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Estimating Benefits of Inspection/Maintenance Programs for Evaporative Control Systems

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Section 1 Introduction

This report outlines how MOBILE6 will adjust evaporative (non-exhaust) emission estimates to account for Inspection/Maintenance (I/M) programs that include tests of automotive evaporative control systems. Evaporative emissions include the evaporation of hydrocarbons (HC) as diurnals, resting loss, hot soak and running loss emissions[1].

A draft version of this report was released in November 1999. This final report has been updated to include EPA's response to comments on the draft report, and to incorporate corrections and additional detail developed as the methodology was coded into the model. Comments on the draft and EPA's responses are listed in Appendix D.

This report focuses on the algorithms and data used to compute evaporative I/M benefits. For details on using the model, see the MOBILE6 user guide. The MOBILE6 algorithms for handling I/M programs for exhaust emissions are not described here, but can be found in reports M6.IM.001 and M6.EXH.007.

MOBILE6 will calculate adjustments to the evaporative emission estimates for I/M tests applied to Light-Duty Gasoline Vehicles (LDGV), Light-Duty Gasoline Trucks (LDGT), Heavy-Duty Gasoline Vehicles (HDGV), and Heavy-Duty Gasoline Buses (HDGB). Estimates will be calculated for the following tests:

- Check of On-board Diagnostics (OBD) II indicator light.
- Check of gas cap for presence, damage or leaks[2]
- Pressure test from fuel-pipe inlet ("fill-pipe" tests)

The draft report also discussed modeling effects of a purge test. However, because an

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[1]Evaporative crankcase emissions exist for some of the oldest vehicles (non-tampered vehicles of 1967 and earlier, tampered vehicles of later years). Evaporative I/M programs do not effect these emissions. Anti-tampering programs (see section 1.3) do reduce these emissions. This effect will be unchanged in MOBILE6.

[2]Preliminary evidence suggests that vehicles with missing gas caps have higher running loss emissions than vehicles with leaking gas caps. However, the result is based on tests of only three vehicles (these vehicles are among those listed in Appendix C), and only a small fraction of the fleet has missing caps, Therefore, we have decided not to treat missing cap emissions separately in MOBILE6. We hope to have enough data to address this issue in future models.

effective purge test is not available for general I/M use, benefits of a traditional I/M purge test are not calculated in the final version of MOBILE6.

The gas cap and fill-pipe pressure tests are described in detail in the EPA report: "IM240 & Evap Technical Guidance," EPA report no. EPA420-R-98-010, dated August 1998. It is available on the EPA web site http://www.epa.gov/oms/im.htm.

MOBILE 6 will calculate emissions separately for each of the types of evaporative emissions (diurnals, resting loss, hot soak, and running loss). In this document, when "emissions" are mentioned without further description, the need to distinguish by emissions type should be assumed. Note that the equations given in this document do not include units because the units for emissions (g/soak, g/hour-veh, g/mile-veh) vary with the type of emission.

Also, note that evaporative emissions vary by time of day due to variation in temperature and activity and these parameters will affect the magnitude of emissions with and without I/M. However, the model's calculation of I/M effects is independent of hour, temperature and activity, so these parameters are not addressed in this report.

When the draft version of this report was released, we hoped to have the capability to model evaporative emission credits for selective I/M programs such as remote sensing and change-of-ownership programs. However, time constraints made it impossible to code evaporative emission credits for these types of selective programs in the final release of MOBILE6.

1.1 Overview

For MOBILE6, the vehicles studied to develop evaporative emission rates were recruited based on their status on laboratory pressure and purge tests, so the emission rates used in the model are test-status specific. Evaporative emissions are calculated as a weighted average of emissions of the test-status sub-groups. There are four original test-status groups: pass/pass, pass pressure/fail purge, fail pressure/pass purge and fail/fail. To calculate the benefits of evaporative I/M, we assume that the effect of I/M is to shift vehicles from higher-emitting sub-groups to lower-emitting groups.

Section 1.2 describes the empirical data available on evaporative I/M.

Section 1.3 summarizes the calculation of evaporative emissions in areas without I/M. This provides a baseline for the I/M calculations.

Section 2 describes how MOBILE6 will estimate the shift of vehicles from higher-emitting sub-groups to lower-emitting groups at the time of inspection and repair by evaluating the effectiveness of different kinds of evaporative I/M tests and the interaction between tests.

Section 3 describes how MOBILE6 will account for the fact that inspections and repairs are distributed throughout the year and will calculate different effects for programs with different inspection frequencies.

Section 4 provides comparisons to MOBILE5 in terms of the fraction of the fleet in various test status groups.

Appendix A describes the calculation of default fail rates based on empirical data.

Appendix B provides a mathematical treatment of the calculation of inspection frequency effects for evaporative I/M.

Appendix C compares proposed MOBILE6 repair effects to laboratory test data.

Appendix D summarizes the comments received on the draft report, and EPA's response.

1.2 Data

The data available on emission reductions from evaporative I/M programs are limited in quantity, as well as in the type of data available.

1.2.1 State Data

As of 1998, when this analysis was begun, there were 20 states[3] with active gas cap tests, three with active fill-pipe pressure tests (Arizona, Kentucky and Delaware), and four with OBD checks (Utah, Colorado, Wisconsin and Vermont). No state had an active I/M purge test. Only Arizona and Delaware had both a fill-pipe pressure test and a gas cap program. In evaluating evaporative I/M data for this report, we focused on data from Arizona, which is the state with the longest running evaporative I/M program, and data from Illinois, which has a gas cap program more typical of other states.

The Arizona program includes a fill-pipe pressure test where vehicles' fuel systems are pressurized to 14 inches of water at the fillpipe and failures are defined as those losing more than 6 inches of pressure in 2 minutes or less. The Arizona also includes a gas cap test for leaks of 200 cc/min or more. Gordon Darby provided EPA with test result counts for initial tests by month and vehicle class for 536,520 LDVs, 227,753 LDT1s and 67,292 LDT2s (831,565 total) that came in for fill-pipe pressure tests and gas cap tests between August 1997 (when the test was automated)

[3]AZ, CA, CO, CT, DE, DC, GA, IL, IN, ME, NM, OR, PA, RI, TX, UT, VA, VT, WA, WI

and August 1998 (when the data was requested). Model years from 1981 to 1999 were included in the data.

The Illinois program tests gas caps for leaks of 60 cc/min or more. We were able to obtain gas cap test result counts for 1,877,191 LDVs and LDTs of model year 1971-1997, tested from April 1997 to April 1998.

As explained in this report and Appendix A, the Illinois and Arizona data were used to determine several parameters for the evaporative I/M methodology. Arizona data were used to determine the fill-pipe pressure test fail rate by age, the fill-pipe pressure test testability rate by model year, and the percent by age of gas cap failures that also had fill-pipe pressure test failures. The Illinois data were used to determine gas cap test fail rates by age, and gas cap testability rates by model year.

1.2.2 Laboratory Data

In addition to data from state programs, there are data on repair effects from an EPA test program,[4] which measured pre- and post-repair diurnal, hot soak and running loss emissions for about 20 vehicles which failed either an I/M lane fuel-inlet pressure test and/or an I/M lane gas cap test. This study sampled a wide range of model years (1983-1995), fuel delivery systems, test status groups and evaporative problems. MOBILE6 cannot use these data directly to generate evaporative I/M repair effects. Rather, these data were used as a check of the MOBILE6 assumptions. The data and this comparison are presented in Appendix C.

1.3 Emissions in Areas without I/M

The details of how MOBILE6 will compute evaporative emissions are described in a series of reports (M6.EVP.001- M6.EVP.009) which focus on the specific data and analysis used to compute emissions for each of the evaporative emission types. This detail will not be repeated here. However, to understand how these emissions will be adjusted to account for I/M, it is important to understand the underlying approach used for all evaporative emissions calculations. Evaporative emissions for a vehicle of a given age are calculated as follows:

$$ENoIM_{age} = \sum Emissions_{test\_status} \times NoIMWeighting_{test\_status,age}$$

[4]EPA contract 68-C5-006, Automotive Testing Laboratory, Work Assignment 1-8.

Where *Emissions* vary with the test-status group,[5] and *NoIMWeighting* is a fraction from 0 to 1 describing the fraction of a given age and model year that has a specific test status. In MOBILE6, *NoIMWeighting* is calculated as a function of *Age*, *Test Status* and *Model year*.

Age is calculated as the calendar year of evaluation minus the model year of the vehicle.[6]

Test_status The vehicles studied to develop emission rates were recruited based on their pressure and purge test status, so the emission rates are test-status specific.[7] Note that the pressure test used for this purpose is not the same as the pressure test used for I/M tests. The emission rate stratification is based on a laboratory pressure test performed by applying pressure from the cannister, while the I/M test applies pressure from the fuel-inlet (or "fill pipe"). There are four test-status groups relevant for I/M calculations: pass both, pass pressure/fail purge, fail pressure/pass purge and fail both.[8]

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[5]Emissions are also a function of model year, fuel delivery system, temperature, fuel vapor pressure and other variables specific to the emission type, but independent of I/M. Resting loss and Diurnal emissions estimates are described in M6.EVP.001, M6.EVP.002, M6.EVP.003, M6.EVP.005 and M6.EVP.006. Hot soak emissions are described in M6.EVP.004. Running loss emissions are described in M6.EVP.008. Crankcase emissions will be the same as in MOBILE5.

[6]This age value is, of course, an estimate. As described in Section 3.0, the vehicle model year does not exactly match the calendar year of sale and sales (and I/M tests) are distributed throughout the year. In draft M6.EVP.006, age is calculated as for an April evaluation date, as Calendar Year- Model Year + 6 months. The effect of these differences in age calculations is negligible.

[7]For some emission types, these groups may be collapsed; that is, two groups may have the same emission rate.

[8]MOBILE6 also uses an additional "test status" strata that is not relevant for I/M. As discussed in earlier papers, especially M6.EVP.009, vehicles with gross liquid leaks may contribute a substantial portion of the evaporative emission inventory. However, at this writing there are no I/M tests designed to detect gross liquid leakers. Thus, for I/M purposes, MOBILE6 will ignore the gross liquid leakers. While the default values in MOBILE6 include a fraction of gross liquid leakers, the model will remove this fraction for the I/M calculations described here, and then add it back in the same proportion once the test-status weightings for the original four test-status groups are revised to account for I/M effects. Therefore, for the remainder of this paper we will use "test-status" to refer to the four original pressure and purge test status groups, and will use "*Weighting*" to refer to the normalized fraction of the fleet in each of the four groups.

A vehicle's *Model Year* determines whether a vehicle is subject to the enhanced evaporative emission standard and OBD-II. The observed phase-in of these technologies for light-duty vehicles is described in Table 1.1. This phase-in rate was adjusted from the draft report to account for data from Wisconsin's I/M program that demonstrated that vehicle manufacturers phased-in OBD equipment and compliance with the enhanced standard more quickly than required by regulation. Although most heavy-duty vehicles are not required to have OBD, the lightest HD vehicles (HDGV2b and HDGV3) are required to meet the enhanced standard with the same phase-in schedule as light-duty vehicles.

Table 1.1

Observed Phase-in of Vehicles With Enhanced Evaporative Controls and Light Duty OBD

Model Year	Percentage
1995	0%
1996	30%
1997	55%
1998	90%
1999	100%

As explained in M6.EVP.006, vehicles subject to the enhanced evap standard will have adjusted test-status rates. For the enhanced vehicles, the fail rates will rise at half the rate of the previous vehicles. These vehicles also have OBD systems designed to detect failures in evaporative emission controls. In areas without an I/M program, M6.EVP.006 states that OBD will reduce the incidence of new pressure or purge failure in vehicles equipped with OBD by the percentages listed in Table 1.2. The resulting test-status weighting factors as a function of age including Gross Liquid Leakers are given in Appendix E of M6.EVP.006. They have been copied into the worksheet, "from M6.EVP.006" of the Excel 97 Workbook, *M6IM003.xls*. For I/M purposes, the Gross Liquid Leaker fraction must be temporarily removed and the weighting factors must be re-normalized to 100 percent.

Table 1.2

Reductions in failures due to OBD in Non-I/M Areas					
Age	Mileage	Failures of OBD System	Fraction of failures detected by OBD.	Owner Response Rate	Reductions in failures due to OBD, No I/M
0-3	0-36,000	15%	85%	90%	76.5%
3-6	36,000-80,000	15%	85%	10%	8.5%
7+	80,000+	15%	85%	0%	0%

From M6.EVP.006

1.4 Tampering and Anti-Tampering Programs

In MOBILE5 and previous versions of MOBILE, crankcase, hot soak and diurnal emissions were decreased to account for anti-tampering programs.

The crankcase tampering effects in MOBILE5 are an additive offset that is calculated based on the frequency of various kinds of tampering events. Based on these frequencies, the crankcase emissions increase with mileage. For 1981 and later vehicles at 150,000 miles, average (tampered and non-tampered) hydrocarbon emissions are estimated at 0.015 g/mi for light-duty gas vehicles, 0.024 for light-duty gas trucks, and 0.025 for heavy-duty gas trucks.[9] The frequency of the tampering events is decreased for areas with anti-tampering programs, leading to a decline in these values. Because no new data are available and because crankcase emissions are such a small fraction of total emissions, in MOBILE6 the crankcase emissions and anti-tampering program effects on these emissions will be the same as in MOBILE5.

However, in MOBILE6 we have removed the tampering effects for diurnal and hot soak emissions, as well as the hot soak and diurnal benefits for anti-tampering programs. In MOBILE5, the effects of tampering on hot soak and diurnal emissions are calculated by assuming that vehicles with tampered evaporative control systems are a subset of the vehicles with pressure failures. In areas with evaporative I/M pressure tests, the entire fraction of pressure failures is decreased. In areas without evaporative I/M, but with anti-tampering programs, only the tampered fraction is decreased. Since the tampering data are outdated and since areas currently are not performing evaporative anti-tampering programs in the absence of fill-pipe pressure checks, there is no need to retain this code in MOBILE6.

[9]See AP-42, Appendix H, Tables 1.2B1, 2.2B1, 3.2B1 and 4.2B1.

Section 2 Basic Revised Weighting Factors

This section describes the computation of basic revised weighting factors, that is, weighting factors revised to account for the effect of I/M at the time immediately after inspection and repair. Section 3 will take the basic weighting factors described here and describe how they are transformed to final weighting factors that take into account the distribution of repairs throughout the year and the effects of different inspection frequency designs.

From a computational point of view, the basic function of the I/M tests is to adjust the fraction of vehicles that fall into the various test-status groups. Thus:

$$EwithIM_{age} = \sum \left[Emissions_{test\_status} \times IMWeighting_{test\_status,age} \right]$$

Where *Emissions* are the same emissions used in the No I/M case, but *IMWeighting* is a revised set of weighting factors for the test status groups.

