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Estimating Running Loss Evaporative Emissions in MOBILE6

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ABSTRACT

In earlier versions of EPA's MOBILE model, running loss emissions (defined as evaporative hydrocarbons that are emitted when the vehicle is in operation) were calculated as functions of ambient temperature, fuel volatility, driving cycle, and vehicle parameters (i.e., fuel delivery system, model year ranges, and functionality of the evaporative control system). This report is not a complete re-analysis of the older data used in those previous versions of MOBILE. Rather, this report examines the effects of "gross liquid leakers" (see report M6.EVP.009), and then compares recent running loss test results with the result of combining the estimated emissions of those leaking vehicles with the MOBILE5 running loss estimates.

Please note that EPA is seeking any input from stakeholders and reviewers that might aid us in modeling any aspect of running loss evaporative emissions.

Comments on this report and its proposed use in MOBILE6 should be sent to the attention of Larry Landman. Comments may be submitted electronically to mobile@epa.gov, or by fax to (734) 214-4939, or by mail to "MOBILE6 Review Comments", US EPA Assessment and Modeling Division, 2000 Traverwood Drive, Ann Arbor, MI 48105. Electronic submission of comments is preferred. In your comments, please note clearly the document that you are commenting on, including the report title and the code number listed. Please be sure to include your name, address, affiliation, and any other pertinent information.

This document is being released and posted. Comments will be accepted for sixty (60) days. EPA will then review and consider all comments received and will provide a summary of those comments, and how we are responding to them.

*** DRAFT ***

Estimating Running Loss Evaporative Emissions in MOBILE6

Report Number M6.EVP.008

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1.0 Introduction

Running loss emissions are defined as evaporative hydrocarbons that are emitted when the vehicle is in operation. Since the MOBILE4 computer model, the US Environmental Protection Agency (EPA) has estimated running loss emissions based on analyses of testing performed by one of its contractors (Automotive Testing Laboratories, Inc.).

The test programs were designed to test in-use vehicles with three different driving cycles:

- a low speed cycle (known as the New York City Cycle [NYCC]) with an average speed of 7.1 mph,
- a Federal Testing Procedure (FTP) LA-4 driving cycle with an average speed of 19.6 mph, and
- a high speed cycle (or Highway Fuel Economy Test [HFET]). with an average speed of 47.9 mph.

The duration of the running loss test is approximately one hour for each of those three driving cycle. Therefore, the NYC driving cycle is repeated six times (6 bags), the two portions of the LA-4 cycle are repeated three times (6 bags), and the HFET driving cycle is repeated five times (5 bags).

The running loss emissions test programs were designed to collect data at four levels of fuel volatility (7.0, 9.0, 10.4, 11.7 psi in Reid Vapor Pressure [RVP]) and at three levels of ambient temperature (80, 95, and 105° F). Not all vehicles were tested for all combinations of fuel RVPs and ambient temperatures, however. There was usually no testing at extreme conditions, such as the combinations of high RVP fuel and high ambient temperature (e.g., 11.7 psi/105° F), and low RVP fuel and low ambient temperature (e.g., 7.0 psi/80° F), because of their less likely occurrences in the real world. Also, if the running loss emission

results from a test vehicle were low (less than 0.5 grams) at certain fuel and temperature combination (for example, 9.0 psi/95° F), it was assumed that at the combinations of lower fuel volatility and/or lower ambient temperatures (i.e., 7.0 psi/95° F, 9.0 psi/80° F, and, 7.0 psi/80° F), this vehicle would have emissions at a similarly low level. Therefore, to save resources, the vehicle was not tested for the combinations of lower fuel volatility and lower ambient temperatures. Further, there have been no tests on 11.7 psi RVP fuel shortly after the issuance of MOBILE4 in 1989.

In MOBILE4 model, when the test data were not available at certain combinations of fuel volatility and ambient temperature, the gram per mile (g/mi) running loss emissions were estimated from a variable called "True Vapor Pressure (TVP)." In the MOBILE4.l model, this TVP was used to correlate with the running loss emissions from failed vehicles. These TVPs by bag are expressed as functions of fuel volatility and fuel tank temperature. The TVP values were calculated for all combinations of fuel volatility (7.0, 9.0, 10.4, and 11.7 psi RVP) and tank temperature profiles (with the initial tank temperatures at 80, 87, 95, and 105° F).

In recent years, industry sources have performed running loss testing programs in which random samples of in-use vehicles were tested (see Section 2). In this analysis, we will compare these new data to the MOBILE5 predictions to determine whether changes need to be made for MOBILE6.

