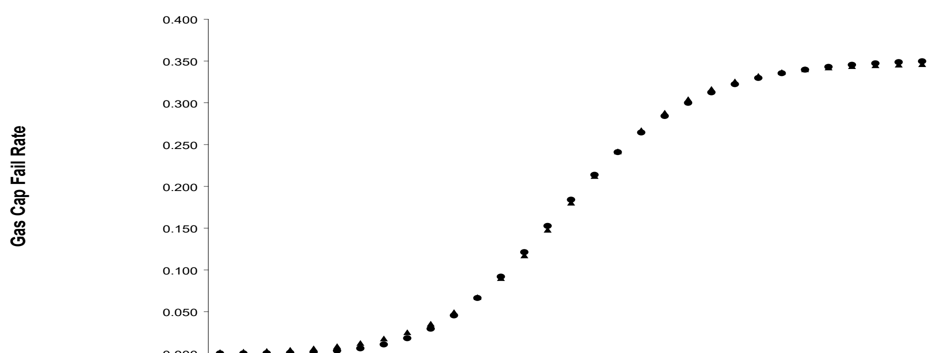
5.1.5.2 Regime Growth Rates for Vehicles Certifying to the Near Zero Evaporative Emissions Standard

Vehicles certifying to the near zero evaporative emissions standard will be phased in beginning with the 2004 calendar year. This requires the combined hot soak plus multi-day diurnal evaporative standard to be reduced from the current 2 grams per test to 0.5 grams per test for passenger cars. While this standard is only designed to reduce hot soak and diurnal emissions; manufacturers will have to design more durable evaporative control systems which will reduce the number of high emitting vehicles (Equation 5.1-2) by a certain percentage. To determine this percentage staff reviewed data collected by Automotive Testing Laboratories (ATL)[2] under contract to the American Petroleum Institute and the CRC, and concluded that the frequency of high emitting vehicles would be reduced by 50% for vehicles certifying to the enhanced and near zero evaporative emission standards. This percentage was determined by reviewing the failure modes of the 22 vehicles found with evaporative system defects and using engineering judgement to decide which failures would not occur on vehicles certified to the near zero evaporative emissions standard. Appendix 5.1-B contains a table describing these vehicles and also lists the defects. An asterisk denotes failures that will not occur in vehicles certified to the near zero evaporative emissions standard.

5.1.6 Effect of Inspection and Maintenance

The distribution of vehicles by emissions regime will change when the vehicles undergo a smog check. In California, the repair mechanics are required to inspect vehicles for leaking or missing gas caps. In 1996 the Bureau of Automotive Repair conducted a roadside inspection test and performed the gas cap test on all vehicles. Figure 5.1-2 shows the observed and predicted gas cap failure rates as a function of the vehicle odometer.

Figure 5.1-2 The Observed and Predicted Gas Cap Failure Rates by Odometer



	0.0	2.8	4.1	6.5	8.6	10.6	11.4	13.0	14.4	15.7	16.3	17.5	18.6	19.1	20.2	21.3	22.3	22.8
▲ Gas Cap Failure Rate**	0.001	0.003	0.004	0.009	0.018	0.035	0.049	0.090	0.148	0.212	0.242	0.288	0.316	0.325	0.336	0.342	0.345	0.345
● Predicted_FR	0.000	0.000	0.001	0.003	0.011	0.030	0.045	0.092	0.153	0.214	0.241	0.284	0.312	0.322	0.335	0.343	0.347	0.349

Odo (*10,000) miles

▲ Gas Cap Failure Rate** ● Predicted_FR

The function used to predict the failure rate is:

$$GC\_FR = k/(1+((k-n)/n)*EXP(-r*odo)) \qquad \textbf{(5.1-4)}$$

[2] Raw Fuel Leak Survey in I/M Lanes, prepared for the API and the CRC by Dennis McClement, ATL, 10 June, 1998

Where:
GC_FR is the fraction of vehicles failing the gas cap test
k = 0.3531113949
n = 0.000093504
r = 0.5529518365
odo is the vehicle mileage divided by 10,000

Figure 5.1-2 shows the fraction of all vehicles that fail the gas cap test as a function of vehicle mileage. It is assumed that vehicles in the moderate emission regime are identified by the gas cap test since vehicles with vapor leaks dominate this regime. The number of vehicles that get moved to the normal regime is calculated by subtracting the gas cap failure rate from the percentage of moderates.

