United States Environmental Protection Agency
Air and Radiation
EPA420-P-99-016
March 1999
M6.EXH.008

Overview of Methodology for Tier 0 In-Use Deterioration and Key Issues for Comment

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- Draft -

Overview of Methodology for Tier 0 In-Use Deterioration and Key Issues for Comment

Report Number M6.EXH.008

April 29, 1999

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NOTICE

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

Introduction

There are four draft papers that document the proposed findings on the in-use exhaust deterioration of 1981-1993 model year (Tier 0) cars and trucks:

- M6.STE.002, "The Determination of Hot Running Emissions from FTP Bag Emissions"
- M6.STE.003, "Determination of Start Emissions as a Function of Mileage and Soak Time for 1981-1993 Model Year Light-Duty Vehicles"
- M6.EXH.001, "Determination of Running Emissions as a Function of Mileage for 1981-1993 Model Year Light-Duty Cars and Trucks"
- M6.EXH.002, "Analysis of Emissions Deterioration Using Ohio and Wisconsin IM240 Data"

This brief document provides an overview of the basic methodology being proposed for comment (with references to the appropriate papers), describes the uncertainties/key issues for comment, and compares the results to estimates obtained with MOBILE5.

As background, EPA is proposing that MOBILE6 will separate vehicle exhaust emissions into start emissions and running emissions. The papers described here provide estimates of start emissions as a function of mileage and running emissions as a function of mileage. These are basic emission rates; adjustments for off-cycle driving and other effects are described in other documents.

Peer review comments on these draft papers were solicited and received from three reviewers. A summary of the peer review comments is also available. Comparisons of the proposed findings to other available data sets will also be made available to assist public and stakeholder reviewers.

Methodology for Running Emissions

For running emissions, the following steps were followed:

1) Available FTP data were combined (described in M6.EXH.001 and M6.STE.003).
2) The FTP data were split into start and running portions using equations documented in M6.STE.002.
3) Estimates of average FTP-based running emissions (under standardized laboratory conditions) as a function of mileage were developed (described in M6.EXH.001).
4) Since these estimates of average running emissions are based on FTP tests of vehicles obtained from public vehicle recruitment programs, there is some concern that the low vehicle recruitment acceptance rates (typically less than 25%) in these programs may introduce recruitment bias. In addition, because of the dates of testing, the combined sample of vehicles had a restricted range of accumulated mileages. To address this, IM240 data from Dayton, Ohio were examined. The Dayton data are described in detail in M6.EXH.002.

5) In order to convert the Dayton IM240 data to running emissions, it was necessary to convert the fast-pass results to full IM240s, using equations documented in M6.EXH.002. The predicted full IM240s (under I/M lane conditions) were then converted to estimated running emissions (under standardized laboratory conditions) using equations documented in M6.EXH.002.
6) The IM240-based running estimates were compared to the FTP-based estimates. Based on this comparison, adjustment factors were developed and applied to the FTP-based estimates (described in M6.EXH.001). In most cases, the adjustment factors are positive, i.e., they increase the estimate of in-use emissions, particularly, emissions due to deterioration.
7) Using the final adjusted estimates of fleet average emissions at each mileage, the fractions of normal and high emitters as a function of mileage/age were back-calculated. The normal and high emitter fractions are used to estimate the start emission rates, and are provided in M6.STE.003 (see start methodology below). This is done to provide consistency between the start and running emission estimates.

Methodology for Start Emissions

For start emissions, the following steps were followed (all described in M6.STE.003):

1) Available FTP data were combined. These are the same FTP data sets used for running emissions.
2) The FTP data were split into start and running portions using equations documented in M6.STE.002. Again, this is similar to what was done for running emissions.
3) The start sample was separated into normal and high emitters.
4) The normal and high emitter samples were recombined using the mileage-dependent fractions of normal and high emitters for running emissions (described in step 7 above). Estimates of basic start emissions as a function of mileage were then developed.
5) A relationship between start emissions and soak time was also developed.

Uncertainties/Assumptions

There are a number of uncertainties/assumptions associated with this analysis. These are key issues and are provided below, along with EPA's current view of each. By way of this document, EPA is soliciting comments and/or information pertaining to these issues.

Issue 1: The model year groupings and segregation of fuel system types were based primarily on engineering judgment.

