APPENDIX B
PERMEATION/EMISSIONS INVENTORY

CONTENTS

B-1) Emissions Weighting Factors

Weighting Factors

Tech groups. The fractions of VMT, populations and emissions included in each tech group or model year group were calculated by group. The model-year ranges for each tech group are shown in Table 1 below.

Table 1

Tech Group	Model Year
Tech 1	1965-1974
Tech 2	1975-1980
Tech 3	1981-1985
Tech 4	1986-1995
Tech 5	1996-2015

The NOx, ROG, and CO emissions for each model-year group were calculated for the 2015 calendar year. The values passed from EMFAC to the Predictive Model are shown in Table 2.

These were calculated on a Statewide basis. The "sub-area" option was used, meaning the temperatures and relative humidities for each individual county was used and the result summed for the statewide basis.

These values are for gasoline vehicles only. They are for only the following vehicle types.

Table 3

Veh Class	Description
PC	Passenger Cars
LT1	Light duty trucks <3750 lb GVWR
LT2	Light duty trucks 3750-5750 lb GVWR
MT3	Medium duty trucks 6000-8500 lb GVWR
MT4	Medium duty trucks 8500-10,000 lb GVWR

Summer Planning Conditions. The temperature conditions (and relative humidities) used for summer planning conditions were the ones for the California 8-hour Ozone design value planning day. The default summer planning temperature/humidities for the

EMFAC model are those of the Federal 8-h Ozone Design Value day. Table 4 shows both temperature profiles for average Statewide conditions. In general, the values for the California 8-h Ozone design value day are warmer and drier than the Federal 8-h Ozone design value day values.

Ethanol Sensitivity. The EMFAC model assumes 6% ethanol in the gasoline after the year 2004, and 10% MTBE in the gasoline between 1996 and 2003. A special version of the EMFAC model was made which turned the ethanol introduction feature off. This allowed generation of estimates of emissions with and without ethanol in the fuel.

Table 2
EMFAC Submissions to Predictive Model

		Tech 1	Tech 2	Tech 3	Tech 4	Tech 5	All Techs
Population		70,999	132,309	302,863	2,361,076	24,177,506	
VMT	kmi/d	1,206	2,462	6,085	54,696	874,981	
Exhaust Emissions							
HC Exh	tpd	10.9	10.5	10.1	51.2	73.6	
CO	tpd	117.9	189.6	175.8	797.9	1800.8	
NOx	tpd	6.3	9.4	14.8	92.3	176.5	
Evaporative Emissions							
Diurnal/Resting	tpd	2.1	3.6	5.5	30.3	27.5	69.0
Hot Soak	tpd	1.1	0.9	1.9	16.3	19.8	40.0
Running Loss	tpd	3.6	4.0	5.2	43.5	52.6	108.8
Diurnal/Resting w/o Ethanol	tpd						60.0
Hot Soak w/o Ethanol	tpd						38.9
Running w/o Ethanol	tpd						106.8
Permeation							
Diurnal Permeation	tpd	1.0	1.9	2.8	16.8	16.9	
Hot Soak Permeation	tpd	0.1	0.1	0.2	1.9	2.5	
Running Loss Permeation	tpd	0.1	0.2	0.4	3.8	0.8	
Diurnal Permeation w/o EtOH	tpd	0.9	1.6	2.3	12.4	14.8	
Hot Soak Permeation w/o EtOH	tpd	0.1	0.0	0.1	1.3	1.9	
Running Loss Permeation w/o EtOH	tpd	0.1	0.2	0.3	2.7	0.7	

2015 Statewide, California 8-h O3 DV Summer Planning Temperatures
PC+LT1+LT2+MT3+MT4 vehicle categories, gasoline-fueled

Table 4
Statewide Average Temperature/RH profiles

	California 8-h O3 DV		**Fed 8-h O3 DV**	
Time	**Temperatures**	**Relative Humidity**	**Temperatures**	**Relative Humidity**
h	°F	%	°F	%
0	69.2	44.1	67.6	47.9
1	68.3	44.0	66.7	47.9
2	67.6	44.3	66.2	47.8
3	67.8	42.9	66.7	46.3
4	66.4	44.8	65.0	48.6
5	66.2	45.2	65.0	48.8
6	68.5	44.5	67.3	47.7
7	73.2	40.8	71.9	43.6
8	78.3	35.6	76.7	38.2
9	82.4	31.3	80.9	33.6
10	85.6	28.6	84.0	30.6
11	88.0	26.7	86.3	28.5
12	89.7	25.5	87.8	27.3
13	91.0	24.4	88.8	26.5
14	91.1	24.1	89.0	26.3
15	90.6	24.4	88.4	26.8
16	89.1	25.6	86.9	28.0
17	86.4	27.9	84.1	30.6
18	82.4	31.7	80.3	34.5
19	78.2	36.2	76.3	39.1
20	75.3	39.4	73.7	42.4
21	73.4	41.2	71.9	44.2
22	72.0	42.2	70.3	45.7
23	70.7	43.1	69.2	46.6

Permeation. Organic gas emissions from cars are of two types: exhaust and evaporative. The evaporative emissions are of basically three types: vapor displacement/generation, liquid leaks, and permeation. The volatility (vapor pressure) of the gasoline has a major effect on vapor generation in evaporative processes. It was thought previously that two oxygenated gasolines with the same percent oxygen (2% oxygen is 10% MTBE or 6% ethanol) and the same RVP (Reid vapor pressure) would have the same evaporative emissions.

The CRC E65 test program showed that gasoline oxygenated to 2% O_2 with ethanol had much higher evaporative emissions due to permeation than did gasoline with the same RVP and 2% oxygen but oxygenated with MTBE. Table 5 shows the ratio of permeation emissions of ethanol containing fuel to MTBE-containing fuel determined from the E65 data by ARB staff.

Table 5

Emission Regime	Ethanol Permeation Augmentation over MTBE
Normal Emitters	2.4
Moderate Emitters	1.2
High Emitters	1.02

To use these numbers, one has to know the fraction of the population or the emissions from normal, moderate or high emitters, and one has to know the fraction of the evaporative emissions which is permeation *vs* vapor generation.

The evaporative emission estimates from the EMFAC model include permeation, but do not break it out explicitly. To do this, we assumed that the resting loss process was a surrogate for permeation (that 90% of resting loss was permeation). So we used the EMFAC resting loss correlations as a function of temperature and emission regime to estimate the amount of evaporative emissions which was permeation.

EMFAC performs all the calculations for normal, moderate and high emitting vehicles but does not explicitly print out those results. So to calculate the emissions attributable to each category to be able to apply the proper augmentation ratio for ethanol, the EMFAC correlations for emission rate and population fraction for each emission regime as a function of age and temperature were used.

B-2) Predictive Model Back-up/EMFAC Model Change

SUBJECT: INCREASED EVAPORATIVE EMISSIONS FROM ON-ROAD MOTOR VEHICLES DUE TO ETHANOL PERMEATION: CA 8-h OZONE TEMPERATURE PROFILES

LEAD: BEN HANCOCK

SUMMARY

In EMFAC 2002, the emission benefits for Phase 2 RFG were correlated to oxygen content and Reid Vapor Pressure (RVP) without regard to the oxygenating species. That is, a gasoline with 10% methyl t-butyl ether (MTBE) was assumed to be equivalent with respect to emissions to a gasoline with 5.7% ethanol (EtOH) because both fuels contained 2% oxygen.

Recent testing sponsored by the Coordinating Research Council (CRC) shows that gasoline oxygenated with EtOH results in higher evaporative emissions compared to an MTBE-containing fuel with an equivalent vapor-pressure and oxygen content. In the CRC E65 study the fuel systems of several vehicles were removed and their diurnal evaporative permeation emissions measured with fuels containing either 10% MTBE or 5.7% EtOH. The results of this study are reflected in EMFAC 2007, the update to EMFAC 2002.

