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Estimating Weighting Factors for Evaporative Emissions in MOBILE6

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U.S. Environmental Protection Agency

NOTICE

This technical report does not necessarily represent final EPA decisions or positions. It is intended to present technical analysis of issues using data which are currently available. The purpose in the release of such reports is to facilitate the exchange of technical information and to inform the public of technical developments which may form the basis for a final EPA decision, position, or regulatory action.

ABSTRACT

In parallel documents (M6.EVP.001, M6.EVP.002, and M6.EVP.005), EPA identified the methods used in MOBILE6 for estimating resting loss and diurnal emissions based (in part) on the performance of the vehicles (i.e., pass or fail) on the purge and pressure tests. EPA computes model-year and age specific average resting loss and diurnal emissions by weighting together the emissions of passing and failing vehicles according to their frequency in the in-use fleet. This document describes this approach and EPA's predictions of pass and fail rates (i.e., weighting factors) as functions of vehicle age.

This report was originally released (as a draft) in June 1999. This current version is the final revision of that draft. This final revision incorporates suggestions and comments received from stakeholders during the 60-day review period and from peer reviewers.

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Estimating Weighting Factors for Evaporative Emissions in MOBILE6

Report Number M6.EVP.006

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1.0 INTRODUCTION

In three parallel reports **[1,2,3]***, the US Environmental Protection Agency (EPA) developed methods of estimating the resting loss and diurnal emissions from results of real-time diurnal (RTD) tests of in-use vehicles in which the ambient temperature cycled over a 24 degree Fahrenheit range to simulate in real-time the daily heating and cooling that parked vehicles experience over a 24 hour period. For many of the vehicles used in these studies, the recruitment method was designed to recruit a relatively large number of vehicles that had problems with their evaporative control systems. Specifically, two tests of the integrity of each vehicle's evaporative control system were used to screen the candidate vehicles (a pressure test** and a purge test). This recruitment bias did not affect the analysis of these data as described in earlier reports; since those analyses were performed within each purge/pressure grouping, the selection was random within the purge/pressure and model year groups. However, to correctly represent the entire in-use fleet the results must be weighted. In this report, EPA develops weightings for each stratum to estimate the emissions of the entire in-use fleet. EPA will use these factors to weight together the results of the RTD tests, as well as the results of hot soak tests and running loss tests which were also derived from measurements of a stratified sample.

For each of the parallel analyses of resting loss and diurnal data, the sample of test vehicles was divided into four strata. The first of these strata consisted of several vehicles having substantial leaks of liquid gasoline (as opposed to simply vapor leaks); these vehicles were labeled "gross liquid leakers" (GLLs). EPA will use the following three definitions **[4]** (based

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* The numbers in brackets refer to the references in Section 7 (page 39).

** This pressure test was performed by disconnecting the vapor line at the canister and then pressurizing the tank from that position with the gas cap in its normal position. This procedure differs from the method currently being used in Inspection and Maintenance (I/M) lanes.

on the evaporative emissions test used) for such vehicles with:

- resting loss emissions (i.e., the mean emissions during the last six hours of the 24-hour RTD test) were at least 2.00 grams per hour (see also reference **[1]**), or
- hot soak test emissions were at least 10.00 grams per one-hour test (see also reference **[5]**), or
- running loss test emissions were at least 7.00 grams per mile over a LA-4 driving cycle (or 137.2 grams per hour) (see also reference **[6]**).

These three different definitions will identify potentially different sets of vehicles as being "gross liquid leakers" (see Section 3.2). For the remaining three strata, we used the results of the purge and pressure tests to match the stratification of the recruitment process. This approach produces the following three additional strata:

1) vehicles that pass both the purge and pressure tests,
2) vehicles that fail the pressure test (regardless of their performance on the purge test),* and
3) vehicles that fail only the purge test.

This document reports on EPA's proposal to weight those four strata together to obtain estimates (of running loss, hot soak, resting loss, and diurnal emissions) for the entire in-use fleet.

2.0 DATA SOURCES

To develop the appropriate weighting factor for the stratum of vehicles identified as "gross liquid leakers," EPA relied on five groups of data to estimate the frequency of the occurrence of these vehicles (see also reference **[4]**):

- For the "gross liquid leakers" identified by the RTD test, EPA used a sample consisting of 151 vehicles tested by the Coordinating Research Council (CRC) during 1996 as part of its real-time diurnal testing program (Program E-9) **[7]** combined with 119 vehicles tested by EPA. **[1]**
- For the "gross liquid leakers" identified by the hot soak test, EPA combined the sample of 300 vehicles tested by Auto/Oil during 1993 as part of its real world hot soak testing program with 197 vehicles tested by EPA. **[5]**

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* Vehicles failing both purge and pressure are discussed in Section 3.1.4.

- For the "gross liquid leakers" identified by the running loss test, EPA used a sample consisting of 150 vehicles tested by the CRC during 1997 as part of its running loss testing program (program E-35). **[6]**

- The CRC also tested 50 late-model year vehicles during 1998 as part of its combined hot soak, real-time diurnal, running loss testing program (E-41). **[8]** (These results are used in reference **[4]** to test the predictions of the occurrence of "gross liquid leakers" among newer vehicles.)

- A fifth source of data consisted of the results of a testing program run jointly by the CRC and the American Petroleum Institute (API) **[9]**. This program was designed to determine the frequency of vehicles with liquid leaks. Actual measurements of evaporative emissions were not performed in this program; therefore, we cannot determine which of those vehicles identified as having liquid leaks would have actually met any of our definitions of a "gross liquid leaker."

To develop the appropriate weighting factors based on the performance on the purge and pressure tests, EPA used data from an EPA testing contractor, Automotive Testing Laboratories (ATL), which performed purge and pressure tests on a random sample of 13,425 vehicles at its Inspection and Maintenance (I/M) lanes in Indiana and Arizona between the years 1990 and 1995. Since the testing protocols were changing in the early months of the program, we omitted the first nine months of data. We then identified the initial test of each of the test vehicles and calculated, by vehicle age, the number of pre-1996* model year vehicles in each of the three purge/pressure categories.

We combined the results for the I/M lane testing into a single table (Table 1 on page 5). Omitted from all of the columns in Table 1 are the results on approximately fifteen percent of the vehicles for which the purge or pressure tests were not performed. The reasons that testing was not performed varied, and included both periodic problems with the testing equipment as well as problems related to the vehicle (e.g., presence of check-valves or difficulty accessing the necessary lines). All of the subsequent analyses were performed on the sample of vehicles for which the purge/pressure classification could be made. Since all of the subsequent analyses are based on ratios from Table 1 (e.g., the number of classified pressure failures divided by the total number of vehicles that were

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* Limiting the analysis to pre-1996 model year vehicles is related to the phase-in of the enhanced evaporative control vehicles (see Section 4).

varied, and included both periodic problems with the testing equipment as well as problems related to the vehicle (e.g., presence of check-valves or difficulty accessing the necessary lines). All of the subsequent analyses were performed on the sample of vehicles for which the purge/pressure classification could be made. Since all of the subsequent analyses are based on ratios from Table 1 (e.g., the number of classified pressure failures divided by the total number of vehicles that were

In examining the data in Table 1, we note that there were relatively few vehicles more than 20 years of age. Since small sample sizes tend to result in low statistical confidence in the calculated ratios (i.e., the percent of vehicles at each age that fall into each of the purge/pressure strata), those small sample sizes are an obvious weakness of this analysis. We will address that weakness by using the calculated variances in the ratios to weight the analyses. (That is, the ratios from the model years containing the most vehicles will be counted more heavily than the ratios from the more sparsely sampled model years.)

An alternative approach (not being used) is to smooth the data from the older vehicles by averaging the results from the 66 vehicles over the age of 20 years (all of which were from the industry programs) to obtain a sample with:

- a mean age of 23.23 years,
- 19 vehicles (28.8 percent) passing both the pressure test and the purge test,
- 38 vehicles (57.6 percent) failing the pressure test, and
- 9 vehicles (13.6 percent) failing only the purge test.

That averaged failure rate on the pressure test of almost 60 percent among the vehicles over 20 years of age suggests a substantially higher failure rate among these vehicles than was predicted in MOBILE5 (i.e., under 35 percent). This difference in estimating the failure rate (on the pressure test) of older vehicles is due entirely to data recently obtained in the CRC testing programs. (The EPA testing used in MOBILE5 had no data on vehicles older than 17 years of age.)

Table 1

Distribution of 14,061 1971 - 95 Model Year Vehicles

Vehicle Age*	Performance on Purge and Pressure Tests: Fail Pressure	Fail Only Purge	Passing Both	Total
0	5	9	228	242
1	48	29	1,448	1,525
2	42	33	1,302	1,377
3	61	33	1,494	1,588
4	81	42	1,308	1,431
5	94	50	1,475	1,619
6	91	76	1,403	1,570
7	94	74	1,261	1,429
8	88	46	888	1,022
9	68	68	682	818
10	46	44	369	459
11	41	24	192	257
12	64	23	152	239
13	49	20	102	171
14	29	5	62	96
15	19	6	34	59
16	13	3	17	33
17	7	1	7	15
18	4	0	2	6
19	12	1	4	17
20	12	3	7	22
21	3	2	7	12
22	7	0	5	12
23	10	2	3	15
24	6	2	2	10
25	6	3	1	10
26	6	0	1	7

* The quantity "Vehicle Age" is the whole number calculated by subtracting model year from test year and then changing all negative results to zero.

3.0 ANALYSIS

3.1 Modeling Strata Based on Purge and Pressure Tests

Using the data from Table 1, we calculated the rate at which vehicles were present (by age) in the following three categories determined by the results on the pressure test and the purge test.

- vehicles passing both the pressure test and the purge test,
- vehicles failing the pressure test, and
- vehicles failing only the purge test.

These three categories are not independent. Given the results from any two would permit the size of remaining category to be determined. EPA chose to model the rates at which vehicles were present in the first two of those categories. These rates by vehicle age (in years) along with the corresponding 90 percent confidence intervals are given in Tables 2 and 3. The confidence intervals were calculated separately for each vehicle age rather than having an overall calculation for the entire sample. Calculating confidence intervals independently (as if the failure rate at one age were not related to the failure rates of neighboring ages) emphasizes the disparity in the sizes of some of the samples by age, as the size of the confidence interval is substantially controlled by the sample size.

3.1.1 Vehicles Failing the Pressure Test

Calculating (from Table 1) the rates at which vehicles failed the pressure test (regardless of the performance on the purge test) produces the data given in Table 2.

As previously stated, since the 90 percent confidence intervals in Table 2 were calculated separately for each age that was sampled, the confidence intervals are most representative of the relative sample sizes. Rather than immediately attempting to use a regression analysis to obtain an equation relating the rate of vehicle's failing the pressure test to the vehicle's age, we first examined the calculated 90 percent confidence intervals in Table 2. (Binomial confidence intervals were used since there were exactly two possible values, namely "PASS" and "FAIL.")

Table 2

Estimating Rate of Vehicles that Fail the Pressure Test For 14,061 1971-95 Model Year Vehicles With 90 Percent Confidence Intervals

Vehicle Age	Sample Size	Failure Rate	90 Percent Confidence Interval
0	242	2.1%	0.6% - 3.6%
1	1,525	3.1%	2.4% - 3.9%
2	1,377	3.1%	2.3% - 3.8%
3	1,588	3.8%	3.0% - 4.6%
4	1,431	5.7%	4.7% - 6.7%
5	1,619	5.8%	4.8% - 6.8%
6	1,570	5.8%	4.8% - 6.8%
7	1,429	6.6%	5.5% - 7.7%
8	1,022	8.6%	7.2% - 10.1%
9	818	8.3%	6.7% - 9.9%
10	459	10.0%	7.7% - 12.3%
11	257	16.0%	12.2% - 19.7%
12	239	26.8%	22.1% - 31.5%
13	171	28.7%	23.0% - 34.3%
14	96	30.2%	22.5% - 37.9%
15	59	32.2%	22.2% - 42.2%
16	33	39.4%	25.4% - 53.4%
17	15	46.7%	25.5% - 67.9%
18	6	66.7%	35.0% - 98.3%
19	17	70.6%	52.4% - 88.8%
20	22	54.5%	37.1% - 72.0%
21	12	25.0%	4.4% - 45.6%
22	12	58.3%	34.9% - 81.7%
23	15	66.7%	46.6% - 86.7%
24	10	60.0%	34.5% - 85.5%
25	10	60.0%	34.5% - 85.5%
26	7	85.7%	64.0% - 100.0%

Examining the confidence intervals in Table 2, we found that some of those confidence intervals are so large as to be almost useless. (For example, for vehicles 17 years of age, knowing that the actual failure is most likely between 25 percent and 68 percent is not helpful in predicting the true failure rate.) However, using both the sample failure rates and the confidence intervals, we were able to make the following four observations that were then used to select an appropriate mathematical model:

- The pressure failure rate appears to start (i.e., for new vehicles) between two and four percent.

- The pressure failure rate increases gradually for the first seven years of the vehicle's life.
- The pressure failure rate then increases more rapidly for the next ten years.
- The pressure failure rate then begins to level off (approaching 60 percent, according to the data from the industry programs) (see third "bullet" on page 4).

This type of behavior is typical of a logistic growth function.

Prior to constructing an appropriate logistic growth function, we first "adjusted" the values of the variable "AGE" (in Tables 1 through 4) which are based on the test date (since it is the integer calculated by subtracting the model year from the test year). In the MOBILE model, the (default) age is the integer age as of January 1 of the evaluation year. However, the approximately 14,000 tests in Tables 1 through 4 occurred over all 12 months of the testing years. Thus, the average (i.e., typical) test date was in early July (mean date of July 3 and median date of July 10). To adjust for that six month difference (between the default month of January and the average test date in July), we modified that age value in the tables by adding 0.5 years (six months) to it prior to the analyses.