EPA's Current View: This reflects a belief, shared by the automobile industry, that vehicles in different groups are of sufficiently different design that the emission performance of one group cannot be attributed to any other.

Issue 2: The representativeness of the FTP data sample. The vehicles in the FTP data set were generally 1-5 years old at the time of testing, making age-related analyses difficult. Some of the high mileage data, particularly for the newer vehicles, come from vehicles specifically recruited to meet a mileage target, and thus may not be representative of all vehicles of their model year and age. Sample sizes are limited. Many of the vehicles were not recruited and tested under EPA supervision. Also uncertain is whether the mail-based public recruitment used in FTP studies introduces significant bias.

EPA's Current View: FTP tests are believed to provide the highest quality exhaust emissions data because vehicles are preconditioned in a consistent manner and the test is designed to simulate real world driving. The mail-based public recruitment may introduce bias, but the magnitude and even direction cannot be determined reliably without comparison to another data source. Any bias would be less strong at lower mileages, since all significant repairs required at these low mileages would be covered under warranty.

Issue 3: The FTP data are not considered to represent the fleet, and need to be adjusted based on IM240 data.

EPA's Current View: The disparity between emissions from the FTP and Dayton IM240 data sets is quite evident, even for comparable mileages. At lower mileages, the adjustment was less (trending towards no adjustment at zero miles) and at higher mileages the adjustment grew linearly. This appears consistent with the theory that the FTP data may be subject to a recruitment bias and, therefore, underrepresent the number of high emitting vehicles relative to the real fleet (as represented by the observations in Dayton).

Issue 4: The separation of FTP measurements into start and running emissions are based on results from 76 cars of limited model year range, which are assumed to be representative of the national fleet.

EPA's Current View: There was no better alternative approach, because data to support another approach did not exist.

Issue 5: The representativeness of the IM240 data sample. The IM240 data were collected over a period of just one year, representing a snapshot in time for the fleet, and making age-related analyses difficult. Fuel, vehicle preconditioning, and ambient temperature are uncontrolled. The Dayton sample is assumed to be sufficiently representative of the national fleet. The odometer readings were judged to be unreliable, making it necessary to substitute regional-specific annual average odometer readings by vehicle age for the reported odometers.

EPA's Current View: The Dayton sample was selected because it was the only area performing IM240 tests, while not having previously been subject to any emissions inspection program. Since Dayton is a biennial program, this sample contains about one-half the cars in the Dayton I/M area. The sample size is thus quite large, relative to the FTP sample. Also, since the program is mandatory, the data set should not be subject to significant recruitment bias. Since the comparison to the FTP data was done within each model year group by comparing mean emissions corresponding to mean odometer values, the regional odometer estimates were thought to adequately represent the mean odometer values for the Dayton sample.

Issue 6: The translations of the Dayton fast pass IM240 measurements to full IM240, and from full IM240 (under I/M lane conditions) to running emissions (under standardized lab conditions), are based on data obtained in other state and EPA programs from several years earlier.

EPA's Current View: The translation from fast pass measurements to full IM240 required second-by-second measurements from a program that performed random full IM240s. Wisconsin IM240 data were chosen over data from the other two IM240 states with second-by-second data because of the geographic, demographic, and meteorological similarities between Ohio and Wisconsin. Alternative statistical models developed by others using Colorado and Arizona IM240 data give similar results.

The translation from full IM240 under I/M lane conditions to running LA4 emissions under standard laboratory conditions required data from vehicles that were tested on both the FTP and lane IM240 cycles. The "Indiana" EPA data set used for this analysis was the sole data set that met this requirement.

The "Indiana" data set allows the adjustment from lane IM240 to lab running LA4 emissions to be separated into two parts, one for the driving cycle difference and one for all other factors which would include the fuel, temperature, and prior operation for the two testing situations. We observed that these non-cycle factors did have a substantial effect on measured emissions. Vehicles were considerably cleaner under the laboratory conditions than under the I/M lane conditions. From a variety of indications, we believe that much of this difference is due in large part to the unusual vehicle operation just before many IM240 tests, namely the long period of waiting. This waiting period can accentuate the influence of fuel volatility and/or cause catalyst cool down, which can affect the measured emissions of all cars both passing and failing. Most cars receive their IM240 test with no preconditioning to reverse these prior-operation effects. If we had used the Ohio IM240 data without adjusting for the differences, the estimate of in-use running emissions would have been higher, but not appropriately so. The long waiting-in-line periods at IM240 lanes are not representative of normal driving. Of course, lab conditions are also not representative of typical driving. To make the final estimates reflect normal driving, MOBILE6 will apply correction factors for fuel and temperature to the lab running LA4 estimates.