This methodology assumes that the identification and repair correction rates are 95 percent. The gas cap inspection test will mainly identify vapor leaks from poorly sealed, missing or damaged gas caps. However, vapor leaks can occur from other sources within the evaporative control system. Ideally, one should ascertain what fraction of the total vapor leaks result from vehicles with leaking gas caps. These vehicles will be identified and repaired under the current smog inspection test.

5.1.7 RVP and Temperature Correction Factors

CARB's running loss data (used in modeling the RVP and temperature correction factors or RVP&TCF) consists of data collected during various in-house research projects and data supplied by the USEPA. These data are fragmented in that the vehicles were not tested over the entire range of fuel RVPs or over a single prescribed driving cycle. In order to develop an RVP&TCF for running losses, the modal data were normalized with respect to testing conducted using 9.0 RVP fuel at a temperature of 95°F. The majority of the vehicles were tested under these conditions.

This data set was then analyzed using SAS to determine if the RVP&TCF vary between passenger cars and light-duty trucks or with fuel metering system or by model year. Staff found that the RVP&TCF varied by fuel metering system (carbureted, TBI and PFI). However, for modeling purposes it was decided to combine the TBI and PFI vehicles. There were 126 carbureted and 308 TBI/PFI vehicles that were tested with 9.0 RVP fuel at 95°F and at other fuel/temperature conditions. Equations 5.1-5 and 5.1-6 describe the multiplicative RVP&TCF applicable to carbureted and fuel injected vehicles, respectively.

Carbureted Vehicles

$$RVP\&TCF = \frac{(1.2293 + Time*(0.0002*RVP*Temp - 0.0091*rvp - 0.0006*Temp))}{(1.2293 + 0.00735*Time)} \quad \textbf{(5.1-5)}$$

Fuel Injected Vehicles

$$RVP\&TCF = \frac{(1.0858 + Time*(0.0003*RVP*Temp - 0.0144*rvp - 0.0009*Temp))}{(1.0858 + 0.00615*Time)} \quad \textbf{(5.1-6)}$$

Where:

Time is engine time-on in minutes.
Temp. is the ambient temperature (ºF) experienced during the trip.
RVP is Reid Vapor Pressure (a measure of fuel volatility) in pounds per square inch.

Domain
The equations described above are only valid over the following range:
RVP= 6.5 – 13.0
Temperature = 80 – 110 ºF
Time = 0 – 60 minutes

Basically, if the RVP is less than 6.5 then the RVP term is set to 6.5. Similarly, if the ambient temperature is less than 80ºF then the temperature is set to 80ºF. If the trip is longer than 60 minutes then the time is set to 60 minutes.

Equations 3 & 4 are only valid over the domain mentioned above because this incorporates most of the test data. Outside of this range, the RVP&TCF equation and correction factors become unstable. Figures 5.1-3 and 5.1-4 show the change in the RVP&TCF for carbureted and fuel-injected vehicles, respectively, for trip lengths of 10 and 60 minutes.