Staff developed new summer planning daily temperature profiles for all the counties in California, based on more recent temperature data and using improved gridding allocation methods.

Staff correlated the E65 diurnal data with temperature, and made separate correlations for normal and moderate emitters. Staff extended the diurnal results to the running loss and hot soak processes.

The CRC E65 study was amended (E65 Phase 3) to include two near-zero evap technology vehicles. These data were included, modifying the ethanol augmentation values from the first set of 10 vehicles.

The emissions estimates for this change are shown below in Tables 1 through 4. The emissions estimates we are presenting in this paper are Reactive Organic Gases (ROG). The population is gasoline passenger cars and light and medium-duty trucks up to 10000 lb GVWR. The emissions increase is mostly in the diurnal/resting process. The emissions increases fall with time. This is due to the shift to cleaner cars. The emissions increase for 2005 represents about 9% of the evaporative inventory and about 4% of the total onroad ROG emissions. For 2015 the emissions increase is about 7% of the total evaporative inventory and 3.4% of the total onroad ROG inventory. This is due to greater implementation of near-zero evap vehicles as time progresses.

Table 1
Summary of Emissions Changes due to Ethanol Permeation
Cal 8-h O_3 Temperature Profiles
Gasoline PC+LT1+LT2+MT3+MT4
Calendar Year 2005

Basin	Evaporative Emissions Increase, tons per day				
	Diurnal	Resting	Running	Hot Soak	Total Evap
Statewide	10.9	12.0	3.0	2.8	28.8

Table 2
Summary of Emissions Changes due to Ethanol Permeation
Cal 8-h O_3 Temperature Profiles
Gasoline PC+LT1+LT2+MT3+MT4
Calendar Year 2010

Basin	Evaporative Emissions Increase, tons per day				
	Diurnal	Resting	Running	Hot Soak	Total Evap
Statewide	6.8	7.5	2.4	1.8	18.4

Table 3
Summary of Emissions Changes due to Ethanol Permeation
Cal 8-h O_3 Temperature Profiles
Gasoline PC+LT1+LT2+MT3+MT4
Calendar Year 2015

Basin	Evaporative Emissions Increase, tons per day				
	Diurnal	Resting	Running	Hot Soak	Total Evap
Statewide	4.2	4.8	2.0	1.2	12.1

Table 4
Summary of Emissions Changes due to Ethanol Permeation
Cal 8-h O_3 Temperature Profiles
Gasoline PC+LT1+LT2+MT3+MT4
Calendar Year 2020

Basin	Evaporative Emissions Increase, tons per day				
	Diurnal	Resting	Running	Hot Soak	Total Evap
Statewide	2.5	3.3	1.6	0.8	8.1

NEED FOR REVISION

In response to Executive Order D-5-99 issued by Governor Gray Davis, MTBE was phased out of all gasoline sold in California in 2003. The addition of ethanol to gasoline as a replacement for MTBE was required in 2004. Some refiners switched to ethanol oxygenate in 2003, the rest in 2004. Because of the difficulty of tracking these individual formulation changes, EMFAC assumed the switch from MTBE to ethanol happened at once in 2004.

As a result, the fuel correction factors in EMFAC must be updated to reflect the impact that EtOH has on emissions, most notably, higher permeation rates through fuel tank walls, hoses, and fittings.

METHODOLOGY FOR REVISION

The Coordinating Research Council (CRC) sponsored a study (E65)[1] in which the fuel systems of several cars were removed and tested for diurnal evaporative emissions using Phase 2 reformulated gasoline (RFG2) containing either MTBE or EtOH. Although the test procedure was only designed to estimate the impact of EtOH for the diurnal heating process, ARB staff also developed a methodology to adjust the emission inventory for the running loss and hot soak evaporative emission processes.

The proposed modifications will correct the evaporative emission rates in EMFAC to reflect the presence of EtOH. The development of process specific correction factors is proposed for this purpose. The form of the correction factor is given below.

$$\mathbf{ER_{etoh} = ER_{t,rvp} * (PERMfr * EtRFG2r + 1 - PERMfr)} \qquad \textbf{Eqn 1}$$

Where

Where	$\mathbf{ER_{etoh}}$	is the ethanol fuel emission rate expressed in grams per hour (g/hr)
	$\mathbf{ER_{t,rvp}}$	is the MTBE emission rate expressed in g/hr, corrected for temperature and RVP (internal to EMFAC)
	PERMfr	is the permeation fraction for each evaporative process (equation 3)
	EtRFG2r	is the EtOH to MTBE ratio, as a function of temperature and emission regime (equation 2)

Ethanol-to-MTBE ratio (EtRFG2r)

$$\textbf{EtRFG2r = diurnal rate on EtOH fuel} \div \textbf{diurnal rate on MTBE fuel} \qquad \textbf{Eqn 2}$$

The ARB staff modeled the CRC E65 permeation study results as the ratio of diurnal emissions of ethanol-containing RFG2 to emissions of MTBE-containing RFG2. For the 10 vehicles

[1] Haskew, H., T. Liberty and D. McClement. 2004. Fuel Permeation from Automotive Systems. Final Report for CRC Project E-65. Coordinating Research Council, Alpharetta GA. Available at www.crcao.com/reports/recentstudies2004/E65 Final Report: 90204.pdf or www.arb.ca.gov/fuels/gasoline/permeation/090204finalrpt.pdf.

tested, the ratios of the 48 hourly diurnal emission rates for the EtOH and MTBE-containing fuels were analyzed.

In the E65 project, the fuel systems from 10 cars were removed from the chassis and subjected to normal diurnal tests. In a diurnal evaporative test, the subject vehicle or system is placed in a temperature-controlled sealed chamber, and the temperature of air in the chamber is slowly varied, to mimic changes in ambient temperature typical of an average summer day or other day. During the test, the air in the enclosure is sampled periodically for gas-phase hydrocarbon concentration. The cumulative gas-phase inventory is calculated nominally at each hour as the hydrocarbon (HC) concentration times volume, and differentiated to derive the hourly emission rates. These tests are normally done for multiples of 24 hours: 24 hours, 48 hours and 72 hours being most common.

A description of the vehicles tested in CRC E65 is presented in Table 5 below. They were distributed in age like the South Coast vehicle population. (One particular model year vehicle to represent a decile of the population of that age range.)