To account for differences in the size of the confidence intervals (or, equivalently the sample sizes) the data were weighted by the reciprocal of the variance. The "logistic growth" function that best models the weighted pressure test failure rates from Table 2 is given by the following equation:

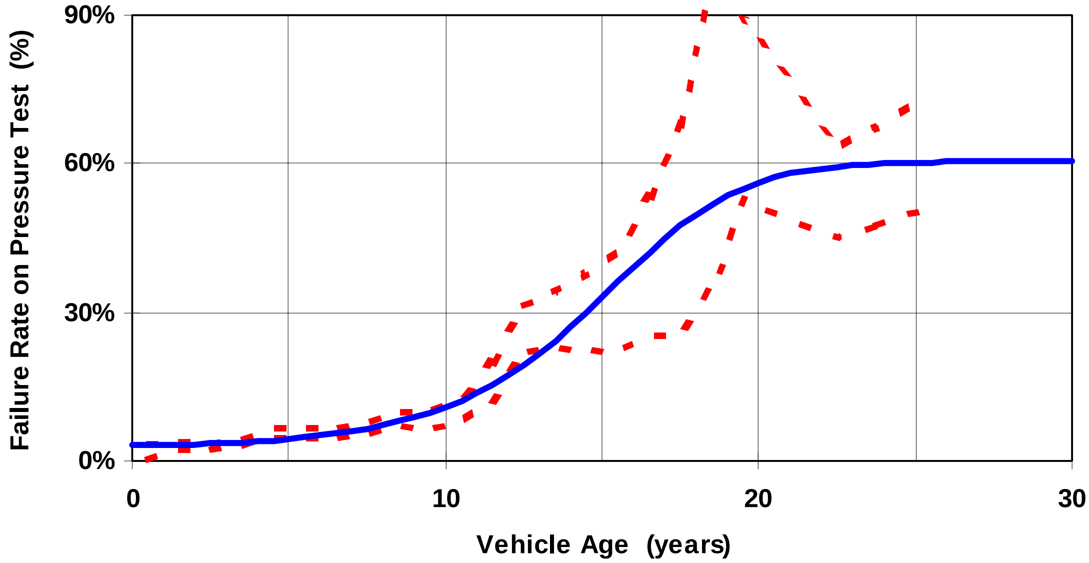
$$\text{Pressure Failure Rate} = \frac{0.6045}{1 + 17.733 * \exp[-0.01362 * (AGE \wedge 2)]} \qquad (1)$$

Estimates based on this equation of failure rates on the pressure test are given in Appendix A. These estimates must be adjusted for the "gross liquid leakers" (see Section 3.3).

In Figure 1 (on the following page), we plotted both the curve described by equation **(1)** (as a solid line) as well as the 90 percent confidence intervals (as dotted lines) for the failure rate on the pressure test (from Table 2, shifted by six months to compensate for the July testing). (The small sample of vehicles at least 20 years of age was combined to produce reasonably sized confidence intervals.) That graph suggests that equation **(1)** is a very good fit for the measured failure rates except at ages for which fewer than 20 vehicles were recruited at each age. Also, for vehicles over 20 years of age, the predicted failure rate on the pressure test is close to 60 percent which closely approximates the results of those 66 tests from industry programs (see third "bullet" on page 4).

Figure 1

Comparison of Predicted Rates to Confidence Intervals of Measured Rates For Vehicles Failing the Pressure Test (by vehicle age)



3.1.2 Vehicles Passing Both the Pressure and the Purge Tests

As described in the preceding section, we first calculated from Table 1 the rates at which vehicles passed both the pressure and the purge tests, yielding the results given in Table 3.

As in the case of the failure rate on the pressure test, we were able to make the following four observations from Table 3:

- The rate at which vehicles passed both the pressure test and the purge test starts (i.e., for new vehicles) between 92 and 96 percent.

- The rate at which vehicles passed both the pressure test and the purge test decreases gradually for the first seven years of the vehicle's life.

- The rate at which vehicles passed both the pressure test and the purge test then decreases more rapidly for the next ten years.

- The rate at which vehicles passed both the pressure test and the purge test then begins to level off (approaching 20 to 40 percent, according to the data from the industry programs) (see second "bullet" on page 4).

Table 3

Estimating Rate of Vehicles that Pass Both the Pressure and Purge Tests For 14,061 1971-95 Model Year Vehicles With 90 Percent Confidence Intervals

Vehicle Age	Sample Size	Failure Rate	90 Percent Confidence Interval		
0	242	94.2%	91.7%	-	96.7%
1	1,525	95.0%	94.0%	-	95.9%
2	1,377	94.6%	93.5%	-	95.6%
3	1,588	94.1%	93.1%	-	95.1%
4	1,431	91.4%	90.2%	-	92.6%
5	1,619	91.1%	89.9%	-	92.3%
6	1,570	89.4%	88.1%	-	90.6%
7	1,429	88.2%	86.8%	-	89.6%
8	1,022	86.9%	85.2%	-	88.6%
9	818	83.4%	81.2%	-	85.5%
10	459	80.4%	77.3%	-	83.4%
11	257	74.7%	70.2%	-	79.2%
12	239	63.6%	58.5%	-	68.7%
13	171	59.6%	53.5%	-	65.8%
14	96	64.6%	56.6%	-	72.6%
15	59	57.6%	47.0%	-	68.2%
16	33	51.5%	37.2%	-	65.8%
17	15	46.7%	25.5%	-	67.9%
18	6	33.3%	1.7%	-	65.0%
19	17	23.5%	6.6%	-	40.5%
20	22	31.8%	15.5%	-	48.2%
21	12	58.3%	34.9%	-	81.7%
22	12	41.7%	18.3%	-	65.1%
23	15	20.0%	3.0%	-	37.0%
24	10	20.0%	0.0%	-	40.8%
25	10	10.0%	0.0%	-	25.6%
26	7	14.3%	0.0%	-	36.0%

As before, the "logistic growth" function appeared to be the best choice for modeling the rates at which vehicles passed both the pressure and the purge tests. After adjusting for age, the resulting equation is given below as equation **(2)**:

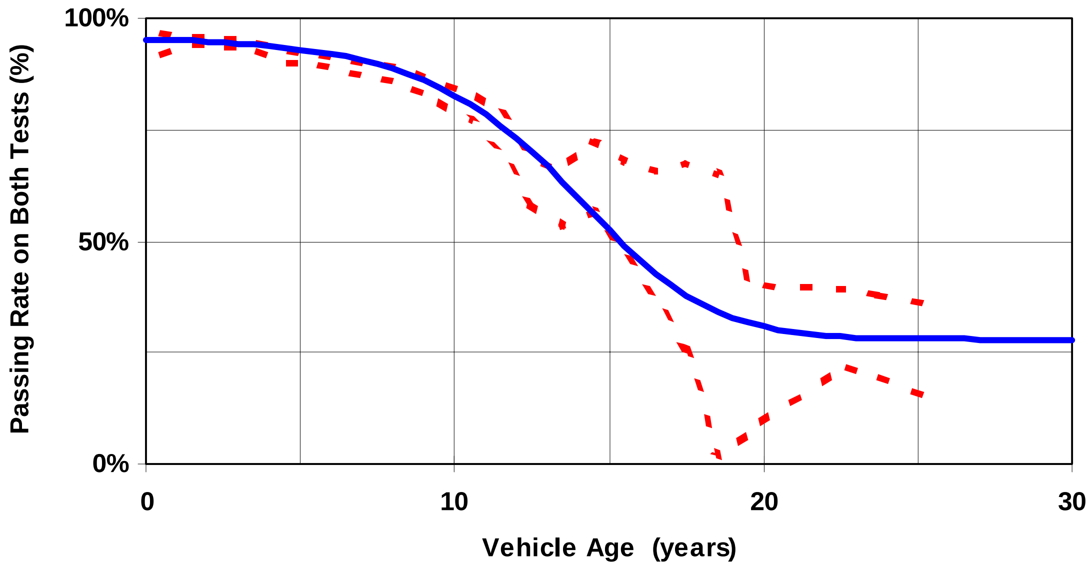
$$\text{Rate of Passing Both} = 1 - \frac{0.7200}{1 + 13.40 * \exp[-0.0145 * (AGE \wedge 2)]} \qquad (2)$$

Estimates based on equation **(2)** of the rates of vehicles passing both the purge and pressure tests are given in Appendix A. These estimates must be adjusted for the "gross liquid leakers" (see Section 3.3).

In Figure 2 (below), we plotted both the curve described by equation **(2)** (as a solid line) as well as the 90 percent confidence intervals (as dotted lines) for the rate of vehicles passing both the purge and pressure tests on the pressure test (from Table 3, shifted by six months to compensate for the July testing). (The small sample of vehicles at least 20 years of age was again combined to produce reasonably sized confidence intervals.) That graph suggests that equation **(2)** is a very good fit for the measured rates for ages at which at least 20 vehicles were sampled. Also, for vehicles over 20 years of age, the predicted rate of vehicles passing both the purge and pressure tests is close to 29 percent which closely approximates the results of those 66 tests from industry programs (see second "bullet" on page 4).

Figure 2

Comparison of Predicted Rates to Confidence Intervals of Measured Rates For Vehicles Passing Both the Purge and Pressure Tests (by vehicle age)



3.1.3 Vehicles Failing ONLY the Purge Test

The third (and final) stratum based on vehicles' performance on the purge and pressure tests is that containing vehicles that failed only the purge test. EPA will estimate that stratum by subtracting from one hundred percent the total of equation **(1)** plus equation **(2)** (prior to adjusting for the gross liquid leakers, as discussed in Section 3.3). Since, for some vehicle ages, the rate of decline in equation **(2)** is greater that the rate of growth in equation **(1)**, this approach has the effect of predicting a decrease in the rate of purge only failures for vehicles older than 16 years of age. (This effect suggests that some of the vehicles that only failed the purge test in a prior year would begin to also fail the pressure test, thus migrating into the pressure failure stratum.)

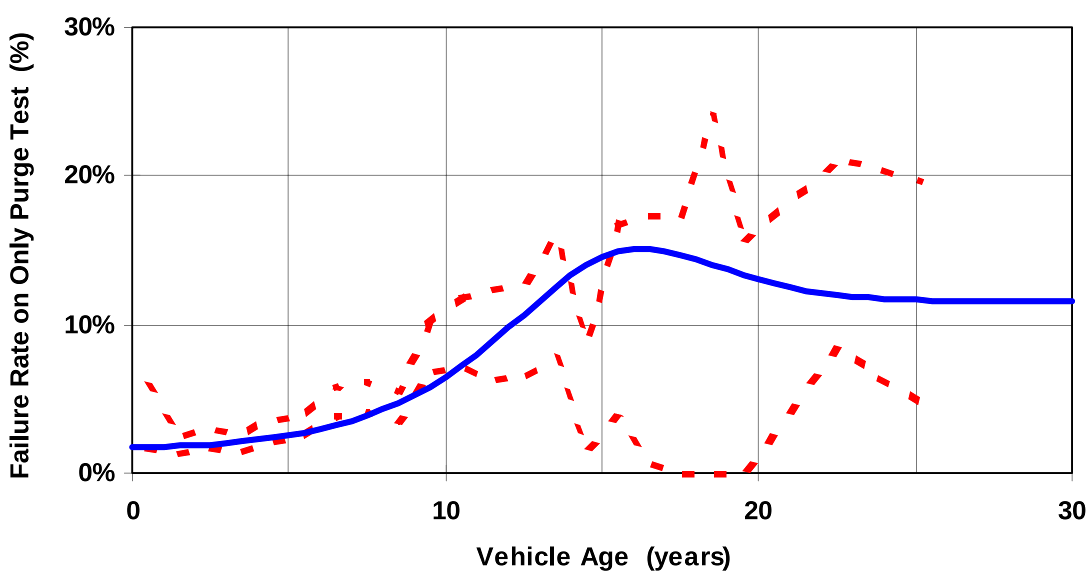
This effect is illustrated in Figure 3. If we combine this estimate of the incidence of vehicles' failing only the purge test with the estimate (from Section 3.1.4) of failing both the purge and pressure tests, we obtain a predicted failure rate on the purge test (regardless of any pressure test result). This purge test failure rate does not exhibit that quirk of a decrease in failure rate with increasing age.

The predicted size (in percent) of the stratum of vehicles that failed only the purge test is given in Appendix A. These estimates must be adjusted for the "gross liquid leakers" (see Section 3.3).

In Figure 3, for vehicles failing only the purge test, we plotted both the 90 percent confidence intervals (calculated from Table 1 and shifted by six months to compensate for July testing) and the curve described by subtracting from one hundred percent the total of equation **(1)** plus equation **(2)**.

Figure 3

Comparison of Predicted Rates to Confidence Intervals of Measured Rates For Vehicles Failing ONLY the Purge Test (by vehicle age)



The preceding graph indicates that the combination of equations **(1)** and **(2)** is a very good fit for the measured rates for ages at which at least 100 vehicles were sampled (i.e., through age 13).

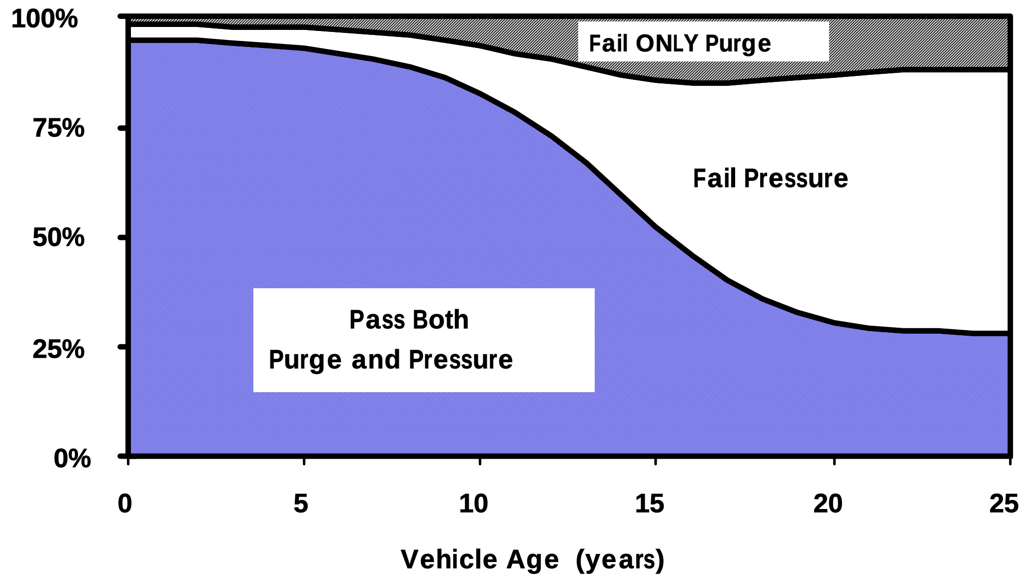
Also, for vehicles over 20 years of age, the predicted rate of vehicles failing only the purge test is close to 12 percent which closely approximates the results of those 66 tests from industry programs (see fourth "bullet" on page 4).

