United States
Environmental Protection
Agency

Air and Radiation

EPA420-R-02-002
January 2002
M6.EXH.001

EPA

Determination of Running Emissions as a Function of Mileage for 1981-1993 Model Year Light-Duty Cars and Trucks

Printed on Recycled Paper

EPA420-R-02-002
January 2002

Determination of Running Emissions as a Function of Mileage for 1981-1993 Model Year Light-Duty Cars and Trucks

M6.EXH.001

Phil Enns
Ed Glover
Penny Carey
Assessment and Modeling Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

NOTICE

This technical report does not necessarily represent final EPA decisions or positions. It is intended to present technical analysis of issues using data that 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.

1.0 INTRODUCTION

The MOBILE6 emissions inventory model will allocate vehicle exhaust emissions between engine start (start emissions) and travel (running emissions). This split allows the separate characterization of start and running emissions for correction factors such as fuel effects and ambient temperature. It also enables a more precise weighting of these two aspects of exhaust emissions for particular situations such as morning commute, parking lot and freeway driving. This document describes the methodology used to calculate the in-use deterioration of running emissions and presents estimates for model year 1981-1993 light-duty cars and trucks proposed for use in MOBILE6. The deterioration of start emissions is addressed in a separate document.[1]

Section 2 describes the Federal Test Procedure (FTP) data sources and the model year and technology groups used. Section 3 presents the methodology for calculating running emissions from FTP bag data. It contains a basic overview of the FTP, defines all of the applicable emission terms, and provides the calculations for determining the base unit of engine running emissions. Section 4 describes models and results for the in-use deterioration of running emissions as a function of mileage. Section 5 reports on high emitter correction factors which are applied to the deterioration estimates. Section 6 displays the final results in tabular form.

2.0 FTP DATA SOURCES USED

FTP datasets were used to determine in-use deterioration. The FTP-based emission estimates were then adjusted by applying high emitter correction factors derived using Ohio IM240 data. This section describes the FTP data sources used. Three FTP data sources were used: (1) the test results from the EPA laboratory in Ann Arbor, Michigan; (2) data received from the American Automobile Manufacturers Association (AAMA) based on testing conducted in Michigan and Arizona; and (3) American Petroleum Institute (API) data collected in Arizona. Model years range from 1981 through 1993, and vehicles include both cars and trucks. Table 1 gives a breakdown for the light duty vehicle sample by vehicle type, model year, and technology for the three datasets combined.

Most of the 1990 and later model year vehicle data were supplied by AAMA, while most of the pre-1990 data came from EPA laboratory testing. The API sample is a relatively small sample (99 cars and trucks). Its chief appeal is that the vehicles have generally higher mileage readings (all over 100,000 miles) than the rest of the sample. There is a general trend from carbureted and open loop technologies in early model years to fuel injection in more recent

[1] Glover, E. and P. Carey, "Determination of Start Emissions as a Function of Mileage and Soak Time for 1981-1993 Model Year Light-Duty Vehicles," Report No. M6.STE.003, October, 1998.

years. Port fuel injected vehicles dominate in 1990 and later model years. Although not explicitly shown in the table, new catalyst technology was phased slowly into the fleet starting in the mid 1980's.

For this analysis, cars and trucks were each classified into the following model year/technology groups:

MY Group / Technology Type - Cars

1988-93 Port Fuel Injection (PFI)
1988-93 Throttle Body Injection (TBI)
1983-87 Fuel Injection (PFI plus TBI)
1986-93 Closed Loop Carbureted/Open Loop
1983-85 CL Carb/Open Loop
1981-82 FI (PFI plus TBI)
1981-82 CL Carb/Open Loop

MY Group / Technology Type - Trucks

1988-93 Port Fuel Injection (PFI)
1988-93 Throttle Body Injection (TBI)
1981-87 FI (PFI plus TBI)
1984-93 Closed Loop Carbureted/Open Loop
1981-83 CL Carb/Open Loop

These groupings were selected on the basis of changes in emission standards or the development/refinement of new fuel metering or catalyst technologies. Because of the relatively large amount of 1988-93 fuel injected data, this category was split into PFI technology and TBI technology for both cars and trucks. This produces separate deterioration functions based on these fuel delivery technologies and allows the modeling of the future penetration of PFI technology into the in-use fleet.