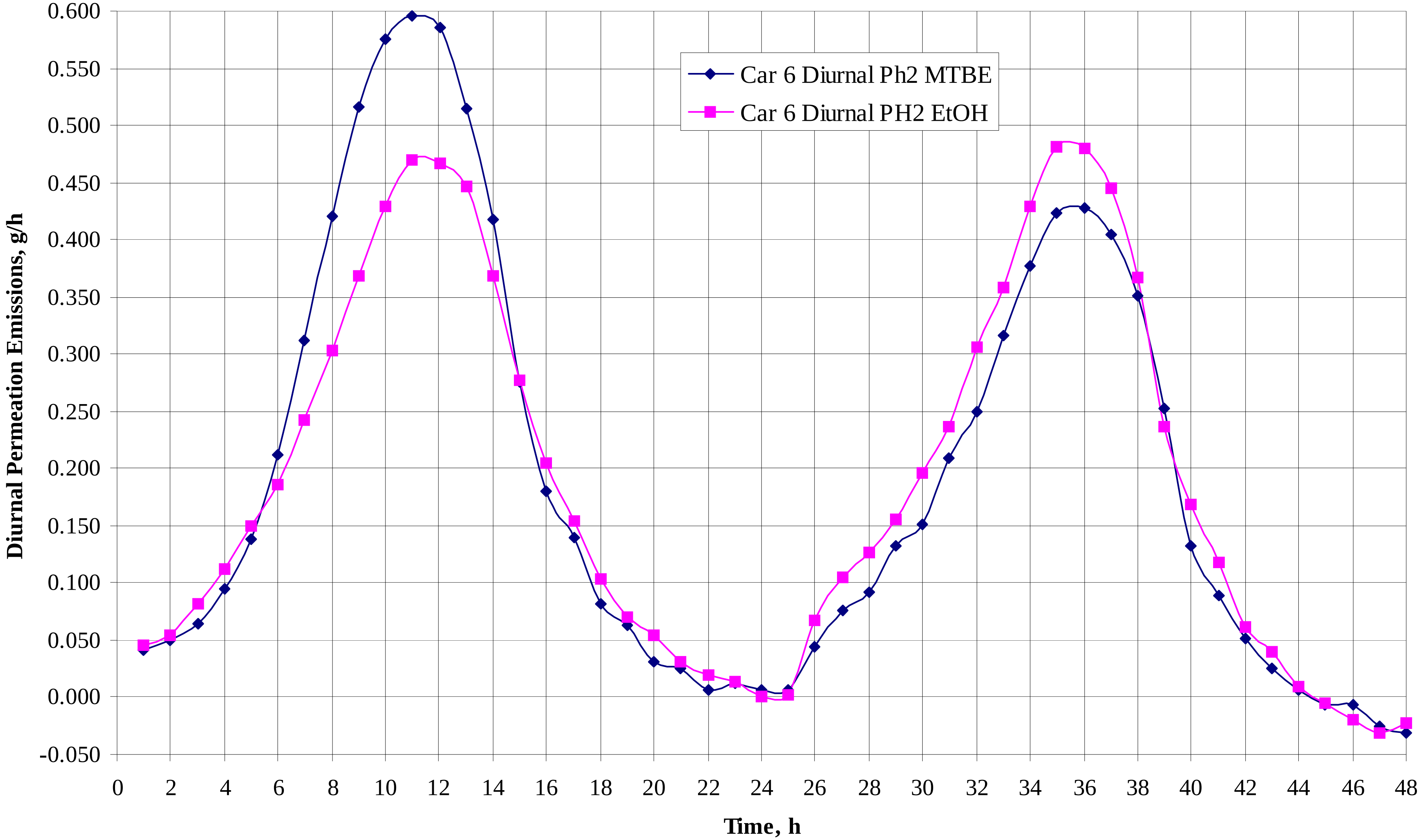
Table 5 – CRC E65 Test Fleet

Veh #	Vehicle Description	Veh #	Vehicle Description
1	2001 Tacoma Pickup	6	1993 Caprice
2	2000 Odyssey Van	7	1991 Accord
3	1999 Corolla	8	1989 Taurus
4	1997 Caravan Van	9	1985 Sentra
5	1995 Ranger Pickup	10	1978 Cutlass

For the E65 data, the only pattern that staff could discern from the diurnal permeation rate results was that two of the vehicles (5 and 6) had absolute emissions that were five to ten times higher than the others. However, these vehicles had much lower increases in emissions due to EtOH, resulting in lower ratios. Staff considered the results for Car 6 anomalous in that the diurnal emissions recorded for the MTBE fuel were higher than for EtOH fuel for the first 24-hour diurnal, but not for the second. For all the other vehicles tested, the EtOH results were consistently higher than the MTBE results. (See Figure 1).

..

Figure 1
E65 Diurnal Permeation Results, Car 6



The CRC, as an add-on to the E65 effort, contracted for the testing of some newer vehicles and several different ethanol/gasoline mixtures[2]. The two cars are described below in Table 6.

Table 6 – CRC E65 Phase 3 Test Cars

Veh #	Vehicle Description	Veh #	Vehicle Description
11	2004 Taurus	12	2004 Sebring

The results from Vehicle 11, a near-zero evap vehicle, were very similar to those from Vehicle 1, an enhanced-evap vehicle. The results from Vehicle 12, a zero-evap vehicle, had lower ethanol augmentation than Vehicles 11 or 1.

In EMFAC, evaporative emissions are modeled utilizing three emission regimes: normal, moderate and liquid leaker. "**Normal**" emitting vehicles are defined as those that are generally free of defect and have HC emissions at or below their certification standard. "**Moderate**" emitters have some defect that can be detected through inspection or by the On-Board Diagnostic System (OBD) and emit at levels higher than the certification standard but less than vehicles with liquid leaks. As the name implies, "**liquid leakers**" are those vehicles that literally drip fuel. These vehicles are the evaporative equivalent to "Super Emitters" for exhaust.

Given EMFAC's structure, staff decided to group the CRC data into these three emission regimes. Based on analysis of the E65 data, the vehicles were classified as follows:

- 10 normal-emitting vehicles, 1, 2, 3, 4, 7, 8, 9, 10, 11 and 12
- 2 moderate-emitting vehicles, 5 and 6.
- 0 liquid leakers (reflects study design).

Separate ethanol-MTBE ratios were derived from data for normal and moderate emitters. There were no data or experiments for liquid leakers (high emitters). In discussions with stake holders, a value of 1.02 was chosen to make the per car ethanol emissions increase about equal to that of the other regimes. For vehicle 6, the moderate-emitting vehicle with the anomalous first day test on MTBE fuel, the day-2 results for both MTBE and EtOH were also assumed for the first day.

All of the hour-by-hour ethanol-to-MTBE ratios were plotted versus temperature. Scatter plots for the normal and the moderate emitters are shown in Figures 2 and 3. There is little variation of the hourly ratios with temperature. Therefore, the mean values were used. The results of the linear regression analysis are shown in Table 7 below. The final recommended values for EtRFG2r are shown in Table 8.

[2] Haskew, H. M., T. F. Liberty and D. McClement. 2006. Fuel Permeation from Automotive Systems: E0, E6, E10 and E85. Interim Report for CRC Project E-65-3. Coordinating Research Council, Alpharetta, GA.