3.1.4 Summary of Purge and the Pressure Failure Rates

Combining the predicted rates from Figures 1, 2, and 3 (or Appendix A) into a single area graph produces the following graph (Figure 4).

<u>Figure 4</u>

Predicted Distribution of Pressure and Purge Failures
(by vehicle age)



3.1.5 Vehicles Failing Both the Purge and the Pressure Tests

When EPA analyzed the RTD data, it was determined that there were insufficient test results to distinguish between the diurnal emissions of vehicles that failed both the purge and pressure tests from those that failed only the pressure test. Therefore, those vehicles were combined into the single stratum of vehicles that failed the pressure test (regardless of their performance on the purge test). Since the purpose of this study is to develop factors to weight together the estimates of the individual stratum to predict the in-use fleet emissions, it was not necessary to model frequency of the stratum of vehicles that failed both the purge and pressure tests.

As a service to possible future researchers and modelers who may require an estimate of the number of vehicles failing both the purge and pressure tests (and based on the same sample that produced equations **(1)** and **(2)**), EPA performed the following analysis.

The approach was similar to the one used in Sections 3.1.1 and 3.1.2 in which a table containing the frequencies with the corresponding ninety percent confidence intervals was created (see Table 4).

Table 4

Estimating Rate of Vehicles that Fail BOTH the Pressure and Purge Tests For 1971-95 Model Year Vehicles With 90 Percent Confidence Intervals

Vehicle Age	Sample Size	Failure Rate	90 Percent Confidence Interval		
0	242	0.0%	0.0%	-	0.5%
1	1,522	0.2%	0.0%	-	0.4%
2	1,377	0.0%	0.0%	-	0.2%
3	1,587	0.3%	0.0%	-	0.5%
4	1,430	0.8%	0.4%	-	1.1%
5	1,619	0.4%	0.1%	-	0.6%
6	1,568	0.6%	0.3%	-	0.9%
7	1,428	0.8%	0.4%	-	1.2%
8	1,020	1.3%	0.7%	-	1.9%
9	814	1.5%	0.8%	-	2.2%
10	458	2.6%	1.4%	-	3.8%
11	254	2.8%	1.1%	-	4.4%
12	235	6.0%	3.4%	-	8.5%
13	169	7.1%	3.9%	-	10.4%
14	94	7.4%	3.0%	-	11.9%
15	58	6.9%	1.4%	-	12.4%
16	33	15.2%	4.9%	-	25.4%
17	15	26.7%	7.9%	-	45.4%
18	6	0.0%	0.0%	-	28.5%
19	17	23.5%	6.6%	-	40.5%
20	22	4.5%	0.0%	-	11.9%
21	12	0.0%	0.0%	-	17.7%
22	12	16.7%	0.0%	-	34.4%
23	15	53.3%	32.1%	-	74.5%
24	10	30.0%	6.2%	-	53.8%
25	10	30.0%	6.2%	-	53.8%
26	7	57.1%	26.4%	-	87.9%

As the reader may note, some of the sample sizes in Table 4 do not match the supposedly same samples in the first three tables. In the first three tables, vehicles that failed the pressure test but did not have a successful purge test were included in the stratum "fail pressure" and, thus, included in the total as well. However, those same vehicles would not be included in Table 4.

After adjusting for age (by adding 0.5), the "logistic growth" function that best models the frequency of vehicle's failing both the pressure and purge tests from Table 4 is given by the following equation:

$$\text{Rate of Failing Both} = \frac{0.3536}{1 + 414.96*\exp[-0.32955*AGE]} \quad (3)$$

In Figure 5, for vehicles failing both the purge and pressure tests, we plotted both the 90 percent confidence intervals (from Table 4, shifted by six months to compensate for the July testing) and the curve described by equation **(3)**. (Again, the small sample of vehicles at least 20 years of age was combined to produce reasonably sized confidence intervals.)

Figure 5

Comparison of Predicted Rates to Confidence Intervals of Measured Rates For Vehicles Failing Both the Pressure and Purge Tests (by vehicle age)

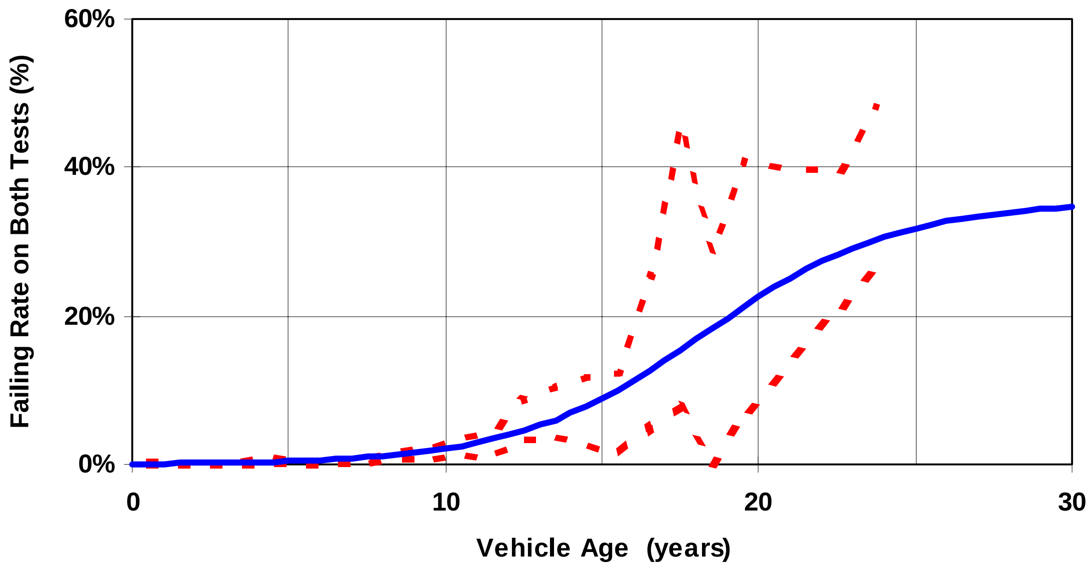


Figure 5 suggests that equation **(3)** is a very good fit for the measured rates for ages at which at least 30 vehicles were sampled (i.e., through age 16). Also, for the vehicles over 20 years of age, the data in Table 4 indicates that 20 out of 66 (30.3%) of those vehicles over 20 years of age (with a mean age of 23.2 years) failed both the purge and pressure tests, and equation **(3)** predicts that the failure rate would be 29.5 percent. Thus, equation **(3)** is also a very good fit for the measured rates for the older vehicles.

3.1.6 Effects of Inspection / Maintenance (I/M) Programs

As part of an Inspection and Maintenance (I/M) program, a state may choose to perform a functional test (e.g., a pressure test) of each vehicle's evaporative control system. Vehicles failing the test would be required to be repaired. Thus, the presence of such a program would alter the number of failing vehicles.

The data used in the analyses in Sections 3.1.1 through 3.1.5 were obtained from two geographic areas (Hammond, Indiana and Phoenix, Arizona) in which the vehicles were not required to pass either a purge or pressure test. Therefore, those analyses and the resulting estimates of failure rates (i.e., equations **(1)**, **(2)**, and **(3)**) are used in MOBILE6 for geographic areas in which there is no I/M for evaporative emissions.

In a parallel report **[10]**, EPA explains how those rates are adjusted in MOBILE6 to account for the presence of an I/M program for evaporative emissions.

3.2 Modeling the Stratum of "Gross Liquid Leakers" (GLLs)

The set of vehicles identified as "gross liquid leakers" varies depending upon which type of evaporative emission is being considered. Earlier (see "bulleted" points on page 2), we presented three definitions each based on one type of test (i.e., RTD test, hot soak test, and running loss test). EPA developed these definitions in a parallel report devoted exclusively to the subject of "gross liquid leakers" **[4]**. In that report, EPA produced the following two equations to predict the frequency of "gross liquid leakers" occurring on the RTD and on the running loss tests for evaporative emissions:

$$\text{Rate of Gross Liquid Leakers Based on RTD Testing} = \frac{0.08902}{1 + 414.613 * \exp[-0.3684 * AGE]} \quad (4)$$

$$\text{Rate of Gross Liquid Leakers Based on Running Loss Testing} = \frac{0.06}{1 + 120 * \exp[-0.4 * AGE]} \quad (5)$$

A different approach was necessary in predicting the frequency of "gross liquid leakers" on the hot soak test because that (hot soak) testing had been limited to only newer vehicles (i.e., no vehicles older than 12 years of age). The approach developed in that report was based on the untested hypothesis that the vehicles classified as hot soak "gross liquid leakers" are the same vehicles identified as gross liquid leakers on either the running loss or RTD tests. This hypothesis is based on the assumptions that:

- If a vehicle has a leak of liquid gasoline that is severe enough to classify the vehicle as a "gross liquid leaker" on the resting loss mode, then that leak will likely result in the vehicle’s being classified as a "gross liquid leaker" on the hot soak test as well.

- If a vehicle has a leak of liquid gasoline that is severe enough to classify the vehicle as a "gross liquid leaker" on the running loss test, then there will likely be enough liquid gasoline remaining after the engine is shut off to classify that vehicle as a "gross liquid leaker" on the subsequent hot soak test as well.

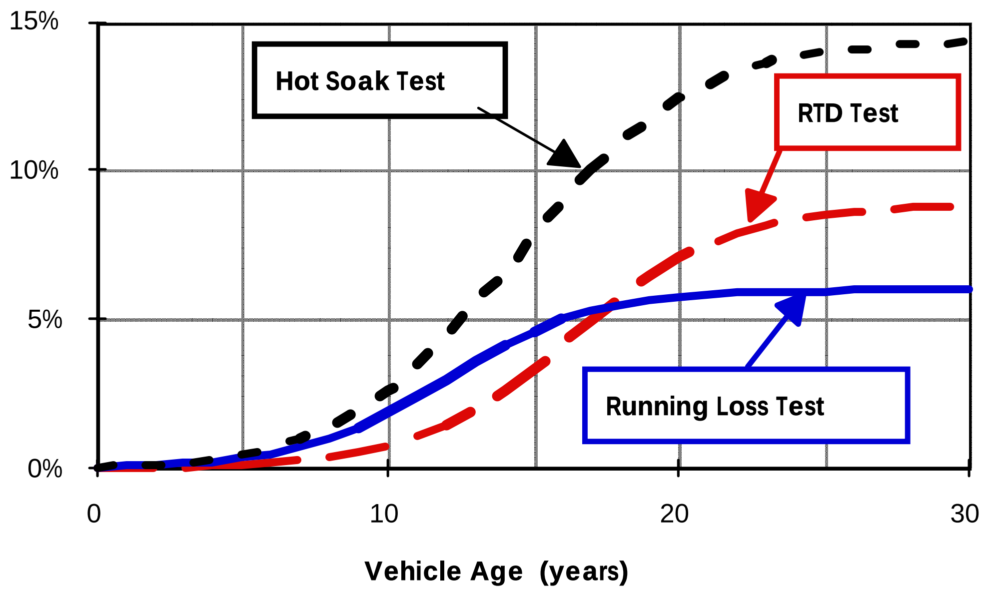
That is, the set of vehicles classified as gross liquid leakers on the hot soak test is the union of the set of vehicles classified as gross liquid leakers on the RTD test with the set of vehicles classified as gross liquid leakers on the running loss test. (These hypotheses are "untested" because none of the vehicles classified as "gross liquid leakers" on one test procedure were tested over either of the other two procedures.)

Therefore, the rate of gross liquid leakers as identified on the hot soak test would be the sum of the two rates for the RTD testing and the running loss testing minus the number of double counted vehicles (i.e., the product of those two rates assuming these two categories are independent of each other). Using equations **(4)** and **(5)** plus the preceding assumption, the predicted rates of "gross liquid leakers" were calculated (for each of the three test types) and are plotted in Figure 6 (on the following page) and appear in Appendix B.

It is important to note that this model of the frequency of gross liquid leakers is based on the assumption that modern technology vehicles (through model year 1995) will show the same tendency toward gross liquid leaks as do the older technology vehicles at the same age. However, if the modern technology vehicles were to exhibit a lower tendency to leak (due to the more stringent demands imposed by the new evaporative emissions certification procedure as well as heightened attention to safety, e.g., fuel tank protection and elimination of fuel line leaks), the effect would be to replace each of the three logistic growth functions with two or three curves specific to different model year (or technology) groups.

Figure 6

Predicted Occurrences of "Gross Liquid Leakers" On Each of Three Tests of Evaporative Emissions (by vehicle age)



Since EPA has no data to indicate model-year specific rates, EPA will use the model illustrated in Figure 6, to estimate the occurrence in the in-use fleet of these vehicles that have substantial leaks of liquid gasoline (i.e., "gross liquid leakers") for vehicles that were not designed to meet the new enhanced evaporative test procedure (i.e., vehicles up through the 1995 model year along with some of the 1996 through 1998 model years). For the vehicles designed to meet the new enhanced evaporative test procedure, EPA will modify that equation (see Section 4.0).

3.3 Combining Purge/Pressure Rates with Gross Liquid Leaker Rates

In Section 3.1 we characterized the three strata resulting from the individual vehicle's performance on the purge and pressure tests. In Section 3.2, we characterized the additional stratum created for the "gross liquid leakers." In order to make these strata non-overlapping (i.e., mutually exclusive), we must remove the "gross liquid leakers" from the other three strata.

To determine the distribution of the gross liquid leakers among the other three strata, we examined the 270 vehicles in the combined EPA/CRC RTD testing programs. Seven vehicles were identified as "gross liquid leakers" out of those 270 vehicles that were tested. Of these seven gross liquid leakers:

- four had failed both the purge and pressure tests,
- two had failed only the pressure test, and
- one had passed both the purge and pressure tests.

This distribution of seven gross liquid leakers proves that gross liquid leakers can and do occur within all three of the purge/pressure strata. From these statistics, EPA first estimated the number of gross liquid leakers within each of the purge/pressure strata and then removed them to form a fourth stratum consisting of only the gross liquid leakers. Rather than attempting to estimate the distribution of all gross liquid leakers based on a sample of only seven vehicles, MOBILE6 will simply distribute the liquid leakers proportionately among the three purge/pressure categories.