The purpose of the evaporative I/M algorithm is to determine the new weighting factors *IMWeighting* for the I/M program chosen by the user. The I/M program may vary in the kinds of tests that vehicles are subject to, as well as in the ages subject to testing and the frequency of tests. The benefit of I/M also depends on other factors, including the fraction of vehicles that show up for testing and are eventually passed or waived (compliance), the fraction that can be tested on a given test (testability), and the fraction of failing vehicles that actually get repaired (waivers).

This section describes how program characteristics such as compliance, testability and observed fail rates are used to calculate new basic weighting factors $IM_{teststatus,\ age}$.

Section 3.0 describes how information on inspection frequency and grace periods are used to transform the basic revised weighting factors $IM_{test\_status,\ age}$ into the final revised weighting factors $IMWeighting_{test\_status,\ age}$.

$$IMWeighting_{test\_status,age} = f\,(IM_{test\_status,age})$$

The basic weighting factors $IM_{test\_status,\ age}$ will be calculated based on the repairs due to combinations of gas cap, fill pipe, and OBD tests as follows:

$$IM = FractSubjToTest \times FailRate \times FractRpaired$$

Each of the factors that determine I/M weight is described in detail below.

2.1 Fraction Tested

The fraction tested is the fraction of vehicles of a given model year that actually are tested in the interval specified. It is the product of applicability, compliance and testability.

2.1.1 Applicability

Applicability is the fraction (0 to 1) of the fleet required to be tested for a given test, model year and age. MOBILE6 computes this fraction based on user input of the program description. For example, to model a gas cap test for light duty cars and trucks of Model Year 1981 and later, applicability for the gas cap test is set to one for these model years and to zero for all previous model years. Note that applicability is **not** used to model the effects of test frequency (annual, biennial, etc.) or to model the effects of age restrictions on testing.

2.1.2 Compliance Rate

The Compliance Rate is the fraction of the applicable fleet that show up for testing and are eventually passed or waived[10]. Note, this characteristic is different than the "Fraction Repaired" which is discussed below. MOBILE6 accepts Compliance Rate values ranging from 0.50 to 1. This user-input rate would be the same both for exhaust and for evaporative I/M, and the same for all model years and vehicle classes.

The compliance rate is difficult to measure. It accounts for vehicles that fail a test and do not return for retest, but also for vehicles do not show up for initial testing, either because they ignore the requirement or because vehicles otherwise included in the fleet are registered outside the I/M area. Studies suggest that as many as 10-18% of the vehicles driven in a typical non-attainment area may not be properly registered. Thus compliance rates may be in the 80 to 90 percent range. In the draft report, EPA requested comments on the default rate. None were received. We have used a default rate of 85 percent in the final MOBILE6 model.

[10] In the draft report, calculations used both a "participation rate" and a "compliance rate". For consistency with exhaust I/M calculations, these were combined in the final MOBILE6.

2.1.3 Testability

Testability is the fraction of vehicles that show up that actually can be tested. This fraction depends on the vehicle model year and the type of test under consideration. In the draft report, we reported that user inputs for testability would be allowed. We have since determined that user inputs are unnecessary. MOBILE6 defaults will be used as described below:

- Gas cap test–Most vehicles have gas caps that can be tested. The default values for MOBILE6 are listed in Table 2.1. They are based on Illinois tests of 1,877,191 vehicles. For model years 1984-1997, all vehicles were testable. The rate declines for earlier model years. There is a large drop in the 1970s when evaporative regulations for trucks were less stringent. (Note, we did not have data to develop separate rates for LDVs and LDTs, but this might be a useful area to explore in the future.) For 1998 and later vehicles, default testability is set to 1.

- Fill-Pipe Pressure Test–In a high-traffic I/M setting, many old and new vehicles cannot be tested with the pressure test. The default values for MOBILE6 are listed in Table 2.2. They come from Arizona data on 831,565 vehicles of model years 1981-1999. Model years 1981 and earlier will use the 1981 default rate. Model years 1998 and later will use the 1998 default rate. Note, manufacturers recommend no fill-pipe tests for OBD-II equipped vehicles.

- OBD check–MOBILE6 will handle the phase-in of OBD-II vehicles by separately computing I/M weightings for vehicles with and without OBD-II and averaging these together using the OBD phase-in schedule listed in Table 1.1. For those vehicles not equipped with OBD-II, testability for the OBD check will be zero. For vehicles with OBD-II, we assume most will be testable with an OBD check. However, as explained in M6.EVP.006, we assume that 15 percent of all OBD systems do not successfully identify failures. Thus, the default testability rate for OBD-II vehicles is 85 percent.[11]

For the I/M calculations it is necessary to determine what fraction of vehicles receive what combination of tests. In particular, we must establish a relationship between testability on one test and testability on another. For example, if vehicles cannot be tested for gas cap leaks, are they likely to be among the vehicles that can not be tested with a fill-pipe pressure test? We assume so. For the portion of the fleet equipped with OBD, testability

[11]Note, the ability of OBDII systems to detect evaporative problems is expected to improve in time as vehicle manufacturers gain experience and as stricter tolerances are required in 2002. However, we do not have the data to model this in detail. The 85 percent is a predicted average rate for all vehicles with OBDII systems, regardless of model year.

Table 2.1
Gas Cap Testability, IL data

Model Year	Vehicles	Fraction Testable
1971	2822	0.88
1972	1582	0.87
1973	4156	0.85
1974	1505	0.81
1975	4202	0.78
1976	2623	0.75
1977	12654	0.79
1978	6583	0.75
1979	23440	0.93
1980	6545	0.94
1981	18062	0.96
1982	10372	0.97
1983	45294	0.97
1984	33484	0.98
1985	111601	1
1986	58215	1
1987	159608	1
1988	87439	1
1989	213017	1
1990	98152	1
1991	226168	1
1992	62406	1
1993	196814	1
1994	128597	1
1995	361680	1
1996	122	1
1997	48	1

Table 2.2
Fill-pipe Testability, Arizona Data

Model Year	Vehicles	Fraction Testable
81	11180	0.61
82	13332	0.63
83	18440	0.68
84	30982	0.71
85	41442	0.73
86	50738	0.77
87	51687	0.79
88	56864	0.78
89	63926	0.77
90	59650	0.76
91	63379	0.79
92	62335	0.80
93	74693	0.79
94	81892	0.76
95	90748	0.64
96	37946	0.44
97	19186	0.35
98	3107	0.12
99	38	0.16 *

*From data. Due to small sample. 1998 rate will be used for this and later years. Note, OBD checks are expected to replace pressure checks for OBD equipped vehicles.

on fill-pipe pressure tests is independent of OBD testability.[12] We assume that most vehicles that can be tested with pressure or OBD tests can also be tested on gas cap tests. The equations proposed to handle these correlations are embedded in the worksheets “sample calc” and “sample calc OBD” of the Excel workbook *M6im003.xls*.

2.2 Failure Rate

Failure rate is the fraction of vehicles that are actually tested that fail the test they are given and are, therefore, eligible for repair. This varies by model year and by test (and combination of tests).[13] Failure rates for traditional I/M tests (gas cap tests and fill-pipe pressure tests) and for OBD checks are treated differently.

2.2.1 Traditional I/M tests

For traditional I/M tests, the test status weighting factors used for non-I/M emission factors are based on lab tests and do not correspond exactly to I/M tests used in I/M lanes, so we have to construct a relationship between the MOBILE6 weighting factors and the in-use tests. The categories that need to be mapped are listed below:

<u>Test Status Weighting Factors</u>

Cannister Pressure Test Status	Lab Purge Test Status	Acronym
Pass	Pass	PP
Pass	Fail	PF
Fail	Pass	FP
Fail	Fail	FF

[12] Pressure tests generally will not be applicable to OBD-equipped vehicles. However, if a pressure test program were modeled for OBD-equipped vehicles, there is no expected relationship between pressure testability of the OBD-equipped vehicles and OBD-system malfunction. Since OBD-equipped vehicles are considered testable unless they malfunction, we treat testability for pressure and OBD as independent parameters.

[13]“Failure Rate” is similar to the “ID Rate” used in discussions of exhaust I/M. However, “ID Rate” refers to a fraction of emissions, while “Failure Rate” is used for a fraction of vehicles.

<u>Possible In-Use Test Result*</u>

Gas Cap Test	**Fill-Pipe Pressure Test**	**Purge Test**	**Acronym**
Pass	Pass	Pass	PPP
Pass	Pass	Fail	PPF
Pass	Fail	Pass	PFP
Pass	Fail	Fail	PFF
Fail	Pass	Pass	FPP
Fail	Pass	Fail	FPF
Fail	Fail	Pass	FFP
Fail	Fail	Fail	FFF

** Note, this table and naming scheme were developed when the purge test was still considered a viable in-use test that needed to be included in the model. We have kept the naming scheme from the draft report, but the in-use purge test is not modeled in MOBILE6.*

The task then is to establish a relationship between the four test-status groups and the eight possible in-use test results. To do this, we make three assumptions:

1. As stated before, gross liquid leakers are not relevant for these I/M calculations. We assume gross liquid leakers are distributed equally among all other groups, so the "no I/M" test status weighting factors are normalized without GLLs.

2. We assume that if an I/M lane purge test were viable, it would be the same as the "lab" purge test. Therefore, the lane purge test failure rate is set to equal the original test-status weighting for vehicles failing the lab purge test (That is, all vehicles in the test status groups PF and FF would have in-use test results of either PPF, PFF, FPF or FFF).

3. We assume the gas cap and fill-pipe failures (based on I/M lane data) are a subset of the cannister pressure test failures (based on lab data).[14] That is, we assume that all gas cap

[14]The assumption that vehicles that fail gas cap tests are a subset of cannister pressure test failures is a simplifying assumption proposed for MOBILE6, but is not always true. Some small gas cap leaks are not caught by the cannister pressure test (or OBD). The emissions of vehicles with these small gas cap leaks are currently included in the cannister pressure pass/purge pass (PP) average emissions. To model the repair of these small leaks we would need data on the

failures and all fill-pipe failures are cannister pressure test failures, but some cannister pressure test failures (FP, FF) may pass both the gas cap and fill-pipe tests.[15]

Based on the preceding three assumptions we can construct Table 2.3 describing which in-use test outcomes could be matched with which test-status groups.

Table 2.3 Matching Test-status groups and in-use test outcomes

Possible In-Use Test Outcomes	(Lab) Test Status Group*			
	Pass Press./ Pass Purge	Fail Press./ Pass Purge	Pass Press./ Fail Purge	Fail Press/ Fail Purge
Pass Gas Cap/Pass Fill-pipe/PassPurge	PP_PPP	FP-PPP		
Pass Gas Cap/Pass Fill-pipe/Fail Purge			PF_PPF	FF_PPF
Pass Gas Cap/Fail Fill-pipe/Pass Purge		FP_PFP		
Pass Gas Cap/Fail Fill-pipe/Fail Purge				FF_PFF
Fail Gas Cap/Pass Fill-pipe/Pass Purge		FP_FPP		
Fail Gas Cap/Pass Fill-pipe/Fail Purge				FF_FPF
Fail Gas Cap/Fail Fill-pipe/Pass Purge		FP_FFP		
Fail Gas Cap/Fail Fill-pipe/Fail Purge				FF_FFF

* The empty cells indicate categories for which we predict no vehicles.

We can then predict the frequency of in-use test failures based on the original laboratory test-status group weighting factors. To do this, we make a few additional assumptions.

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difference in emissions between vehicles with and without these small leaks for hot soak, running, diurnal and resting loss emissions. In the absence of such data, we will assume that repairs to these leaks have the same effect as repairs to larger leaks, but will cap the proportion of all gas cap and fill-pipe failures at the cannister pressure fail weighting factor. One consequence of this approach is that the marginal benefit of adding a gas cap check to an OBD check on vehicles is limited to a gas cap benefit for only the fraction of vehicles that we assume have malfunctioning MIL lights. (See M6.EVP.006 for a discussion of OBD assumptions.)

[15]Some vehicles may fail the lab cannister pressure test but pass both the fill-pipe pressure test and the gas cap test due tighter time constraints in the I/M lane and to other differences between the lab and lane test procedure.

1. We assume the distribution of purge failures is independent of the kind of pressure failure. That is, the fraction of pressure failures with purge failures in M6.EVP.006 equals the fraction of fill-pipe pressure failures with purge failures, and the fraction of gas cap failures with purge failures.

$$\frac{FF}{FF + FP} = \frac{PFF}{PFF + PFP} = \frac{FPF}{FPF + FPP} = \frac{FFF}{FFF + FFP}$$

2. We assume the Illinois gas cap fail rate(IL) (see Appendix A) describes the distribution of gas cap failures.

3. We assume the Arizona fill-pipe failure rates (AZFP) (see Appendix A) describes the distribution of fill-pipe failures.

4. We also need to determine what fraction of vehicles fail both the gas cap test and the fill-pipe pressure test. Because we are using gas cap and fill-pipe fail rates from different states, we need to make additional assumptions. Appendix A describes how we used the Arizona data to calculate the proportion of gas cap failures that are both gas cap and fill-pipe failures as opposed to "gas cap only" failures. As explained in Appendix A, we call this last fraction "AZOnly" For the default case, we assume that "AZOnly" describes a fraction of all gas cap failures that is the same for all state programs and is the same regardless of purge status. In particular,

$$AZOnly = \frac{FPP}{FPP + FFP} = \frac{FPF}{FPF + FFF}$$

5. We assume the total fraction of fill-pipe and gas cap failures cannot be greater than the fraction of (lab) cannister pressure failures. This is a simplification for modeling purposes. If for some reason the total fraction of fill-pipe and gas cap failures does exceed the fraction for cannister pressure failures, the values are reduced proportionally.

6. We assume that I/M lane checks of OBD indicator lights detect cannister pressure failures and purge failures, that is, we assume they detect all vehicles in the PF, FP and FF groups, except those vehicles with malfunctioning OBD indicator lights .[16]

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[16]We assume that 15 percent of the OBD-equipped vehicles that would fail the cannister pressure test or the purge test do not have illuminated indicator lights. While the faulty MIL rate is actually a measure of false passes; in the MOBILE6 I/M computations, the same result is

Using the assumptions described above, we can derive predictions of the frequency of in-use I/M test failures where each of the following equations describes the fraction of vehicles assigned to the respective cell in Table 2.3. Note, the empty cells of Table 2.3 indicate categories for which we predict zero vehicles.