The issue of prior operation and lack of preconditioning on all cars is a serious complication in interpreting IM240 data. EPA invites comments on how it can be best addressed. EPA would also welcome a large data set from IM240 testing in which all cars are preconditioned once on the IM240 before the actual IM240 measurement.

Issue 7: The manufacturer mix is not necessarily representative of the national mix, particularly for 1988 and newer model years.

EPA's Current View: This pertains to the FTP data obtained by the domestic manufacturers. The vehicles were roughly 2-3 years of age at the time of testing. It is the largest single source of FTP data. The Ohio IM240 data has a better mix of imported and domestic models.

Issue 8: Certain data sets (in particular, the Colorado IM240 data) were not used for the analysis.

EPA's Current View: EPA obtained the Colorado IM240 data from the Colorado Department of Public Health and the Environment and used it to validate the MOBILE6 predictions obtained using the Dayton IM240 data. Specifically, the Colorado data were used in place of the Dayton data to calculate the running emissions estimates. The results indicate that the running emissions are somewhat higher when Colorado data are used. When combined with start emission estimates to obtain composite FTP values, the effect of using Colorado data in place of the Dayton data is considerably diminished. The MOBILE6 emission deterioration rates are still much smaller than those predicted by MOBILE5, regardless of which state's IM240 data are used. This work and comparisons to other available data sets are described in M6.EXH.010, which is also being made available for public and stakeholder review. The Colorado data set is subject to issues of prior operation and lack of 100% preconditioning, discussed above in item 6.

Issue 9: The effect of road grade has not been considered.

EPA's Current View: Road grade may have a significant effect on emissions and there may be an interaction between in-use deterioration and emissions under grade, but data and time were not available to address this issue for MOBILE6. It will be considered for later analysis.

Issue 10: The MOBILE model has historically predicted lower emissions than those estimated from tunnel and ambient studies. In particular, MOBILE predicts lower NMHC/NOx ratios than those observed in the tunnel and ambient studies. The lower in-use exhaust deterioration estimates in MOBILE6 would appear to increase, rather than decrease, this discrepancy.

EPA's Current View: This is a serious and complex issue which EPA has considered, and about which there should be continuing discussion and research. As long as there are apparent discrepancies between models like MOBILE and tunnel/ambient field studies, air quality planners and decision makers should keep the possible underestimation of emissions in mind as they decide on control programs.

It must be recognized that tunnel and ambient studies are not foolproof, and by their nature are not direct and irrefutable tests of the accuracy of a model like MOBILE. Beyond that, there are some specific reasons why EPA has not proposed to apply any adjustment to the emission rates based on comparisons to tunnel and ambient studies. Tunnel and ambient studies can indicate whether there may be a mismatch in estimates of fleet emissions, but they have not identified how the mismatch may depend on the model year of the vehicles or on exhaust versus evaporative emissions. It is plausible that there are different errors in MOBILE5 emission estimates for different model years, and for evaporative versus exhaust emissions.