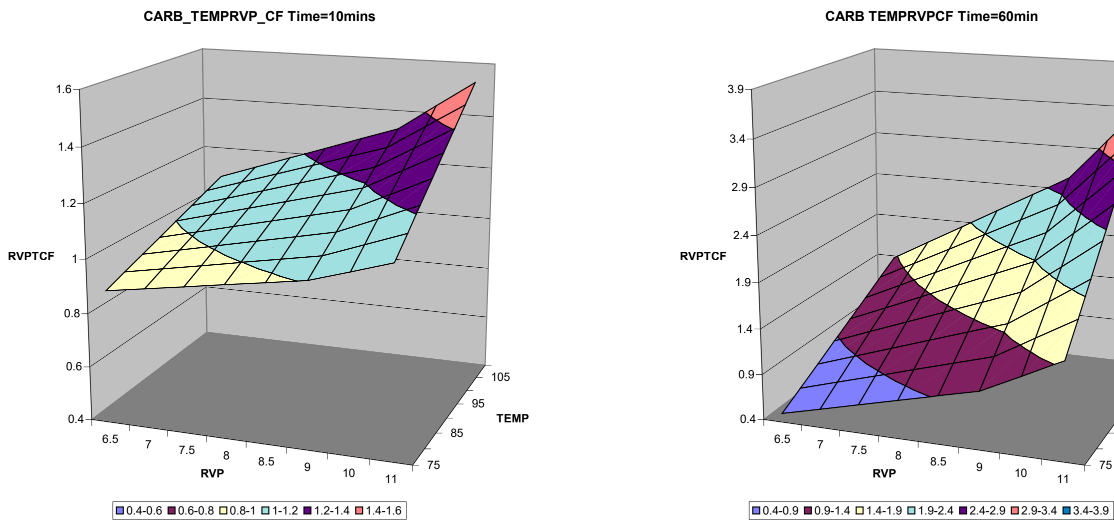


Figure 5.1-3 <u>Change in the RVP&TCF as a Function of Trip Length for Carbureted Vehicles</u>

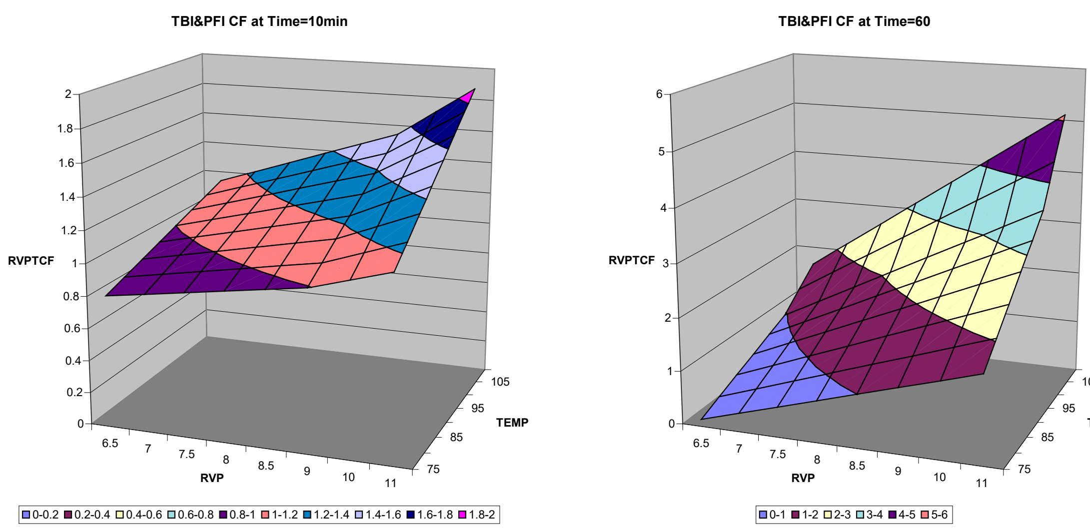


Figure 5.1-4 <u>Change in the RVP&TCF as a Function of Trip Length for Fuel-Injected Vehicles</u>

5.1.8 Discussion and Recommendations

One of the weaknesses of this analysis is with the estimation of the regime growth rates. Ideally the regime growth rates should be calculated for each technology group and vehicle type. However, lack of data necessitated the estimation of regime growth rates by fuel metering system. This assumption is valid if the population of normal, moderate and high emitting vehicles is the same across all carbureted or fuel-injected technology groups. However this assumption may not apply to situations where a particular technology group has a lower percentage of high emitting vehicles than another technology groups simply because the definition of normal, moderate and high changes by technology group. Staff recommend that in future surveillance programs all vehicles should be subject to a single modal LA4 running loss test. This information is necessary in assessing/revising the regime specific growth rates.