Table 2.4: Frequency of In-Use Test Failure/Lab Test Status Combinations

Pre-Repair Category	Frequency as a function of observed rates and age
PP_PPP	PP
PF_PPF	PF
FP_PPP	FP- FP/(FP+FF) x (AZFP + IL x AZOnly)
FF-PPF	FF- FF/(FP+FF) x (AZFP + IL x AZOnly)
FP_PFP	FP/(FP+FF) x (AZFP - IL x (1-AZOnly))
FF_PFF	FF/(FP+FF) x (AZFP - IL x (1-AZOnly))
FP_FPP	FP/(FP+FF) x (IL x AZOnly)
FF_FPF	FF/(FP+FF) x (IL x AZOnly)
FP_FFP	FP/(FP+FF) x (IL x (1-AZOnly))
FF_FFF	FF/(FP+FF) x (IL x (1-AZOnly))

Where:

PP= Test status weighting for pass pressure/pass purge
PF= Test status weighting for pass pressure/fail purge
FP= Test status weighting for fail pressure/pass purge
FF= Test status weighting for fail pressure/fail purge

IL= Gas cap fail rate (based on Illinois data)
AZFP= Fill-pipe pressure test fail rate (based on Arizona data)
AZOnly=Fraction of gas cap failures with fill-pipe pass (based on Arizona Data)

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obtained by treating the rate as a testability fraction.

For a given evaluation year, MOBILE6 will compute the frequencies listed in Table 2.4 for each model year based on the MOBILE6 default values for PP, PF, FP, FF, AZFP, IL and AZOnly.

The default test status rates (PP, PF, FP and FF) for 1995 and earlier vehicles are listed in Appendix A of M6.EVP.006. For 1999 and later vehicles, the PP, PF, FP and FF rates are replaced with the rates from Appendix D of M6.EVP.006, which account for the owner response to OBD that would be predicted without I/M checks. (For 1996-1998, the rates should be a weighted average of the OBD and pre-OBD rates using the observed phase-in schedule in Table 1.1.)

The default rates for AZFP, IL, and AZOnly are listed in Appendix A of this document. In the draft report, we proposed that MOBILE6 include a user input for alternate rates. However, we determined that this input was unlikely to be used, and did not program this capability into the model.

2.2.2 OBD Checks

The MOBILE6 approach for modeling the benefits of OBD systems and I/M tests that include checks of OBD systems is detailed for exhaust emissions in the paper M6.EXH.007. The approach includes assumptions about OBD "false passes" and owner response rates to illuminated MILs.

In the report M6.EVP.006, we adapted this proposal for evaporative emissions to calculate test-status rates for OBD equipped vehicles in I/M and non I/M areas. However, the with I/M rates proposed in M6.EVP.006 need to be adjusted to account for differences in local I/M programs. Thus, for the No I/M case, we use the Failure Rates (Estimates of Strata Size by Vehicle Age–From a non-I/M Area) in Appendix D of M6.EVP.006 as the Failure rates for vehicles in model years and calendar years with an OBD check. In particular, we assume that the OBD failure rate is the sum of the FP, PF and FF rates. As described in Section 2.1.3, we reduce testability to account for cases where OBD does not successfully identify failures. The owner response rate for these vehicles is described in section 2.4.

For exhaust emissions, we assume that there is no additional benefit for a traditional I/M check when an OBD check is performed. For evaporative emissions, some additional benefit may be gained from gas cap tests because we assume the MIL functions correctly for only a portion of the vehicles.[17] More research is needed on the marginal benefit of combining gas cap checks with OBD checks.

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[17] Also see footnote 14 on small gas cap leaks.

2.3 Repair Benefits--Adjusting Weighting Factors

The benefits of a repair depend on what test the vehicle failed and was repaired to pass. Based on EPA program staff experience of what test combinations are used in state I/M programs, MOBILE6 models the following test combinations:

- Gas Cap Test Only
- Gas Cap Test and Fill-pipe Purge Test
- Gas Cap and OBD Check
- OBD Check Only

As detailed in Section 1.2 and Appendix C, there are limited data available on the emission benefits of evaporative emission repairs. Thus, the repair benefits in MOBILE 6 will assume that a repair moves a vehicle from one test-status category to another and the repair benefit will be the difference between the emissions assigned to the two relevant test-status categories.

Because the in-use I/M tests are not the same as the test-status categories used for non-I/M emissions in MOBILE6, it is necessary to determine what the appropriate categories are. Again, because data are severely limited, it has been necessary to make a number of assumptions. In particular:

- When failed with a gas cap test, repair moves vehicles predicted to have gas-cap failures and no fill-pipe failures from a pressure fail (FP_FPP or FF_FPF) to a pressure pass category (PP_PFP or PF_PFF). Likewise, when failed with a fill-pipe test, repair moves vehicles predicted to have fill-pipe failure (FP_PFP or FF_PFF) to a pressure pass category (PP_PPP or PF_PPF).

- When vehicles predicted to have both gas cap and fill-pipe failures (FP_FFP or FF_FFF) are failed and repaired with a gas-cap only test, we assume that the gas cap problem is fixed, and the fill-pipe problem remains. While some vehicles might see some decrease in emissions from the gas cap repair, this is likely to be small since there is still a pressure leak. We assign no emission benefit and the vehicle remains in the pressure fail category (FP_PFP or FF_PFF). Similarly, if a vehicle with a gas cap problem and a fill-pipe problem (FP_FFP or FF_FFF) receives a fill-pipe test but no gas cap test, we assume the vehicle remains a pressure failure (FP_FPP or FF_FPF). MOBILE6 only gives such a vehicle credit for a full pressure repair if it is subject to both kinds of tests. (In which case FP_FFP is repaired to PP_PPP, and FF_FFF is repaired to PF_PPF.) While this approach may slightly underestimate the benefits of an evaporative I/M program, the underestimate is expected to be negligible because the fraction of vehicles that simultaneously fail both the gas cap and the fill-pipe pressure tests is very small (see Appendix A for rates.)

- For evaporative emissions, we assume the vehicles failed by OBD checks will move from a failing test-status category to the pass/pass category on repair.

- As explained in M6.EVP.009, gross liquid leakers are not identified by gas cap checks, fill-pipe tests, or OBD checks. Thus, we assume that their fraction is unchanged by the I/M programs modeled in MOBILE6.

These assumptions lead to Table 2.5, which describes our model of how I/M repairs move vehicles between the cells in Table 2.3, and thus between test-status categories. Note that because different tests have different testability rates, different portions of the model year fleet in the same test program will experience different combinations of tests in the same evaluation year. MOBILE6 models the benefits separately for each combination of tests that vehicles of a given model year could receive.

Table 2.5: Effects of Test and Repair on MOBILE6 Evaporative I/M Categories

Pre-Repair Category *	Pre-Repair Test-Status**	Tests Experienced	Post-Repair Category*	Post-Repair Test-Status**
PP_PPP	PP	any or none	PP_PPP	PP
FP_PPP	FP	OBD	PP_PPP	PP
		other***	FP_PPP	FP
FP_FPP	FP	OBD or gas cap	PP_PPP	PP
		other	FP_FPP	FP
FP_FFP	FP	OBD, or gas cap and fill pipe	PP_PPP	PP
		gas cap, no fill pipe	FP_PFP	FP
		other	FP_FFP	FP
FP_PFP	FP	OBD or fill pipe	PP_PPP	PP
		other	FP_PFP	FP
PF_PPF	PF	OBD	PP_PPP	PP
		other	PF_PPF	PF
FF-PPF	FF	OBD	PP_PPP	PP
		other	FF-PPF	FF
FF_FPF	FF	OBD	PP_PPP	PP
		gas cap	PF_PPF	PF
		other	FF_FPF	FF
FF_PFF	FF	OBD	PP_PPP	PP
		fill-pipe	PF_PPF	PF
		other	FF_PFF	FF
FF_FFF	FF	OBD	PP_PPP	PP
		gas cap and fill-pipe	PF_PPF	PF
		gas cap only	FF_PFF	FF
		other	FF_FFF	FF

*These categories refer to the cells in Table 2.3.
**The test-status groups are defined in Section 2.2.1
*** “Other” refers to any remaining combination of evaporative I/M tests, as well as no test at all.

2.4 Waivers and Fraction Repaired

"Fraction Repaired" is the fraction of failing cars that get repaired. It is reduced from one to account for waivers[18]. For traditional I/M tests, the default waiver rate is the same value as for exhaust programs. As for exhaust, we assume that 5 percent of compliant failed vehicles receive waivers.[19] Users will have the option to enter their own waiver rates; these need not be the same as for exhaust emissions.

We assume that waived vehicles undergo some repairs before being granted a waiver. We assume these limited repairs have some fractional emission benefit, with the fraction the same as that assumed in the exhaust I/M calculations. The default emission benefit for waived vehicles is the same as for exhaust: 20 percent. Users will have the option to enter their own waiver benefit rates; these need not be the same as for exhaust emissions.

The "Fraction Repaired" for fill pipe and gas cap tests will be calculated using the following equation:

$$FractRepaired=(1-W)+(W*WBen)$$

Where:

W	=Waiver rate (default is 0.05)
WBen	=Repair Benefit for waived vehicles (default is 0.20)

Thus, using default values, the Fraction Repaired for gas cap and fill pipe pressure tests is 96 percent.

For OBD tests, our draft report proposed not calculating the Fraction Repaired based on these parameters, but instead choosing a value based on the expected owner response rate for exhaust emissions. In the final MOBILE6 model, we chose a different approach that better allows users to adjust benefits for local program data. We assume that, in an I/M program, regardless of vehicle warranty, the base fraction of vehicles with an illuminated OBD light that are repaired is 99 percent. This accounts for intentional tampering with the OBD light and is consistent with the

[18]In the draft report, "Fraction Repaired" was calculated in a slightly more complicated manner, but it was simplified for consistency with exhaust I/M calculations.

[19]The draft version of this report erroneously reported a higher default rate.

assumptions for exhaust vehicles. The Evap OBD Fraction Repaired is then reduced to account for waivers and waiver benefits.

$$FractRepaired = C * ((1-W)+(W*WBen))$$

Where:

W	=Waiver rate (default is 0.05)
WBen	=Repair Benefit for waived vehicles (default is 0.20)
C	=OBD Coverage (0.99)

Thus, using default values, the Fraction Repaired for OBD vehicles is is 95.04 percent.

2.5 Technician Training

In MOBILE6, as in MOBILE5, the evaporative I/M repair benefits assume that all technicians have sufficient training to make effective evaporative emission repairs. Thus there is no extra benefit for technician training for evaporative I/M.

2.6 Sample Computations

For sample calculations for light-duty vehicles, see worksheets “sample calc” and “sample calc OBD” of the attached Excel 97 spreadsheet, *m6im003.xls*. These have been revised and corrected since draft spreadsheets were distributed with the draft report. “Sample calc” is designed for modeling weighting factors for vehicles without OBD or ETP (pre-1996), and is set up to model a calendar year 1995 scenario. “Sample calc OBD” is designed for vehicles with OBD and ETP (1999 and later) and is set up to model a calendar year 2025. Model years 1996-1998 are modeled in MOBILE6 as a weighted average of the results from the two spreadsheets.

The worksheets are designed for users to input data into yellow cells. Users can define a scenario using the worksheets “1995 s descriptions” or “2025 s descriptions” to specify the evaluation years, vehicle ages, and program parameters (applicability, compliance, and waiver rates). Blue cells are values that are looked up in other worksheets. Green cells indicate results used elsewhere in the workbook.

Section 3 Effects of Inspection Frequency (Sawtooth Methodology)

As is true for exhaust I/M, the length of time between evaporative system inspections is an important variable for determining the emission benefit of the inspections. Thus, MOBILE6 will calculate different evaporative test status *IMWeightings* for annual and biennial I/M programs.

To calculate the effects of the different program designs, MOBILE uses the "sawtooth methodology." This methodology is designed to account for two I/M facts: (1) failures occur between inspections, and (2) because vehicles are tested throughout the year, emissions at any point in time are actually an average of the emissions before and after testing.

The sawtooth used for evaporative system I/M is based on the sawtooth used for exhaust emissions (see M6.IM.001), modified to apply to the unique aspects of MOBILE6 evaporative emissions calculations. In particular, it takes into account the fact that evaporative I/M reductions are not calculated as a credit subtracted from no-I/M emissions, but as a re-weighting of the test-status categories.

3.1 General Sawtooth Method

For purposes of modeling, we assume all vehicles are inspected on the first anniversary of their purchase and periodically thereafter, always on that same date. It is also assumed that sales occur exactly in the 12 month period from October of the calendar year previous to the model year through September of the next calendar year. For example, in January 1999, the age distribution of the 1997 model year vehicles will range from 1.25 years to 2.25 years. With an annual inspection program, most of these vehicles will have been inspected only once, several months earlier, but those sold in October-December of 1996 will have experienced a more recent second inspection.

Because of the distribution of inspection times, the sawtooth methodology divides the vehicle of a given model year into two groups, (1) the younger cars, those purchased between the evaluation date (typically July 1) and September 30, and (2) the older cars, those purchased between October 1 of the previous year and the evaluation date. As in the description of the exhaust I/M sawtooth method, the first group is referred to as the "first segment"; the second is the "second segment".

For exhaust emissions, we assume that the type of problems which cause I/M failures can re-occur as often in the repaired vehicles as they do in the unrepaired fleet. We will assume that this holds true for evaporative failures as well. Thus, it is assumed that the fleet, after repair, will have the same rates of new failures as vehicles of the same age before repairs. For evaporative emissions, this assumption means that, within each model year, the oldest and newest cars will have low rates of new failure after repair, while middle-aged vehicles will have much higher rates of new failures. This assumption is not completely satisfactory; however, we do not believe it has a significant impact on our results (see footnote 24 in Section 4). In our draft report, we requested comments on ways to modify the sawtooth methodology in order to account for fail rates that differ for repaired and unrepaired vehicles, and for suggestions of alternative rates to be used for the vehicles with evaporative system repairs. None were received and we have retained the methodology described in the draft report.

The MOBILE6 approach is illustrated in Figure 3.1 which shows a generalized version of the I/M sawtooth methodology. The top set of points represents a set of original test-status weightings at various ages for a given test-status.[20] For instance, Points A, B, and C might illustrate the non I/M case fail pressure/fail purge test status fraction for vehicle ages of 0, 1, and 2 years.[21] The lower curve represents the fraction after I/M repair (without the sawtooth). In particular, points E and G represent the revised fail rates calculated for a given age as described in Section 2.