As an example, if we were to take a hypothetical fleet of 10,000,000 vehicles, each 10 years of age, then Appendix B predicts that 78,000 (0.78 percent) of them will be "gross liquid leakers" on the RTD test. Similarly, Appendix A indicates that 1,091,000 (10.91 percent) will fail the pressure test, 647,000 (6.47 percent) will fail only the purge test, and the remaining 8,262,000 (82.62 percent) will pass both tests. Distributing those 78,000 "gross liquid leakers" proportionately among the three purge/pressure strata predicts the following distribution:

Table 5

Predicted Distribution on RTD Test
(For Vehicles at 10 Years of Age)

Purge/Pressure Strata	"Gross Liquid Leakers"	Not "Gross Liquid Leakers"	TOTALS
Fail Pressure	8,510	1,082,490	1,091,000
Fail ONLY Purge	5,047	641,953	647,000
Pass Both	64,444	8,197,556	8,262,000
TOTALS	78,000	9,922,000	10,000,000

Thus, Table 5 indicates that for 10 year old vehicles on the RTD test:

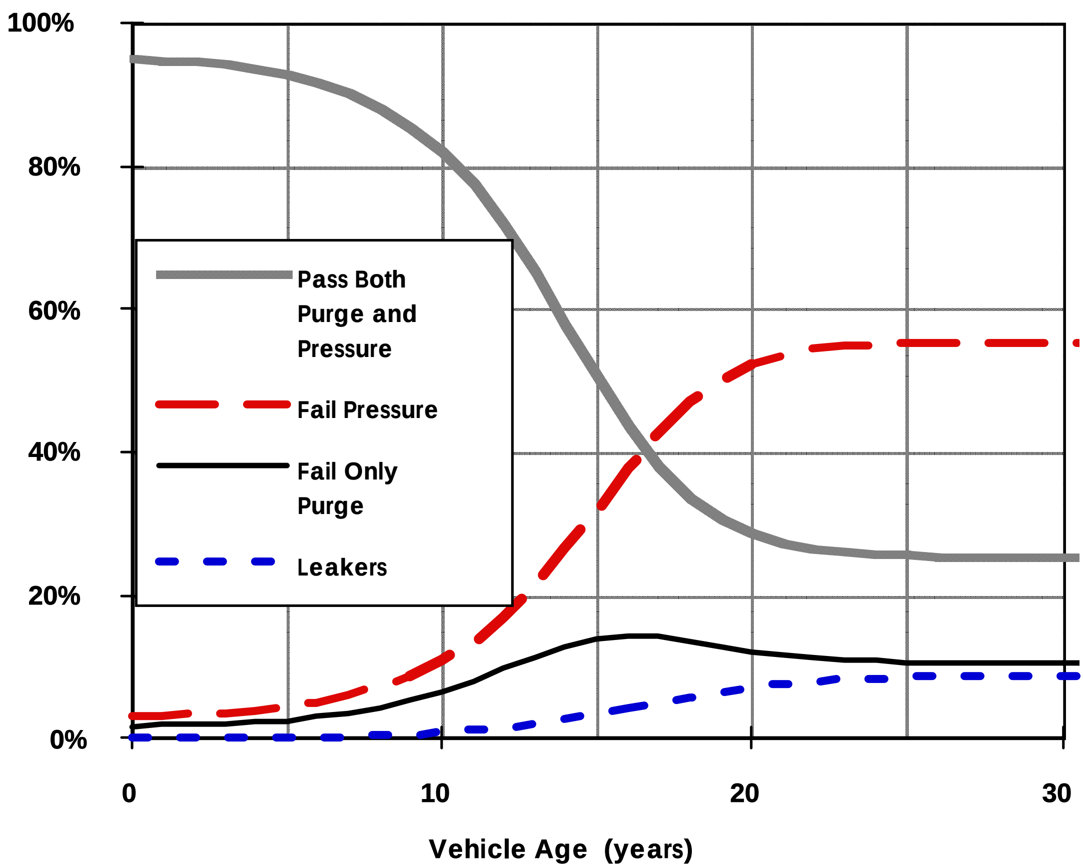
- 0.78 percent of those vehicles will be "gross liquid leakers" on a RTD test,
- 10.82 percent of those vehicles will fail the pressure test, but will not be "gross liquid leakers,"

- 6.42 percent of those vehicles will fail only the purge test, but will not be "gross liquid leakers," and
- 81.98 percent of those vehicles will pass both the pressure and purge tests, and will not be "gross liquid leakers."

Repeating this process for each vehicle age in Appendices A and B produces the estimated size of each of the four strata for the RTD test for each age. The results are plotted below (Figure 7):

Figure 7

Predicted Strata Sizes on RTD Test
(by vehicle age)



Repeating this process using the "running loss" and "hot soak" columns from Appendix B will produce the estimates of the size of the four strata for use with each of those two types of evaporative emissions.

4.0 MODELING ENHANCED EVAP VEHICLES EQUIPPED WITH OBD

Beginning with the 1996 model year, manufacturers were required to certify at least twenty percent of their vehicles using a new "enhanced" evaporative testing procedure (ETP); that percentage of ETP vehicles was required to increase from the twenty percent in 1996 up to one hundred percent by 1999. The actual phase-in of these ETP vehicles proceeded at a slightly faster pace (based on EPA's analysis of data from the Wisconsin Inspection/Maintenance program for model years 1996-1999). The phase-in rate required by the regulations is given below in Table 6 (copied from **40 CFR 86.096-8**) along with the observed (actual) phase-in rate.

Table 6

Phase-In of Vehicles with Enhanced Evaporative Controls

Model Year	Required Percentage	Observed Percentage
1995	0%	0%
1996	20%	30%
1997	40%	55%
1998	90%	90%
1999	100%	100%

To predict the performance of these 1996 and newer vehicles on the purge and pressure tests, the effects of two factors must be considered:

1) A change in the regulations requires a doubling of the period during which these vehicles must meet the evaporative emissions standards (increased from 5 years / 50,000 miles to 10 years / 100,000 miles for light-duty vehicles).

2) Most of these ETP vehicles are equipped with an on-board diagnostic (OBD) system that is expected to alert each vehicle's owner (or driver) to most problems with the evaporative control system, thus permitting the owner to decide whether to repair the problem.

In order to meet the increased durability and more stringent evaporative standards, manufacturers have implemented a number of changes, including (but not limited to):

- "quick connects" that reduce the possibility of improper assembly when the vehicle is serviced,

- advanced materials that are less permeable, less susceptible to puncture, and more durable (i.e., elastomeric materials used in hoses and connectors),
- improvements made to the purge system (to enable the vehicles to pass both the running loss test and the multi-day diurnal test),
- tethered gas caps, and
- improved fractional-turn gas caps.

Since these changes are expected to result in improved control of evaporative emissions, in a parallel report (M6.EVP.005), EPA decided to use a separate set of estimates of both resting loss and diurnal emissions for these vehicles. However, EPA does not have actual data on the effects of these changes in durability that translates into changes in the purge and pressure failure rates estimated in Section 3.1 for the pre-1996 model year vehicles.

EPA, therefore, will use the doubling in the durability requirement to modify equations **(1)**, **(2)**, **(4)**, and **(5)** (from Sections 3.1.1, 3.1.2, and 3.2) by replacing the variable "**AGE**" with "**AGE/2**" resulting in:

Pressure Failure Rate of Enhanced Evaporative Control Vehicles

$$= \frac{0.6045}{1 + 17.733*\exp[-0.003405*(AGE\textasciicircum 2)]} \qquad (6)$$

Rate of Passing Both for Enhanced Evaporative Control Vehicles

$$= 1 - \frac{0.7200}{1 + 13.40*\exp[-0.003625*(AGE\textasciicircum 2)]} \qquad (7)$$

Rate of Gross Liquid Leakers on the RTD Test for the Enhanced Evaporative Control Vehicles

$$= \frac{0.08902}{1 + 414.613*\exp(-0.1842*AGE)} \qquad (8)$$

Rate of Gross Liquid Leakers on the Running Loss Test for the Enhanced Evaporative Control Vehicles

$$= \frac{0.06}{1 + 120*\exp[-0.2 * AGE]} \qquad (9)$$

Using these equations, we first generated the estimated failure rates for those (1996 and newer) vehicles certified to the enhanced evaporative control standards. Since these estimates assume only the benefits of changes in durability with no estimation of the effect from the OBD system, they are adjusted in MOBILE6 (Appendices C and D).

Since the OBD system is designed to alert each vehicle's owner to problems with the evaporative control system. The appearance of a warning light should result in at least some owners having their malfunctioning vehicles repaired. Thus, the OBD system has the potential to affect the relative sizes of the purge/pressure strata, depending both on its ability to identify problems in the evaporative control systems and on the owners inclination to repair such problems. (In a parallel report **[10]**, EPA explains how those rates are adjusted in MOBILE6 to account for the presence of an I/M program for evaporative emissions.)

In that parallel report **[10]**, EPA assumes that the effect of an OBD system will vary, based on the vehicle's warranty and the presence of an I/M program. Those assumptions stated that:

- The vehicle's malfunction indicator light (MIL) would detect/identify 85 percent of the instances of the vehicle's failing the purge test or failing the pressure test. (It is assumed that the OBD system would <u>not</u> detect the presence of a gross liquid leak.)

- While the vehicle is under its full ("bumper to bumper") warranty (i.e., up through 3 years / 36,000 miles), 90 percent of the owners will have the vehicle repaired when the MIL indicates a problem. (These first two assumptions suggest that the OBD system combined with the manufacturer's warranty program will reduce the incidence of vehicles failing either the pressure or purge tests by 76.5 percent (76.5% = 85% * 90%).)

- When the warranty covers only the electronic control module and the catalytic converter (i.e., from 36,000 through 80,000 miles, approximately ages four through six years), only 10 percent of the owners will have the vehicle repaired when the MIL indicates a problem. (This assumption suggests that the OBD system combined with the manufacturer's warranty program will reduce the incidence of vehicles that in their fourth, fifth, or sixth years newly fail either the purge or pressure tests.) That percentage would increase from 10 to 90 percent if that geographic area has an I/M program that requires the MIL to indicate that there are no problems.

- When the vehicle is no longer covered by a manufacturer's warranty (i.e., over 80,000 miles or beyond six years of age), none (i.e., zero percent) of the owners will have the vehicle repaired when the MIL indicates a problem.

That percentage would increase from zero to 90 percent if that geographic area were to have an I/M program requiring the MIL to indicate that there are no problems.

EPA will adapt those assumptions (modified slightly) for evaporative emissions. Specifically:

- The vehicle's malfunction indicator light (MIL) would detect/identify 85 percent of the instances of the vehicle's failing the purge test or failing the pressure test. (It is assumed that the OBD system would <u>not</u> detect the presence of a gross liquid leak.)

- While the vehicle is within its full warranty period (i.e., approximately through the age of three years), 90 percent of the owners will have the vehicle repaired when the MIL indicates a problem. (These first two assumptions suggest that the OBD system combined with the manufacturer's warranty program will reduce the incidence of vehicles failing either the pressure or purge tests by 76.5 percent (76.5% = 85% * 90%).)

- While the vehicle is under its partial warranty period (i.e., approximately ages four through six years), only 10 percent of the owners will have the vehicle repaired when the MIL indicates a problem. (This assumption suggests that the OBD system combined with the manufacturer's warranty program will reduce the incidence of vehicles (ages four through six) that fail either the purge or pressure tests for the first time.) That percentage would increase from 10 to 90 percent if that geographic area were to have an I/M program requiring the MIL to indicate that there are no problems.

- When the vehicle's evaporative control system is no longer covered by a manufacturer's warranty (i.e., beyond about six years of age), none (i.e., zero percent) of the owners will have the vehicle repaired when the MIL indicates a problem. That percentage would increase from zero to 90 percent if that geographic area were to have an I/M program requiring the MIL to indicate that there are no problems.

Note: EPA is continuing to study in-use OBD systems. The assumptions listed here may be revised in future models.

These MOBILE6 assumptions are different from what was used in MOBILE5. In that previous model, while the evaporative emissions of the ETP vehicles were reduced to reflect the more stringent standards, the weighting factors were not changed to reflect either the improved durability or the OBD system.

5.0 COMPARISONS WITH MOBILE5

5.1 Comparisons of Weighting Factors

Both the MOBILE5 model and this proposal weight the estimated evaporative emissions based on each vehicle's performance on purge and pressure tests; however there are several structural differences:

- The weighting factors in MOBILE5 are each functions of a continuous variable (i.e., each model year's average odometer) while the weighting factors in MOBILE6 are functions of a discrete variable (i.e., each model year's estimated age).
- The weighting factors in this proposal are smooth functions (i.e., exponential) of the estimated age. Although the weighting factors in MOBILE5 are continuous, they are not smooth functions (they are piece-wise linear functions of odometer, thus almost linear with age).
- MOBILE5 does not have a separate stratum for the vehicles classified as "gross liquid leakers" while this proposal does. We will, therefore, compare the MOBILE5 weighting factors with the unadjusted factors from Section 3.1 of this report.

The comparisons between the MOBILE5 weighting factors for light-duty vehicles for each of the three purge/pressure strata and the weighting factors in this proposal are illustrated in the following three figures:

- Figure 8 compares the estimates of Pre-ETP vehicles (i.e., 1995 and older) passing both the purge test and the pressure test. (Subtracting each of those estimates from 100 percent will yield the associated rates of vehicles failing either the purge test, or the pressure test, or both tests.)
- Figure 9 compares the estimates of Pre-ETP vehicles failing the pressure test (regardless of the performance on the purge test).
- Figure 10 compares the estimates of Pre-ETP vehicles failing only the purge test.

