
ANALYSIS OF HIGH-MILEAGE- VEHICLE EMISSIONS DATA FROM LATE-MODEL, FUEL-INJECTED VEHICLES

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Analysis of High-Mileage-Vehicle Emissions Data from Late-Model, Fuel-Injected Vehicles

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ABSTRACT

A recent analysis of the Environmental Protection Agency's (EPA) on-road vehicle emission factors model, MOBILE5a, suggested that exhaust emissions of newer model, fuel-injected vehicles were over-predicted at high mileage. That over-prediction, which results in over-predictions of fleet-average emission rates for future calendar years, was related to the paucity of data from modern technology, high-mileage vehicles available for the development of MOBILE5a. To bolster the database available for the next version of the MOBILE model, the American Petroleum Institute (API) sponsored a test program to investigate the exhaust emission control system deterioration characteristics of late-model, fuel-injected vehicles. Seventy-five light-duty vehicles were procured and tested over the Federal Test Procedure in this program. Vehicles included in the program were from the 1985 to 1992 model years, had accumulated at least 100,000 miles, and had never been subject to an inspection and maintenance (I/M) program. Vehicles were recruited at a site in Chicago Heights (CH), Illinois, and two separate sites in Phoenix, Arizona. The test program was conducted from April 1995 to August 1996.

Analysis of the data collected in this High-Mileage Vehicle (HMV) project revealed that model year was a more important determinant of emissions than fuel-injection technology (i.e., port fuel injection versus throttle body injection), with vehicles in the 1988 and later model year group demonstrating substantially lower emissions than vehicles in the 1985 to 1987 model year group. A comparison of emissions results from vehicles tested in this program to predictions from EPA's TECH5 model (which was used to generate base emission rate equations for MOBILE5a) indicated that TECH5 may be overpredicting emissions of late-model vehicles at high mileage, which has a significant impact on fleet-average emission rates calculated by MOBILE5a for future analysis years. Finally, a comparison of high-mileage vehicle emissions data from this project to data collected by EPA in Hammond, Indiana (which were collected approximately four to five years prior to the HMV project and were the basis of MOBILE5a) indicated that newer model year vehicles are more durable (from an emissions perspective) at equivalent age and mileage.

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EXECUTIVE SUMMARY

To investigate the emission control system deterioration characteristics of late-model, fuel-injected vehicles, the American Petroleum Institute (API) sponsored a test program in which 75 high-mileage light-duty vehicles were procured and tested over the Federal Test Procedure (FTP). Vehicles included in the test program had accumulated at least 100,000 miles and had never been subject to an inspection and maintenance (I/M) program. Vehicles were recruited at a site in Chicago Heights (CH), Illinois, and two separate sites in Phoenix, Arizona. The test program began in April 1995 and continued through August 1996.

Based on a previous analysis of the U.S. Environmental Protection Agency's (EPA's) on-road motor vehicle emission factors model, MOBILE5a, it appeared that the assumptions built into the development of the non-I/M base emission rate equations were resulting in an over-prediction of emissions at high mileage for late-model vehicles (Sierra Research, 1994). EPA's rationale for using some of those assumptions was related to the sparsity of data for vehicles at high mileage (i.e., over 100,000 miles). Therefore, API sponsored this test program with the intent of bolstering the database used by EPA to develop base emission rate equations for the next version of the MOBILE model.

When data collection in the High-Mileage-Vehicle (HMV) project was completed, API retained Sierra Research, Inc., to perform an analysis of those data, which is the subject of this report. The results of that evaluation are summarized below.

STATISTICAL ANALYSIS OF THE DATABASE

A general statistical analysis of the data revealed the following:

- A total of 75 light-duty vehicles were included in the sample: 50 of those were equipped with port fuel-injection (PFI) systems, 25 were equipped with throttle-body injection (TBI) systems.