2.0 New Running Loss Test Data

During the summer of 1997, running loss tests were performed on 150 vehicles as part of a testing program (project number E-35) conducted for the Coordinating Research Council (CRC). The running loss emissions for these vehicles were measured over a single LA-4 driving cycle, using tank fuel (RVP about 6.8 psi), and ambient temperature about 95 degrees Fahrenheit. **[1]*** The following summer (1998), CRC conducted a testing program in which running loss tests were performed on 50 late-model year vehicles (1992 through 1997, with a mean age of 4.5 years) (project number E-41). These 50 newer vehicles were again tested using tank fuel (RVP about 6.8 psi) and with an ambient temperature of about 95 degrees Fahrenheit; however, a longer driving cycle was used consisting of an LA-4 followed by two NYCC cycles followed by a second LA-4. **[2]** A summary of the results from those two programs are given in Table 1 (on the following page). Within each age range, the mean running loss test emissions was adjusted by subtracting the estimated resting loss emissions (calculated as in reference **[3]**) for each fuel delivery system, model year range, and

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* The numbers in brackets refer to the references in Section 6 (page 7).

then separately for vehicles that failed the pressure test* and those that passed the pressure test. In Table 1, the value "**Mean Age**" was calculated by subtracting the model year from the test year (either 1997 or 1998).

Table 1

Summary of CRC Running Loss Testing

CRC Project	Md Yr Range	Mean Age (years)	Sample Size	Run Loss Minus Rst Loss (gram/mile)	Std Dev Run Loss (gram/mile)
E-35	Pre-80	21.984	61	2.2951	6.2995
	80-85	13.744	39	1.3467	2.9659
	86-91	8.340	50	0.4514	1.3099
E-41**	92-97	4.320	50	0.3220	1.0533

** The running loss results of the vehicles tested in Project E-41 are based on a longer driving cycle but at a slower average speed than the E-35 cycle.

3.0 MOBILE5 Predictions of Running Loss Emissions

The MOBILE5 model was run to generate predictions of the running loss emissions in the CRC project E-35, that is:

- the ambient temperature was set equal to 95° F,
- the driving cycle was set to a single LA-4, and
- the fuel RVP was set to 6.8 psi.

MOBILE5 estimates were calculated for each model year within each of the three purge/pressure strata from reference [4]. Then, using the weighting factors from Appendix A of that reference, revised (i.e., re-weighted) MOBILE5 predictions were produced.

Since most of the CRC testing was performed during the summer of 1997, two separate MOBILE5 runs were necessary (one at January 1, 1997 and the second at January 1, 1998). The two MOBILE5 runs were averaged together to estimate the running loss emissions of the in-use fleet (by vehicle age) measured during summer 1997. Those predictions are given in Table 2 on the following page.

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* While vehicles in the CRC testing programs were not recruited based on their performance on the purge and pressure tests (as the EPA vehicles were), those tests were performed on all of the vehicles.

Table 2

Re-Weighted MOBILE5 Predictions of Fleet Running Loss (At CRC Test Conditions)

Age (years)	Predicted Run Loss (g/mi)	Age (years)	Predicted Run Loss (g/mi)	Age (years)	Predicted Run Loss (g/mi)
0	0.0974	9	0.2090	18	0.5751
1	0.1152	10	0.2372	19	0.5936
2	0.1340	11	0.2719	20	0.6054
3	0.1374	12	0.3149	21	0.6126
4	0.1423	13	0.3639	22	0.6167
5	0.1490	14	0.4160	23	0.6190
6	0.1583	15	0.4667	24	0.6198
7	0.1707	16	0.5118		
8	0.1872	17	0.5482		

Even the most cursory comparison between the average running loss emissions in Table 1 and the re-weighted MOBILE5 predicted running loss emissions in Table 2 suggests that the predicted values underestimate the observed mean values. This underestimation is most significant for vehicles over the age of 10 years. There are a number of possible explanations for those differences; however, EPA believes that the most likely explanation is the presence of vehicles identified as "gross liquid leakers" (see reference **[5]**) in the CRC sample.

In reference **[5]**, EPA used the term "gross liquid leaker" to identify vehicles having substantial leaks of liquid gasoline, as opposed to simply vapor leaks. In that report, EPA stated that the running loss emissions from such a vehicle tested over a single LA-4 driving cycle would be at least 7.0 grams per mile. When we examine the running loss test data used in the analysis for MOBILE5, it is questionable whether any of the test vehicles would meet EPA's definition of a "gross liquid leaker."* In the upcoming section (Section 4.0), we will consider the effect of adding the emissions from the "gross liquid leakers" to the (above) MOBILE5 estimate.

4.0 Effect of "Gross Liquid Leakers" on Running Loss Emissions

In reference **[5]**, EPA defined for running loss testing, "gross liquid leakers" to be vehicles with both liquid leaks of

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* The possible absence of "gross liquid leakers" in the data set used for MOBILE5 is not unreasonable considering the relatively small number of such vehicles in the in-use fleet.

gasoline and running loss test emissions of at least 7.0 grams per mile. Using that definition, we note that six (6) of the vehicles in the CRC testing programs met those criteria. We can then revise Table 1 by omitting those "gross liquid leakers." The revised values are given below in Table 3:

Table 3

Summary of CRC Running Loss Testing
Only Vehicles NOT "Gross Liquid Leakers"