The toothed line (A, B, E, F, G,....) between the no-I/M curve and the repair curve represents the repair and subsequent deterioration of a cohort of vehicles of the exact same age. All deterioration slopes are parallel with the no-I/M curve (i.e., segment E-F is parallel to segment B-C). Note that the slope varies for different ages. Also note that the assumption that the lines are parallel (that the rate of new failures is a function of age, but are not affected by I/M inspections) does not affect the fail rate after inspection (points E and G in Figure 1), these are assumed to be independent of inspection frequency and are the values determined in Section 2. However, the rate of new failures does determine the slope of the I/M line between inspections and the estimated fail rate before inspection, thus determining the value for point F and the average values of Segments 1 and 2.

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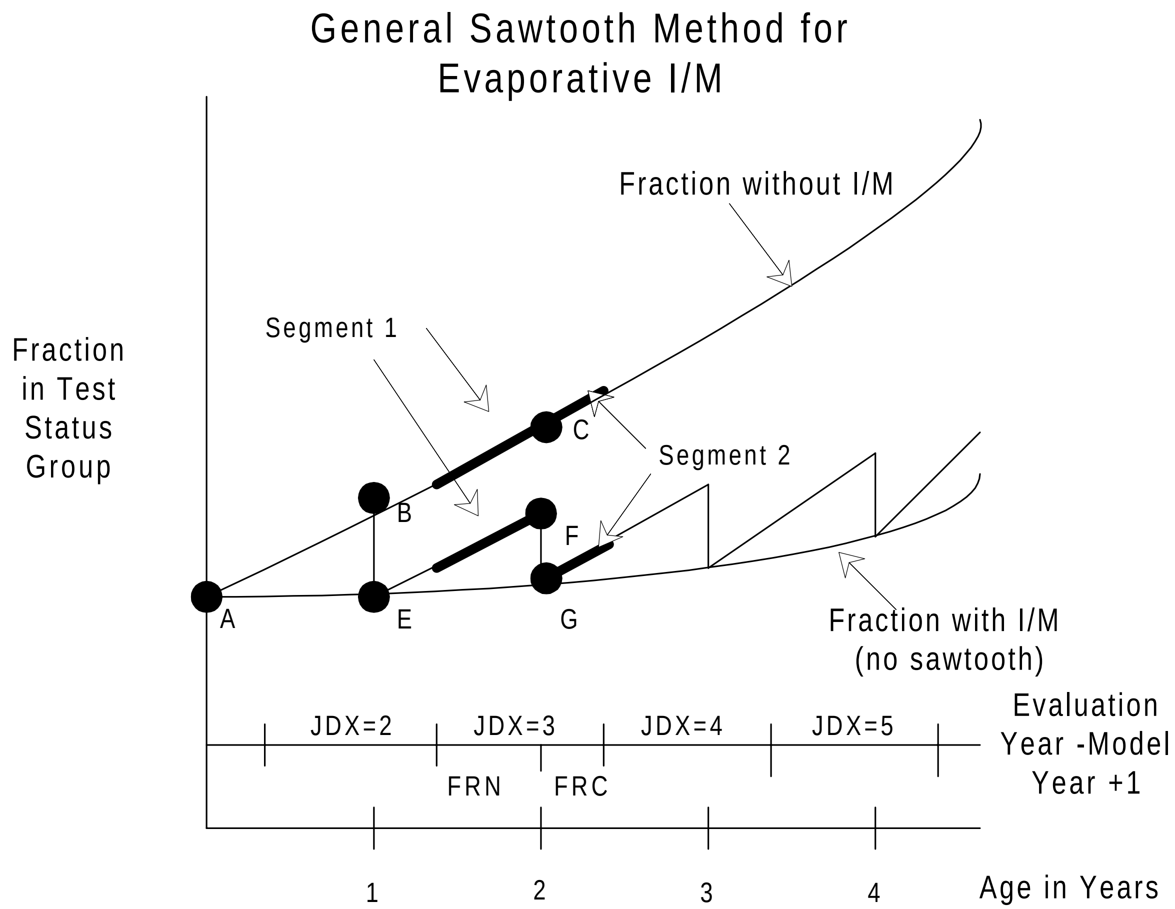
[20]These calculations will be made for the test-status groups that involve failure (PF, FP, FF). The rate for passing group (PP) will be calculated by subtracting all the failing fractions from 1.0

[21]As explained in M6.EVP.005 and summarized in the introduction of this document, there are different curves for traditional vehicles and vehicles subject to the enhanced evaporative test procedure and vehicles equipped with OBD.

Figure 3.1



General Sawtooth Method for Evaporative I/M
Fraction in Test Status Group
Fraction without I/M
Segment 1
Segment 2
A
B
C
E
F
G
Fraction with I/M (no sawtooth)
JDX=2
JDX=3
JDX=4
JDX=5
FRN
FRC
Evaluation Year -Model Year +1
1
2
3
4
Age in Years

In the illustration, the repair effect is represented by the sudden change in test status weighting at each inspection interval (i.e, from Point F to Point G)[22]. However, this represents only a single cohort of vehicles inspected on the same day. To compute the evaluation-date value of inspections distributed throughout the year, we calculate an average. The heavy shaded portions of the lines illustrate how the test status weighting for a model year of index 3 (JDX=evaluation year-model year +1) is produced. The user chooses either January or July of a calendar year as the evaluation date. This example shows a January evaluation. Segment 1 represents the vehicles sold from January through September, which are still less than 2 years old at the January 1 evaluation date. The vehicles sold from October through December are represented by Segment 2. These are vehicles which are older than 2 years. The average value for each segment is calculated and the two are weighted together by the model year fractions, FRC and FRN, that are represented by each segment. FRC and FRN are calculated from the evaluation month (for example, for January, FRC=0.25, FRN=0.75). This weighted average is used in MOBILE6 as the fail rate for the age in the post-I/M case. For less frequent periodic inspections (biennial programs.) the "teeth" of the sawtooth are more widely spaced. The mathematical details of this methodology are described in Appendix B.

3.2 Algebraic and Numeric details

The Excel workbook *m6im003.xls* includes two worksheets ("pre-OBD sawtooth" and "OBD sawtooth") that provide examples of the sawtooth calculations. These may be modified by using the scenario worksheets ("2025 s descriptions" and "1995 s descriptions) to enter alternate evaluation months, test frequencies and grace periods. Note that while Figure 3.1 implies that I/M is modeled as a continuous curve, I/M effects are actually modeled only at integer ages and benefits are interpolated between. For vehicles with age less than one, no I/M benefits are calculated.

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[22]The after-repair I/M weighting will actually increase for some test-status groupings. The fraction of pass pressure/pass purge should always increase. Furthermore, for example, in an I/M program with only a gas cap test, repairs may increase the fraction of vehicles in the pass pressure/fail purge category as vehicles are repaired from fail pressure/fail purge status.

Section 4   Comparisons to MOBILE5

MOBILE6 computes the emission impact of evaporative I/M programs by combining the methodology presented in this report with updated approaches for estimating diurnal, hot soak and running loss emissions, including emissions from gross liquid leakers and estimates of the effects of ambient temperature, fuel composition, and patterns of vehicle activity. Thus, a comparison of evaporative I/M benefits between MOBILE5 and MOBILE6 represents many more changes than just the changes in evaporative I/M methodology described in this report. To compare MOBILE5 and MOBILE6 evaporative I/M benefits for an area, it is necessary to run the two models with the area's specific ambient conditions, fuel, vehicle fleet mix and vehicle activity. Such comparison is beyond the scope of this report.

Instead, to help explain the technical basis for differences users will see between MOBILE6 and MOBILE5 benefits, this chapter compares the algorithms used in MOBILE5 and MOBILE6 and the effect of this algorithm change on the weighting factors used in the two models.

The MOBILE5 methodology for estimating emissions from evaporative I/M is less elaborate than what we have proposed for MOBILE6, but the two approaches have basic similarities. Like MOBILE6, the MOBILE5 methodology is based on varying the fraction of vehicles in the pressure and purge test status groups. In MOBILE5, the weighting factors for the no I/M case are modified to account for I/M and modified to account for I/M effectiveness and the "sawtooth" effect of failures between inspections. MOBILE5 only estimates evaporative I/M effects for pressure and purge tests. The effects of OBD tests are not computed, and gas cap effects have to be calculated outside the model as a fraction of the pressure test effect.[23]

In MOBILE5, test-status weightings for vehicles failing the pressure test, the purge test and both were estimated using a zero mile intercept and slopes for below and above 50,000 miles. These rates were based on data from Hammond, Indiana I/M lanes. MOBILE 5 then calculates a percent reduction in the fraction of failing vehicles. This is based on a user-input compliance rate (typically 96 percent) and a "sawtooth" effectiveness based on age that is calculated outside the model, based on an assumed 95 percent detection rate and an assumed cyclical pattern of repeat failures in previously repaired vehicles.

Table 4.1 lists the age-weighted average of the failing weighting factors for LDGV in MOBILE5 and MOBILE6. The MOBILE5 "with I/M" rates were computed for a test-only program of annual pressure tests with 96 percent compliance. The MOBILE6 rates were

[23] "Credit for Gas Cap Check plus Purge Test," memo from Phil Lorang to Regional Air Directors, December 1994.

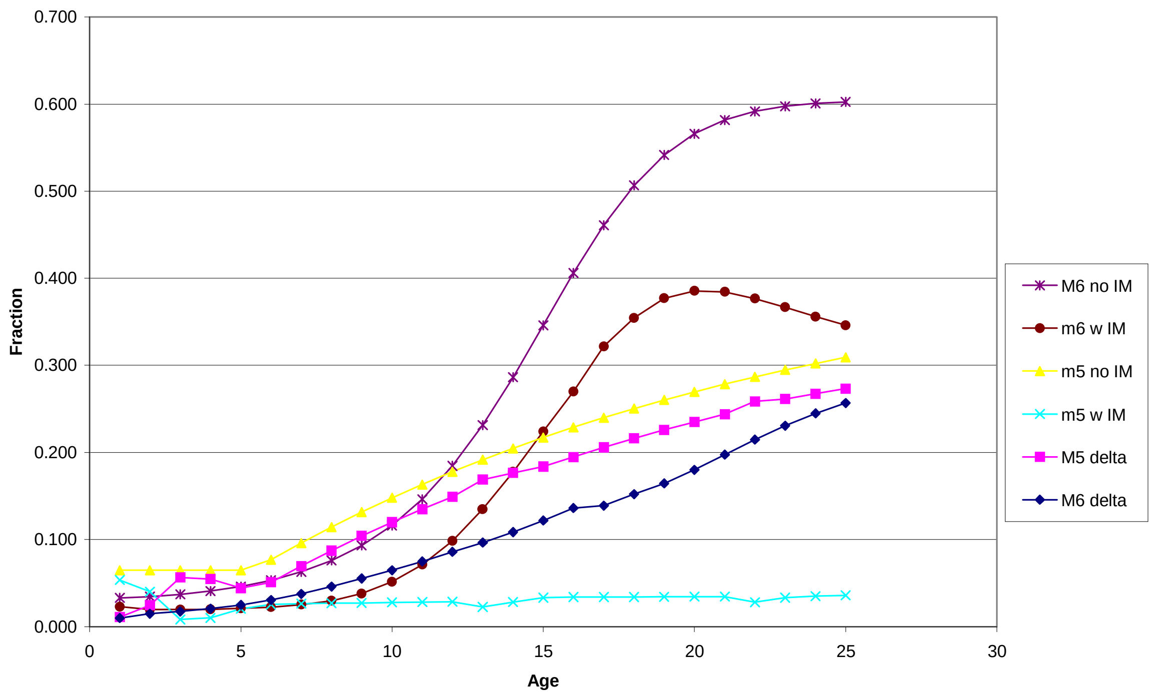
computed for a July 1995 evaluation of a program of annual fill-pipe and gas cap tests with 85% compliance, 5 percent waivers, 20 percent benefit for waived vehicles and a one year grace period.

Table 4.1 Age Weighted Test Status Fractions (1995 fleet)

	Without I/M		With I/M	
	MOBILE5	MOBILE6	MOBILE5	MOBILE6
Fail Pressure Tests (FP+FF)	0.131	0.140	0.027	0.077

Chart 4.1 illustrates the difference between MOBILE5 and MOBILE6 in the pressure failure rate as a function of age.

Chart 4.1 Pressure Failures, M5 vs M6, 1995 Calendar Year



In Chart 4.1, “M6 delta” is the difference between the MOBILE6 with I/M and MOBILE6 no I/M pressure fraction. “M5 delta” is the corresponding difference for MOBILE5.

While the table and graph do not compare evaporative emissions between the two models, they do illustrate several important differences between the models:

1. MOBILE5 includes a purge test option. Purge tests are not modeled in MOBILE6 because, in practice, purge tests are not performed in I/M programs.

2. The“no I/M” pressure failure curves have quite different shapes in the two models. The MOBILE6 curves show lower failure rates in early years and a steep increase in failures after about age 10. For the oldest cars, MOBILE6 predicts much higher failure rates than MOBILE5. This is based on new data on vehicles over 20 years old collected by the Coordinated Research Council (CRC). However, averaged across all ages, the two models lead to very similar average fail rates for the “no I/M” case. For more information on the “no I/M” rates, see M6.EVP.006.

3. The MOBILE5 model (in particular, the external model used to estimate I/M effectiveness values for MOBILE5) is based on the assumption that detection and repair of failures in one year is independent of detection and repair in future years, thus with an I/M program, virtually all failing vehicles will eventually be detected and repaired if they go through enough I/M cycles. On the other hand, the MOBILE6 approach is based on testing experience that shows some vehicles are inherently “untestable” because of their design, and will never be repaired, no matter how many inspections they undergo. Furthermore, the MOBILE6 methodology assumes that vehicles that are not repaired in one year due to non-participation, non-compliance or waiver, also will not be repaired in future years. Thus, in the MOBILE 6 modeling approach, failures accumulate in a subset of vehicles despite the existence of an I/M program. We believe this is a more realistic algorithm.

4. The MOBILE5 model (in particular, the external model used to estimate I/M effectiveness values for MOBILE5) assumes a cyclical pattern of repeat failures in previously repaired vehicles. This leads to periodic dips in the MOBILE5 “with I/M” curve. MOBILE6 assumes that repaired vehicles fail at the same rate as non-repaired vehicles of the same age, leading to a noticeable downturn in the “with I/M” failures at ages where the fail rate in the “no I/M” case has flattened out (for example, at ages greater than 20 in Chart 4.1). Because the fraction of the fleet at these ages is small, we believe that the MOBILE6 approach is an acceptable simplification.[24] In the draft report, EPA requested comments on how to better model repeat failures. None were received. We have used our simplified “equal fail rate” approach in the final version of MOBILE6.