3.0 DETERMINATION OF RUNNING LA4 EMISSIONS

3.1 Overview of the Federal Test Procedure (FTP)

The Federal Test Procedure (FTP) is a test cycle which is used to certify new vehicles to emission performance standards.[2] The FTP consists of a cold start segment (Bag 1), a hot stabilized segment (Bag 2), and a hot start segment (Bag 3). Initially, the vehicle is stored for

[2] 40 CFR Part 86, Subpart B, Section 86.144

a minimum of 12 hours before testing to simulate a 12 hour overnight soak period. It is then driven over the cold start segment, which lasts 505 seconds over a length of 3.59 miles, and the emissions collected as Bag 1. Bag 2 emissions are then immediately collected from the hot stabilized segment, which lasts 867 seconds over a length of 3.91 miles. After a 10 minute soak, the 505 seconds of the start segment is repeated and the emissions are collected as Bag 3.

The FTP composite emission rate is a weighted combination of the three measured bags designed to represent two trips. The first trip is a cold start after a 12 hour soak, and the other is a hot start after a 10 minute soak. Each trip is a “LA4" cycle, which is a combination of the 505 cycle (either Bag 1 or Bag 3) and the Bag 2 cycle. In a typical FTP test, the Bag 2 is only measured once and the results are used for both trips. Since the 505 cycle is 3.59 miles long and the Bag 2 cycle is 3.91 miles long, each LA4 trip is 7.5 miles long. Based on findings about driving activity from the original FTP study, the cold start trip is weighted 43% and the hot start trip weighted 57%. Hence the fraction of vehicle miles traveled (VMT) in Bag 1 (containing the cold start) is:

FTP Bag 1 VMT Weighting = 43%*(3.59 miles / 7.5 miles) = 0.206

Similarly, since 57% of trips involve a hot start, the VMT weighting for Bag 3 (containing the hot start) is:

FTP Bag 3 VMT Weighting = 57%*(3.59 miles / 7.5 miles) = 0.273

The remaining VMT represents stabilized driving (Bag 2). Since it is used for both the cold start and hot start trips, its VMT weighting is computed from both:

FTP Bag 2 VMT Weighting = (43% + 57%)*(3.91 miles / 7.5 miles) = 0.521

Thus, the standard VMT weighting of the bags reported in grams per mile (g/mi) for the full FTP is:

FTP = (Bag 1*0.206) + (Bag 2*0.521) + (Bag 3*0.273)

where the fractions represent the proportion of vehicle miles traveled within the three modes during the FTP trip in grams per mile.

3.2 Overview of the Hot Running 505 and Its Use

The FTP testing method outlined above does not allow the precise separation of start and running emissions, since Bags 1 and 3 contain both start and running emissions. Bag 2 of the FTP does not contain an engine start; however, the driving cycle used in the second bag is significantly different from the cycle used for Bags 1 and 3. Thus, to estimate the amount of

FTP emissions that can be allocated to engine start and running emissions, the concept of the Hot Running 505 (HR505) must be introduced.

The HR505 refers to emissions measured from a driving test performed on the 505-second cycle of FTP Bags 1 and 3 without an engine start.[3] Appending the HR505 cycle to a standard three-bag FTP produces values that can be used to estimate the portions of Bags 1 and 3 attributable to start emissions following a 12 hour soak and start emissions following a 10 minute soak, respectively.

Since the HR505 has not historically been included in FTP test programs, a method of estimating the HR505 from FTP bag data was developed using data from a special test program. Briefly, HR505 emissions were measured in a sample of 77 cars and trucks tested under EPA contract. The results from this sample were used to develop a correlation between the HR505 and FTP bag data. This correlation was then used to estimate HR505 results for the larger FTP dataset used in this analysis.

3.3 Basic Running LA4 Emission Rate

The LA4 refers to a cycle comprised of the 505-second driving cycle used for Bags 1 and 3 of the FTP and the 867-second cycle of Bag 2. Running LA4 emissions are defined as emissions from this 1372-second cycle with no engine start. For the MOBILE6 separation of start and running emissions, the running LA4 represents the running portion. For a given three-bag FTP, running LA4 emissions can be estimated using a VMT-weighted combination of the HR505 and the Bag 2 emissions (stabilized operation). This estimate contains all of the driving behavior in the LA4 cycle, without engine starts. Mathematically, it is given by:

$$\text{Running LA4 Emissions (grams/mile)} = (\text{HR505}*(0.206+0.273)) + (\text{Bag 2} * 0.521)$$

where 0.206, 0.273, and 0.521 are the VMT weightings for Bags 1, 3, and 2, respectively.