In estimating the benefits from a gas cap test, it is assumed that a vehicle failing the gas cap test has emissions that correspond to a vehicle in the moderate emissions regime. Staff recommend that this be verified given that the regime definition change by technology group. It may be possible that some older vehicles that fail the gas cap test may fall into the normal emissions regime. Ideally, one should determine the fraction of vehicles in each emissions regime and technology group that fail the gas cap test. This is the fraction most likely to get repaired under the current smog check.

Appendix 5.1-A

Table 5.1-A1 shows the emission rate of fuel-injected cars and trucks not subject to the enhanced evaporative running loss standards.

Table 5.1-A1

				Intercept A	Time B	Time^2 C	Odometer D	Age E
Cars	TBI/PFI	All	Normal	-0.1115497	0.0223147	0	0	0.00800653
			Moderate	-0.12943963	0.11137024	0	0	0
			High	-1.48947344	0.60721658	0	0	0
Trucks	TBI/PFI	All	Normal	-0.18308557	0.00961453	0	0	0.0213216
			Moderate	-2.08792222	0	0.00688323	0	0.27679645
			High	-1.48947344	0.60721658	0	0	0

The enhanced evaporative running loss regulation requires vehicles at 100,000 miles to meet the 0.05 grams per mile standard when tested at 105ºF over three back-to-back LA4's. In order to estimate the emission rates for vehicles subject to this standard, staff has assumed that this standard will be met at 100,000 miles or by a 9-year-old vehicle using 7.0 RVP fuel, when tested at 105ºF. The average time to complete three back-to-back LA4's is 75 minutes. Using the equations in Table 5.1-A1, the emissions at the end of 3 LA4's are:

Cumulative emissions (grams) at time=75 minuntes, age=9 years and odometer =100,000 miles				
				grams
Cars	TBI/PFI	All	Normal	1.634
			Moderate	8.223
			High	44.052
Trucks	TBI/PFI	All	Normal	0.730
			Moderate	39.121
			High	44.052

These emissions are then adjusted with respect to the temperature (105ºF) and fuel RVP (7.0) used during vehicle certification. The RVP&TCF are calculated by substituting these values in to equation 2 and the result is 1.78567. Table 5.1-A2 shows the temperature and RVP adjusted emission rates, which were calculated by multiplying the emissions in Table 5.1-A2 by RVP&TCF.

Table 5.1-A2

	Car	Truck
	Total grams per 75 mins	
Normal	2.918	1.303
Moderate	14.684	69.858
High	78.662	78.662

The running loss emissions from vehicles meeting the enhanced evaporative standard is: 3*7.5*0.05=1.125 grams. In order to meet these standards the emission rates from cars and trucks in the normal emission regime must be reduced by 61.45% and 13.68%, respectively. The new rates are calculated by multiplying the car and truck emission rates by 0.38554 and 0.86315, respectively.