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[24]To test the assertion that the downturn in the “MOBILE6 with I/M” pressure fail rate (illustrated in Chart 4.1, Pressure Failures, M5 vs M6, 1995 Calendar Year) has a negligible impact, we tested setting the fraction of failures to be constant for ages greater than 20. This increased the fleetwide average fraction of remaining pressure failures by only one tenth of a percent.

As the chart and table indicate, these comparisons suggest that for an annual gas cap and fill-pipe pressure test for all ages, MOBILE6 may indicate significantly less credit for evaporative I/M programs than MOBILE 5. However, these results look at test-status weighting factors only. They do not include the new MOBILE6 estimates for evaporative emissions, and gross liquid leakers. They do not include changes in RVP and temperature effects or vehicle activity. In addition, the results discussed here are only for a specific scenario. With other program designs, such as gas-cap only tests and programs with longer grace periods, the MOBILE6 I/M benefits may be closer to, or even exceed those estimated in MOBILE5. Users can best compare MOBILE5 and MOBILE6 I/M benefits by running the two models side-by-side for the scenarios of interest.

References

(Available on EPA website http://www.epa.gov/oms/m6.htm unless otherwise noted.)

M6.EVP.001 "Evaluating Resting Loss and Diurnal Evaporative Emissions Using Real Time Diurnal Tests," Larry Landman, April 2000, EPA420-R-01-018.

M6.EVP.002 "Modeling Hourly Diurnal and Interrupted Diurnal Emissions Based on Real-time Data," Larry Landman, April 2001, EPA420-R-01-019.

M6.EVP.003 "Evaluating Multiple Day Diurnal Evaporative Emissions Using RTD Tests," Phil Enns, April 2001, EPA420-R-01-020.

M6.EVP.004 "Update of Hot Soak Emissions Analysis," Terry Newell, April 2001, EPA420-R-01-026.

M6.EVP.005 "Modeling Diurnal and Resting Loss Emissions from Vehicles Certified to Enhanced Evaporative Standards," Larry Landman, April 2001, EPA420-R-01-021.

M6.EVP.006 "Estimating Weighting Factors for Evaporative Emissions in MOBILE6," Larry Landman, April 2001, EPA420-R-01-022.

M6.EVP.007 "Hot Soak Emissions as a function of Soak Time," Ed Glover, draft 6/23/98 EPA420-P98-018.

M6.EVP.008 "Running Loss Emissions," Larry Landman, April 2001, EPA420-R-01-023.

M6.EVP.009 "Gross Liquid Leakers," Larry Landman, April 2001, EPA420-R-01-024.

M6.EXH.007 "Determination of NOx and HC Basic Emission Rates, OBD and I/M Effects for Tier 1 and Later LDVs and LDTs," John Koupal, draft 5/3/99, EPA420-P-99-009.

M6.FLT.007 "Fleet Characterization Data for MOBILE6: Development and Use of Age Distributions, Average Annual Mileage Accumulation Rates and Projected Vehicle Counts for Use in MOBILE6," Tracie Jackson, September 2001, EPA420-R-01-047.

M6.IM.001 "MOBILE6 Inspection/Maintenance Benefits Methodology for 1981 through 1993 Model Year Light Duty Vehicles," Ed Glover and David Brzezinski, draft, March 1999, M6.IM.001, EPA420-P-99-007.

AP-42 “Compilation of Air Pollutant Emission Factors, Volume II: Mobile Sources" pending 5th edition, updated 1998. Available at http://www.epa.gov/oms/ap42.htm

"IM240 & Evap Technical Guidance," EPA420-R-98-010, August 1998. Available at http://www.epa.gov/oms/im.htm.

“Credit for Gas Cap Check plus Purge Test,” memo from Phil Lorang to Regional Air Directors, December 1994. (available from EPA on request.)

Appendix A Observed Fail Rates

Observed fail rates are the percent of tested vehicles that failed a given evaporative emission test. They are used in MOBILE6 to determine the failure rates for specific tests as described in Section 2.2 of this report. Observed fail rates are likely to vary with individual program design, and ideally should be measured from the program being modeled. However, for prospective modeling, it is necessary to provide rates. This appendix explains how MOBILE6 values were determined for the variables AZFP, IL and AZGCOnly.

Gas Cap Tests ("IL" gas cap fail rate)

For gas cap tests, the observed fail rates in MOBILE6 are derived from data from the Illinois evaporative I/M program. This program tests gas caps for leaks of 60 cc per minute or more. Data is available on 1,865,029 LDVs and LDTs of model year 1971-1997, tested from April 1997 to April 1998.

To determine a smooth function describing how gas cap fail rates increase with age, we used the following approach:

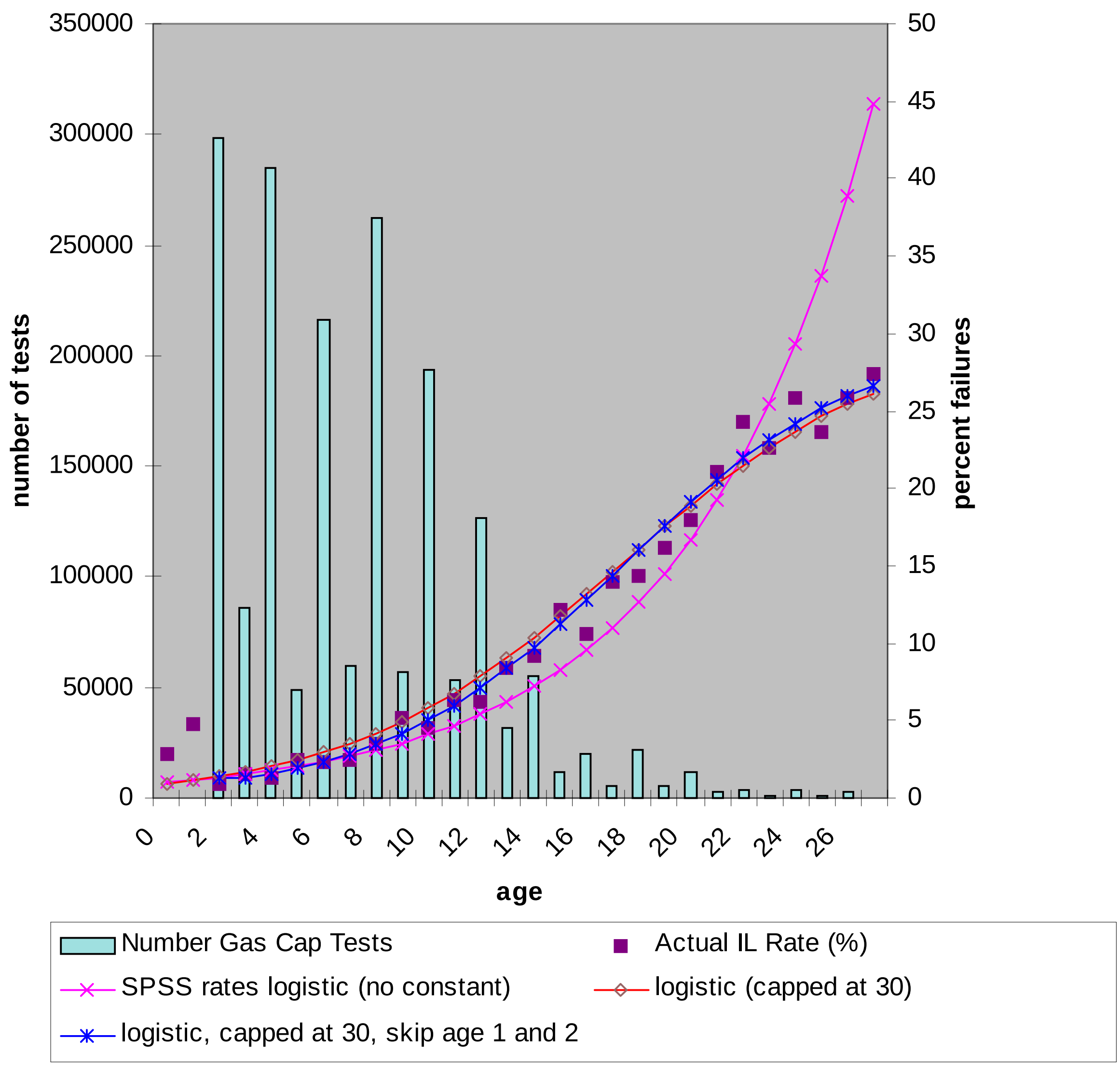
1. Age was calculated as test year minus model year.
2. Test results by model year and test month were grouped by age.
3. Failing vehicles were defined as vehicles that had leaking, missing, damaged or wrong gas caps.
4. Failure rates were defined as the number of failing vehicles divided by the number of vehicles receiving a gas cap test.
5. Regressions were run though the failure rate data. These are displayed in Table A-1 and Figure A-1.
6. The logistic regression capped at 30 percent was chosen as the best fit to represent the fail rates. Like the un-capped logistic regression, this regression provides a close fit for the most abundant model years. Compared to the uncapped logistic, it provides slightly higher fail rate estimates for younger vehicles, but it provides a much better representation of the osbserved "leveling-off" of fail rates in the oldest vehicles.
7. Because the data from the latest model years (ages 0,1 and 2) included vehicles built to the enhanced evaporative emission standard and equipped with OBD, the regression was run again without these vehicles. (The number of vehicles of age 0 and 1 was also orders of magnitude lower than the number of older vehicles, thus there was much greater uncertainty in the fail rate for these very young vehicles.)
8. The coefficients from this regression were used to develop an equation describing the fail rate that could be used to predict the fail rate at ages 1 and 2.

Table A-1

AGE BASED GAS CAP TEST RESULTS Initial Tests for April 1997 Through April 1998							
First Model Year	Age	Number Gas Cap Tests	Actual IL Rate* (%)	Linear Regression (no constant)	Logistic Regression (no constant)	Logistic Regression (capped at 30)	Logistic, capped at 30, skip age 0,1 and 2
1971	27	336	27.4	24.11	44.77	26.14	26.67
	26	2782	25.8	23.22	38.89	25.43	25.98
	25	1218	23.6	22.32	33.78	24.62	25.16
	24	3634	25.9	21.43	29.35	23.69	24.22
	23	1085	22.6	20.54	25.49	22.66	23.14
	22	3856	24.3	19.65	22.14	21.51	21.92
	21	2269	21.0	18.75	19.24	20.26	20.58
	20	11435	17.9	17.86	16.71	18.93	19.13
	19	5352	16.1	16.97	14.52	17.52	17.58
	18	21995	14.3	16.07	12.61	16.07	15.98
	17	5621	13.9	15.18	10.95	14.59	14.36
	16	20038	10.6	14.29	9.51	13.12	12.75
	15	11582	12.1	13.39	8.26	11.69	11.19
	14	55440	9.2	12.50	7.18	10.32	9.72
	13	31974	8.4	11.61	6.24	9.03	8.35
	12	126805	6.2	10.72	5.42	7.84	7.11
	11	53179	6.3	9.82	4.71	6.76	6.00
	10	193384	4.5	8.93	4.09	5.78	5.03
	9	56621	5.2	8.04	3.55	4.92	4.19
	8	262211	3.5	7.14	3.08	4.16	3.46
	7	59887	2.5	6.25	2.68	3.50	2.85
	6	216051	2.3	5.36	2.33	2.94	2.34
	5	48952	2.5	4.46	2.02	2.46	1.91
	4	285036	1.3	3.57	1.76	2.05	1.56
	3	85945	1.6	2.68	1.53	1.70	1.27
	2	298243	0.9	1.79	1.33	1.41	
	1	62	4.8	0.89	1.15	1.17	
	0	36	2.8	0.00	1.00	0.97	
Totals		1865029	3.7				
R2				0.958	0.967	0.979	0.982

* Calculated from Illinois data. “Age” equals calendar year minus model year.

Figure A-1
Illinois Gas Cap Fail Rates--Possible Fits



Thus, to represent the fail rates of 1995 and earlier model years, MOBILE6 will use the fail rates computed with the coefficients from the capped logistic regression on the data minus ages 0, 1 and 2. The associated logistic equation is:

$$F \times 100 = \frac{1}{\frac{1}{u} + b_0 \times b_1^{a}}$$

Where:

F = the fail rate
u = the upper bound, 30
b_0 = 1.4462
b_1 = 0.8051
a = age

This leads to the fail rate percentages listed in Table A-2.

For 1996-1998 model years, the I/M benefits will be calculated using both 1995 and 1999 rates. After emissions are calculated, these will be weighted together based on the enhanced test procedure phase-in schedule given in Table A-3.

For 1999 and later years, this fail rate will be adjusted to account for the enhanced evaporative emission standard and OBD since we would expect fewer failures in these vehicles. As is done for test status groups (see Section 1.3 of this document and also M6.EVP.006), the failures in these vehicles will be adjusted to double the time for failure and to reduce failures to account for OBD. For age 0-3, we assume that 76.5 percent of new failures are detected by OBD and repaired.[25]

$$F \times 100 = \left[\frac{1}{\frac{1}{u} + b_0 \times b_1^{\left(\frac{a}{2}\right)}}\right] \times (1 - 0.765)$$

[25]The OBD detection rate is the product of the OBD failure rate and the owner response rate.

For 1999-and-later year vehicles of ages from 3 to 6, we assume the doubling of durability and that 8.5 percent of new failures are detected and repaired. The 0.63 in the equation accounts for the difference in fail rates at age 3.

$$F*100 = \left(\frac{1}{\frac{1}{u} + b_0 \times b_1^{\left(\frac{a}{2}\right)}} \right) \times (1 - 0.085) - 0.63$$

For 1999-and-later year vehicles of age greater than 6, we assume no OBD repairs in the absence of an I/M program. The 0.74 in the equation is the difference in fail rates at age 6 due to the owner response rate under warranty.

$$F \times 100 = \frac{1}{\frac{1}{u} + b_0 \times b_1^{\left(\frac{a}{2}\right)}} - 0.74$$

This leads to the fail rate percentages listed in Table A-2.

Table A-2

Gas Cap Fail Rates (in percent) For MOBILE6		
Age	MY 1995 and earlier	MY 1999 and later*
0	0.68	0.16
1	0.83	0.18
2	1.03	0.20
3	1.27	0.22
4	1.56	0.31
5	1.91	0.42
6	2.34	0.53
7	2.85	0.67
8	3.46	0.82
9	4.19	0.99
10	5.03	1.18
11	6.00	1.38
12	7.11	1.60
13	8.36	1.85
14	9.72	2.12
15	11.20	2.41
16	12.76	2.73
17	14.36	3.07
18	15.99	3.45
19	17.59	3.85
20	19.13	4.29
21	20.59	4.76
22	21.93	5.27
23	23.14	5.80
24	24.22	6.37
25	25.17	6.98
26	25.98	7.62
27	26.68	8.29

*For 1996-1998 model years, I/M benefits will be calculated using both 1995 and 1999 rates. Emissions will be weighted together based on the enhanced test procedure phase-in schedule given in Table A-3.

