

**PRELIMINARY DRAFT—Do Not Cite or Quote**

**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

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**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 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 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 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 6.5% of the total evaporative inventory and 3.8% 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<sub>3</sub> Temperature Profiles  
Calendar Year 2005**

Basin	Evaporative Emissions Increase, tons per day				
	Diurnal	Resting	Running	Hot Soak	Total Evap
Statewide	16.2	16.1	4.4	3.8	40.4
South Coast AB	4.6	5.9	1.4	1.2	13.1

**Table 2**  
**Summary of Emissions Changes due to Ethanol Permeation**  
**Cal 8-h O<sub>3</sub> Temperature Profiles**  
**Calendar Year 2010**

Basin	Evaporative Emissions Increase, tons per day				
	Diurnal	Resting	Running	Hot Soak	Total Evap
Statewide	11.0	11.0	3.8	2.6	28.4
South Coast AB	3.0	3.9	1.1	0.8	8.7

**Table 3**  
**Summary of Emissions Changes due to Ethanol Permeation**  
**Cal 8-h O<sub>3</sub> Temperature Profiles**  
**Calendar Year 2015**

Basin	Evaporative Emissions Increase, tons per day				
	Diurnal	Resting	Running	Hot Soak	Total Evap
Statewide	7.2	7.5	3.0	1.7	19.4
South Coast AB	1.9	2.6	0.9	0.5	5.9

**Table 4**  
**Summary of Emissions Changes due to Ethanol Permeation**  
**Cal 8-h O<sub>3</sub> Temperature Profiles**  
**Calendar Year 2020**

Basin	Evaporative Emissions Increase, tons per day				
	Diurnal	Resting	Running	Hot Soak	Total Evap
Statewide	4.8	5.4	2.3	1.1	13.7
South Coast AB	1.3	1.9	0.7	0.3	4.2

**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)<sup>1</sup> 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.

$$ER_{\text{etoh}} = ER_{\text{t,rvp}} * (\text{PERMfr} * \text{EtRFG2r} + 1 - \text{PERMfr}) \quad \text{Eqn 1}$$

Where

<b>ER<sub>etoh</sub></b>	is the ethanol fuel emission rate expressed in grams per hour (g/hr)
<b>ER<sub>t,rvp</sub></b>	is the MTBE emission rate expressed in g/hr, corrected for temperature and RVP (internal to EMFAC)
<b>PERMfr</b>	is the permeation fraction for each evaporative process (equation 3)
<b>EtRFG2r</b>	is the EtOH to MTBE ratio, as a function of temperature and emission regime (equation 2)

**Ethanol-to-MTBE ratio (EtRFG2r)**

$$\text{EtRFG2r} = \text{diurnal rate on EtOH fuel} \div \text{diurnal rate on MTBE fuel} \quad \text{Eqn 2}$$

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

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<sup>1</sup> 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](http://www.crcao.com/reports/recentstudies2004/E65) Final Report: 90204.pdf or [www.arb.ca.gov/fuels/gasoline/permeation/090204finalrpt.pdf](http://www.arb.ca.gov/fuels/gasoline/permeation/090204finalrpt.pdf).

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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**

<b>Veh #</b>	<b>Vehicle Description</b>	<b>Veh #</b>	<b>Vehicle Description</b>
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).

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 ten vehicles were binned as follows:

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- 8 normal-emitting vehicles, 1, 2, 3, 4, 7, 8, 9 & 10,
- 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. Staff assumed a small, non-unity ratio (1.05) for liquid leakers. 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. Therefore, the mean values were used. The results of the linear regression analysis are shown in Table 6 below. The final recommended values for EtRFG2r are shown in Table 7.

**Table 6 – Linear Regression Statistics for E65 diurnal Augmentation Ratios**

	Best fit Slope	Intercept	p-statistic on slope	Mean	Standard deviation
	per degree F				
Normals	0.0097	1.695	0.133	2.55	1.58
Moderates	0.0006	1.151	0.787	1.20	0.24
Liquid Leakers				1.05*	