Figure 8

Comparison of Predictions of Percentage of Pre-ETP Vehicles Passing Both the Purge and Pressure Tests (by vehicle age)

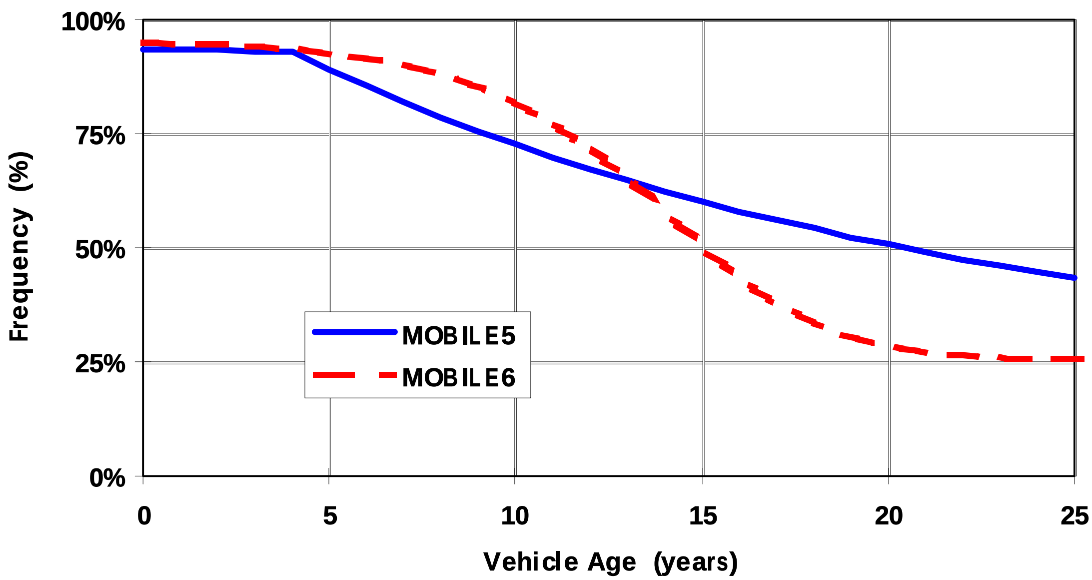


Figure 9

Comparison of Predictions of Percentage of Pre-ETP Vehicles Failing the Pressure Test (by vehicle age)

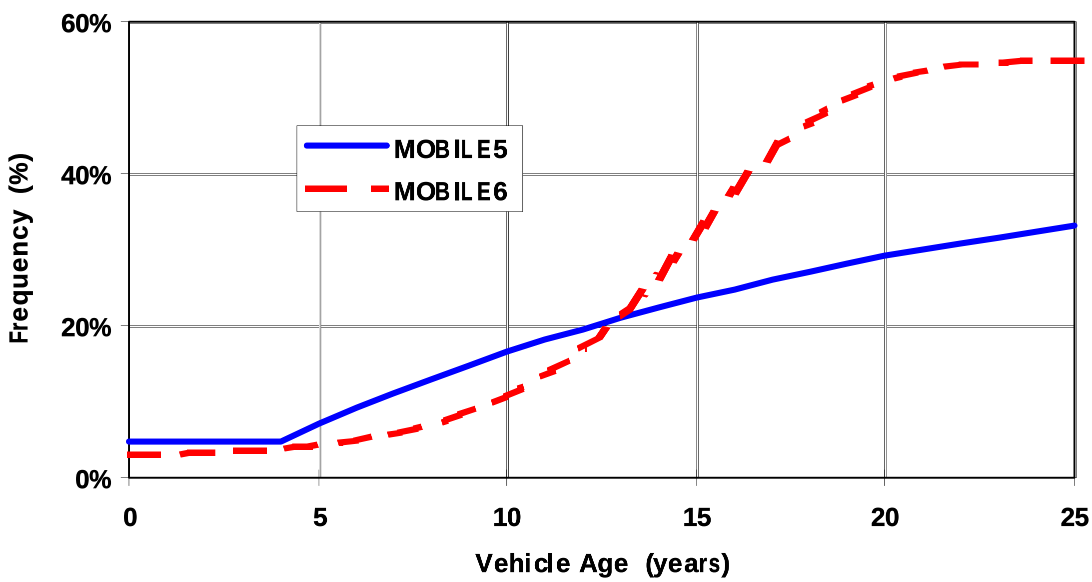
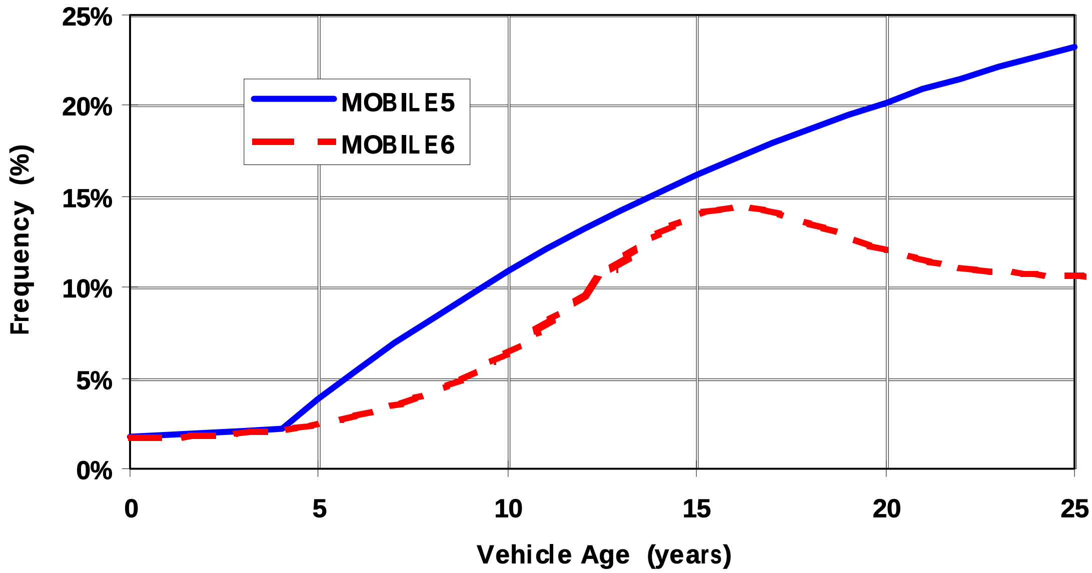


Figure 10

Comparison of Predictions of Percentage of Pre-ETP Vehicles Failing ONLY the Purge Test (by vehicle age)



Based on examinations of these three graphs, we can make the following observations for the Pre-ETP vehicles:

- The most obvious difference between the weighting factors used in MOBILE5 and those developed in this report is that the factors in this report are capped (around age 20) while the MOBILE5 factors are not.

- Despite the structural differences (i.e., smooth function of a discrete variable versus piece-wise linear function of a continuous variable) between these two sets of weighting factors, they produce similar results for vehicles up to about 12 to 13 years of age.

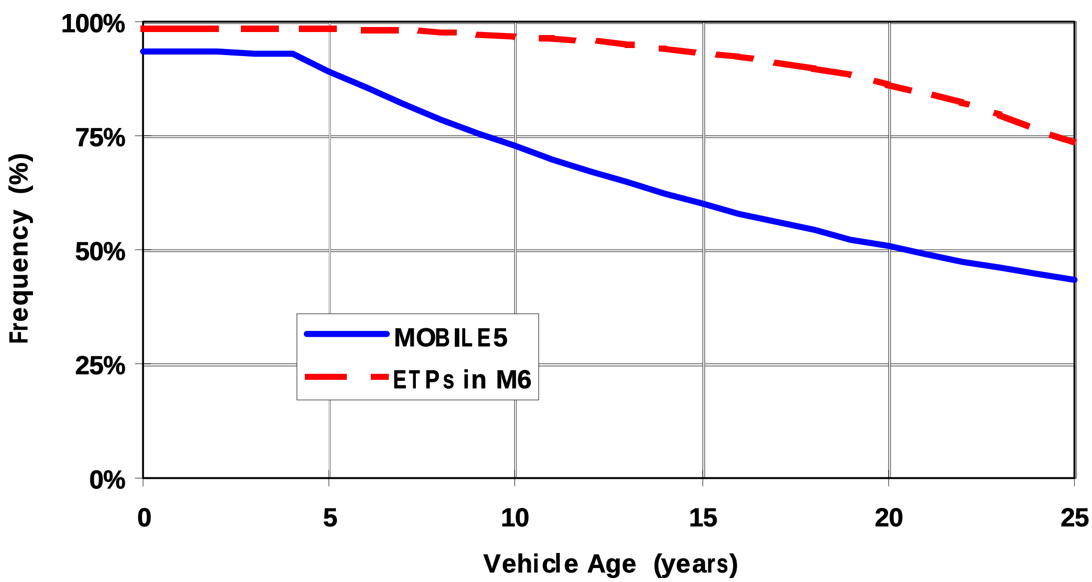
- The estimates developed in this report predict a substantially higher proportion of vehicles failing the pressure test for vehicles older than 13 years of age than does the MOBILE5 model.

The reader can make similar comparisons for the ETP vehicles by replacing the MOBILE6 (dotted) line in each figure with the values in Appendix D. (As stated at the end of Section 4, while MOBILE6 uses different distributions for the ETP vehicles, MOBILE5 uses the same distributions for the Pre-ETP and the ETP.) This results in MOBILE6 predicting a smaller number of malfunctioning ETP vehicles at any given age than did MOBILE5.

For example, MOBILE6 predicts that at age 25 years with no I/M program, approximately 26 percent of the ETP vehicles would fail either the purge or the pressure test while MOBILE5 predicts that approximately 56 percent would fail either test. This much lower predicted failure rate is illustrated in the following graph (Figure 11 which is a modification of Figure 8) in which the MOBILE6 curve (from Appendix A) is replaced with the corresponding curve from Appendix D (i.e., ETP vehicles in a non-I/M area passing both the purge test and pressure test).

Figure 11

Comparison of Predictions of Percentage of ETP Vehicles Passing Both the Purge and Pressure Tests (by vehicle age)



5.2 Comparisons of Weighted Full-Day Diurnal Emissions

By combining the information in this report with the information in parallel reports (i.e., M6.EVP.001 and M6.EVP.005), we can estimate the diurnal emissions for the in-use fleet (containing the 25 most recent model years). To compare these estimates with those predicted by the MOBILE5 model, the MOBILE5 model was run for a fleet with a national distribution of model years (as of January 1, 1995) with two likely combinations of temperature cycle and fuel RVP (assuming no weathering of the fuel):

- daily temperatures cycling between 60 and 84 degrees Fahrenheit using fuel with a 9.0 RVP (see Figure 12) and

- daily temperatures cycling between 82 and 106 degrees Fahrenheit using fuel with a 7.0 RVP (see Figure 13).

Each MOBILE5 run generates estimated diurnal emissions for the 25 most recent model years, which for these runs were the 1971 through 1995 model years. In these two examples the variable **MODEL YEAR** can be transformed into **AGE** using the equation:

AGE = 95 - (MODEL YEAR).

It is important to note that these (following) estimates are only of the full one-day diurnal emissions. They do include diurnal emissions from "gross liquid leakers." But, they do <u>not</u> include evaporative emissions from interrupted (i.e., partial-day) diurnals, nor from multi-day diurnals, nor from running loss, nor from hot soaks. Estimates of these excluded sources are developed in parallel reports. A complete comparison between MOBILE6 and MOBILE5 requires using activity data to weight together all of these individual components of evaporative emissions; this can be done by running each model.

<u>Figure 12</u>

Comparison of Predictions for In-Use Diurnal Emissions by Model Year (Total Grams Per Full-Day Test) 60° to 84° F Cycle -- Using 9.0 psi RVP Fuel (As of January 1, 1995)

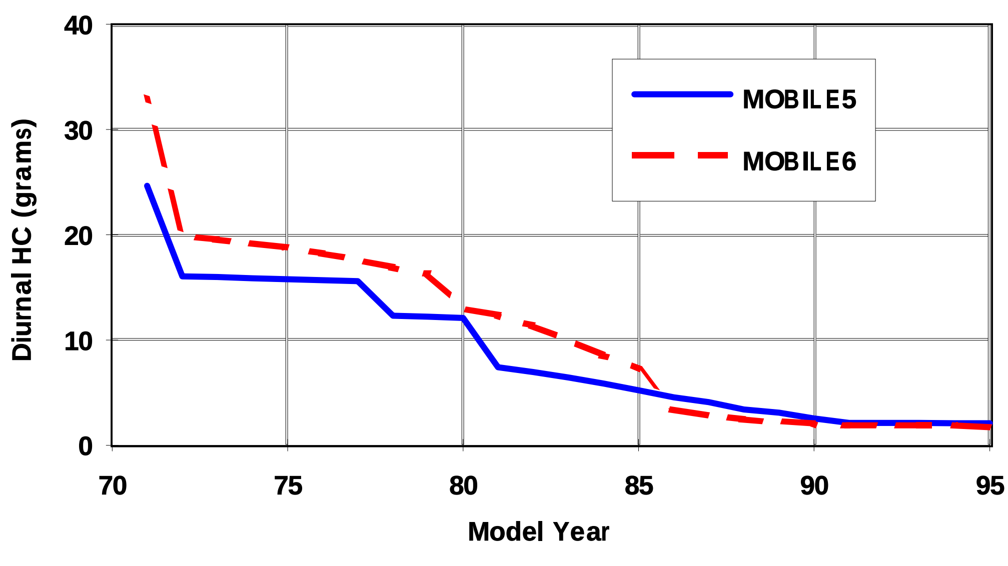
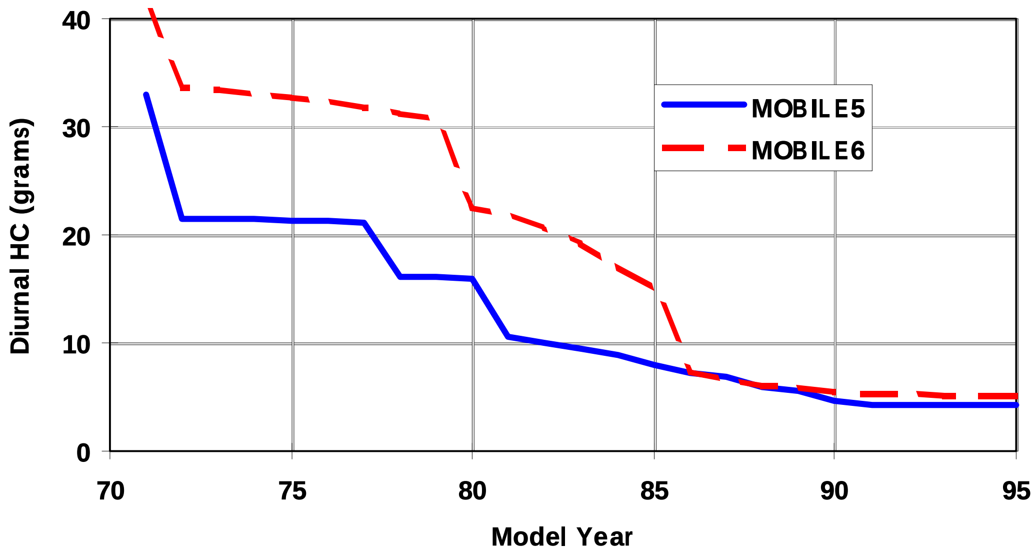


Figure 13

Comparison of Predictions for In-Use Diurnal Emissions by Model Year (Total Grams Per Full-Day Test) 82° to 106° F Cycle -- Using 7.0 psi RVP Fuel (As of January 1, 1995)



In Figures 12 and 13, the typical (i.e., mean) 24-hour diurnal emissions for each vehicle are plotted against model year. Visual inspections of Figures 12 and 13 suggest that the estimates of diurnal emissions resulting from MOBILE6 (for each of those two combinations of fuel RVP and temperature cycle) for each model year are:

- close (within a gram per vehicle per day) to MOBILE5 estimates for the 1986 to 1995 model year vehicles,
- typically 25 to 75 percent higher (for 9.0 and 7.0 RVP fuels, respectively) than MOBILE5 estimates for 1980 to 1985 model year vehicles, and
- typically 30 to 40 percent higher than MOBILE5 estimates for 1972 to 1979 model year vehicles.