- Model years included in the sample ranged from 1985 to 1992. Thirty-seven vehicles were in the 1985 to 1987 model year group; 38 were in the 1988 and later model year group.
- Model year appeared to be a more important determinant of emissions than fuel-delivery technology, with the 1988 and later model year group demonstrating substantially lower emissions than the 1985 to 1987 group.
- A single “super” emitter was tested in the HMT project. This vehicle (1985 model year, TBI fuel-delivery system) had hydrocarbon (HC) emissions of 10.32 g/mi and carbon monoxide (CO) emissions of 149.45 g/mi. Because it had a significant impact on the mean emission rate calculations presented in the report, most statistics are presented with and without this vehicle included.
- The site at which the vehicles were recruited appeared to have little impact on the mean emission levels of the sample.

DEVELOPMENT OF BASE EMISSION RATE EQUATIONS

The data collected in the HMT project were used to develop alternative emission factors for use in MOBILE5a. The modeling methodology used for this analysis relied on the emitter category definitions developed by EPA for MOBILE5a. Figure ES-1 compares the HMT study HC emission rates* to those predicted by TECH5 (a pre-processor model to MOBILE5a that generates base emission rate equations and I/M credits for the model). That figure, which also shows the mean emission rates of the HMT database by model-year group and mileage increment (i.e., 100,000 to 125,000; 125,000 to 150,000; and over 150,000), indicates that MOBILE5a (i.e., TECH5) is significantly over-predicting HC emissions of late-model vehicles at high mileage. Similar trends were also observed for CO and oxides of nitrogen (NOx) emissions.

* Note that the “HMT Study” line in Figure ES-1 reflects modeled predictions described later in the report. Because only vehicles with more than 100,000 miles were tested in this study, the modeled emission rates from 0 to 50,000 miles were based on TECH5, while emission rates from 50,000 to the first mileage increment of the HMT data (approximately 110,000 miles) were based on simple interpolation.