Table A-3

Observed Phase-in of Light Duty Vehicles With Enhanced Evaporative Controls and Light Duty OBD	
Model Year	Percentage
1995	0%
1996	30%
1997	55%
1998	90%
1999	100%

Fill-Pipe Pressure Test Fail Rates ("AZFP" pressure rate)

For fill-pipe pressure tests, fail rates are based on rates measured in Arizona's I/M program. Gordon Darby provided test result counts by month and vehicle class for 536,520 LDVs, 227,753 LDT1s and 67,292 LDT2s that received fill-pipe pressure tests and gas cap tests between August 1997 and August 1998. Model years from 1981 to 1999 were tested in a program that pressurizes to 14 inches of water column at the fillpipe and looks for a loss of more than 6 inches of water in 2 minutes or less.

To determine a smooth function describing how fill-pipe pressure fail rates increase with age, we used the following approach:

1. To derive rates appropriate for vehicles built prior to the advanced evaporative test procedure, data on model years 1996-and-later were removed from the data set, leaving 497,227 LDVs, 214,049 LDT1s and 61,634 LDT2s of model year 1981-1995. For consistency with other evaporative emissions work, we combined all data on the three vehicle classes.

2. Age was defined as model year minus test year.

3. Fill-pipe failures were defined as vehicles that failed to pressurize or had visual failures of missing canisters, damaged canisters or missing hoses.

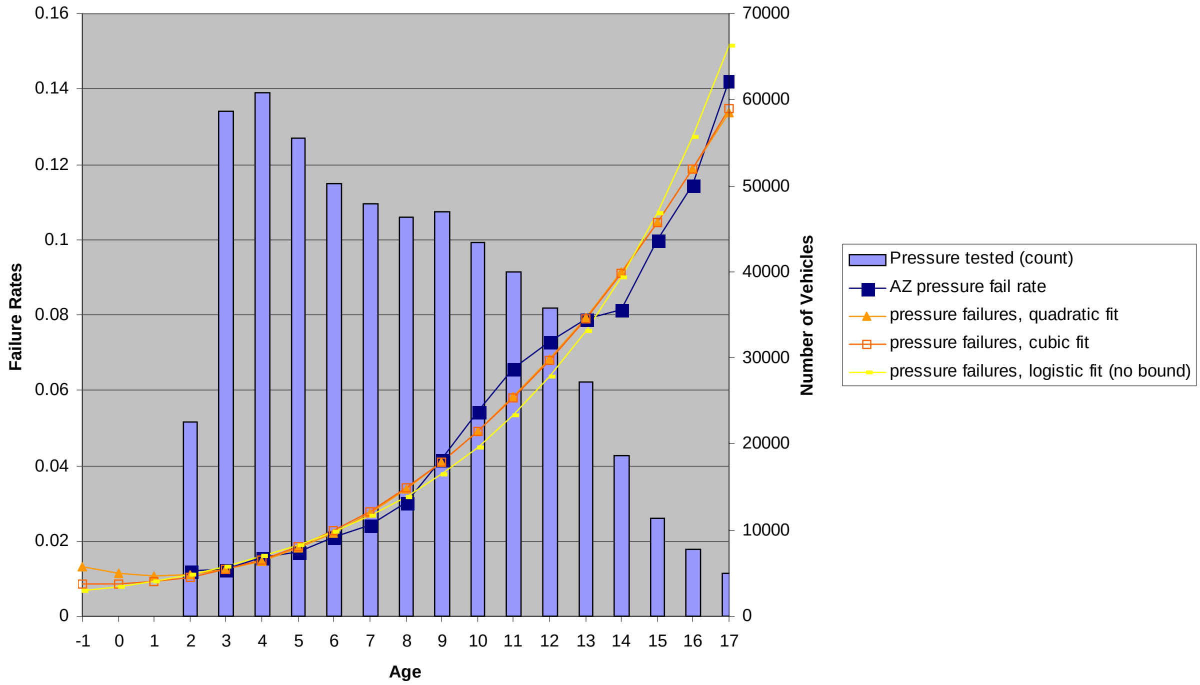
4. The Arizona fail rate was computed as the number of failures divided by the number of vehicles with successful tests for each age.

5. This rate was graphed versus age, and a number of statistical fits were computed with SPSS software. The raw data and the three best fits are shown in Figure A-2 and Table A-4. The cubic and quadratic equations offer the best fits to the data, each with an R-squared of 0.986. In SPSS the two equations provide almost identical predicted values as shown in Table A-4. For simplicity, the quadratic form will be used. However, because the curvature of the quadratic form predicts slightly more failures at age 0 than at age 1, we will set the values for ages 0 to be the same as the value at age 1.

Table A-4

Arizona Pressure Fail Rates, MY 1981-1995, Possible Fits					
Age	Number of Vehicles Tested	Pressure Fail Rate	Quadratic Fit	Cubic Fit	Logistic Fit (no upper bound)
0	0		0.011	0.009	0.008
1	0		0.011	0.009	0.009
2	22596	0.012	0.011	0.010	0.011
3	58576	0.012	0.012	0.012	0.013
4	60745	0.016	0.015	0.015	0.016
5	55611	0.017	0.018	0.018	0.019
6	50282	0.021	0.022	0.023	0.022
7	47890	0.024	0.027	0.028	0.027
8	46381	0.030	0.034	0.034	0.032
9	46942	0.042	0.041	0.041	0.038
10	43468	0.054	0.049	0.049	0.045
11	39917	0.066	0.058	0.058	0.053
12	35770	0.073	0.068	0.068	0.064
13	27259	0.079	0.079	0.079	0.076
14	18729	0.081	0.092	0.091	0.090
15	11310	0.100	0.105	0.104	0.107
16	7721	0.115	0.119	0.119	0.127
17	4928	0.142	0.134	0.135	0.151
		R-squared	0.986	0.986	0.982
		b0	0.0115	0.0086	126.536
		b1	-0.0012	0.0002	0.8406
		b2	0.0005	0.0003	
		b3		5.90E-06	

Figure A-2
AZ Pressure Fail Rates, Possible Fits



So, for light-duty vehicles and trucks, model years 1981-1995, the default fill-pipe pressure test fail rate in percent will be:

$$F = 0.0115 - 0.0012a + 0.0005a^2$$

Where F = the fail rate in percent
a = the age in years.

The default rates are listed in Table A-5

For model years 1999 and later, these fail rates will be adjusted to account for the enhanced evaporative test procedure (ETP) requirement and OBD.

As previously explained for gas caps and test status groups, the increased durability due to the ETP will be expected to decrease the age effects by a factor of two. The OBD effects in a non-I/M area are expected to decrease the occurrence of failures by 76.5 percent in years 1-3 and 8.5% in years 3-6. Thus we will use the following equations to predict fail rates:

For light-duty vehicles and trucks, model years 1999-and-later, age 2-3:

$$F = \left[0.0115 - 0.0012\left(\frac{a}{2}\right) + 0.0005\left(\frac{a}{2}\right)^2\right] \times (1 - 0.765)$$

Because the equation predicts higher rates for for ages -1,0 and 1 than for age 2, we will use the value calculated for age 2 for these rates.

For ages greater-than-3 up to 6, the calculation includes the ETP durability effect (division of age by two), and the non-I/M area reductions of new failures by 8.5%, but the total fail rate also is shifted to account for the reductions in years 1-3. Thus, the fail rate includes a term (0.0074) subtracting the difference between the fail rate at age 3 with the 90% and the 10 percent owner response assumptions.

$$F = \left\{\left[0.0115 - 0.0012\left(\frac{a}{2}\right) + 0.0005\left(\frac{a}{2}\right)^2\right] \times 0.915\right\} - 0.0074$$

For ages greater than 6, the calculation is similar, except there is no reduction in new failures due to OBD, and the rate is adjusted by 0.0084 to account for the difference at age 6 in the fail rate with the 10% and the zero response assumptions.

$$F = \left[0.0115 - 0.0012\left(\frac{a}{2}\right) + 0.0005\left(\frac{a}{2}\right)^2\right] - 0.0084$$

Table A-5

Fill Pipe Pressure Test Failure rates for MOBILE6*		
Age	Model Years 1995 and earlier	Model Years 1999 and later**
-1	0.011	0.003
0	0.011	0.003
1	0.011	0.003
2	0.011	0.003
3	0.012	0.003
4	0.015	0.003
5	0.018	0.003
6	0.022	0.004
7	0.028	0.005
8	0.034	0.006
9	0.041	0.008
10	0.050	0.010
11	0.059	0.012
12	0.069	0.014
13	0.080	0.016
14	0.093	0.019
15	0.106	0.022
16	0.120	0.025
17	0.136	0.029
18	0.152	0.033
19	0.169	0.037
20	0.188	0.041
21	0.207	0.046
22	0.227	0.050
23	0.248	0.055
24	0.271	0.061
25	0.294	0.066

* (Calculated in M6IM003.xls, “Az pres rates”, 3/26/99. Values differ from those in table A-4 due to rounding of coefficients in SPSS output.)
** Emissions for Model Years 1996-1998 will be a weighted average based on the phase-in schedule given in Table A-3.

“Gas Cap Only” Rates (“AZOnly”)

The first section of this appendix describes the fraction of all vehicles that have gas cap failures. Some of these vehicles have both gas cap problems and additional problems that would be detected with a fill-pipe pressure test. For MOBILE6 we need to determine the distribution of these vehicles in the fleet. Specifically, for the calculations described in this report, we need to determine the fraction of all gas cap failures that are “gas cap only” failures (rather than both gas cap and “fill-pipe” failures). Since the only states performing both tests were Arizona and Delaware, and Arizona data were readily available, the Arizona data were used.

1. To derive rates appropriate for vehicles built prior to the advanced evaporative test procedure, data on model years 1996-and-later were removed from the data set, leaving 497,227 LDVs, 214,049 LDT1s and 61,634 LDT2s of model year 1981-1995. For consistency with other evaporative emissions work, we combined the three vehicle classes.

2. Age was defined as model year minus test year.

3. Total gas cap failures for a given age were defined as the sum of the vehicles failing the gas cap test and having a missing or damaged gas cap.

4. “Failed both pressure and gas cap” numbers were provided by Arizona and summed for each age. This number includes vehicles that failed both tests for any reason, including visual failures such as missing gas caps and missing hoses.[26]

5. Because many vehicles that were tested with the gas cap test were not testable with the fill-pipe pressure test, the “gas cap only” fraction of gas cap failures could not be computed directly. Instead we computed a ratio of Arizona fail rates. The gas cap only rate was defined as (gas cap failures/total gas cap tests - failed both/total pressure tests)/(gas cap failures/total gas cap tests), ie 1- (failed both/gas cap failures)(total gas cap tests/total pressure tests).

6. This rate was computed for each age, and regressions were run through the data (eliminating years where data was not available). The best fit regression was a quadratic. The actual and predicted values are listed in Table A-6 below. The SPSS statistical output is also shown.

7. Since the “gas cap only” ratio is a ratio of fail rates, the predicted improvements due to OBD and enhanced durability should generally cancel out. Thus, in MOBILE6, the gas cap only ratio is used for all model years.

[26] Per email from Jeff Reeves, Gordon Darby, Inc., 11/11/98.

Table A-6 Gas Cap Only Failures as a Fraction of Gas Cap Failures

Age	Measured Rate	Predicted
0	na	0.985
1	na	0.982
2	0.987	0.979
3	0.971	0.975
4	0.966	0.969
5	0.955	0.963
6	0.954	0.955
7	0.952	0.947
8	0.931	0.937
9	0.937	0.927
10	0.926	0.916
11	0.911	0.903
12	0.861	0.890
13	0.872	0.875
14	0.859	0.860
15	0.852	0.843
16	0.846	0.826
17	0.791	0.808
18	na	0.788
19	na	0.768
20	na	0.746
21	na	0.724
22	na	0.701
23	na	0.676
24	na	0.651
25	na	0.624
	b0	0.9849
	b1	-0.0019
	b2	-0.0005
	Adj. r2	0.9504

23 Mar 99 SPSS for MS WINDOWS Release 6.1

Dependent variable.. RATE Method.. QUADRATIC

Multiple R	.97828
R Square	.95703
Adjusted R Square	.95042
Standard Error	.01258

Analysis of Variance:

	DF	Sum of Squares	Mean Square
Regression	2	.04584293	.02292147
Residuals	13	.00205838	.00015834

F = 144.76411 Signif F = .0000

-------------------- Variables in the Equation --------------------

Variable	B	SE B	Beta	T	Sig T
AGE	-.001948	.003236	-.164156	-.602	.5575
AGE**2	-.000499	.000166	-.817201	-2.997	.0103
(Constant)	.984878	.013561		72.626	.0000

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Appendix B Mathematical Treatment of Inspection Frequency for Evaporative I/M

This appendix describes a mathematical approach to calculate the effects of inspection frequency for evaporative I/M as summarized and illustrated in Section 3.0 of this report.

Note that these calculations must be made for each of the three failing test status groups (pressure fail, purge fail, purge and pressure fail.) For simplicity, this distinction is not detailed in the equations below.

The "No-I/M" case

The sawtooth methodology (see Figure 3.1 in the main document) is used in the No-I/M case to determine the test status weightings appropriate for the evaluation month. While simpler methods could accomplish this, this case provides an opportunity to explain many details of the sawtooth methodology before adding the additional complications of the I/M case.

1. Where MEVAL is the month of evaluation, (e.g. January = 1, July=7)[27], we compute *FRC*, the fraction of the year since the model year changed on October 1 as follows:

$$DIFF = MEVAL - 10$$

$$FRC(DIFF \geq 0) = DIFF/12$$
$$FRC(DIFF < 0) = 1 + DIFF/12$$
$$FRN = 1 - FRC$$

Thus, for the evaluation months of January-September, $FRC \geq 0.25$, for October-December, FRC<0.25. Because we assume sales are uniform throughout the year, *FRN* may be considered the fraction of the fleet represented by Segment 1; *FRC* is the fraction of the fleet represented by Segment 2 in figure 3.1.

[27]MOBILE calculates emissions only for January and July (FRC= 0.25 and FRC = 0.75). However, for completeness and future coding flexibility, this report describes a method that could be used for any month of the year.

2. MOBILE tracks model year through an integer index of model year, *JDX*.

JDX=Calendar Year of Evaluation -Vehicle Model Year +1

This means, for example, in every month of 1990, a 1990 vehicle has a *JDX* of 1.