A similar comparison for the vehicles certified to the new enhanced evaporative emission requirements (i.e., 1999 and newer vehicles, along with some 1996-98 model year vehicles) is provided in Section 5.3.

In Figures 12 and 13, we weighted each model year's estimated diurnal emissions by the relative number of vehicles in the fleet, we obtain the estimate of the mean full-day diurnal emissions for an average in-use vehicle subject to a full-day's diurnal:

Estimates of Full-Day Diurnal Emissions
For the In-Use Fleet (As of January 1995)
In Units of Grams per Day per Vehicle

Temperature Cycle and Fuel	MOBILE5 Estimate	MOBILE6 Estimate
60° to 84° F with 9.0 psi RVP	4.86	5.42
82° to 106° F with 7.0 psi RVP	7.61	10.86

We repeated these calculations for several dozen combinations of fuel RVP and temperature cycles and then graphed the resulting averages in Figures 14 through 17. The first three figures (Figures 14 through 16) are based on January 1, 1995 (thus covering model years 1971 through 1995). Figure 17 is based at January 1, 1985 (thus, covering model years 1961 through 1985). Therefore, Figures 16 and 17 differ only by the model years covered. Since both the horizontal and vertical scales vary among these four graphs, care should be taken in making comparisons between these figures.

Figure 14

Comparison of Predictions of Full-Day Diurnal Emissions by RVP
For the In-Use Fleet (as of January 1995) with the 60° to 84° F Cycle
In Units of Grams per Day per Vehicle

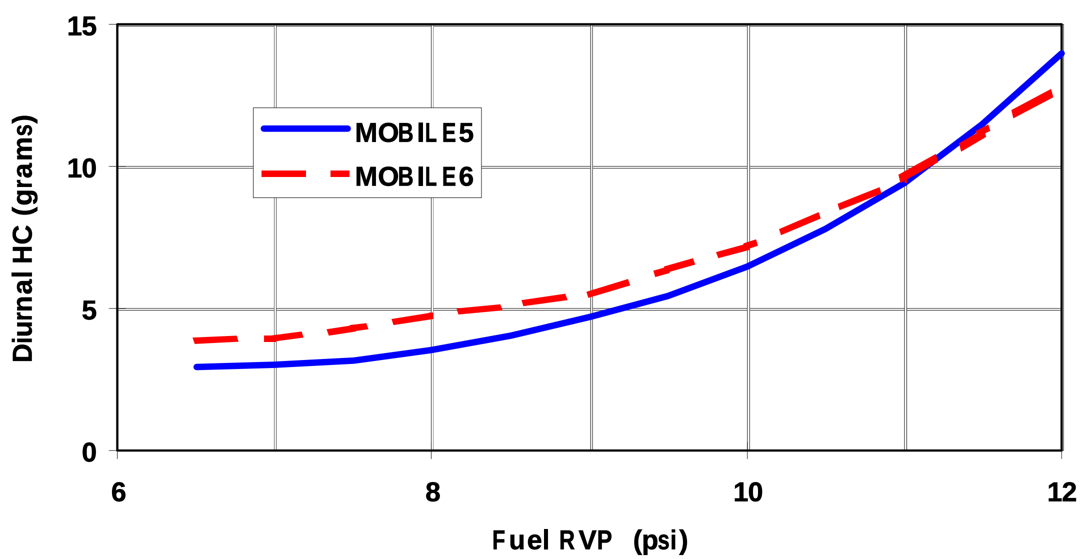


Figure 15

Comparison of Predictions of Full-Day Diurnal Emissions by RVP
For the In-Use Fleet (as of January 1995) with the 72° to 96° F Cycle
In Units of Grams per Day per Vehicle

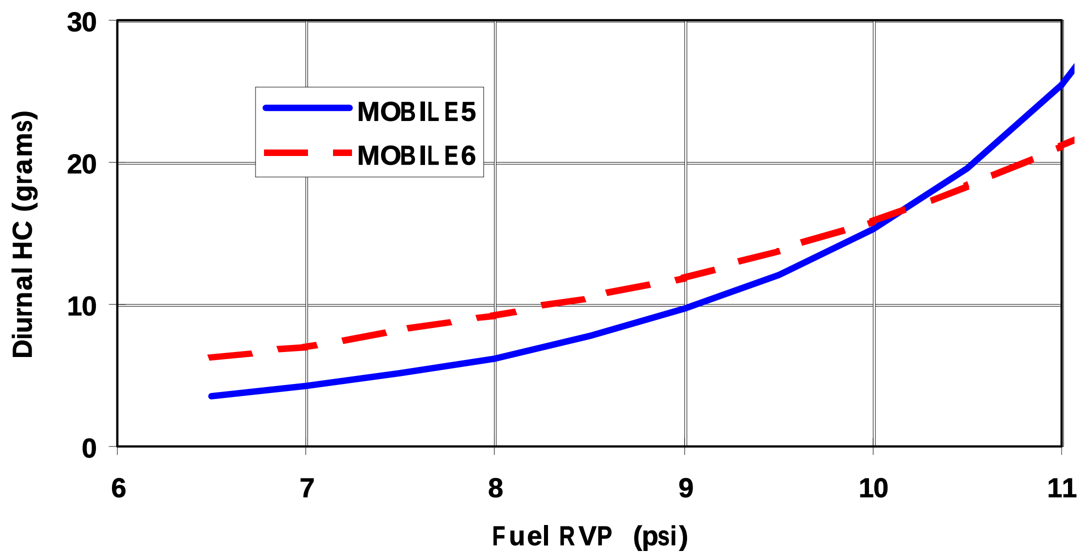


Figure 16

Comparison of Predictions of Full-Day Diurnal Emissions by RVP
For the In-Use Fleet (as of January 1995) with the 82° to 106° F Cycle
In Units of Grams per Day per Vehicle

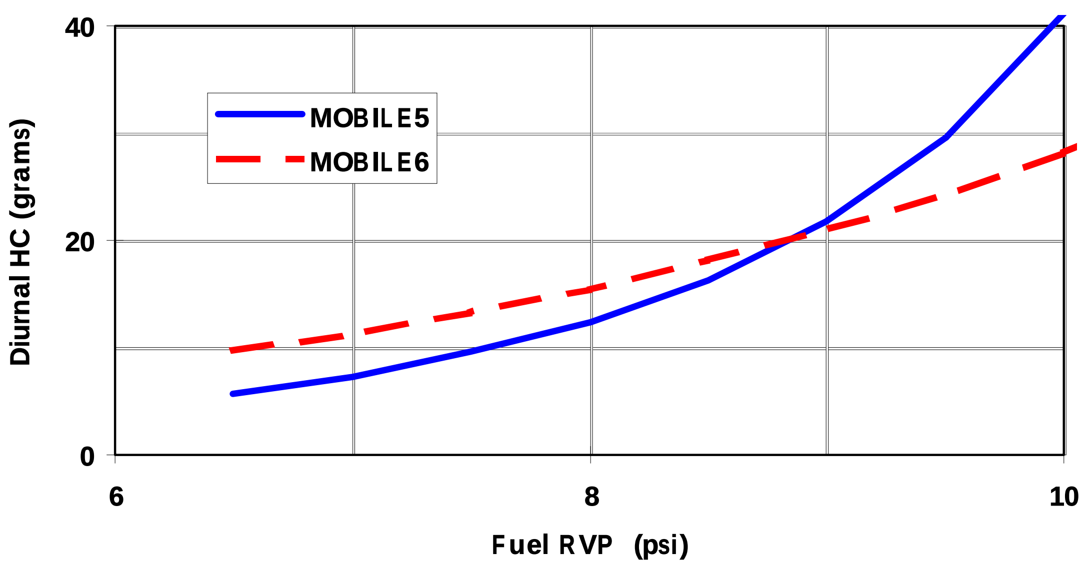
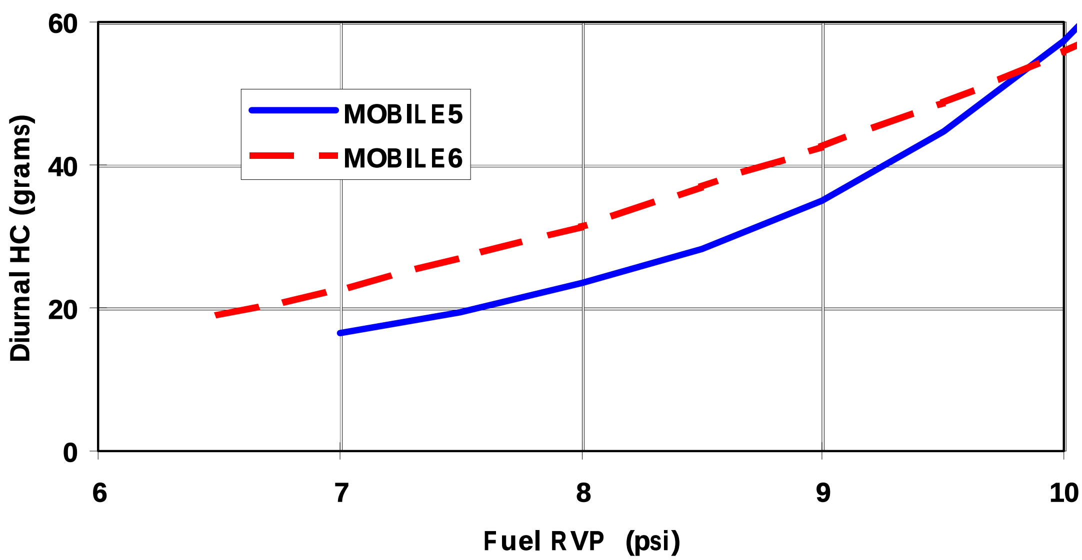


Figure 17

Comparison of Predictions of Full-Day Diurnal Emissions by RVP For the In-Use Fleet (as of January 1985) with the 82° to 106° F Cycle In Units of Grams per Day per Vehicle



Based on examinations of these four graphs, we made the following observations (for Pre-ETP vehicles):

- For the lowest temperature cycle (i.e., daily temperatures cycling between 60° and 84°F), the MOBILE6 approach to predicting fleet full-day diurnal emissions produce results quite similar to MOBILE5 for the full range of fuel RVPs. (Figure 14.)

- For the two higher temperature cycles, the MOBILE6 approach to predicting full-day diurnal emissions produce results similar to MOBILE5 for fuel RVPs up to 10 psi, which is a reasonable upper bound for in-use fuel RVP at those temperatures. (Figures 15 through 17.)

- The MOBILE6 approach (compared to MOBILE5) predicts slightly higher full-day diurnal emissions for the lower RVP fuels and the reverse (i.e., lower diurnal emissions) for the higher RVP fuels. The range of RVPs for which the new estimates are higher than the MOBILE5 estimates varies with the temperature cycle:

  - •• For the low temperature cycle (i.e., 60° to 84°F), the MOBILE6 approach predicts slightly higher diurnal emissions for fuel RVPs up through 11 psi. For fuel RVPs near 7 psi, the higher MOBILE6 predictions are within 0.9 grams of HC (of the MOBILE5 estimates) per day per vehicle undergoing a full (24-hour) diurnal. This difference gradually shrinks to zero as the fuel RVP nears 11 psi. For fuel RVPs above 11 psi, the MOBILE6 estimates are slightly lower than the MOBILE5 estimates.

- For the moderate temperature cycle (i.e., 72° to 96°F), the new approach predicts slightly higher diurnal emissions for fuel RVPs up through 10 psi. For fuel RVPs above 10 psi, the new estimates are lower than the MOBILE5 estimates. For RVPs above 11 psi (an unlikely occurrence with this temperature cycle), the two models move farther apart.

- For the high temperature cycle (i.e., 82° to 106°F), the new approach predicts slightly higher diurnal emissions for fuel RVPs up through 8.5 psi for the in-use fleet as of January 1995 (Figure 16). For fuel RVPs above 8.5 psi, the new estimates are lower than the MOBILE5 estimates. For RVPs above 10 psi (an unlikely occurrence with this temperature cycle), the two models move farther apart. A snapshot of the in-use fleet as of January 1985 (Figure 17) yields similar results.

A more complete comparison of predicted diurnal emissions (i.e., one that takes activity data into account) can be obtained by running the two models. Similarly for the other evaporative emissions.

5.3 Comparisons of Diurnal Emissions from Vehicles Certified to the Enhanced Evaporative Control Standards

In Section 5.2, we compared, for 1995 and older model year vehicles, these MOBILE6 estimates of full-day diurnal emissions with those predicted by the MOBILE5 model. In this section, we perform a similar comparison of the two estimates for the vehicles certified to the enhanced evaporative standard (i.e., the 1999 and newer along with some 1996 through 1998 model year vehicles).

Repeating the process used to create Figures 12 and 13 but with January 1, 2020 as the evaluation date produced Figures 18 and 19.