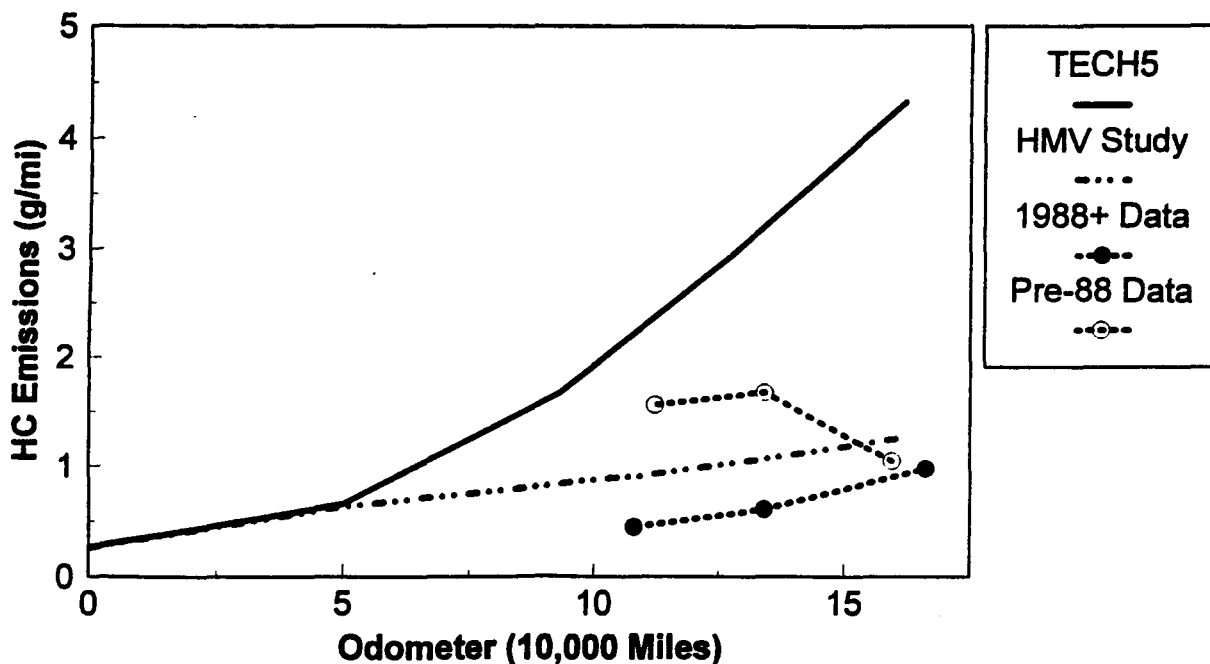


Figure ES-1. Comparison of HC Emission Factors from TECH5 and the High-Mileage-Vehicle Study. (Data points reflect mean emission rates calculated from the HMV data; the “HMV Study” line represents modeled predictions based on this work.)

It is interesting to note that the mean emission rates by emitter category (i.e., normal, high, very high, and super emitters) are not dramatically different when the HMV results are compared to TECH5. Rather, the difference in the distribution of vehicles among emitter categories is responsible for the large difference in predicted emission rates between TECH5 and the HMV study, i.e., more high-emitting vehicles are being predicted by TECH5 than are observed in the HMV database. (For a discussion of the basis for the TECH5 emitter distributions, please refer to Sierra Research, 1994.)

IMPACT OF HMV EMISSION FACTORS ON MOBILE5a PREDICTIONS

The emission factors illustrated in Figure ES-1 were used in conjunction with the MOBILE5a model to generate light-duty-vehicle, fleet-average HC emission rates for calendar years 1995 to

2010. (Note that the HMV study emission factors were calculated only for 1985 and later model year vehicles.) The results of the MOBILE5a runs are illustrated in Figure ES-2, which shows a significant decrease in fleet-average emissions when the emission factors are based on the HMV study. Also of note in Figure ES-2 is that the impact of the revised emission factors is most pronounced on the non-I/M estimates, and the difference between the MOBILE5a rates and the HMV study rates increases in future years as the fleet turns over.