\*Assumed number

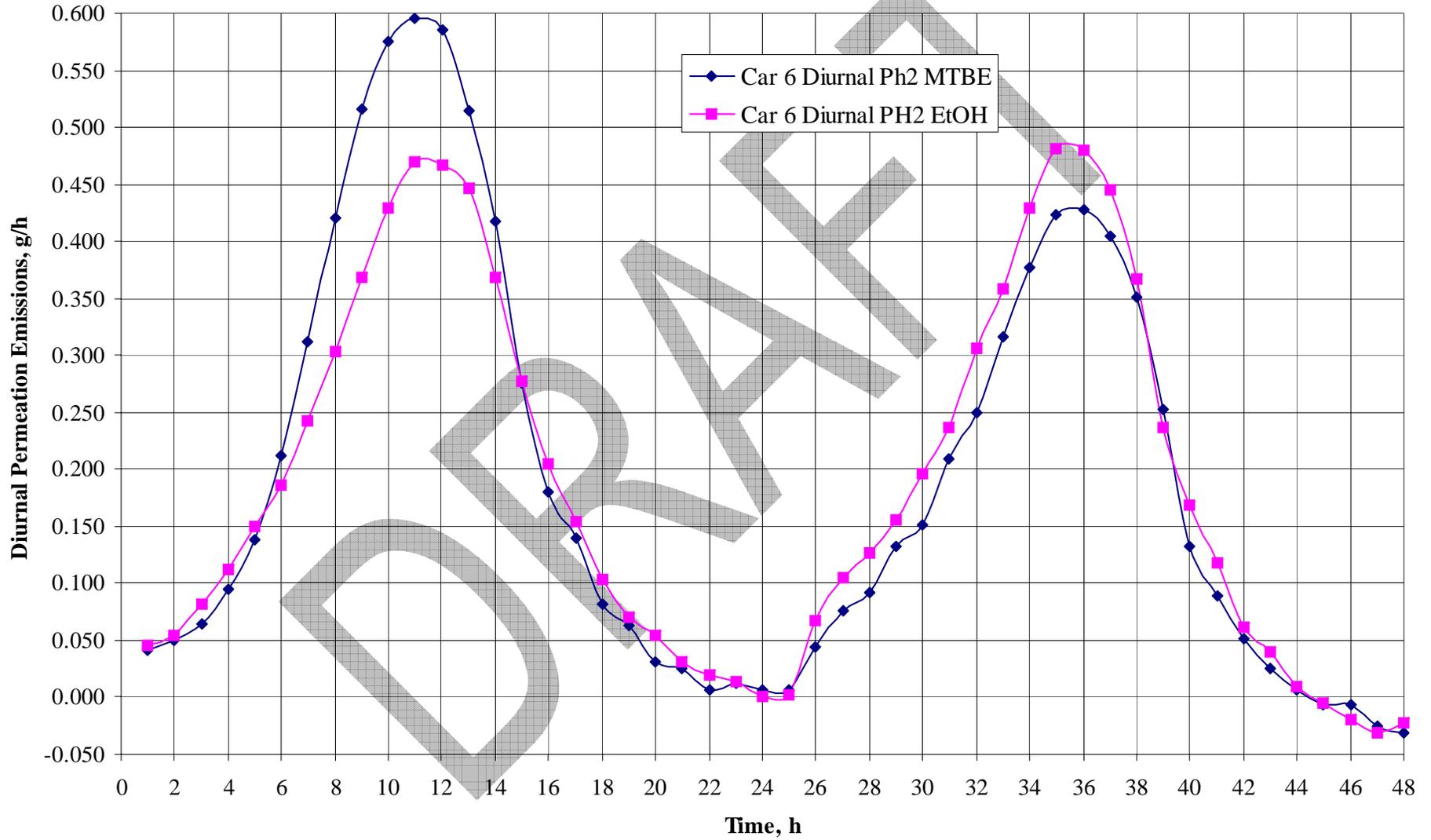
**Table 7—Augmentation ratio values**

Emitter Category	Ratio	Absolute Permeation MTBE fuel*	Absolute Permeation Ethanol Fuel*
		g/d	g/d
Normals	2.55	0.44	1.15
Moderates	1.20	1.4	1.7
Liquid Leakers	1.05	33.8	36.2

\* Values for 2005 fleet EMFAC 2002 Default Temperatures

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**Figure 1**  
**E65 Diurnal Permeation Results, Car 6**