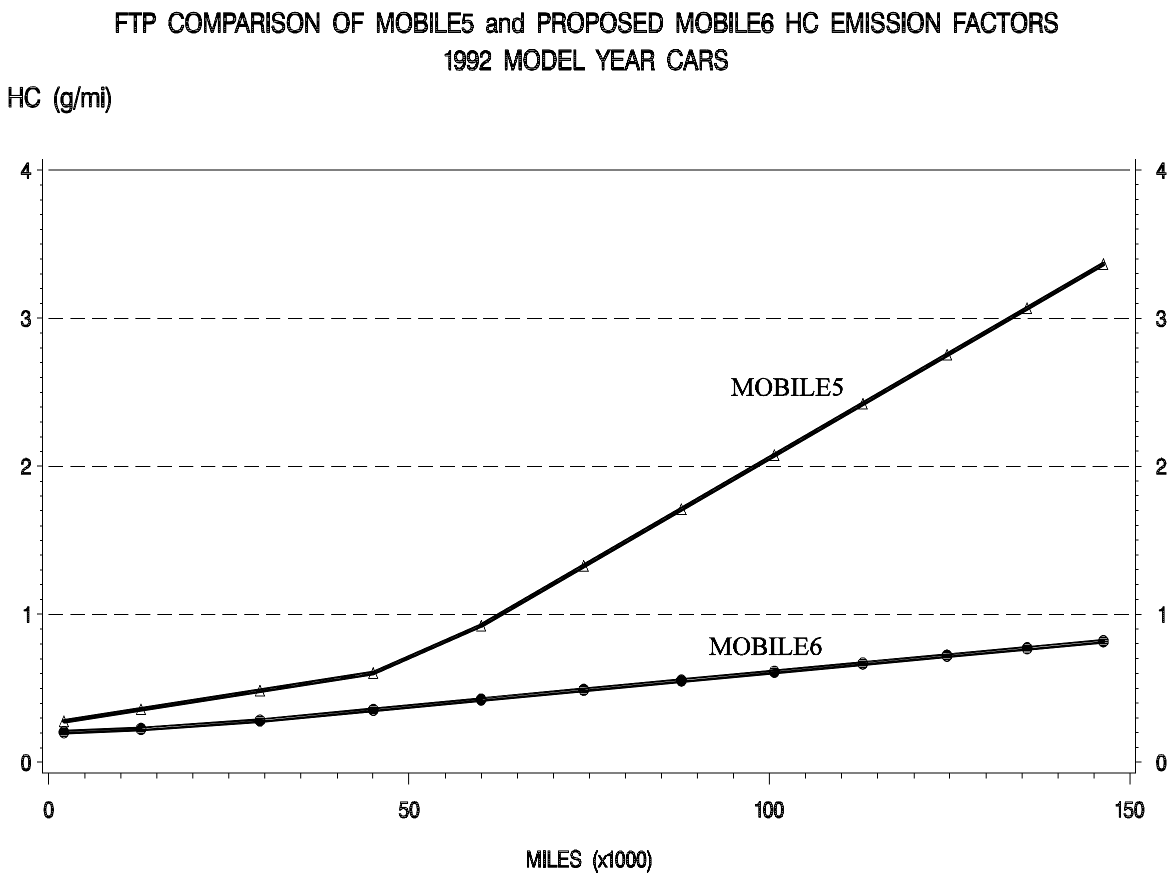
The studies in question were generally done in the early to mid 1990's. Some were done in California, which is known for the high average age of its fleet. In that time frame, a very large fraction of modeled fleet emissions is estimated to come from cars from the mid-1980's and earlier. In addition, a large portion of NMHC emissions were due to evaporative emissions. Therefore, errors in the estimates for these emission categories could explain much of the apparent discrepancies between models and tunnel/ambient studies. In particular, the failure to recognize (until MOBILE6) that these early model years suffered from high emissions during typical driving is a partial explanation that is unrelated to in-use deterioration of later model year cars.

For MOBILE6, we are proposing downward revisions of the in-use deterioration rates primarily for cars sold after the mid-1980's. For many of the available tunnel/ambient studies, the time frame of the study was such that some of these model years were still young enough that even MOBILE5 predicted them to have low in-use deterioration, i.e., they were still before their "kink." Therefore, EPA does not presently consider the discrepancies with field studies to be a decisive indictment of the revisions being proposed here for comment, but continues to welcome views and data analyses from others.

Comparison of MOBILE5 and Proposed MOBILE6 Emission Factors

In order to compare the MOBILE6 estimates with MOBILE5, it is necessary to combine the start and running estimates to calculate composite FTP emissions. In general, the MOBILE6 estimates of FTP exhaust emissions as a function of mileage for Tier 0 vehicles fall substantially below those predicted by MOBILE5. To illustrate, Figures 1, 2, and 3 provide a comparison of the MOBILE5 and proposed MOBILE6 HC emission factors for 1992, 1987, and 1981 model year cars, respectively.