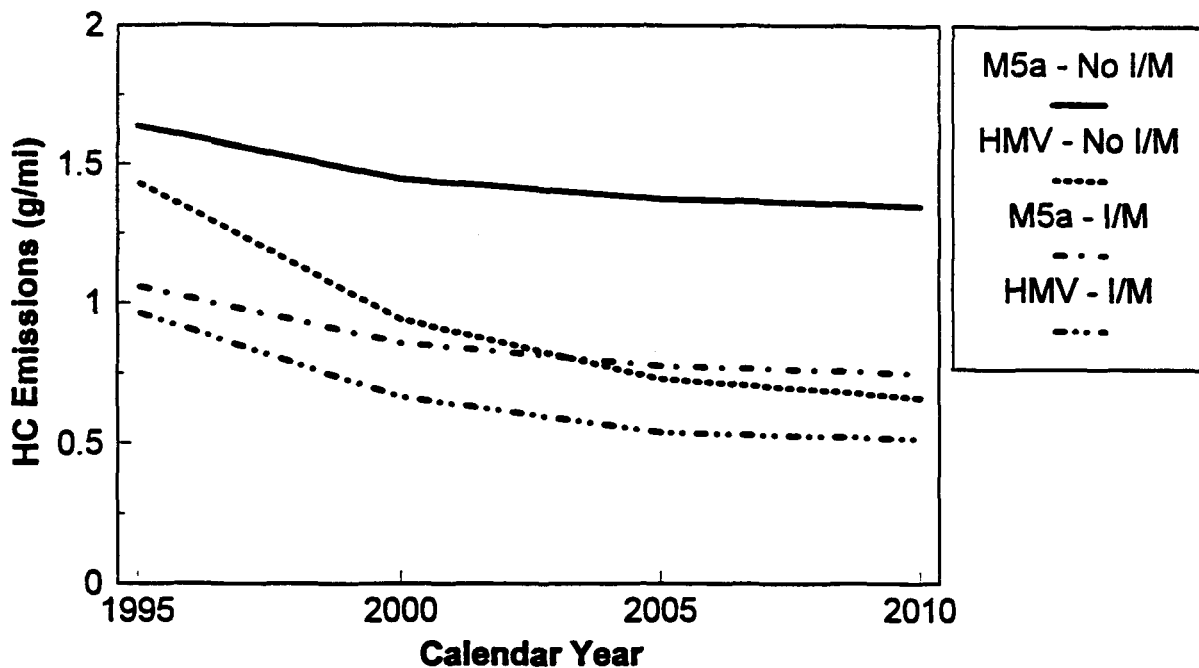


Figure ES-2. Comparison of Fleet-Average HC Emission Factors – MOBILE5a Versus the High-Mileage-Vehicle Study.

INFLUENCE OF MILEAGE ACCUMULATION RATES AND VEHICLE AGE ON EMISSIONS

A final evaluation performed in this study was a comparison of FTP-based emission rates from the EPA's Hammond, Indiana, IM240 and emission factors test program and the emission rates from the HMV study.¹ One complicating factor related to this comparison is that the HMV study was conducted about 4.5 years after the Hammond data were collected; thus, it represents a newer fleet of vehicles (on a model-year basis) relative to the Hammond project. In addition, although vehicles in the HMV project were limited to a maximum mileage accumulation rate of 33,000 miles per year, some of those vehicles accrued mileage at a much faster rate than modeled by MOBILE5a. In particular, vehicles in the 3- to 6-year age range had accumulated 40,000 to 60,000 more miles than would have been predicted by MOBILE5a.

To determine if emission control system in-use performance has improved with more recent model years, as the data from the HMV project suggest, emission rates from vehicles in EPA's Hammond, Indiana, emission factors program were compared to those from the HMV project *at equivalent ages and mileages* (i.e., only vehicles with more than 100,000 miles from the Hammond database were included in this comparison). The results of this comparison for HCs are illustrated in Figure ES-3, which shows that vehicles in the HMV database have lower HC emissions, on average, than vehicles in the Hammond database, at least up through about 8.5 years of age. This age corresponds to a mean model year of 1982.7 in the Hammond database and 1987.2 in the HMV database.

¹ The Hammond database used for this comparison was that used by EPA to develop base emission rate equations for MOBILE5a and reflects the in-use fleet in the 1990 to 1992 timeframe. Not all vehicles in that database received FTP tests; rather, correlation equations were used to predict FTP values from IM240 results for vehicles that were not FTP tested. This approach was taken because vehicles selected for FTP testing were not chosen at random (i.e., the FTP sample was skewed with high-emitting vehicles), and this methodology ensured that an unbiased sample was obtained for subsequent analysis. A detailed description of this approach can be found in Sierra Research, 1994.