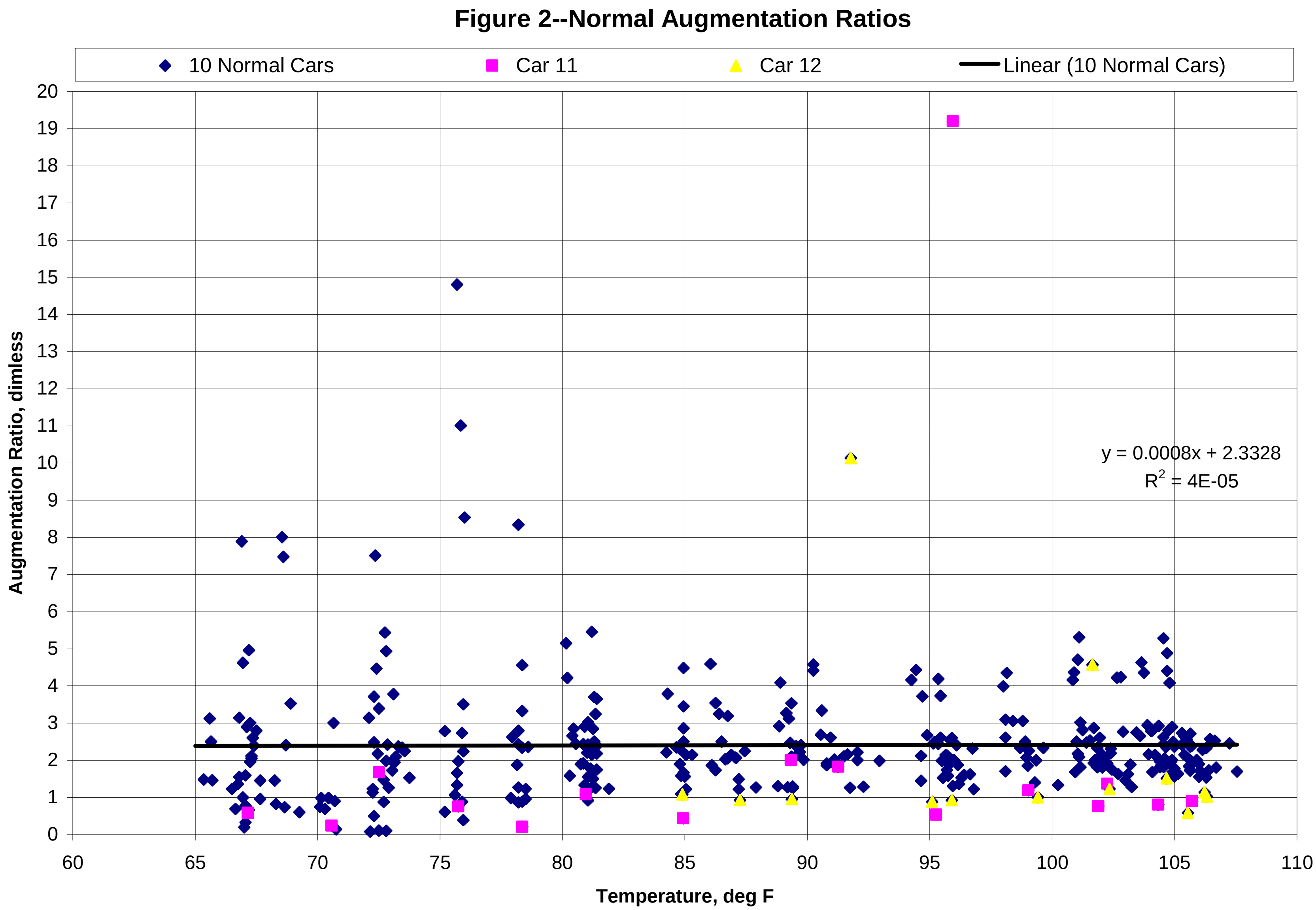


Figure 2--Normal Augmentation Ratios
10 Normal Cars
Car 11
Car 12
Linear (10 Normal Cars)
y = 0.0008x + 2.3328
R2 = 4E-05
Augmentation Ratio, dimless
Temperature, deg F
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
60
65
70
75
80
85
90
95
100
105
110

Figure 3
E65 Diurnal Ratios, Moderates

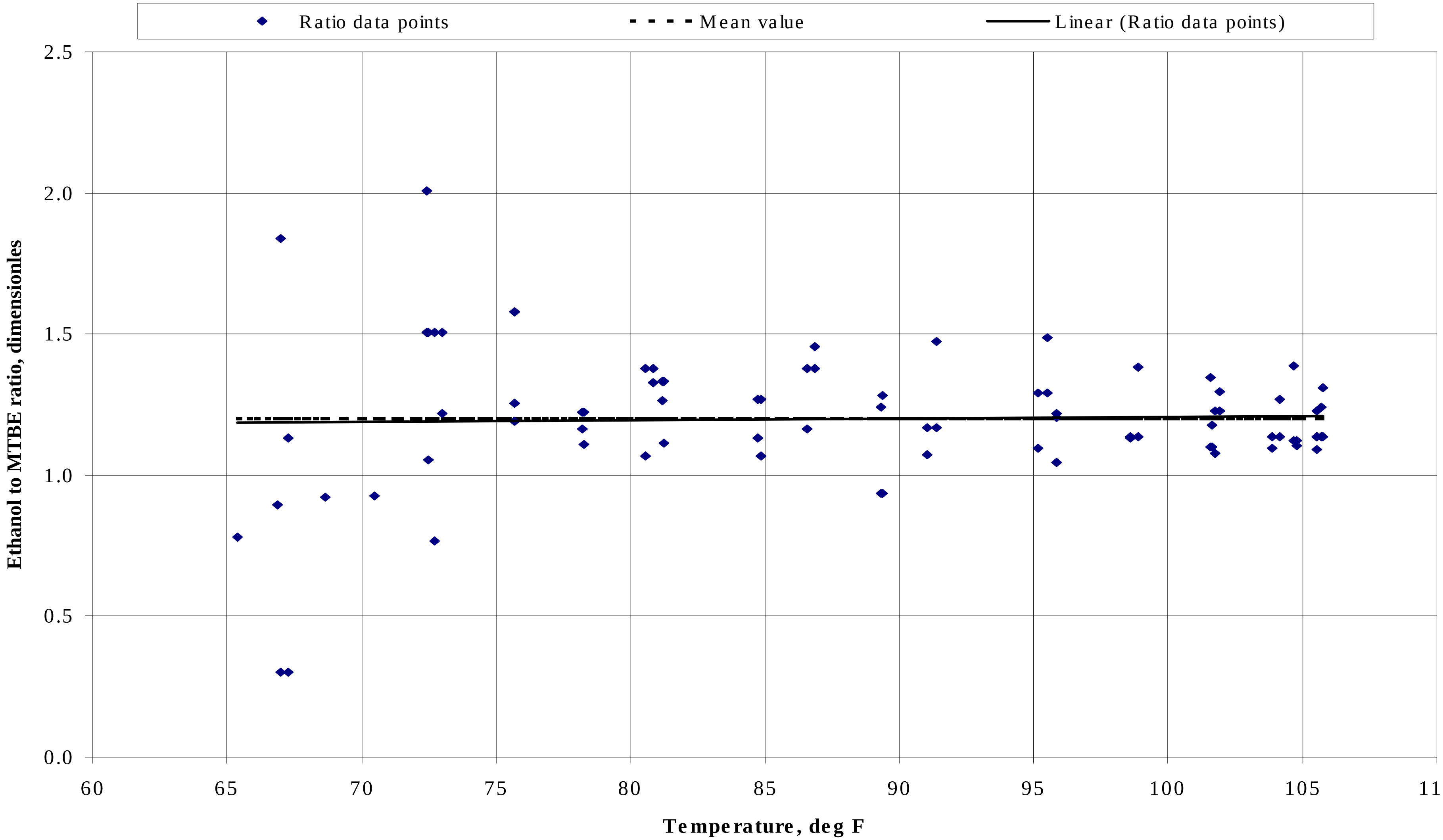


Table 7 – Linear Regression Statistics for E65 diurnal Augmentation Ratios

	Best fit Slope	Intercept	p-statistic on slope	Mean	Standard deviation
	per degree F				
Normals	0.0008	2.333	0.801	2.38	1.99
Moderates	0.0006	1.151	0.787	1.20	0.24

Table 8—Augmentation ratio values

Emitter Category	Ratio	Absolute Permeation MTBE fuel*	Absolute Permeation Ethanol Fuel*
		g/d	g/d
Normals	2.4	0.3	0.8
Moderates	1.2	2.0	2.8
Liquid Leakers	1.02	30.6	31.2

* Approximate values for 2010 fleet

Permeation Fraction (PERMfr)