3. For the specific model year and evaluation month, we compute the average age for vehicles.

$$AvAge(JDX = 0, FRC < 0.25) = 0.5 \times FRC$$
$$AvAge(JDX = 1, FRC \geq 0.25) = 0.5 \times FRC$$

$$AvAge\left(JDX = 1, FRC < 0.25\right) = FRC \times \left[(JDX - 1) + (0.5 \times FRC)\right] + FRN \times \left[(JDX - 1) - (0.5 \times FRN)\right]$$
$$AvAge(JDX > 1) = FRC \times \left[(JDX - 1) + (0.5 \times FRC)\right] + FRN \times \left[(JDX - 1) - (0.5 \times FRN)\right]$$

4. Based on the previous equations for average age, we can compute the test status weighting for each test status group in the NoIM case as the following[28]:

$$NoIMWeighting(JDX = 0, FRC < 0.25) = NoIM\left[0.5 \times FRC\right]$$
$$NoIMWeighting(JDX = 1, FRC \geq 0.25) = NoIM\left[0.5 \times FRC\right]$$

$$NoIMWeighting\left(JDX = 1, FRC < 0.25\right) = FRC \times \left[NoIM\,(JDX - 1 + 0.5 \times FRC)\right] + FRN \times \left[NoIM\,(JDX - 1 - 0.5 \times FRN)\right]$$
$$NoIMWeighting(JDX > 1) = FRC \times \left[NoIM\,(JDX - 1 + 0.5 \times FRC)\right] + FRN \times \left[NoIM\,(JDX - 1 - 0.5 \times FRN)\right]$$

[28]This equation could be simplified for the No I/M case as was done in the description of exhaust I/M calculations (M6.IM.001, Appendix D), but the format given here has a parallel structure to the format for the I/M calculations.

Where:

NOIMWeighting is the weighted average of the two segments of the model year,
NoIM is *NoIM* from Section 2.2

5. MOBILE6 will not actually calculate the noI/M or I/M values as it makes the sawtooth calculation, but will look up the appropriate value in a previously calculated array. Because the array has values only for integer ages, the MOBILE code must interpolate between these ages. This interpolation is not detailed here, but can be seen in the "sawtooth" worksheets of Excel workbook *M6IM003.xls.* By assumption, the I/M test-status weighting at age 0 is the same as the non-I/M weighting.

Annual I/M program starting with Age=1

In a periodic I/M program, the test status weighting at an evaluation date can be considered a weighted average of the cars that recently had an inspection (the *FRC* fraction) and those with a more distant (or no) inspection (*FRN*). For both the recent and the distant cases, we assume that the test status weighting at the date of inspection was the I/M test-status weighting (that is, *IM* from Section 2.0) for the average age at inspection (*AIM*).

In the time elapsed since the inspection, we assume more vehicles have entered the failing test status categories. In particular, we assume that the additional vehicles have entered the failing categories at the same rate as they would in the same time period without an I/M program.[29]

Thus, we need to figure the average age at last inspection and the average time since the last inspection.

1. As was explained for exhaust emissions (M6.IM.001, Appendix D), we assume each vehicle is tested on its "birthday," and *AIM* is the average vehicle age at the last inspection (*AIM1* is the age for Segment 1; *AIM2* is the age for Segment 2.) For an annual inspection program where vehicles are first inspected at age one year, the age at most recent inspection is listed in Table B-1. We will define *AIM=0* to mean no prior inspection.

[29] This is a low rate for low and high ages and a high rate in the middle years. The low rate makes sense for low ages, but makes less sense for high ages where the noI/M rate reaches an equilibrium we wouldn't necessarily expect with I/M. However, alternative approaches require separate rates for vehicles that have and have not been repaired, and, therefore, would require a more complicated algorithm that tracks these vehicles separately.

Table B-1 Age at most recent inspection, annual I/M, first inspection at age 1 year

JDX	Segment of Model Year	AIM
1	1	na*
1	2	0**
2	1	0**
2	2	1
3	1	1
3	2	2
4	1	2
4	2	3
JDX	1	JDX-2
JDX	2	JDX-1

* Vehicles in this category have not been sold to original owner yet.
**Vehicles in these categories are less than one year old.

2. Unlike exhaust emissions, where emissions are a function of mileage, we also need to calculate the average time in years since the most recent inspection for both the FRN and FRC segments. If there have been no prior inspections, we calculate the average time since the vehicle was first sold. For an annual inspection program, *DeltaT* is calculated as follows for each of the two segments:

   DeltaT1 = 1-*FRN*/2
   DeltaT2 = *FRC*/2

   For example, for a January evaluation date, *DeltaT1*=0.625, *DeltaT2*=0.125; for July *DeltaT1*=0.875, *DeltaT2*=0.375.

   More generally:

   DeltaT1 = 1-*FRN*/2 + (JDX-2-AIM1)
   DeltaT2 = *FRC*/2 + (JDX-1-AIM2)

3. The deterioration D(JDX, segment) is the additional growth in the failing test status group during the time DeltaT since the most recent inspection. Since the change in test-status weighting is the same for both the I/M and the NoIM case:

$$D(JDX,1) = NoIM(AIM1 + DeltaT1) - NoIM(AIM1)$$
$$D(JDX,2) = NoIM(AIM2 + DeltaT2) - NoIM(AIM2)$$

4. Given the previous calculations, we can compute test status weightings for an annual I/M program as follows:

$$IMWeighting(JDX = 0, FRC < 0.25) = NoIM[0.5 \times FRC]$$
$$IMWeighting(JDX = 1, FRC \geq 0.25) = NoIM[0.5 \times FRC]$$

$$IMWeighting(JDX = 1, FRC < 0.25) = FRC \times [IM(AIM2) + D(JDX,2)] + FRN \times [NoIM(JDX - 1 - 0.5 \times FRN)]$$
$$IMWeighting(JDX > 1) = FRC \times [IM(AIM2) + D(JDX,2)] + FRN \times [IM(AIM1) + D(JDX,1)]$$

Where:

IMWeighting	is the weighted average of the two segments of the model year.
IM(AIM)	is the test status weighting for age at I/M (AIM) after repair, waiver, and non-compliance factors from Section 3.0, but before taking the variety of ages into account. This value is independent of prior year I/M reductions. We define IM(AIM=0) to be NoIM(0).
AIM1	is the age at the most recent I/M test for vehicles in segment 1 (vehicles sold between the evaluation month and Sept. 30).
AIM2	is the age at the most recent I/M test for vehicles in segment 2 (vehicles sold between October1 and the evaluation month).
JDX	is a model year index. JDX = Calendar year- Model Year +1.

D(JDX,1) is the deterioration, the increase in failing vehicles in the time since the most recent I/M test for Segment 1.

D(JDX,2) is the deterioration, the increase in failing vehicles in the time since the most recent I/M test for Segment 2.

5. As in the No I/M case, the MOBILE model will actually look up values for integer ages and interpolate between them. This is illustrated in the “sawtooth” worksheets of *M6EVP002.xls.*

I/M with age exemptions

As is the case for exhaust I/M, emissions differ for I/M programs that exempt specific ages from testing. The exemptions may vary depending on the test conducted. For exemptions at the beginning of a vehicles life (grace periods), we set the age of last I/M inspection (AIM) to zero. In particular:

If JDX<GRPD + 1, AIM1=0, AIM2=0
If JDX=GRPD+1, AIM1=0, AIM2=JDX-1
If JDX>GRPD+1, AIM has normally computed value

Where GRPD = the highest age that is exempt from I/M. at the beginning of the vehicle life, for example, if a program begins testing vehicles at age 4, GRPD=3.

For age exemptions at the end of the vehicle life, we set the age of the last I/M inspection to the age computed for the last eligible model year. That is, for a user input “MaxAge:”

If AIM1>MaxAge, AIM1=MaxAge
If AIM2>MaxAge, AIM2=MaxAge

N-enniel Inspections

This section describes how MOBILE6 will compute evaporative test status weightings for vehicles subject to annual and inspections. The methodology is very similar to that described in Appendix D of M6.IM.001 for exhaust I/M programs. While MOBILE will calculate benefits only for annual and biennial programs, this analysis would apply to other periodic inspections as well.

In N-ennial IM programs vehicles are inspected every N years on the anniversaries of the sale to their first owner. In this general case, all vehicles with model year index greater than GRPD+1 should receive one inspection in the 12*N month period preceding the date when the emissions are to be evaluated.

The principle that a unique value of AIM can be calculated for each model year segment holds true for arbitrary values of N and GPRD. Thus, to compute I/M weighting factors we can use the same equations as in step 4 of the annual case, where AIM1 and AIM2 denote the integer ages in years of vehicles on the date of their previous IM test that were purchased new in the first and second segments of the JDXth model year.

The N-ennial case differs from the annual case in the calculation of the age at the last I/M inspection. For the N-ennial case, AIM1 and AIM2 are calculated as follows:

$JDX \leq GPRD+1$: AIM1=0

$JDX > GPRD+1$: AIM1= JDX-2-MOD((JDX-2-GPRD), N)

$JDX < GPRD+1$: AIM2=0
$JDX \geq GPRD+1$: AIM2=JDX-1-MOD((JDX-1-GPRD), N)

Where

JDX	= calendar Year- model year +1
GPRD	= oldest year exempt from I/M at the beginning of the vehicle life
N	= frequency of regular inspections in years
MOD(a,b)	= the remainder of a divided by b

For illustration, we compute the following table of ages at most recent inspection for the first eight model years.

Table B-2

JDX	Annual GPRD=0		Biennial GPRD=0		Biennial GPRD=1	
	AIM1	AIM2	AIM1	AIM2	AIM1	AIM2
1	0	0	0	0	0	0
2	0	1	0	1	0	0
3	1	2	1	1	0	2
4	2	3	1	3	2	2
5	3	4	3	3	2	4
6	4	5	3	5	4	4
7	5	6	5	5	4	6
8	6	7	5	7	6	6

Program Start and End

An evaporative I/M program has a start and end year. We assume that there is no benefit for the program prior to the start year. At the end year, we assume a sudden end to benefits.[30]

As for exhaust I/M, in the start up year itself, benefits are 0 for a January evaluation date since no cars have been evaluated at that time. For an annual program, July benefits in the start-up year are two-thirds what they would be in a normal year (since the Oct-Dec cars were not tested). For a biennial program with a mix of “1,3,5" and “2,4,6" testing, the start-up effect continues into the year after the start up year. Benefits in January of this second year are four-fifths the benefit of a normal year. Benefits in July of the second year are six-sevenths of those of a normal year.

[30]In our draft report, we proposed that benefits decline by a third each year for three years. However, this would have been very difficult to code into the model and would have a limited impact on results. For the final MOBILE6 we chose the much simpler “abrupt end to benefits” approach.

Appendix C Laboratory Data on Evaporative I/M Repairs

As explained in Section 2.3, EPA proposes modeling the effect of an emission repair as a change of test-status, so the emission benefit of the repair is the difference in emissions between a vehicle in a failing test status group and a passing test status group as those emissions are defined in the other reports on evaporative emissions. In this appendix, we compare this modeling approach to recently collected empirical data.

EPA contracted with ATL to collect data on real time diurnal, running loss and hot soak evaporative emissions before and after the repair of problems found with fill-pipe and gas cap I/M tests. This repair effects data was collected under EPA Contract 68-C5-0006, Work Assignment 1-8. At the time the draft report was written, we expected to receive additional data under this work assignment, but this was not the case.

In the study, 26 failing vehicles were recruited from Arizona I/M test lanes; two vehicles did not return for retest after repair. Four vehicles with missing gas caps were tested only for running loss. Table C1 on the following page gives summary data for the difference in emissions before and after repair for the vehicles, with the difference listed both as an emission rate (g/test or g/mi) and as a percent reduction.

The test data indicate that, while repairs are almost always beneficial, there is substantial variation between vehicles. We examined the data in aggregate as well as grouped by the type of test that was failed, fuel delivery system and model year (see Table C.1).[31] ANOVA analysis ($p < 0.05$) suggests that the data can be disaggregated by fuel delivery system (for running loss emissions), model year (for running loss emissions in g/mi and percent), and the type of I/M test that was failed (for running loss in g/mi and percent, and for hot soak in percent), but we did not see any trends in the data that made sense based on an engineering understanding of the evaporative systems.

In order to test the assumptions made in the MOBILE6 handling of evaporative I/M, we compared repair data for real-time diurnal emissions to the emission benefits that MOBILE6 will predict as described in M6.EVP.001. To match the test conditions, the MOBILE6 predictions were made for a 24 hour cycle from 72°F-96°F, at 9.0 RVP. The results are given in the following table (Table C.2). The results vary by fuel delivery system, model year and test type, and in a number of cases. On average, the MOBILE6 predictions are fairly close to the ATL data, although they consistently underestimate the repair effects.

At this time, we do not intend to alter the MOBILE6 proposal to account for differences between our proposed benefits and the empirical data. This is for three reasons:

[31] A model-year split at 1985 was considered to account for the effect of cumulative improvements in evaporative emission control during the 1980s.

1. First, we do not believe the magnitude of the possible effect warrants the time and effort that would be needed to make a wholesale revision to the evaporative emissions modeling approach.

2. Second, the MOBILE6 proposed rates are based on tests of hundreds of vehicles (as described in M6.EVP.001 and the other reports on evaporative emissions) while the repair effects data, although more directly applicable, are a much smaller dataset.

3. Third, if we were to use the repair effect data, it is not clear how to best adjust repair effects for variation in RVP, ambient temperatures and differences between vehicle groups in a way that is consistent with the evaporative emissions proposed in the absence of I/M.

EPA requested comments on whether the proposed MOBILE6 evaporative I/M benefits should be adjusted to account for differences between the current MOBILE6 proposal and the empirical data, and suggestions on how this could best be done. None were received, and we have retained our methodology for the final version of MOBILE6.