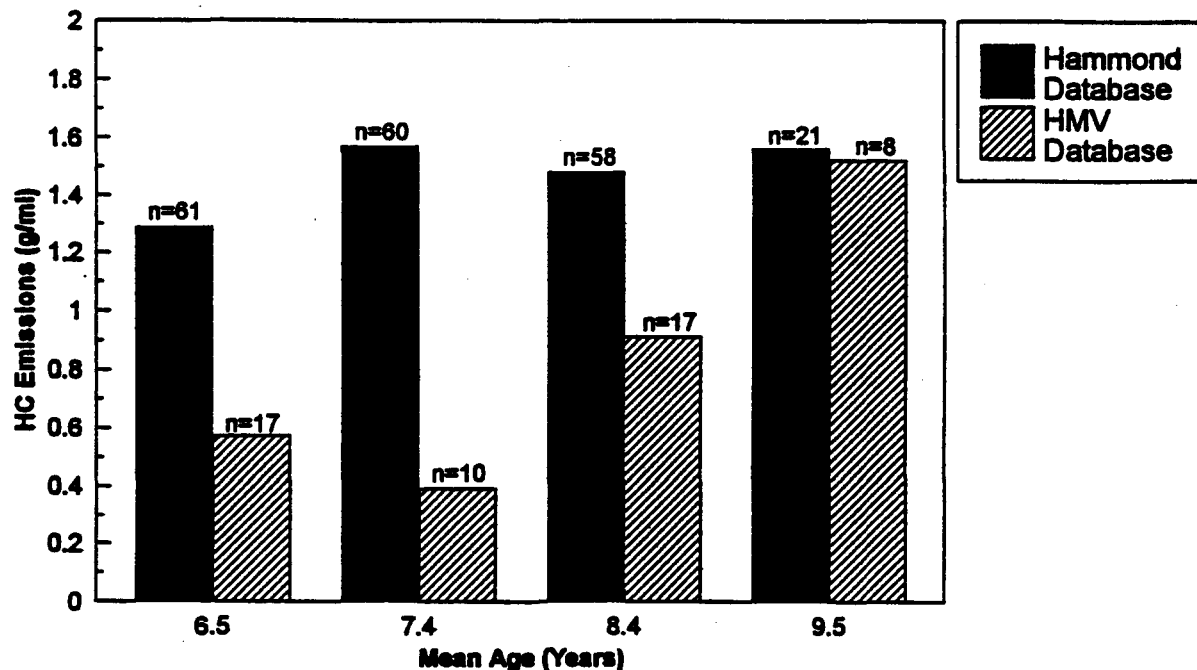


Figure ES-3. Comparison of Age-Based HC Emission Rates for Fuel-Injected Vehicles with More Than 100,000 Miles – Hammond Versus the High-Mileage-Vehicle Database. (Note that the HMV database reflects vehicles that are 4.5 to 5 years newer on a model-year basis.)

Results for CO and NO_x are shown in Figures ES-4 and ES-5, respectively. Note that the CO results are somewhat erratic in that the HMV database has much higher CO emissions than the Hammond database for vehicles that are 9.5 years old; however, the sample size for this group is very small (i.e., 8 vehicles in the HMV database and 21 in the Hammond database). On the other hand, NO_x emissions from vehicles in the Hammond database are much higher for all age groups.