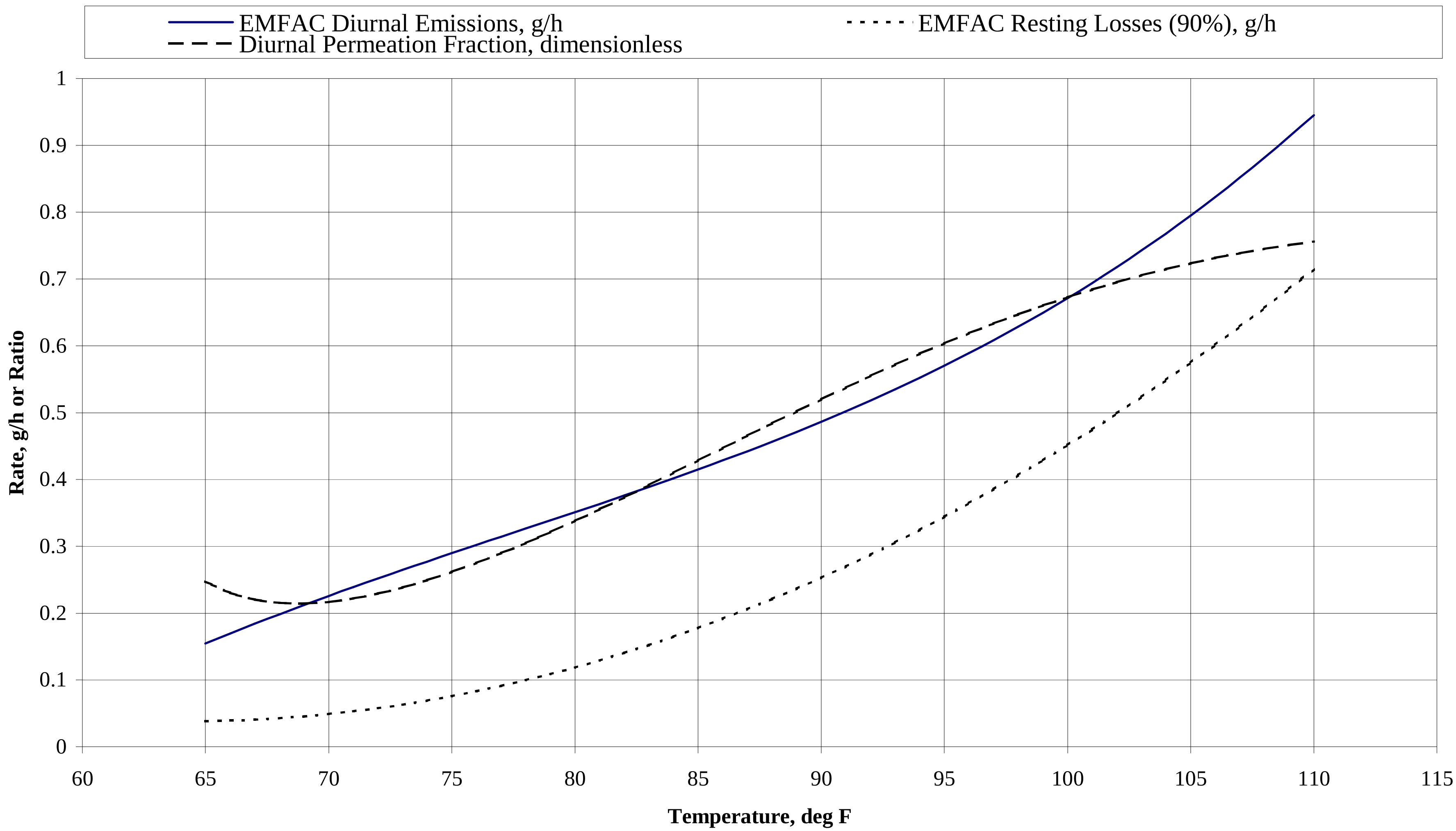
The CRC E65 study was only designed to investigate the emission effects of permeation through hoses and fuel tanks. No liquid leaks were present in the vehicle sample. Vapor losses were excluded from the diurnal results by venting the vapor storage canisters outside of the test enclosure. Therefore, the ethanol increases described above are only applicable to that part of the diurnal emissions attributable to permeation.

To determine this fraction, staff assumed that resting losses were a reasonable approximation for permeation. Resting losses are those evaporative emissions that occur when the engine is not running and the ambient temperature is falling or stable. The ratio of resting loss to the diurnal emissions would approximate the fraction of permeation for the diurnal heating process. This ratio was corrected by a factor of 90% in recognition that not all resting losses would be attributable to permeation.

$$\mathbf{PERMfr = 0.9 * ER_{resting} * RVPTCF / (ER_{process} * RVPTCF)} \qquad \textbf{Eqn 3}$$

Where
- **PERMfr** is the permeation fraction
- $\mathbf{ER_{resting}}$ is the emission rate for evaporative resting loss in grams per hour, as a function of temperature, tech group, and emission regime (internal to EMFAC)
- **RVPTCF** is the vapor pressure and temperature correction factor (internal to EMFAC)
- $\mathbf{ER_{process}}$ is the emission rate for the particular evaporative process expressed in grams per hour (internal to EMFAC)
- **0.9** is the fraction of resting loss assumed to be attributable to permeation

Figure 4
Diurnal Permeation Fraction
Example, 79-94 Fuel Injected



Application by Process

Diurnal/Resting Permeation Fraction

The ratio was calculated using the relationship between resting loss and diurnal emissions as a function of temperature as estimated by EMFAC. Figure 4 illustrates the diurnal emission rate *vs* temperature, 90% of resting loss *vs* temperature, and their ratio for 79-94 model year fuel-injected cars using the 65-110°F correlation.

Running Loss Permeation Fraction

As with diurnal emissions, staff assumed that resting loss was a reasonable surrogate for permeation. Therefore, the ratio of resting losses expressed in grams per hour, to running loss expressed in those units would be used to approximate the permeation fraction for running loss.

The running loss correlations for the different technology groups give the cumulative emissions as a function of time, corrected to a given ambient temperature. To compare with the resting losses, which are correlated as grams per hour at a given hour's ambient temperature, the running loss correlations must be differentiated with time. The value for 15 minutes (weighted average trip length) was chosen to calculate the permeation fraction.

Hot Soak Permeation Fraction

As with the other evaporative processes, the permeation fraction for hot soak is calculated as the ratio of resting losses in grams per hour to hot soak emissions in those units. EMFAC models hot-soak emissions as a function of ambient temperature and fuel volatility (RVP). The correlations give the hot soak emissions for a 35-minute period. This was converted to a 1-hour basis for comparison with the resting loss correlation, which is in grams per hour for a given hourly ambient temperature.

Application by Technology Group

The resting loss basic emission rates and corrections are given in EMFAC as a function of technology group, aspiration technology, and model year. Likewise, the BERs for running loss are given as functions of these parameters, but often in different model year ranges, or subdivided by truck or car. For this reason, Table 9 was developed to display the combinations of technology groupings that were used, and the extension of the combinations to evaporative technology groups in EMFAC.

Table 9—Evap Tech group assignments

	Table 5.1-3*			Table 5.3-2a*		Table 5.2-4*	
EMFAC2002 Tech Group Mapping	Vehicle Type	Running Loss Grouping		Diurnal/Resting Grouping		Hot Soak Grouping	
1, 21	Car/Truck	Carb	Pre-1970	CARB	Pre-77	CARB	Pre-77
2, 3	Car	Carb	1970-76				
4, 5	Car	Carb	1977+	CARB	77+	CARB	77+
6, 7, 8, 9, 10, 11, 12, 13	Car	TBI/PFI	All Pre-Enhanced Evap	FI	79-94	FI	86+
14,	Car	TBI/PFI	Enhanced Evap(1)	FI	Enhanced	FI	Enhanced
15, 17	Car	TBI/PFI	Cloned From Enh Evap above	FI	Zero Evap	FI	Zero Evap
22, 23	Truck	Carb	Pre-1980	CARB	Pre-77	CARB	Pre-77
24, 25	Truck	Carb	1980+	CARB	77+	CARB	77+
26, 27, 28, 29, 30, 31,32, 33	Truck	TBI/PFI	All	FI	79-94	FI	86+
34	Truck	TBI/PFI	Enhanced Evap(1)	FI	Enhanced	FI	Enhanced
35, 37	Truck	TBI/PFI	Cloned From Enh Evap above	FI	Zero Evap	FI	Zero Evap

* Table numbers refer to coefficients in the EMFAC 2000 Technical Support Document, available at www.arb.ca.gov/msei/onroad/doctable_test.htm

1) Note for Diurnal/Resting and Hot Soak emissions, the truck rates have been cloned from cars.
2) For Hot Soak emissions, the Pre-Enhanced Evap FI group has 3 tech groups (pre-79, 79-85, and 86+). I suggest using rates from the 86+ grouping since its rates are based on a larger data set.
3) For running losses, the zero-evap group cloned from the enhanced evap group.
4) Note, not doing anything for near-zero evap.