**Figure 2**  
**E65 Diurnal Augmentation Ratios, Normals**

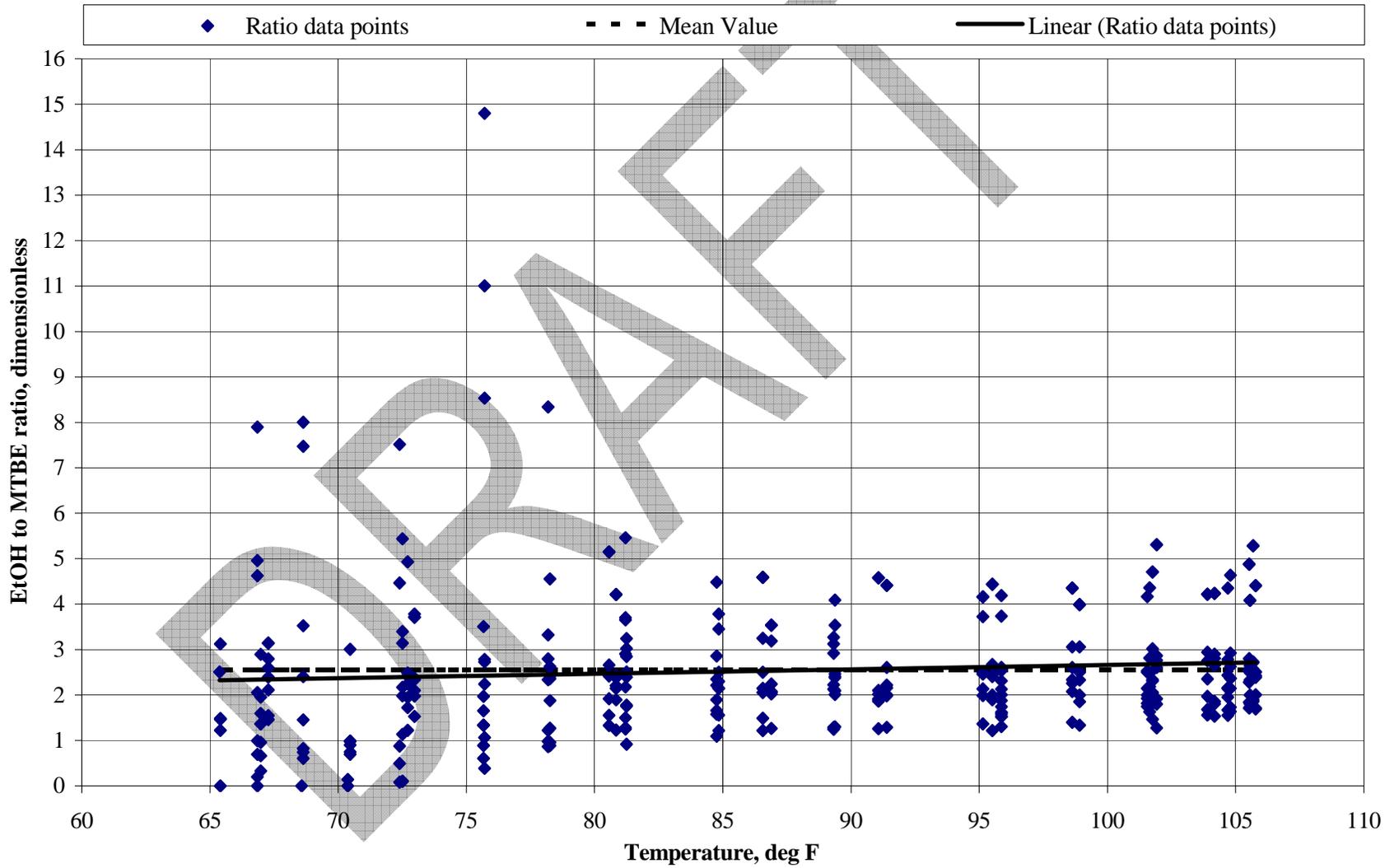
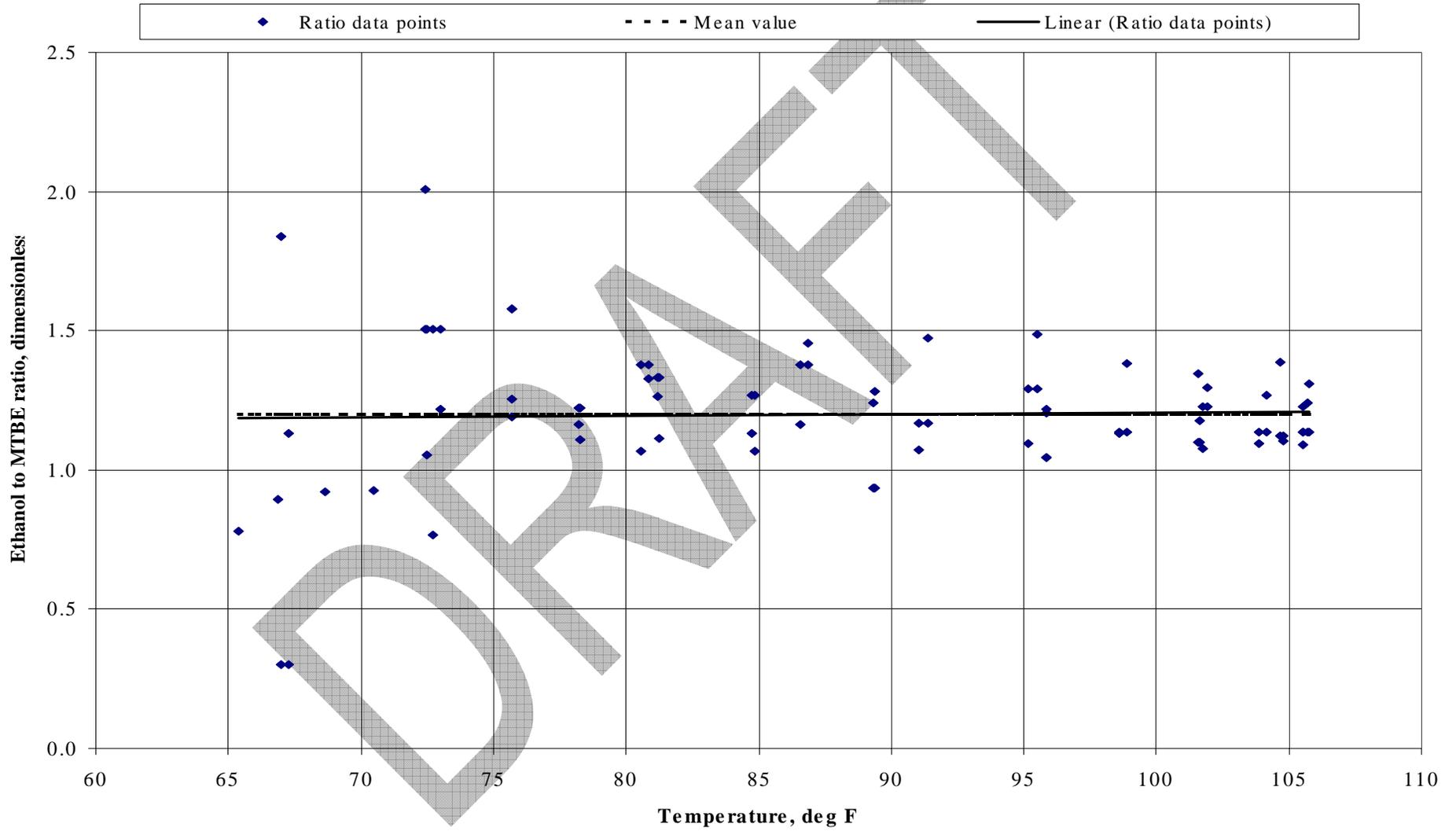