CRC Project	Md Yr Range	Mean Age (years)	Sample Size	Run Loss Minus Rst Loss (gram/mile)	Std Dev Run Loss (gram/mile)
E-35	Pre-80	21.984	58	1.1113	1.5031
	80-85	13.744	37	0.7128	1.1103
	86-91	8.340	49	0.2825	0.5435
E-41	92-97	4.320	50	0.3220	1.0533

We then plotted, on the same graph (Figure 1 on the following page) both the re-weighted MOBILE5 estimates (from Table 2) and "Non-Gross Liquid Leaker" mean emissions (from Table 3). A visual examination of Figure 1 (and Tables 2 and 3) indicates that for vehicles up through the age of 11 years, the re-weighted MOBILE5 predictions are excellent estimates of the mean CRC results (i.e., within 0.20 grams per mile). And, even though that difference grew to almost 0.50 grams per mile for the oldest vehicles:

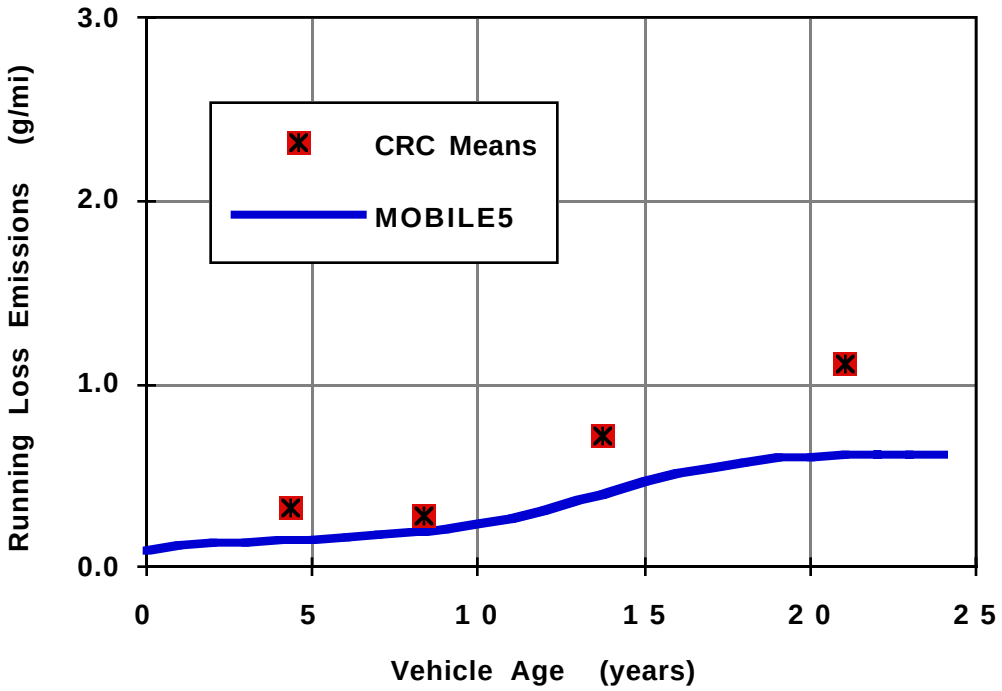
- From a statistical standpoint, those differences are relatively small, less than one-third of a standard deviation.

And,

- The largest differences between the CRC averages and the predicted results occur in the portion of the in-use fleet that contributes the least to the total emissions due to the small number of in-use vehicles involved. For example, fewer that one-tenth of the fleet is composed of vehicles older than 15 years, thereby reducing the effect of any potential offset.

Figure 1

Comparing Re-Weighted MOBILE5 Predictions to CRC Running Loss Emissions Excluding "Gross Liquid Leakers"



5.0 Conclusions

EPA proposes, for MOBILE6, to use the MOBILE5 model to estimate the running loss emissions from that portion of the fleet that does not contain vehicles that are "gross liquid leakers." For the portion of the fleet composed (entirely) of vehicles that are "gross liquid leakers," EPA proposes to use report M6.EVP.009 (i.e., reference [5]) to both estimate and weight the emissions. The mean running loss emissions of "gross liquid leakers" was estimated to be 17.65 grams per mile (less the resting loss emissions).

In that same report, the estimated frequency of "gross liquid leakers" in the in-use fleet (as a function of the vehicle's age) is given by the equation:

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

6.0 References

1) D. McClement, "Measurement of Running Loss Emissions from In-Use Vehicles (CRC Project E-35)", CRC Report No. 611, Prepared for the Coordinating Research Council, Inc. by Automotive Testing Laboratories, Inc., February 1998.

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

3) Larry Landman, "Evaluating Resting Loss and Diurnal Evaporative Emissions Using RTD Tests," Report numbered M6.EVP.001, July 1999.

4) Larry Landman, "Estimating Weighting Factors for Evaporative Emissions in MOBILE6," Report numbered M6.EVP.006, June 1999.

5) Larry Landman, "Evaporative Emissions of Gross Liquid Leakers in MOBILE6," Report numbered M6.EVP.009, June 1999.