Permeation Fraction Correlations

The resulting running loss and hot soak permeation fractions were calculated from the BER correlations and correction factors in the EMFAC 2000 Technical Support Document for the tech group combinations, and for the regimes of normal, moderate, and liquid leakers. The calculations were done for the range of 65 to 110°F, and then fitted to a 2, 3, or 4-power polynomial. An example of the calculated data and the polynomial fit is shown in Figure 5. These coefficient results are displayed for the hot soak process in Table 10. These coefficient results are displayed in Tables 11a and 11b for the running loss process.

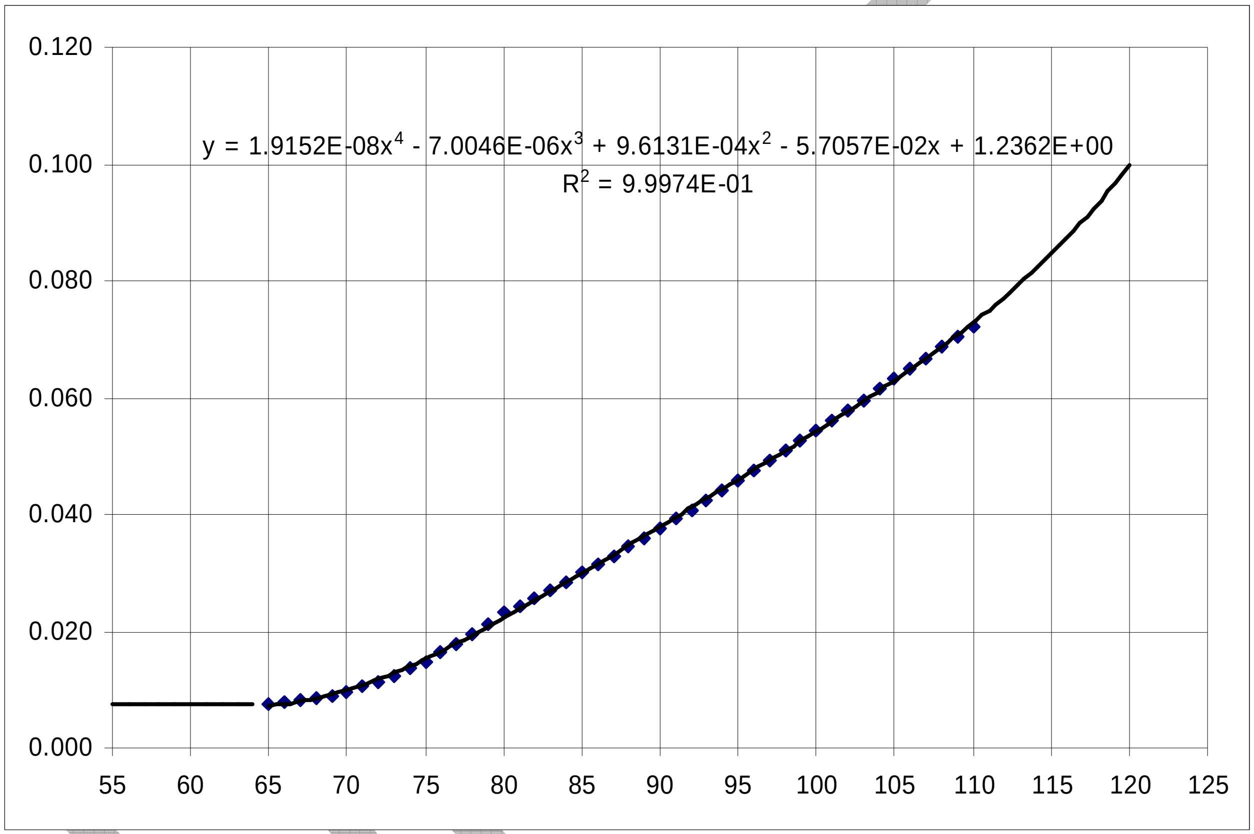
In keeping with the previous EMFAC protocol, the liquid leaker correlations for running loss and hot soak were not temperature-corrected.

Temperature Profiles

The planning temperatures used in this analysis are the statistical average of those of days which distribute around the ozone concentration of the California 8-hour Ozone Standard Design Value. They were interpolated and extended on a 4-km grid throughout the State. The profiles for each county or sub-area were determined by VMT-weighting on this grid.

Figure 6 shows the weighted temperature profiles for the State and the South Coast Air Basin.

Figure 5
Running Loss Permeation Fraction Example
Car Enhanced Evap Normal



Note: Constant 0.008 value below 65°F.

Table 10—Hot Soak Permeation Fraction Correlations

Tech Groups	Fuel sys/ Model yr	Regime	Coefficients for Hot Soak Permeation Factor Correlations: A	B	C	D	E	Domain Restrictions: Lower		Upper	
Car TGs 1, 21	Carb 77-	Normal	6.7473E-08	-2.7737E-05	4.1488E-03	-2.5670E-01	5.6790E+00	T < 65	PF = 0.110	None	
Truck TGs 22, 23		Moderate		-1.4121E-06	3.8110E-04	-3.0577E-02	8.0438E-01	T < 65	PF = 0.041	None	
		High	-3.3470E-08	1.2209E-05	-1.5761E-03	8.8644E-02	-1.8020E+00	T < 65	PF = 0.055	None	
Car TGs 4, 5	Carb 77+	Normal		-6.4757E-06	1.7765E-03	-1.4672E-01	3.9217E+00	T < 65	PF = 0.118	None	
Truck TGs 24, 25		Moderate	-8.5461E-08	3.1508E-05	-4.1687E-03	2.3742E-01	-4.9149E+00	T < 65	PF = 0.031	None	
		High	-3.3470E-08	1.2209E-05	-1.5761E-03	8.8644E-02	-1.8020E+00	T < 65	PF = 0.055	None	
Car TGs 6, 7, 8, 9, 10, 11, 12, 13	FI 86+	Normal		-6.0616E-06	1.3658E-03	-9.5670E-02	2.4026E+00	T < 65	PF = 0.29	None	
Truck TGs 26, 27, 28, 29, 30, 31, 32, 33		Moderate		-1.7869E-06	4.6374E-04	-3.7838E-02	1.0082E+00	T < 65	PF = 0.017	T >110	PF = 0.08
		High	-3.3470E-08	1.2209E-05	-1.5761E-03	8.8644E-02	-1.8020E+00	T < 65	PF = 0.055	None	
Car TG 14	FI Enhanced Evap	Normal		-2.3621E-06	5.3395E-04	-3.7670E-02	9.5892E-01	T < 65	PF = 0.117	None	
Truck TG 34		Moderate		-6.8803E-07	1.7862E-04	-1.4585E-02	3.8929E-01	T < 65	PF = 0.007	T >110	PF=0.0309
		High	-3.3470E-08	1.2209E-05	-1.5761E-03	8.8644E-02	-1.8020E+00	T < 65	PF = 0.055	None	
Car TGs 15, 17	FI Zero Evap	Normal		-2.2394E-06	5.0155E-04	-3.4570E-02	8.3653E-01	T < 65	PF = 0.094	None	
Truck TGs 35, 37		Moderate		-6.5466E-07	1.7002E-04	-1.3899E-02	3.7240E-01	T < 65	PF = 0.0075	T >110	PF = 0.0298
		High	-3.3470E-08	1.2209E-05	-1.5761E-03	8.8644E-02	-1.8020E+00	T < 65	PF = 0.055	None	

Perm Fract = $AT^4 + BT^3 + CT^2 + DT + E$, T in deg F

Table 11a—Running Loss Permeation Fraction Correlations (Cars)