Figure 3  
E65 Diurnal Ratios, Moderates



### 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.

$$\text{PERMfr} = 0.9 * \text{ER}_{\text{resting}} * \text{RVPTCF} / (\text{ER}_{\text{process}} * \text{RVPTCF}) \quad \text{Eqn 3}$$

Where

<b>PERMfr</b>	is the permeation fraction
<b>ER<sub>resting</sub></b>	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)
<b>RVPTCF</b>	is the vapor pressure and temperature correction factor (internal to EMFAC)
<b>ER<sub>process</sub></b>	is the emission rate for the particular evaporative process expressed in grams per hour (internal to EMFAC)
<b>0.9</b>	is the fraction of resting loss assumed to be attributable to permeation

### Application by Process

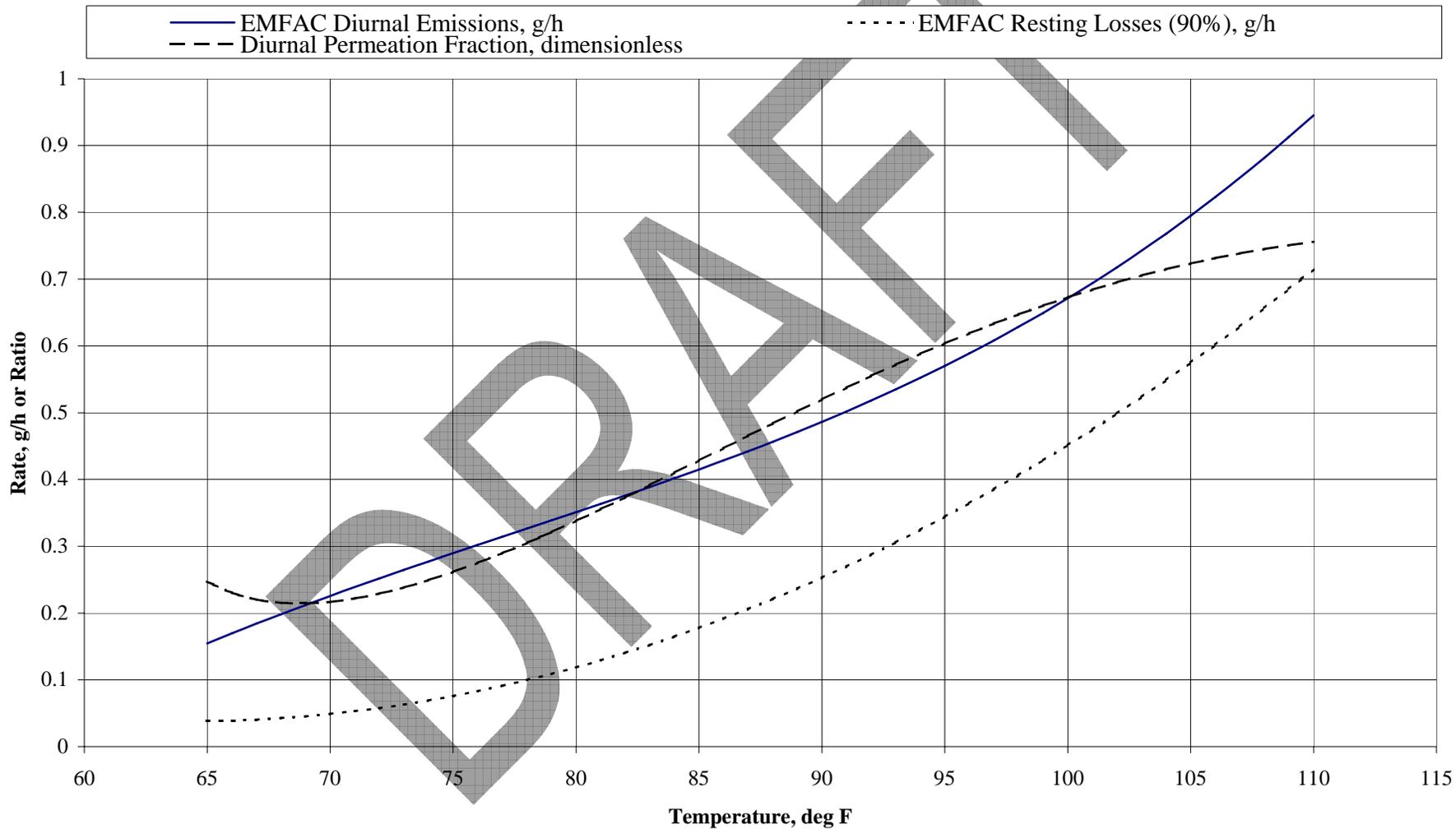
#### **Diurnal/Resting Permeation Fraction**

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.

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



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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 8 was developed to display the combinations of technology groupings that were used, and the extension of the combinations to evaporative technology groups in EMFAC.

### **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 9. These coefficient results are displayed in Tables 10a and 10b 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.