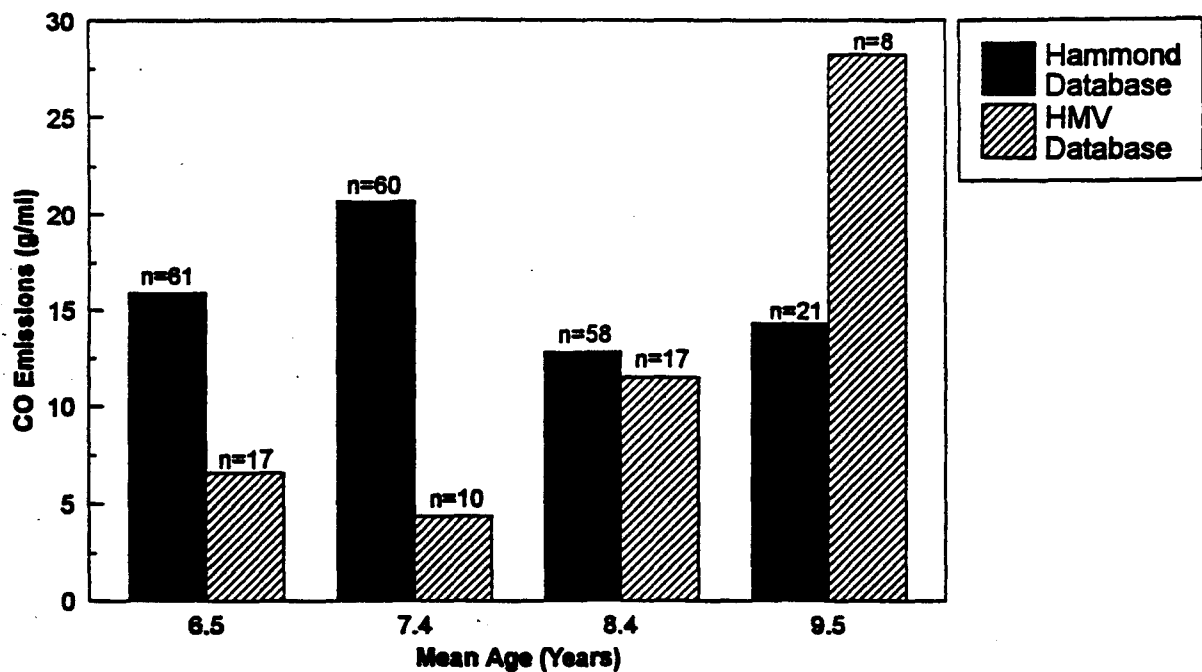


Figure ES-4. Comparison of Age-Based CO Emission Rates for Fuel-Injected Vehicles with More Than 100,000 Miles – Hammond Versus the High-Mileage-Vehicle Database. (Note that the HMV database reflects vehicles that are 4.5 to 5 years newer on a model-year basis.)

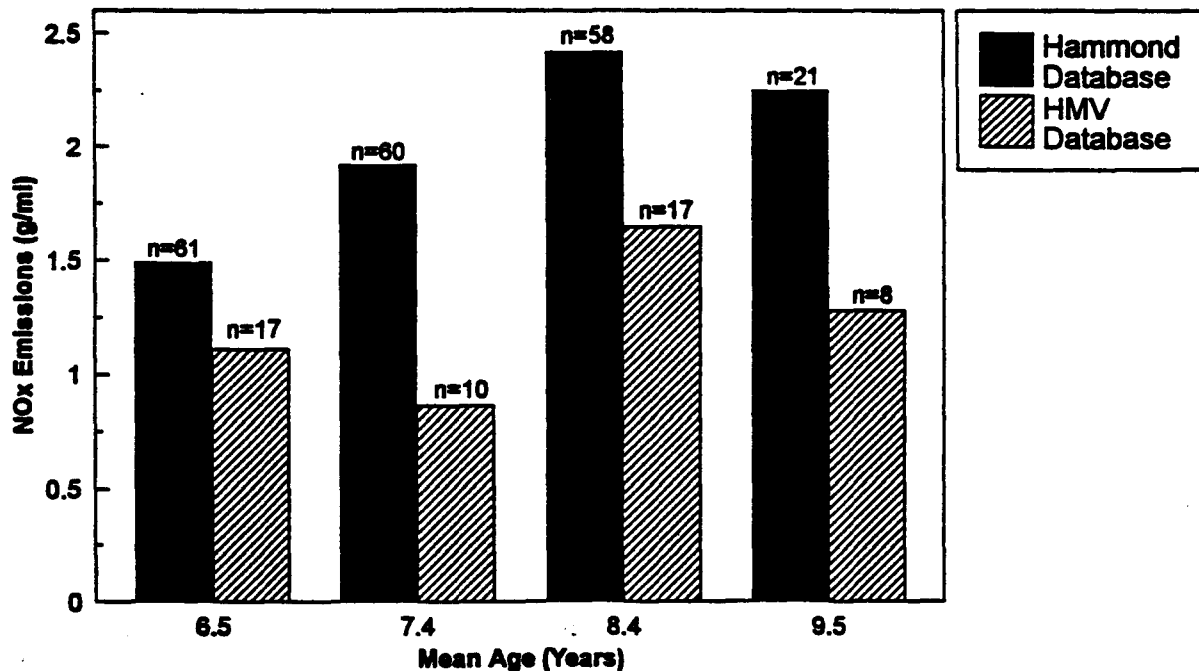


Figure ES-5. Comparison of Age-Based NOx Emission Rates for Fuel-Injected Vehicles with More Than 100,000 Miles – Hammond Versus the High-Mileage-Vehicle Database. (Note that the HMV database reflects vehicles that are 4.5 to 5 years newer on a model-year basis.)