	Tech Groups	Fuel sys/ Model yr	Regime	Coefficients for Running Loss Permeation Factor Correlations					Domain Restrictions	
				A	B	C	D	E		
Car	TGs 1, 21	Carb 70-	Normal			1.8484E-06	-7.9614E-06	-5.7824E-03	T < 65	PF = 0.0018
			Moderate	6.3154E-09	-2.3204E-06	3.2294E-04	-1.9308E-02	4.2001E-01	T < 65	PF = 0.005
			High	-2.7377E-09	9.9867E-07	-1.2892E-04	7.2506E-03	-1.4740E-01	T < 65	PF = 0.0045
Car	TGs 2, 3	Carb 70 to 76	Normal	2.8825E-08	-1.0798E-05	1.5371E-03	-9.4311E-02	2.1034E+00	T < 65	PF = 0.0171
			Moderate	6.3154E-09	-2.3204E-06	3.2294E-04	-1.9308E-02	4.2001E-01	T < 65	PF = 0.005
			High	-2.7377E-09	9.9867E-07	-1.2892E-04	7.2506E-03	-1.4740E-01	T < 65	PF = 0.0045
Car	TGs 4, 5	Carb 77+	Normal	2.8825E-08	-1.0798E-05	1.5371E-03	-9.4311E-02	2.1034E+00	T < 65	PF = 0.0171
			Moderate	-9.9622E-09	4.3594E-06	-6.3898E-04	3.9126E-02	-8.5796E-01	T < 65	PF = 0.005
			High	-2.7377E-09	9.9867E-07	-1.2892E-04	7.2506E-03	-1.4740E-01	T < 65	PF = 0.0045
Car	TGs 6, 7, 8, 9, 10, 11, 12, 13	FI 79-94 Pre Enh Evap	Normal	6.4222E-08	-2.3513E-05	3.2308E-03	-1.9200E-01	4.1642E+00	T < 65	PF = 0.025
			Moderate		5.6941E-07	-3.5135E-05	-2.5610E-03	1.6367E-01	T < 65	PF = 0.004
			High	-3.3608E-08	1.2260E-05	-1.5826E-03	8.9008E-02	-1.8095E+00	T < 65	PF = 0.055
Car	TG 14	FI Enhanced Evap	Normal	1.9152E-08	-7.0046E-06	9.6131E-04	-5.7057E-02	1.2362E+00	T < 65	PF = 0.008
			Moderate		1.6045E-07	-8.1202E-06	-9.6472E-04	5.4652E-02	T < 65	PF = 0.0016
			High	-3.3608E-08	1.2260E-05	-1.5826E-03	8.9008E-02	-1.8095E+00	T < 65	PF = 0.055
Car	TGs 15, 17	FI Zero Evap	Normal	4.7080E-09	-1.7295E-06	2.3851E-04	-1.4230E-02	3.0975E-01	T < 65	PF = 0.0016
			Moderate		4.1347E-08	-2.3857E-06	-2.0622E-04	1.2600E-02	T < 65	PF = 0.0005
			High	-3.3608E-08	1.2260E-05	-1.5826E-03	8.9008E-02	-1.8095E+00	T < 65	PF = 0.055

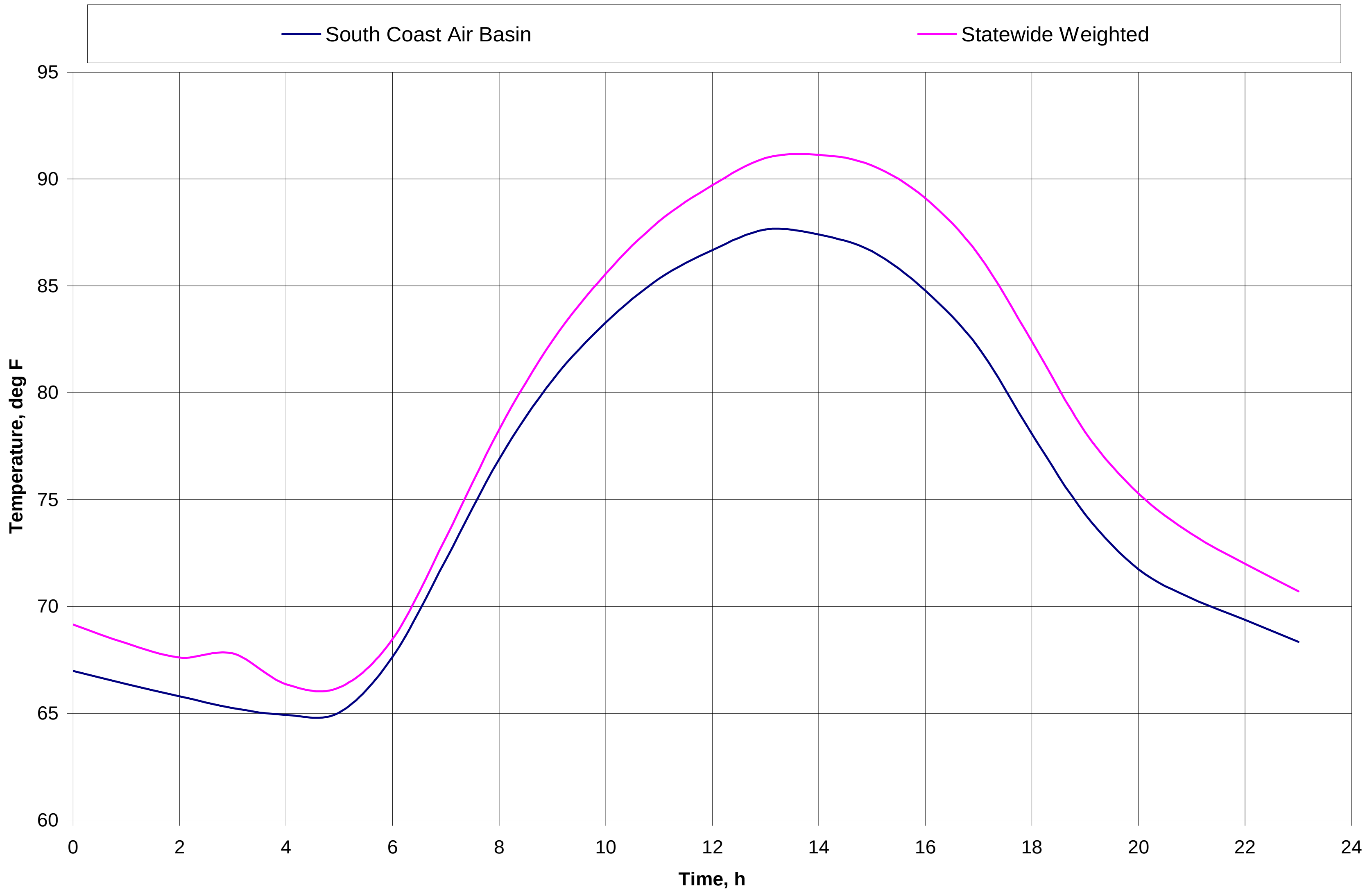
Perm Fract = $AT^4 + BT^3 + CT^2 + DT + E$, T in deg F

Table 11b—Running Loss Permeation Fraction Correlations (Trucks)