Figure 18

For Enhanced Evaporative Control Vehicles (ETPs)
Comparison of Predictions for In-Use Diurnal Emissions by Age
60° to 84° F Cycle -- Using 9.0 psi RVP Fuel
(Non-I/M Area)
In Units of Grams per Day per Vehicle

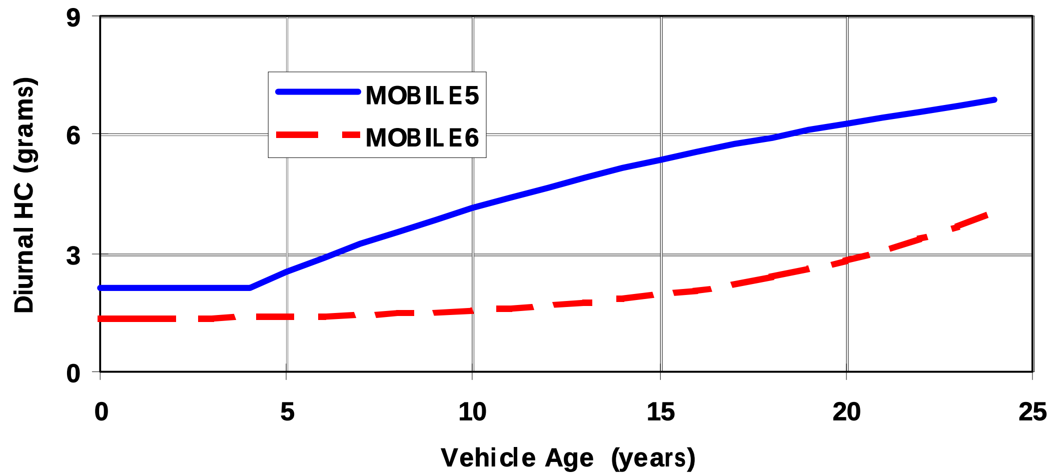
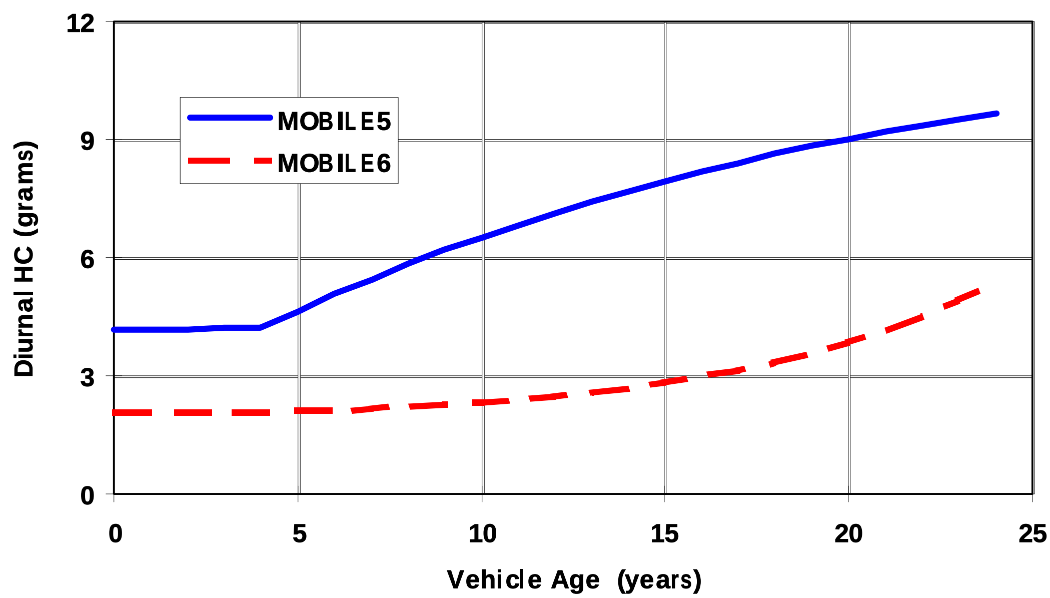


Figure 19

For Enhanced Evaporative Control Vehicles
Comparison of Predictions for In-Use Diurnal Emissions by Age
82° to 106° F Cycle -- Using 7.0 psi RVP Fuel
(Non-I/M Area)
In Units of Grams per Day per Vehicle



Visual inspections of Figures 18 and 19 leads to the following conclusions:

- MOBILE6 predicts substantially lower full-day diurnal emissions for these new vehicles than does MOBILE5. This difference is due (almost entirely) to the substantially lower failure rate (on the purge and pressure tests) predicted in MOBILE6. (MOBILE5 uses the same failure rates for the ETP vehicles as for the Pre-ETPs while MOBILE6 uses Appendices C, D, and E. See Figure 11 on page 29.)

- For vehicles between 10 and 25 years of age, MOBILE6 predicts a substantial rise in the full-day diurnal emissions of the in-use fleet (on a per vehicle basis), but still smaller than the MOBILE5 predicted increase.

  This increase in MOBILE6 predicted emissions is driven primarily by the increasing numbers of gross liquid leakers. This is despite the fact that their predicted rate of occurrence among ETP vehicles is very low (less than two percent at age 25).

  Thus, modifying the assumptions on the frequency of gross liquid leakers as a function of age among these vehicles would significantly affect the graphs for "MOBILE6" in Figures 18 and 19, with that curve remaining much flatter throughout.

6.0 SUMMARY

Estimates of evaporative emissions in MOBILE6 will be modeled based on their type:

- resting loss emissions,
- running loss emissions,
- hot soak emissions, and
- diurnal emissions.

Each of these types will be calculated based on whether the individual vehicles:

- are gross liquid leakers,
- failed the pressure test,

- failed only the purge test, or
- passed both the purge and pressure tests.

Once the estimated evaporative emissions of each sub-strata is calculated, they will be weighted together using the equations developed in this report.

The analyses suggest that for the full-day diurnal (see Sections 5.2 and 5.3), MOBILE6:

- predicts full-day diurnal emissions lower than does MOBILE5 for the 1999 and newer vehicles,
- predicts full-day diurnal emissions similar to those of MOBILE5 for the 1986-1995 model year vehicles, and
- predicts full-day diurnal emissions higher than does MOBILE5 for the 1985 and older vehicles.

Similarly, we can perform a simplified analysis to estimate the effect (benefit) of reducing fuel RVP on full-day diurnal emissions:

- In each of the four figures (Figure 14 through 17), the MOBILE5 graph is steeper than the graph of MOBILE6. The lower slopes associated with the MOBILE6 estimates will result in smaller decreases in predicted full-day diurnal emissions associated with a reduction in fuel RVP than the corresponding changes predicted by MOBILE5.
- Analyses performed to calculate the effect (e.g., either the cost per ton or the benefit) will make RVP control programs slightly less attractive for controlling full-day diurnal emissions.
- The difference in the predicted effect of lowering fuel RVP is small for lower RVP fuels. Thus, estimating the effects of reducing the fuel RVP from 8 psi (or from a lower value) will be similar under both methods.

7.0 REFERENCES

1) Larry Landman, "Evaluating Resting Loss and Diurnal Evaporative Emissions Using RTD Tests," Report numbered M6.EVP.001, April 2001.

2) Larry Landman, "Modeling Hourly Diurnal Emissions and Interrupted Diurnal Emissions Based on Real-Time Diurnal Data," Report numbered M6.EVP.002, April 2001.

3) Larry Landman, "Modeling Diurnal and Resting Loss Emission from Vehicles Certified to the Enhanced Evaporative Standards," Report numbered M6.EVP.005, April 2001.

4) Larry Landman, "Evaporative Emissions of Gross Liquid Leakers in MOBILE6," Report numbered M6.EVP.009, April 2001.

5) Louis Browning, "Update of Hot Soak Emissions Analysis" prepared by Louis Browning of ARCADIS Geraghty & Miller, Inc. for EPA, Report numbered M6.EVP.004, September 1998

6) Larry Landman, "Estimating Running Loss Evaporative Emissions in MOBILE6," Report numbered M6.EVP.008, April 2001.

7) D. McClement, J. Dueck, B. Hall, "Measurements of Diurnal Emissions from In-Use Vehicles, CRC Project E-9", Prepared for the Coordinating Research Council, Inc. by Automotive Testing Laboratories, Inc., June 19, 1998.

8) D. McClement, "Real World Evaporative Testing of Late Model In-Use Vehicles, CRC Project E-41", Prepared for the Coordinating Research Council, Inc. by Automotive Testing Laboratories, Inc., December 17, 1998.

9) D. McClement, "Raw Fuel Survey in I/M Lanes", Prepared for the American Petroleum Institute and the Coordinating Research Council, Inc. by Automotive Testing Laboratories, Inc., June 10, 1998.

10) Megan Beardsley, "Estimating Benefits of Inspection/ Maintenance Programs for Evaporative Control Systems," Report numbered M6.IM.003, November 1999.

Appendix A

Estimates of Purge/Pressure Strata Size by Vehicle Age For 1995 and Older Model Years Vehicles

(For Non-I/M Areas)

Vehicle Age (years)	Failing Pressure Test	Failing Only Purge Test	Passing Both Purge and Pressure Tests
0	3.23%	1.77%	95.00%
1	3.27%	1.80%	94.93%
2	3.40%	1.88%	94.72%
3	3.62%	2.02%	94.36%
4	3.96%	2.23%	93.81%
5	4.44%	2.53%	93.03%
6	5.10%	2.95%	91.96%
7	5.99%	3.51%	90.51%
8	7.18%	4.25%	88.57%
9	8.78%	5.23%	85.99%
10	10.91%	6.47%	82.62%
11	13.70%	8.00%	78.30%
12	17.30%	9.76%	72.94%
13	21.79%	11.61%	66.60%
14	27.12%	13.29%	59.58%
15	33.07%	14.51%	52.42%
16	39.19%	15.06%	45.76%
17	44.90%	14.95%	40.14%
18	49.76%	14.41%	35.84%
19	53.50%	13.70%	32.80%
20	56.16%	13.03%	30.81%
21	57.92%	12.50%	29.58%
22	59.02%	12.13%	28.85%
23	59.66%	11.89%	28.45%
24	60.03%	11.74%	28.23%
25	60.24%	11.65%	28.11%

Appendix B

Predicted Frequency of Occurrence of "Gross Liquid Leakers" by Emission Type and Vehicle Age For 1995 and Older Model Years Vehicles

(Reproduced from Report Number: M6.EVP.009 **[4]**)

Vehicle Age (years)	Resting Loss / Diurnal	Running Loss	Hot Soak
0	0.02%	0.05%	0.07%
1	0.03%	0.07%	0.10%
2	0.04%	0.11%	0.15%
3	0.06%	0.16%	0.23%
4	0.09%	0.24%	0.33%
5	0.13%	0.35%	0.48%
6	0.19%	0.50%	0.70%
7	0.27%	0.72%	1.00%
8	0.39%	1.02%	1.41%
9	0.55%	1.40%	1.95%
10	0.78%	1.88%	2.64%
11	1.08%	2.43%	3.48%
12	1.49%	3.02%	4.46%
13	2.00%	3.61%	5.54%
14	2.63%	4.16%	6.67%
15	3.36%	4.62%	7.83%
16	4.15%	5.00%	8.95%
17	4.97%	5.29%	10.00%
18	5.75%	5.51%	10.94%
19	6.46%	5.66%	11.75%
20	7.05%	5.77%	12.42%
21	7.54%	5.84%	12.94%
22	7.91%	5.89%	13.34%
23	8.19%	5.93%	13.63%
24	8.40%	5.95%	13.85%
25	8.55%	5.97%	14.00%

Appendix C

Estimates of Purge/Pressure Strata Size by Vehicle Age For 1999 and Later Model Years Vehicles

(For I/M Areas*)

Vehicle Age (years)	Failing Pressure Test	Failing Only Purge Test	Passing Both Purge and Pressure Tests
0	0.76%	0.42%	98.83%
1	0.76%	0.42%	98.82%
2	0.77%	0.42%	98.81%
3	0.78%	0.43%	98.79%
4	0.80%	0.44%	98.76%
5	0.82%	0.46%	98.72%
6	0.85%	0.47%	98.67%
7	0.89%	0.50%	98.62%
8	0.93%	0.52%	98.54%
9	0.98%	0.56%	98.46%
10	1.04%	0.60%	98.36%
11	1.11%	0.64%	98.25%
12	1.20%	0.69%	98.11%
13	1.29%	0.75%	97.95%
14	1.41%	0.82%	97.77%
15	1.54%	0.91%	97.56%
16	1.69%	1.00%	97.31%
17	1.86%	1.11%	97.03%
18	2.06%	1.23%	96.71%
19	2.30%	1.37%	96.34%
20	2.56%	1.52%	95.92%
21	2.87%	1.69%	95.44%
22	3.22%	1.88%	94.90%
23	3.62%	2.08%	94.30%
24	4.07%	2.29%	93.64%
25	4.57%	2.51%	92.92%

* This assumes that the I/M program requires repairs to vehicles with a MIL that indicates that there is a problem.

Appendix D

Estimates of Strata Size by Vehicle Age For 1999 and Later Model Years Vehicles

(For Non-I/M Areas*)

Vehicle Age (years)	Failing Pressure Test	Failing Only Purge Test	Passing Both Purge and Pressure Tests
0	0.76%	0.42%	98.83%
1	0.76%	0.42%	98.82%
2	0.77%	0.42%	98.81%
3	0.78%	0.43%	98.79%
4	0.85%	0.47%	98.68%
5	0.94%	0.53%	98.53%
6	1.06%	0.60%	98.34%
7	1.21%	0.70%	98.09%
8	1.39%	0.81%	97.79%
9	1.61%	0.95%	97.43%
10	1.87%	1.12%	97.01%
11	2.18%	1.31%	96.52%
12	2.53%	1.53%	95.94%
13	2.94%	1.79%	95.27%
14	3.42%	2.09%	94.49%
15	3.97%	2.44%	93.59%
16	4.62%	2.83%	92.55%
17	5.36%	3.29%	91.35%
18	6.21%	3.81%	89.98%
19	7.20%	4.40%	88.40%
20	8.34%	5.05%	86.61%
21	9.64%	5.78%	84.57%
22	11.13%	6.58%	82.29%
23	12.82%	7.44%	79.74%
24	14.73%	8.34%	76.92%
25	16.86%	9.27%	73.86%

Up through the age of three (3) years, these values are identical to those in Appendix C.