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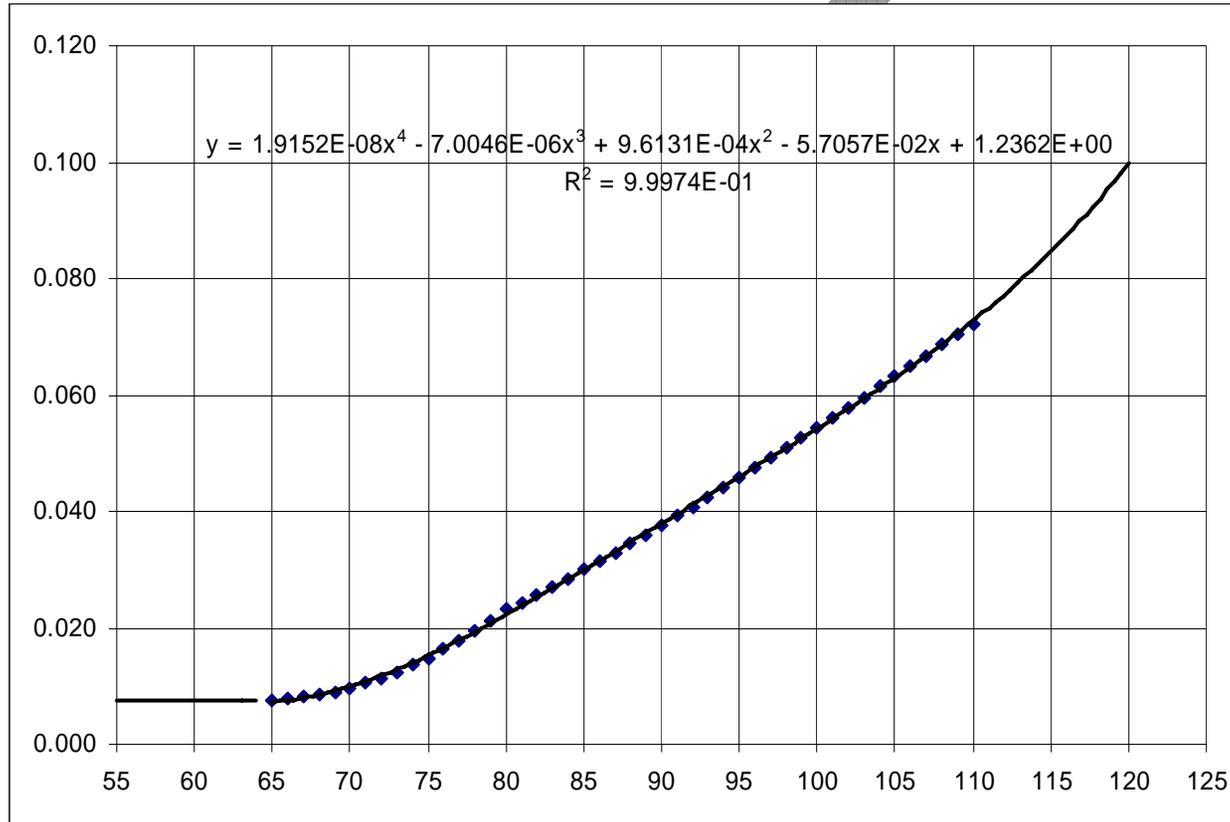
**Table 8—Evap Tech group assignments**

EMFAC2002 Tech Group Mapping	Table 5.1-3*			Table 5.3-2a*		Table 5.2-4*	
	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+				
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](http://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.

Figure 5  
Running Loss Permeation Fraction Example  
Car Enhanced Evap Normal



Note: Constant 0.008 value below 65°F.

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Table 9—Hot Soak Permeation Fraction Correlations

Tech Groups	Fuel sys/ Model yr	Regime	Coefficients for Hot Soak Permeation Factor Correlations					Domain Restrictions		
			A	B	C	D	E	Lower	Upper	
Car TGs 1, 21 Truck TGs 22, 23	Carb 77-	Normal	6.7473E-08	-2.7737E-05	4.1488E-03	-2.5670E-01	5.6790E+00	T < 65	PF = 0.110	None
		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 Truck TGs 24, 25	Carb 77+	Normal		-6.4757E-06	1.7765E-03	-1.4672E-01	3.9217E+00	T < 65	PF = 0.118	None
		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 Truck TGs 26, 27, 28, 29, 30, 31, 32, 33	FI 86+	Normal		-6.0616E-06	1.3658E-03	-9.5670E-02	2.4026E+00	T < 65	PF = 0.29	None
		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 Truck TG 34	FI Enhanced Evap	Normal		-2.3621E-06	5.3395E-04	-3.7670E-02	9.5892E-01	T < 65	PF = 0.117	None
		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 Truck TGs 35, 37	FI Zero Evap	Normal		-2.2394E-06	5.0155E-04	-3.4570E-02	8.3653E-01	T < 65	PF = 0.094	None
		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<sup>4</sup> + BT<sup>3</sup> + CT<sup>2</sup> + DT + E, T in deg F

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**Table 10a—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

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Table 10b—Running Loss Permeation Fraction Correlations (Trucks)

Tech Groups	Fuel sys/ Model yr	Regime	Coefficients for Running Loss Permeation Factor Correlations					Domain Restrictions		
			A	B	C	D	E			
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<sup>4</sup> + BT<sup>3</sup> + CT<sup>2</sup> + DT + E, T in deg F

## 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.

## Population Scaling Factors

In the EMFAC 2007 development process, the DMV registration data for the years 2000 through 2005 have been analyzed and added to the last published EMFAC version, EMFAC 2002.