Table C.1, Evaporative Emission Repair Data

Contract: 68-C5-0006 - Work Assignment 1-8
Evaporative Emission Repair Credits
Vehicle Listing

	Veh. ~~No.~~	Model ~~Year~~	Fuel ~~Sys.~~	Lane ~~Press~~	Lane ~~Cap~~	Delta RTD	%	Delta HotSoak	%	Delta (g/mi)Rur	%
	070	88	2V	Fail	Pass	vehicle not returned					
	080	88	2V	Fail	Pass	0.08	0.01	1.29	0.81	0.88	0.95
Average		All	CARB	Fail	Pass	0.08	0.01	1.29	0.81	0.88	0.95
Std. Dev						na	na	na	na	na	na
	061	83	PFI	Fail	Pass	8.78	0.78	5.07	0.91	1.64	0.98
	065	85	PFI	Fail	Pass	3.89	0.61	6.03	0.95	1.70	0.98
Average		85-	FI	Fail	Pass	6.33	0.69	5.55	0.93	1.67	0.98
Std. Dev						3.45	0.12	0.68	0.03	0.04	0.00
	071	87	PFI	Fail	Pass	13.37	0.92	1.36	0.88	1.80	0.99
	077	87	PFI	Fail	Pass	14.69	0.92	1.95	0.88	1.50	0.97
	063	88	PFI	Fail	Pass	vehicle not returned					
	060	89	PFI	Fail	Pass	19.11	0.77	7.29	0.97	1.80	0.98
	069	89	PFI	Fail	Pass	-0.23	-0.07	1.20	0.67	1.47	0.96
	068	95	PFI	Fail	Pass	23.47	0.91	1.15	0.78	2.90	0.99
*	078	86	TBI	Fail	Pass	-9.52	-0.41	7.94	0.94	1.83	0.97
	084	86	TBI	Fail	Pass	15.25	0.89	4.66	0.93	3.70	0.98
	066	91	TBI	Fail	Pass	1.31	0.20	0.29	0.48	0.33	0.86
Average		86+	FI	Fail	Pass	9.68	0.52	3.23	0.82	1.92	0.96
Std. Dev						11.25	0.53	3.00	0.17	1.01	0.04
Average		All	FI	Fail	Pass	9.01	0.55	3.69	0.84	1.87	0.96
Std. Dev						10.09	0.48	2.83	0.16	0.89	0.04
Average		All	All	Fail	Pass	8.20	0.50	3.48	0.84	1.78	0.96
Std. Dev						9.94	0.48	2.78	0.15	0.90	0.04
	073	83	2V	Pass	Fail	14.75	0.83	2.77	0.79	0.48	0.88
	075	86	2V	Pass	Fail	7.19	0.53	0.61	0.43	0.65	0.93
	076	86	2V	Pass	Fail	9.98	0.68	1.23	0.62	0.56	0.89
	081	87	2V	Pass	Missing	not tested		not tested		-0.01	0.00
Average		All	CARB	Pass	Fail	10.64	0.68	1.54	0.61	0.42	0.67
Std. Dev						3.82	0.15	1.11	0.18	0.30	0.45
	079	84	PFI	Pass	Fail	15.16	0.93	0.44	0.24	1.84	0.76
	064	85	PFI	Pass	Missing	not tested		not tested		2.38	0.99
Average		85-	FI	Pass	Fail	15.16	0.93	0.44	0.24	2.11	0.88
Std. Dev						na	na	na	na	0.38	0.16
	085	86	PFI	Pass	Fail	0.98	0.21	7.29	0.87	4.88	0.96
	062	88	PFI	Pass	Fail	14.00	0.93	8.15	0.98	4.05	0.99
	067	88	PFI	Pass	Missing	not tested		not tested		6.34	0.96
	072	90	PFI	Pass	Fail	0.14	0.05	0.03	0.08	0.08	0.43
	074	91	PFI	Pass	Fail	12.53	0.95	4.90	0.98	2.06	0.99
	082	92	PFI	Pass	Missing	not tested		not tested		4.44	1.00
	083	88	TBI	Pass	Damaged	11.68	0.83	3.20	0.52	9.06	0.99
Average		86+	FI	Pass	Fail	8.12	0.61	2.71	0.53	4.39	0.87
Std. Dev						6.73	0.43	3.27	0.39	2.89	0.21
Average		All	FI	Pass	Fail	9.08	0.65	4.00	0.61	3.90	0.90
Std. Dev						6.71	0.41	3.40	0.39	2.70	0.19
Average		All	All	Pass	Fail	9.60	0.66	3.18	0.61	2.83	0.83
Std. Dev						5.69	0.33	3.01	0.32	2.77	0.29
Average		All	All	All	All	8.83	0.57	3.34	0.74	2.35	0.89
Std. Dev						8.13	0.42	2.81	0.26	2.16	0.22

* This vehicle was repaired twice. Results here are for the difference in emissions between the first and second repair.

Table C.2, Comparison of MOBILE6 predictions and ATL data

24 hour Real Time Diurnal
MOBILE6 predictions compared to ATL data

	Veh.	Model	Fuel	Lane	Lane	Repair Data		M6 Predicted		ratio: ATL/M6	
	No.	Year	Sys.	Press	Cap	grams	percent	grams	percent	grams	percent
	070	88	2V	Fail	Pass	vehicle not returned					
	080	88	2V	Fail	Pass	0.08	0.01	9.09	0.50	0.01	0.01
Average		All	CARB	Fail	Pass	0.08	0.01	9.09	0.50	0.01	0.01
Std. Dev						na	na	na	na	na	na
	061	83	PFI	Fail	Pass	8.78	0.78	15.18	0.68	0.58	1.13
	065	85	PFI	Fail	Pass	3.89	0.61	15.3	0.69	0.25	0.88
Average		85-	FI	Fail	Pass	6.33	0.69	15.24	0.69	0.42	1.01
Std. Dev						3.45	0.12	0.08	0.00	0.23	0.18
	071	87	PFI	Fail	Pass	13.37	0.92	4.58	0.49	2.92	1.88
	077	87	PFI	Fail	Pass	14.69	0.92	4.58	0.49	3.21	1.88
	063	88	PFI	Fail	Pass	vehicle not returned					
	060	89	PFI	Fail	Pass	19.11	0.77	4.69	0.50	4.07	1.54
	069	89	PFI	Fail	Pass	-0.23	-0.07	4.69	0.50	-0.05	-0.15
	068	95	PFI	Fail	Pass	23.47	0.91	4.79	0.51	4.90	1.79
*	078	86	TBI	Fail	Pass	-9.52	-0.41	4.5	0.48	-2.12	-0.85
	084	86	TBI	Fail	Pass	15.25	0.89	4.5	0.48	3.39	1.86
	066	91	TBI	Fail	Pass	1.31	0.20	4.75	0.51	0.28	0.39
Average		86+	FI	Fail	Pass	9.68	0.52	4.64	0.49	2.08	1.04
Std. Dev						11.25	0.53	0.11	0.01	2.42	1.09
Average		All	FI	Fail	Pass	9.01	0.55	6.76	0.53	1.74	1.04
Std. Dev						10.09	0.48	4.47	0.08	2.25	0.96
Average		All	All	Fail	Pass	8.20	0.50	6.97	0.53	1.59	0.94
Std. Dev						9.94	0.48	4.30	0.08	2.20	0.96
	073	83	2V	Pass	Fail	14.75	0.83	8.16	0.45	1.81	1.87
	075	86	2V	Pass	Fail	7.19	0.53	8.9	0.49	0.81	1.08
	076	86	2V	Pass	Fail	9.98	0.68	8.9	0.49	1.12	1.37
	081	87	2V	Pass	Missing	not tested					
Average		All	CARB	Pass	Fail	10.64	0.68	8.65	0.48	1.25	1.44
Std. Dev						3.82	0.15	0.43	0.03	0.51	0.40
	079	84	PFI	Pass	Fail	15.16	0.93	15.25	0.69	0.99	1.36
	064	85	PFI	Pass	Missing	not tested					
Average		85-	FI	Pass	Fail	15.16	0.93	15.25	0.69	0.99	1.36
Std. Dev						na	na	na	na	na	na
	085	86	PFI	Pass	Fail	0.98	0.21	4.5	0.48	0.22	0.44
	062	88	PFI	Pass	Fail	14.00	0.93	4.64	0.49	3.02	1.89
	067	88	PFI	Pass	Missing	not tested					
	072	90	PFI	Pass	Fail	0.14	0.05	4.72	0.50	0.03	0.11
	074	91	PFI	Pass	Fail	12.53	0.95	4.75	0.51	2.64	1.89
	082	92	PFI	Pass	Missing	not tested					
	083	88	TBI	Pass	Damaged	11.68	0.83	4.64	0.49	2.52	1.68
Average		86+	FI	Pass	Fail	8.12	0.61	4.70	0.50	1.73	1.23
Std. Dev						6.73	0.43	0.10	0.01	1.44	0.86
Average		All	FI	Pass	Fail	9.08	0.65	6.42	0.53	1.57	1.23
Std. Dev						6.71	0.41	4.33	0.08	1.32	0.77
Average		All	All	Pass	Fail	9.60	0.66	7.16	0.51	1.46	1.30
Std. Dev						5.69	0.33	3.61	0.07	1.08	0.65
Average		All	All	All	All	8.83	0.57	7.06	0.52	1.53	1.10
Std. Dev						8.13	0.42	3.90	0.07	1.74	0.84

* This vehicle was repaired twice. Results here are for the difference in emissions between the first and second repair.

Appendix D EPA Response to Comments on Draft Report

During the comment period on the draft report, EPA received comments from two organizations, Pennsylvania's Department of Environmental Protection (PA), and the American Petroleum Institute (API). Also, prior to the publication of the draft report, EPA received comments from the California Inspection and Maintenance Review Committee (CIMRC) specifically directed to evaporative emissions I/M. All the comments are summarized below in plain text with EPA responses in italic.

Pennsylvania also has a gas cap test. Please add us to your list of states with such programs. (PA)

This has been done.

Like many other states, the only test Pennsylvania is performing for evaporative emissions is the gas cap test. While EPA has evaluated data from a state (Illinois) that also is only performing a gas cap test, it is significant that Illinois has a centralized program, unlike many other states which either have hybrid or decentralized programs. (PA)

In MOBILE6, the data from Illinois and Arizona was used to generate testability and failure rates. Testability is intended to represent the characteristics of the vehicle, and is not expected to vary with program design. And while it would be very interesting to do a comparison of failure rates between centralized and decentralized programs, such a study was outside the scope of the MOBILE6 analysis.

EPA needs to revise its repair assumptions applying to gas-cap-only programs and treat them differently than full pressure and full purge. In decentralized programs (perhaps in centralized programs, but we can't speak to that), gas cap repairs are almost always made. That is, they are invariably included in the amount that must be spent to obtain a waiver because the expense is so minimal. In decentralized programs, this repair may be made before a tailpipe test is even performed (although the final result of the full test is a "fail"). Therefore, for gas-cap-only programs, these repairs will be almost unaffected by the existence of a waiver and should not be discounted. (PA)

As explained in the report, the default waiver rate may be adjusted with user inputs to more accurately represent the actual rate for the program being modeled.

Again, perhaps the same methodology should not applied to gas cap only as more comprehensive evap tests. A gas cap failure is an all-or-nothing event and the repair is replacement. Therefore, the age of the vehicle, once the gas cap is replaced, is irrelevant. The failure data we see in our program does have the same shape as the Illinois program, that is, is higher in earlier model years. However, once those caps are replaced, it's the age of the cap, not the age of the car that would be the determining factor. It seems like the deterioration should be more of a sawtooth/stairs sort of thing than a straight line.

Unfortunately, data to determine the best estimate for post-repair fail rates is hard to come by; and, even if we did have data, developing a new methodology to properly apply this data is not trivial . We did not have the time or resources to fully explore these options in MOBILE6; however, we do intend to consider using separate failure rates for repaired vehicles in developing the New Generation Model that will follow MOBILE6.

We appreciate EPA providing the ability to model gas cap only programs. Pennsylvania may have increasing use for this feature in the future as discussions continue on how to maintain the one-hour standard in growing areas as well as attain the possible eight-hour standard.

I know EPA has both less experience and skepticism about decentralized programs and data from those programs, but modelers should keep the network design in mind all the time -- ask themselves "would this behavioral assumption still be true in a test and repair network?" (PA)

As much as possible, we have tried to make MOBILE6 include the capacity to modify behavioral assumptions with user inputs if better, more relevant data is available.

The methodology proposed for MOBILE6 represents an improvement relative to MOBILE5 in that it is based on a more realistic estimate of the fraction of the fleet that is "testable" with respect to the evaporative emissions control canister. (MOBILE5 used a 95% testability estimate while use of the Arizona I/M lane data as described in the referenced document results in a more realistic estimate of about 67%.)

However, we have some concerns about: (1) the proposed baseline failure rates for vehicles subjected to the evaporative system pressure test and (2) the apparent EPA assumption that the fuel inlet pressure test will only identify a fraction of the vehicles with pressure test defects. The proposed baseline failure rates appear to be too high for mid 1980s to mid 1990s vintage vehicles and the assumption regarding the fuel inlet pressure test does not seem reasonable. As described more completely in the attached memo from Sierra Research, both of these elements of EPA's evaporative I/M proposal for MOBILE6 may have resulted from the inappropriate mixing of different data sets. (API).

This report acknowledges that fuel-inlet pressure tests are not an exact subset of cannister pressure test failures. The two tests are different and may identify different vehicles. However, given the lack of data in this area, we believe this simplifying assumption is reasonable for estimating I/M benefits.

Comments on the baseline failure rates are addressed in the report that discusses these rates, M6.EVP.006.

API did not mention their contractor's comment that the methodology incorrectly accounts for gas cap durability improvements. Sierra argues that gas cap durability improved significantly in the mid 80s but was not improved by the phase-in of enhanced evaporative *requirements in the late 90s. If true, this suggests that MOBILE6 may overestimate the benefits of gas cap checks for vehicles built in the mid 80s to the late 90s, and underestimates the benefits of gas cap checks for vehicles in the late 90s and beyond. Further investigation of this question would be worthwhile for a future version of the model.*

In the MOBILE6 evaporative emissions module, EPA classifies vehicles based on whether they fail the pressure or purge test. MOBILE6 assumes that gross liquid leaks occur only among vehicles that fail one of these tests. However, EPA's paradigm for evaporative emissions is at odds with the results of real-world studies. For example, an Auto/Oil study of hot soak emissions from 300 vehicles found that more than half of the excess evaporative emissions come from cars that do not fail either the pressure or purge tests. Failure of the pressure or purge tests is thus a poor surrogate for actual evaporative emissions rates. Furthermore, no I/M program includes the pressure or purge tests so failure of these tests does not appear to be a relevant factor in assessing actual I/M programs.

Several studies, including recent CRC-sponsored studies, have measured actual evaporative emissions rates of vehicles. EPA should not continue to base evaporative emissions estimates on an errant paradigm. Instead, EPA should simply use the real world data directly (with appropriate attention to sample validity issues of course) to determine evaporative emission rates.(CIMRC)

MOBILE6 assumes that gross liquid leaks are independent of pressure and purge test results and uses CRC and Auto/Oil results to estimate gross liquid leak emissions (see M6.EVP.009). Furthermore, as stated in the introductory chapter of this report, we assume that gross liquid leakers are not corrected with I/M programs. Thus, our modeling methodology is consistent with CIMRC's comments on these topics.