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* This assumes that either the geographic area has no I/M program or that the existing I/M program does not include a check of the OBD MIL.

Appendix E

Predicted Frequency of Occurrence of "Gross Liquid Leakers" by Emission Type and Vehicle Age For 1999 and Newer Model Years Vehicles

Vehicle Age (years)	Resting Loss / Diurnal	Running Loss	Hot Soak
0	0.02%	0.05%	0.07%
1	0.03%	0.06%	0.09%
2	0.03%	0.07%	0.10%
3	0.04%	0.09%	0.13%
4	0.04%	0.11%	0.15%
5	0.05%	0.13%	0.19%
6	0.06%	0.16%	0.23%
7	0.08%	0.20%	0.27%
8	0.09%	0.24%	0.33%
9	0.11%	0.29%	0.40%
10	0.13%	0.35%	0.48%
11	0.16%	0.42%	0.58%
12	0.19%	0.50%	0.70%
13	0.23%	0.61%	0.83%
14	0.27%	0.72%	1.00%
15	0.33%	0.86%	1.19%
16	0.39%	1.02%	1.41%
17	0.47%	1.20%	1.66%
18	0.55%	1.40%	1.95%
19	0.66%	1.63%	2.28%
20	0.78%	1.88%	2.64%
21	0.92%	2.14%	3.04%
22	1.08%	2.43%	3.48%
23	1.27%	2.72%	3.96%
24	1.49%	3.02%	4.46%
25	1.73%	3.32%	4.99%

Appendix F

Response to Peer Review Comments from Sandeep Kishan

This report was formally peer reviewed by one peer reviewer (Sandeep Kishan). In this appendix, comments from Sandeep Kishan are reproduced in plain text, and EPA's responses to those comments are interspersed in indented italics. Each of these comments refer to page numbers in the earlier draft version (dated June 10, 1999) that do not necessarily match the page numbers in this final version.

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This memorandum provides peer review comments on the EPA draft report: "Estimating Weighting Factors for Evaporative Emissions in MOBILE6," Document No. M6.EVP.006, June 10, 1999.

Overall, this report was clearly written and the general methodology seems good. We do not have any recommendations on alternate datasets. The part of the report that needs a better explanation is the last paragraph on Page 16 describing the relationship among the hot soak, RTD, and running loss gross liquid leakers.

Document No. M6.EVP.006 (June 10, 1999)

We have the following questions, comments, and recommendations on this draft report. For each item we give the page number and paragraph that the comment refers to, if it is a specific comment.

1. Page 3, last paragraph – The text states that approximately 15% of the vehicles did not have purge or pressure tests performed for one reason or another. The report goes on to say that the proposal is to assume that these vehicles were distributed proportionately among the three purge/pressure strata. Are there any engineering reasons to believe that these omitted vehicles are different from the vehicles included in the data analysis with respect to purge/pressure fail rates?

   No, we have no reason to assume (or believe) that these omitted vehicles (that did not have purge and/or pressure tests performed) are different from the remaining vehicles. Which is why we treated them as we did.

2. Page 4, last paragraph – The last sentence in this paragraph needs to be restated. We are not sure what the author is trying to say with this sentence. Is the author trying to say that the CRC data is unreliable since it is not an EPA

data source? Is the author trying to say that the 57.6% fail rate is amazingly high and the value cannot possibly be biased high by EPA since the data is entirely CRC data? The underlining of the word entirely helps add to the confusion that this sentence brings to the mind of the reader.

The wording (and underlining) has been changed to avoid confusion.

3. Page 6, last paragraph in Section 3.1 – How did you calculate the confidence limits given in Table 2? We would have used binomial confidence intervals. It appears this is what the author has done. It should be so stated in the text.

   The reviewer is correct, EPA did use binomial confidence intervals. This fact has been added to the text just prior to Table 2.

4. Page 6, last paragraph in Section 3.1 – The author chose to select the first two of the three categories given at the beginning of the section to model. Was there any basis for the selection? The only reason we can see is that modeling the purge test only failures would appear to be a nightmare as shown in Figure 3 on page 12.

   "Nightmare" is probably too strong a word. We would also have had some difficulty if we had attempted to directly model the vehicles that failed <u>only</u> the pressure test. Since we have three frequency curves that must add to exactly 100 percent at each age, we only need to determine two of those curves (the third being the remainder). This means that there are three different approaches to modeling these three curves. While each approach yields slightly different sets of equations, the predicted values are close for the ages with large sample sizes.

   Since the logistic growth curve is monotonic (strictly increasing or strictly decreasing), EPA chose to model the two curves most likely to also be monotonic, specifically the vehicles failing the pressure test (strictly increasing) and the vehicles passing both tests (strictly decreasing). (Similarly, the vehicles failing both tests are expected to have a strictly increasing curve.)

5. Page 8, first full paragraph – This comment concerns the discussion of the average test date for the dataset. Clearly, if testing is going on all year long at a relatively constant rate, the average date will be near July 1. The middle sentence in this paragraph needs to be reworded. The phrase "the typical test" is a little strange and gives the impression that 14,000 tests were performed during one week in July.

That paragraph has been rewritten to eliminate the confusion.

6. Page 8, second full paragraph – We understand that weighting the vehicle age average values they have fewer observations less than those that have more observations is appropriate but why should the reciprocal of the variance be used? In general, we think that a preferable approach is to use logistic regression on the individual data points, not the averages by age, to determine the logistic growth function. Use of logistic regression would automatically take into account the relatively sparser data for older vehicles and, in addition, would provide confidence limits on the logistic growth curve.

   That approach was attempted but did not produce satisfactory predictions of the failure rates of the older vehicles. That approach gave a relatively little weighting to the small sample of 66 test vehicles older than 20 years of age. EPA's approach allows for models (equations) that predict rates that closely approximated the observed rates listed (as the four bullets) on page 4.

7. Page 8, second full paragraph – The report states that Equation 1 is the resulting function. It would be useful to the reader for the report to state how this function was obtained from the data. Was it obtained using logistic regression, non-linear regression, or some other means?

   "Some other means." Rather than using a "canned" program that minimized the sum of the squares of the residuals, we first divided each residual by the corresponding standard deviation. We then minimized the sum of the squares of those fractions. Included in that sum was the single value of the 66 older vehicles (from page 4). The graphical equivalent of that modified approach is to first take the rates at ages 0 through 20 plus the average of ages 21-26 (as a single point) with the corresponding 22 confidence intervals. Then, construct a curve that lies within all of the confidence intervals and closely approximates all 22 observed rates.

8. Page 16, last paragraph – We did not follow the reasoning behind the concept that the hot soak gross liquid leakers is the union of the RTD gross liquid leakers and the running loss gross liquid leakers. We did not understand the concept in Reference 4 and the text in this report does not help us understand the reasoning either. In our opinion, this paragraph is the weakest part of the report.

   That material has been revised.

9. Page 18, last paragraph – In the text, there is a typographical error. The value 10,910,000 should be 1,091,000.

   The reviewer is correct. The number has been corrected.

10. Page 21, middle of the page – We understand that there is no data for the late model vehicles which have enhanced evaporative emissions control systems. We agree that the replacement of age with age/2 in the equations developed earlier is appropriate. However, it may be useful to the reader to explain the assumption that is being made here. To us, the deterioration of evaporative emission control systems is contributed to by the effects of age and miles which can have different types of effects on systems. By substituting age/2 for age in the equations, the author has made the assumption that 2 times the miles is approximately equal to 2 times the age. We suggest a sentence be added in this vicinity stating that this assumption has been made.

    This statement is now on page 22. Point number 1 on page 21 has been revised to include both age and mileage.

11. Page 22 – This comment concerns the assumed values for the ability of the MIL to detect or identify the vehicles failing the purge or pressure tests. We understand that you have done your best to figure out these values of 85, 10, and 90% but we think that, as the car ages the response will go down continuously rather than a stepwise fashion. Maybe an estimate of a logistic growth function would be better to use here. We realize that there probably is no data.

    This suggestion will be considered once actual data become available.

12. Page 23, first paragraph – It would be helpful to put behind the value 76.5% the following: (= 0.85 * 0.90).

    Done.

13. Page 33 – The first line on the page we believe should read "eventually will drive." If the occurrence of gross liquid leakers is really driving the increase in diurnal hydrocarbon emissions in the older vehicle ages for the 2020 calculation, then we suggest that doing an independent study of gross liquid leakers on vehicles using enhanced evaporative control standards will be suggested by people who are reading this report.

    Done.

14. Page 35, top of the page – The report shows preliminary analyses for full day diurnals and the effects of the

proposals in this report. We think it would also be useful to see comparisons of MOBILE5 versus the proposed modifications when applied to running losses, hot soaks, and resting losses.

At the time of this was peer review, the MOBILE6 model was not fully operational. Since it now is fully operational, the readers of this report can do their own comparisons using whatever assumptions they wish.

Appendix G

Response to Written Comments from Stakeholders

The following comments were submitted in response to EPA's posting a draft of a related report (M6.IM.003) on the MOBILE6 website. The full text of these comments is posted on the MOBILE6 website.

Comment Number: 102

Name / Affiliation: David Lax / API

Date: January 25, 2000

Comment:

"Pilot Lane Data from Hammond and Phoenix - ... Problems with these data (and the analysis) include the fact that all pre-1996 model year vehicles are combined, even though it is clear that evaporative control systems improved significantly between the early-70s and mid-90s."

"In summary, there are some improvements in the evaporative I/M methodology relative to MOBILE5 ... However, the baseline failure rates are too high for the mid-80s to mid-90s vintage vehicles. This is because all 1971 to 1995 model year vehicles were combined to generate baseline failure rates."

EPA's Response:

This is a familiar situation. For example, if during 1995, you wish to obtain (predictions of) test results of 1990 model year vehicles at the age of 15 years, you can either delay the testing for ten years (i.e., until those vehicles actually reach the target age), or you can test vehicles that are then at the target age (i.e., 1980 model year vehicles) and extrapolate the results.

API's concern is that rather than there being a single curve estimating the occurrence of pressure failures, there are in fact two or more curves that are model year specific. While this concern is a possibility, the data necessary to test this hypothesis are not yet available. This report addresses this possibility in the discussion of "gross liquid leakers" (see the last paragraph on Page 17).

Comment:

"In additional, the canister-side procedure [for identifying pressure leaks] can result in failing cars that are not failures if the technician is not careful. This can occur if there is a pressure control valve between the tank and the canister (which most pre-enhanced evap vehicles have). In this case, the line between the canister and the control valve is pressurized to 14 inches of water (inH2O) (which has a very small vapor space), and then the pressure bleeds off through the control valve into the tank. This appears to be a failure, but in fact is not. Unless there is some procedure for estimating the volume of air introduced in the system (and we do not believe there was in this testing), this can result in false failures."

EPA's Response:

EPA does not believe that a significant number of these false failures actually occurred. In Table 1 (Page 5), we note that less than three percent of the vehicles under two years of age (53 of 1,767) were identified as having failed the pressure test. Even if <u>all</u> of these were false failures (which EPA believes is <u>highly</u> unlikely), then that would suggest that the "true" failure rate at 20 years of age would be reduced from 56.2 percent (see Appendix A) down to 53.3 percent. This change is not significant. A more realistic estimate of false failures would produce even a smaller, less significant change.

Additionally, if some of the test vehicles were mislabeled as having (falsely) failed the pressure test, then the emissions from these problem-free vehicles would have been included in the average emissions of this stratum, creating an offsetting error. (That is, predicting a larger number of failing vehicles, but also predicting lower emissions for each of those failing vehicles.)

The contractor that performed the actual vehicle testing for both the EPA and CRC programs (Automotive Testing Laboratories) also believes that this type of technician error was unlikely. This contractor stated:

> *"I disagree with the example about a "careful" technician not being able to discern a restriction in the line from the canister to the tank. When this line is blocked, a 14" pressure is achieved instantly. When a fuel tank is completely full and the purge line is completely unrestricted, it still takes 20 or 30 seconds to fill the system with enough gas to indicate a 14 inch pressure.*

We deliberately limit the maximum pressure (and therefore flow) to about 28" pressure to avoid blowing any lines during the pressurization process. The typical fill time to perform the canister end pressure test is 30 to 120 seconds. The comment about a "careful" technician implies a technician would not notice the difference between a one second fill and a thirty second fill. I would agree that a new technician might not understand there was a problem, but after a single day the tech would realize a normal fill and an abnormal fill, like the one cited.

"I do agree that if the technician is not careful that errors can be made. I personally feel the tank pressure method is much more prone to errors than the canister pressure method. For example, it is very difficult to judge if the vise grips used to pinch off the vapor line are in fact sealing the line. I have seen a number of false failures that were healed by relocating and reclamping the line.

"In either case, a careless or hasty technician can easily report a false failure - the pressure test takes great care to perform accurately.

"During performance of the Hammond and Phoenix pilot programs, we were given an opportunity to monitor the quality of the lane techs in that vehicles that were returned to the lab were given a comprehensive inspection. We would notice when false failures were occurring, and we would initiate intensive training when more than an occasional false failure was recorded for vehicles returning to the lab.

"The most usual cause of false failure was selection of the wrong line to apply pressure to. If the technician pressurized a purge line, the vehicle would not pass the test. Exactly the same risk would apply to pressurizing from the tank - if the technician clamps the wrong hose, the vehicle will fail. Valves and other restrictions were not found to be a major problem.

"There were restrictions placed the vapor lines of most vehicles before enhanced evap was put in

place. Many of these were in the canister, or in the last few inches of vapor line before the canister.

"The pressure test performed in Hammond and Arizona did not include these underhood restrictors and pressure relief valves - pressure was introduced between the valve and the fuel tank. Pressure relief valves located at the fuel tank could not be bypassed. Vehicles that could not be pressurized at a normal rate because of such valves were reported as untestable, or blocked vapor line, not as pressure failures.

"I do agree the CRC data provide some significant insight into the two procedures. E-9, E-35, and E-41 each include tests from the canister to the tank and from the tank to the canister. Because the test from the canister to the tank includes the cap and the seal between the tank and the cap, the failure rate from the canister to the tank is always higher than from the tank to the canister. In these three studies, when there is disagreement between the two methods, the cap is typically failed. Pressure levels are reported for the two methods on each vehicle at initial, one, and two minute periods."