In this round of DMV registration analysis, ARB staff discovered a large number of vehicles which were termed "Registration Pending." Staff included all these vehicles as active in its population inventories. Based on analysis of the 2002 and 2003 calendar year runs from DMV staff found that only about 20% of the pending registrations showed up as normal registrations after the first year. Staff also discovered a large number of old vehicles and alternatively fueled vehicles had been excluded from the population numbers. This resulted in our revising of the estimate of Statewide active vehicles from 29.6 million to 26.0 million for calendar year 2003.

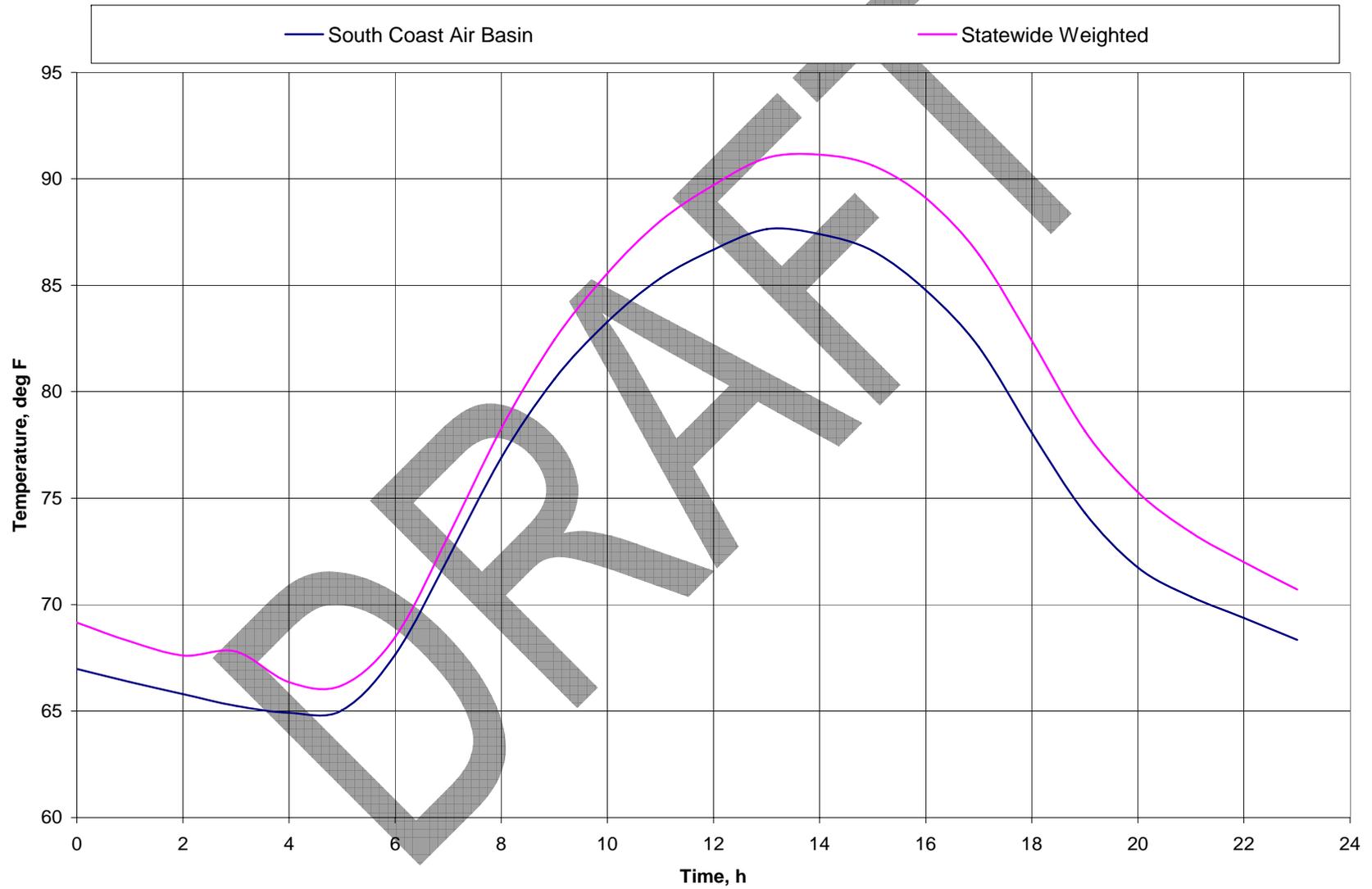
This analysis will be done for all the DMV calendar years and the populations for each of the vehicle classes and each of the counties adjusted for the EMFAC 2007 model release in November. Until that time, scaling factors based on 2002 have been developed and are applied to the model outputs.