	Tech Groups	Fuel sys/ Model yr	Regime	Coefficients for Running Loss Permeation Factor Correlations A	B	C	D	E	Domain Restrictions	
Truck	TGs 22, 23	Carb <80	Normal		-2.9348E-07	9.1217E-05	-5.8658E-03	9.4318E-02	T < 65	PF = 0.0202
			Moderate		-2.4910E-07	8.1519E-05	-6.6678E-03	1.6753E-01	T < 65	PF = 0.0111
			High	-1.1928E-08	4.3511E-06	-5.6168E-04	3.1590E-02	-6.4220E-01	T < 65	PF = 0.0196
Truck	TGs 24, 25	Carb 80+	Normal	2.8017E-08	-1.0538E-05	1.5099E-03	-9.3176E-02	2.0883E+00	T < 65	PF = 0.0175
			Moderate	-1.8457E-08	7.3542E-06	-1.0277E-03	6.1230E-02	-1.3207E+00	T < 65	PF = 0.0078
			High	-1.1928E-08	4.3511E-06	-5.6168E-04	3.1590E-02	-6.4220E-01	T < 65	PF = 0.0196
Truck	TGs 26, 27, 28, 29, 30, 31, 32, 33	FI Pre Enhanced Evap	Normal	1.5571E-07	-5.6665E-05	7.7217E-03	-4.5527E-01	9.8043E+00	T < 65	PF = 0.056
			Moderate		5.6941E-07	-3.5135E-05	-2.5610E-03	1.6367E-01	T < 65	PF = 0.004
			High	-3.3608E-08	1.2260E-05	-1.5826E-03	8.9008E-02	-1.8095E+00	T < 65	PF = 0.055
Truck	TG 34	FI Enhanced Evap	Normal	2.0730E-08	-7.5358E-06	1.0257E-03	-6.0399E-02	1.2993E+00	T < 65	PF = 0.0077
			Moderate		5.5117E-08	-3.8226E-06	-2.0171E-04	1.4634E-02	T < 65	PF = 0.0005
			High	-3.3608E-08	1.2260E-05	-1.5826E-03	8.9008E-02	-1.8095E+00	T < 65	PF = 0.055
Truck	TGs 35, 37	FI Zero Evap	Normal		4.0267E-07	-1.1020E-04	1.0153E-02	-2.9912E-01	T < 65	PF = 0.0066
			Moderate	1.9049E-09	-6.8289E-07	9.2052E-05	-5.3665E-03	1.1527E-01	T < 65	PF = 0.0019
			High	-3.3608E-08	1.2260E-05	-1.5826E-03	8.9008E-02	-1.8095E+00	T < 65	PF = 0.055

Perm Fract = $AT^4 + BT^3 + CT^2 + DT + E$, T in deg F

Figure 6
California 8-h Ozone Design Value Temperature Profiles



INVENTORY EFFECTS

The estimates of the effect of adding the ethanol permeation routine to the EMFAC model are given below for the scenario years of 2005, 2010, 2015, and 2020 for the State as a whole (Tables 12 through 15)

For these comparisons the model was run with California 8-h Ozone Design Value Temperature profiles.

The population is gasoline vehicles only, and only passenger cars, light trucks (<3750 and 3750-5500 lb test weight categories), and medium-duty trucks (6000 to 8500 and 8500 to 10000-lb GVWR categories)

In general most of the effects were due to the diurnal and resting loss process.

The increase due to ethanol was about 9% of evaporative emissions and about 4% of total ROG emissions in 2005. This fell to 7% increase of evaporative emissions and 3.4% of total ROG in 2015.

Table 12
Summary of Emissions Changes due to Ethanol Permeation
Statewide Calendar Year 2005
Gasoline PCs, LT1s, LT2s, MT3s, MT4s

Process	Units	MtBE	EtOH	Increase
Diurnal	tpd	53.4	64.3	10.9
Resting	tpd	30.3	42.4	12.0
Running	tpd	177.2	180.2	3.0
Hot Soak	tpd	50.0	52.8	2.8
Total Evap	tpd	310.9	339.7	28.8

Table 13
Summary of Emissions Changes due to Ethanol Permeation
Statewide Calendar Year 2010
Gasoline PCs, LT1s, LT2s, MT3s, MT4s

Process	Units	MtBE	EtOH	Increase
Diurnal	tpd	42.4	49.3	6.8
Resting	tpd	25.7	33.2	7.5
Running	tpd	128.4	130.8	2.4
Hot Soak	tpd	42.1	43.8	1.8
Total Evap	tpd	238.6	257.0	18.4

Table 14
Summary of Emissions Changes due to Ethanol Permeation
Statewide Calendar Year 2015
Gasoline PCs, LT1s, LT2s, MT3s, MT4s

Process	Units	MtBE	EtOH	Increase
Diurnal	tpd	35.7	39.9	4.2
Resting	tpd	24.3	29.1	4.8
Running	tpd	106.8	108.8	2.0
Hot Soak	tpd	38.9	40.0	1.2
Total Evap	tpd	205.7	217.8	12.1

Table 15
Summary of Emissions Changes due to Ethanol Permeation
Statewide Calendar Year 2020
Gasoline PCs, LT1s, LT2s, MT3s, MT4s

Process	Units	MtBE	EtOH	Increase
Diurnal	tpd	31.3	33.8	2.5
Resting	tpd	22.9	26.2	3.3
Running	tpd	95.6	97.1	1.6
Hot Soak	tpd	35.3	36.0	0.8
Total Evap	tpd	185.0	193.1	8.1

INTENTIONALLY LEFT BLANK

B-3) AN UPDATE TO SUMMER TEMPERATURE AND RELATIVE HUMIDITY PROFILES FOR EMFAC2007 ON-ROAD EMISSIONS MODEL

California's EMFAC emissions model is used to estimate emissions from on-road mobile sources that contribute to emissions inventories for planning purposes and for some modeling purposes. When estimating total emissions in a given area, emissions factors (i.e., emissions per unit of activity) are adjusted before they are applied to travel activity. These adjustments include corrections made when ambient temperatures and humidities differ from the conditions set for standardized emissions tests. Under this project, ARB staff analyzed data for temperature and humidity within each planning sub-region on days when ozone reached levels that challenge efforts to attain and maintain air quality standards for ozone. New diurnal profiles that represent these challenging conditions have been prepared for use in the EMFAC model.

For this task, ARB staff produced diurnal temperature and relative humidity profiles to represent conditions understood to contribute to ozone levels most likely to challenge attainment and maintenance of the federal 8-hour ozone standard. These profiles will replace the current "summer" season profiles in EMFAC, in order to improve emissions estimation and modeling, and support planning decisions that target appropriate emission reductions. In addition to the profiles representing the federal 8-hour ozone standard, profiles were developed to represent challenging meteorological conditions for the State's 8-hour and 1-hour ozone standards. The additional profiles can be used with EMFAC on an ad hoc basis but will not be included at this time as options in EMFAC's routine menus.

The new temperature and relative humidity profiles were developed for each county portion of each air basin using sampling and estimation methods described in this document. The profiles representing the federal 8-hour ozone standard have been installed in a new draft working version of the EMFAC model (version 2.22.8). Following modification of both temperature and relative humidity profiles, emissions of reactive organic gases (ROG), carbon monoxide (CO), and oxides of nitrogen (NOx) increased in all areas of the state. The changes vary by area and by calendar year, as shown below in Table 1. Complete details are available at:

http://www.arb.ca.gov/fuels/gasoline/premodel/081006emfactempprofiles.pdf

Table 1. Changes in Emissions Resulting from Application of Revised (Federal 8-Hour Ozone Standard) Temperature and Relative Humidity Profiles in EMFAC Version 2.22.8, Tons per Day (%)

2002			
Area	ROG-All processes	CO-All processes	NOx-All processes
Statewide	59.22 (5.16%)	302.55 (2.94%)	37.69 (2.95%)
South Coast AB	6.89 (1.55%)	35.40 (0.92%)	15.43 (2.68%)
San Joaquin AB	9.66 (7.62%)	67.45 (6.04%)	12.02 (4.04%)
Sacramento AB	7.61 (7.47%)	54.79 (5.86%)	4.58 (2.74%)
San Diego AB	1.24 (1.41%)	5.01 (0.61%)	4.35 (3.50%)
San Francisco AB	15.29 (6.96%)	91.85 (4.50%)	4.10 (1.40%)
2020			
Area	ROG- All processes	CO-All processes	NOx- All processes
Statewide	31.91 (7.44%)	79.77 (2.90%)	11.24 (1.80%)
South Coast AB	3.50 (2.30%)	8.26 (0.90%)	4.20 (2.28%)
San Joaquin AB	5.43 (10.29%)	17.23 (5.37%)	3.44 (3.21%)
Sacramento AB	4.46 (10.60%)	14.66 (5.43%)	1.32 (2.32%)
San Diego AB	0.92 (2.53%)	1.18 (0.97%)	1.39 (3.00%)
San Francisco AB	7.99 (10.99%)	20.21 (4.05%)	1.07 (1.24%)