Figure 1



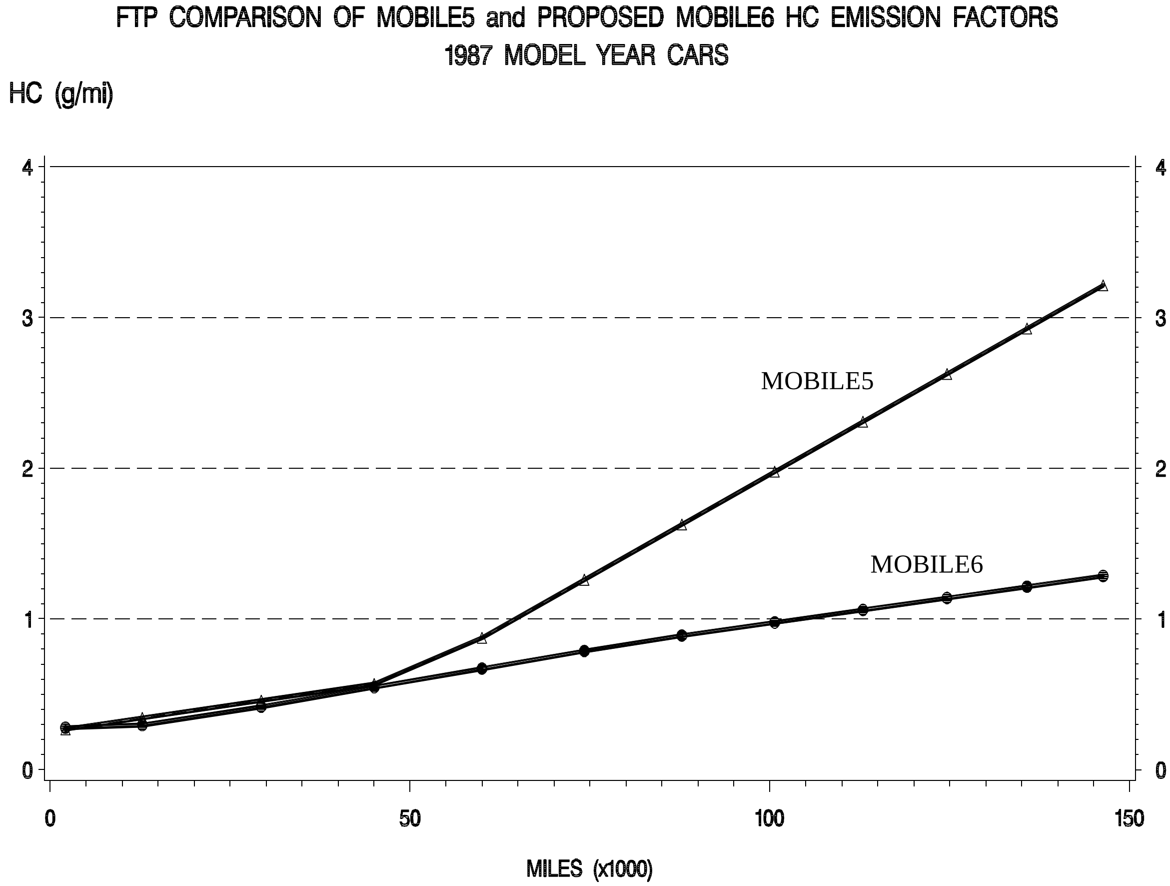
<u>1992 Model Year (Mostly Fuel-Injected) Vehicles</u>

As part of its overall upgrade to MOBILE6, OMS has been studying in-use deterioration. Real world information became available from states who implemented mass emissions I/M programs. That information coupled with traditional EPA FTP data and information received from other sources such as AAMA, API, and state I/M programs was used to calculate the in-use deterioration data for MOBILE6.

As shown in the above graph, rather than beginning to deteriorate more quickly at the "kink" of 50,000 miles as previously projected, newer model vehicles are not only cleaner when new, they stay cleaner longer. In 1990 and later models, port fuel injected systems began to dominate the industry, also contributing to cleaner vehicles.

For brevity, not all model years between 1981 and 1992 are shown in these figures. The MOBILE5 estimates for those model years were all very similar. The draft MOBILE6 estimates show a progressive improvement across time, reflecting the transition to fuel-injection and the manufacturers increasing success at compliance in actual use.