Appendix 5.1-B

Table 1.
Leaking Vehicle Descriptions

Veh	MY	Make	Model	Eng	Fuel	Class	Comment
5	80	CHEV	CUSTOM 10	5.0	Carb	Leak	FUEL LINE TO PUMP LEAK AT HOSE CLAMP DUE TO PINCHED HOSE.
12*	86	OLDS	CUTLASS	5.0	Carb	Gross	FUEL INLET AND FRONT OF CARB 1 DROP EVERY 5 SECONDS. LEAKING AT BASE OF FUEL FILTER 1 DROP EVERY 5 SECONDS. FUEL PUMP, 1 DROP EVERY 20 SECONDS.
71*	86	DODGE	OMNI	2.6	Carb	Gross	LEAKING 1 DROP EVERY 30 SECONDS AT CARB.
82	74	DODGE	VAN	---	Carb	Leak	HEAVY SEEPAGE AT FUEL FILTER, NOT QUITE A DRIP
131*	85	CHEV	MONTE CARLO	5.0	Carb	Gross	LEAKING AT FRONT OF CARB AND FUEL FILTER. GAS ODOR
153*	74	VW	BEETLE	1.6	Carb	Gross	CARB LEAKED ON SIDE. OWNER MADE PLUG WITH EPOXY; STILL LEAKS.
178*	82	TOYOTA	TERCEL	1.5	Carb	Leak	SMALL LEAKAGE AT SIDE OF CARB, LEAKING TO MANIFOLD. SLIGHT ODOR.
183*	73	FORD	F100	5.9	Carb	Leak	VERY SMALL DROP ON CARB AT ACCELERATOR PUMP. LESS THAN ONE DROP EVERY 30 SECONDS. SLIGHT ODOR.
285*	76	CHEV	CORVETTE	5.7	Carb	Leak	SLIGHT LEAK IN FRONT OF CARB-1"ON PAPER TOWEL. SLIGHT ODOR
324*	72	FORD	MUSTANG	5.8	Carb	Leak	SMALL DRIP ON FRONT OF CARB. AT FUEL FILTER, MORE THAN 1" ON TOWEL. SLIGHT ODOR.
326	73	BUICK	WAGON	5.7	Carb	Leak	FUEL LINE CRACKED AT FUEL FILTER, ELECTRIC TAPE USED TO TRY TO REPAIR DRIP. SLIGHT ODOR.
372	80	CHEV	SILVERADO	5.7	Carb	Leak	SMALL LEAK AT FRONT OF CARB AT FUEL FILTER APPROX. 1" ON PAPER TOWEL. SLIGHT ODOR.
375	86	MERCURY	SABLE	3.0	PFI	Leak	HOSE FROM FILLER TUBE TO TANK NEEDS REPLACED-LIGHT DRIPPING. STRONG ODOR UNDER PASSENGER REAR SIDE OF CAR.
665	85	BUICK	CENTURY	2.5	TBI	Leak	LEAKING AT FUEL INLET OF THROTTLE BODY. GAS ODOR
706*	82	MERCURY	LYNX	1.6	Carb	Leak	LEAKING AT FRONT OF CARB AND FUEL FILTER. GAS ODOR
715*	85	FORD	F250 PICKUP	7.4	Carb	Leak	LEAKING AT FRONT OF CARB AND FUEL FILTER. GAS ODOR
722	86	PLYMOUTH	RELIANT	2.2	TBI	Leak	LEAKING AT FUEL INLET OF THROTTLE BODY. GAS ODOR
747*	85	OLDS	CUTLASS	5.0	Carb	Leak	LEAKING AT FRONT OF CARB AND FUEL FILTER. GAS ODOR
786*	83	BUICK	SKYLARK	2.8	Carb	Leak	LEAKING AT FRONT OF CARB AND FUEL FILTER. GAS ODOR
863	84	CHEV	CAVALIER	2.0	TBI	Leak	LEAKING AT FUEL INLET OF THROTTLE BODY. GAS ODOR
949	83	OLDS	OMEGA	2.5	TBI	Leak	LEAKING AT FUEL INLET OF THROTTLE BODY. GAS ODOR
964	79	VW	RABBIT	1.7	Carb	Gross	GAS TANK DRIPPING 1 DROP EVERY 3 SECONDS. NEEDS TANK REPLACEMENT.

Gross leaks - 4 vehicles
Leaks (liquid but less than gross) - 18 vehicles
An asterix denotes vehicles that will not incur defects if designed to meet zero evap standards.