**Table 11**  
**Scaling Factors**

Item	Scaling Factor
ROG_DIURN	0.85065
ROG_HTSK	0.82089
ROG_RUNLS	0.85177
ROG_RESTL	0.84858

Table 11 is our best estimate at this time for adjusting the evaporative inventory for the population changes we expect to include in the November release of EMFAC.

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) and for the South Coast area (Tables 16 to 19).

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

The populations and emissions include the effects of population scaling as described above.

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 6.5% increase of evaporative emissions and 3.8% of total ROG in 2015.

The South Coast Air Basin represents about 40% of the vehicles and 37% of the ROG emissions of the whole state in 2005, but only 32% of the ethanol increase. This is due to the milder temperatures in the South Coast Basin. South Coast Air Basin's share of the ethanol increase falls to about 30% of the Statewide ethanol increase in 2015. This is due to the shift to cleaner cars over those years.

**Table 12  
Summary of Emissions Changes due to Ethanol Permeation  
Statewide Calendar Year 2005**

Process	Units	MtBE	EtOH	Increase
Diurnal	tpd	77.5	93.7	16.2
Resting	tpd	37.9	54.0	16.1
Running	tpd	255.3	259.7	4.4
Hot Soak	tpd	64.8	68.6	3.8
Total Evap	tpd	435.5	476.0	40.4

**Table 13**  
**Summary of Emissions Changes due to Ethanol Permeation**  
**Statewide Calendar Year 2010**

Process	Units	MtBE	EtOH	Increase
Diurnal	tpd	66.5	77.5	11.0
Resting	tpd	34.1	45.1	11.0
Running	tpd	207.7	211.5	3.8
Hot Soak	tpd	56.3	58.9	2.6
Total Evap	tpd	364.6	392.9	28.4

**Table 14**  
**Summary of Emissions Changes due to Ethanol Permeation**  
**Statewide Calendar Year 2015**

Process	Units	MtBE	EtOH	Increase
Diurnal	tpd	55.8	63.1	7.2
Resting	tpd	31.3	38.7	7.5
Running	tpd	170.8	173.9	3.0
Hot Soak	tpd	49.2	50.9	1.7
Total Evap	tpd	307.2	326.6	19.4

**Table 15**  
**Summary of Emissions Changes due to Ethanol Permeation**  
**Statewide Calendar Year 2020**

Process	Units	MtBE	EtOH	Increase
Diurnal	tpd	47.4	52.2	4.8
Resting	tpd	28.3	33.7	5.4
Running	tpd	145.7	148.0	2.3
Hot Soak	tpd	42.4	43.5	1.1
Total Evap	tpd	263.7	277.4	13.7

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**Table 16  
Summary of Emissions Changes due to Ethanol Permeation  
South Coast AB Calendar Year 2005**

Process	Units	MtBE	EtOH	Increase
Diurnal	tpd	23.9	28.5	4.6
Resting	tpd	14.2	20.1	5.9
Running	tpd	99.1	100.4	1.4
Hot Soak	tpd	23.4	24.6	1.2
Total Evap	tpd	160.5	173.7	13.1

**Table 17  
Summary of Emissions Changes due to Ethanol Permeation  
South Coast AB Calendar Year 2010**

Process	Units	MtBE	EtOH	Increase
Diurnal	tpd	19.5	22.5	3.0
Resting	tpd	12.2	16.1	3.9
Running	tpd	77.8	78.9	1.1
Hot Soak	tpd	19.7	20.4	0.8
Total Evap	tpd	129.2	137.9	8.7

**Table 18  
Summary of Emissions Changes due to Ethanol Permeation  
South Coast AB Calendar Year 2015**

Process	Units	MtBE	EtOH	Increase
Diurnal	tpd	16.3	18.2	1.9
Resting	tpd	11.3	13.9	2.6
Running	tpd	64.4	65.2	0.9
Hot Soak	tpd	17.5	18.0	0.5
Total Evap	tpd	109.5	115.4	5.9

**Table 19**  
**Summary of Emissions Changes due to Ethanol Permeation**  
**South Coast AB Calendar Year 2020**

Process	Units	MtBE	EtOH	Increase
Diurnal	tpd	13.9	15.1	1.3
Resting	tpd	10.3	12.2	1.9
Running	tpd	55.4	56.1	0.7
Hot Soak	tpd	15.4	15.7	0.3
Total Evap	tpd	95.0	99.2	4.2

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