Figure 2

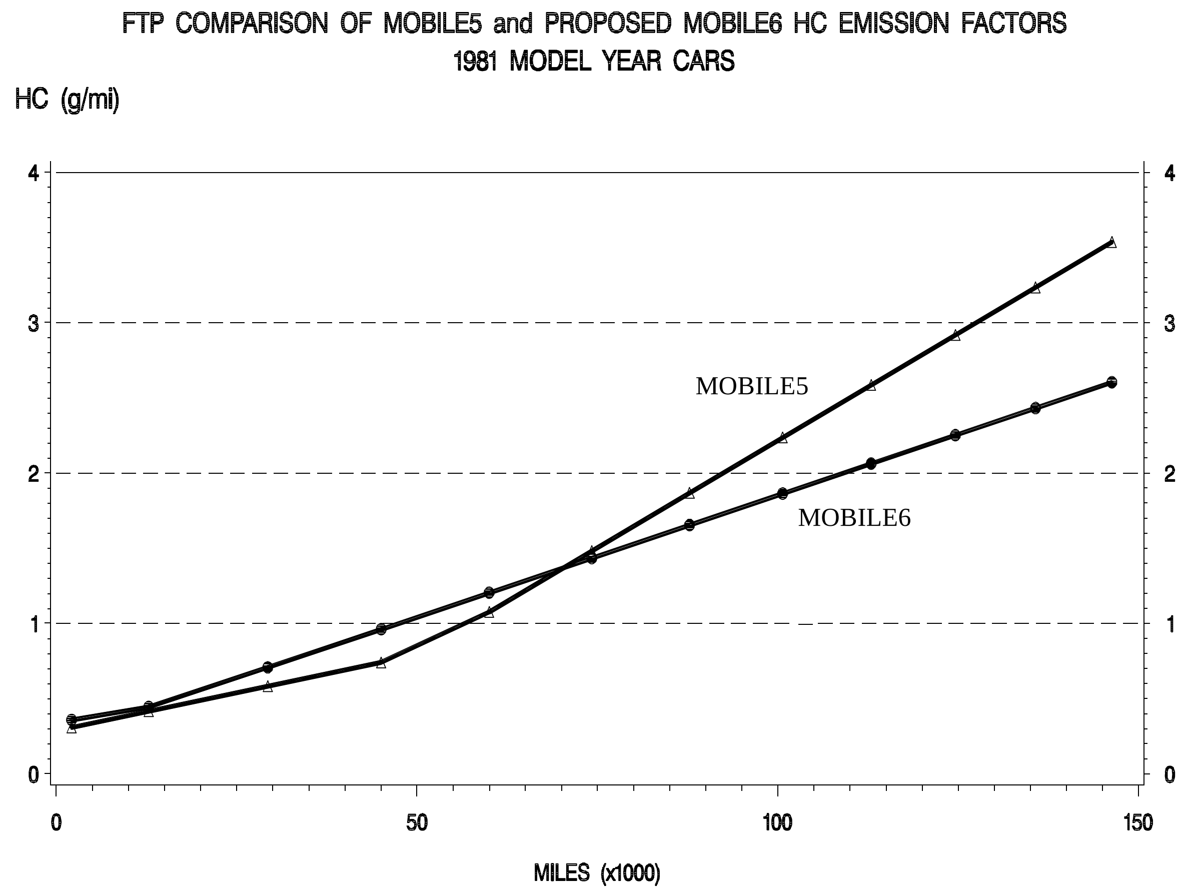


1987 Model Year

Using MOBILE5, projections indicated that after 50,000 miles, MY87 vehicles would deteriorate or become progressively dirtier over the next 100,000 miles. By 150,000 miles, their projected contribution to the emission inventory accounted for approximately 3.2 g/mi HC.

MOBILE6 predicts that after 50,000 miles the MY87 vehicles still become progressively dirtier, but the deterioration is not as dramatic as originally thought. Due to emerging emission control technology and early-model fuel injection systems, the exhaust emitted by light duty cars and light duty trucks during actual use is less than what was predicted in MOBILE5.

Figure 3



<u>1981 Model Year (Carbureted) Vehicles</u>

As this graph illustrates, MOBILE5 projections indicate that the rate of in-use deterioration for 1981 vehicles rose most dramatically at 50,000 miles. MOBILE6 also predicts significant vehicle deterioration but at a much steadier rate over the life of the vehicle.