Like the FTP, running LA4 emissions are measured in units of grams per mile. This estimate is proposed for use in MOBILE6 as the basic exhaust emission rate from which all other running exhaust emission estimates are derived.

Using the methods described in this section, all emissions measured using the FTP and reported by bag can be allocated to start or running emissions before analysis. Average running LA4 and FTP emission rate estimates for each model year are shown in Table 2 for the light-

[3] Brzezinski, D. and P. Enns, "The Determination of Hot Running Emissions from FTP Bag Emissions", Report No. M6.STE.002, December, 1997.

duty cars and trucks in the EPA-industry sample used in this study.

4.0 FTP-BASED MODELS OF RUNNING LA4 DETERIORATION WITH MILEAGE

This section describes the methodology EPA used to estimate the deterioration of running emissions. Deterioration of running emissions as a function of mileage was examined using a number of linear and nonlinear models. The goal was to develop a description of deterioration that is consistent with both the available test data and with engineering judgment of past and likely future technologies.

In particular, for the model year/technology sub-fleets identified above, adequate data are often absent in some part of the useful lifetime mileage range. Such data gaps raised concerns when trying to fit a single functional form to a given data set, as it usually was found that no simple description of deterioration adequately describes the full range. For example, a fitted least squares regression often tends to overestimate emissions at low mileage.

A number of linear and nonlinear models of deterioration were examined. The chosen models represent a balance of simplicity and engineering judgment. They take the general form of expressing emissions as a piecewise linear function of mileage. At low mileage, emissions are assumed to equal the mean level estimated from those vehicles in the dataset with less than 20,000 miles of accumulated driving. This level applies for mileages ranging from zero up to the mean mileage for those vehicles. This approach was thought to give the best prediction, since the vehicles tested at low mileage should not be subject to any recruitment bias influence. The 20,000 mile cutoff is somewhat arbitrary, and was developed in coordination with the FACA In-Use Deterioration Workgroup.

At higher mileage, emissions are modeled to deteriorate linearly. While nonlinear models were investigated, they did not provide significant improvement over simpler linear forms. Two linear functions are used in the final models: (1) a least squares regression using all the data that is constrained to pass through the low mileage sample means; and (2) a least squares regression using all the data, with no constraints. The unconstrained linear model was chosen as the best representation of the data at higher mileages. The constrained line was chosen to provide a transition, when needed, between the low mileage mean and the high mileage unconstrained regression. The connection between these two lines is made based on their relative positions for a given technology/model year class. With a few exceptions, the following steps describe the calculation of this piecewise linear function.

1. For each of the model year/technology groups listed in Section 2.0, the mean CO, HC, and NO_X emissions, and the mean mileage were computed for all vehicles with an odometer reading of less than 20,000 miles. This value is used to model the group's low mileage emission level from zero miles up to the mileage determined

in step 2. An exception occurs when the mean emissions for the entire sample is less than the mean of the low mileage sub-sample, a case that is discussed below.

2. For each group, an (unconstrained) regression line was estimated for emissions versus mileage.

   a. If this line has positive slope and its intercept is less than the low mileage mean emissions from (1) above, it defines estimated emissions beginning at the mileage where it intersects the low mileage mean.

   b. If the (unconstrained) regression has positive slope but the intercept is greater than the low mileage mean, the constrained line defines emissions from the mean of the low mileage sub-sample to the mileage at which it intersects the unconstrained line. Beyond that mileage, emissions are estimated by the unconstrained line. Thus, the constrained line links the other lines for an intermediate range of mileages.

   c. If the unconstrained regression has negative slope or the mean of the full sample is less than low mileage mean, emissions for all mileages are set equal to the mean emissions for the full sample. This assures that negative deterioration cannot occur.

While these rules do not encompass all possible scenarios, they do cover all situations arising with the FTP data on which this analysis is based. The majority of cases are covered by option 2(a), giving a simple two-piece function. The three-piece function of 2(b) applies to several situations, usually with only a small slope change from the constrained to unconstrained line. Finally, the simple horizontal deterioration line of option 2(c) is needed for the CO fits of the 1988-93 TBI cars and the NOx fits of the 1981-83 carbureted trucks. The underlying numerical estimates are listed in Table 3.

For the FTP data set, these rules appear to produce reasonable emission projections in most cases. The two cases in which the full sample mean is less than the low mileage mean are caused by a few low mileage outliers.

5.0 HIGH EMITTER CORRECTION FACTORS

Since the estimates of running emissions deterioration are based on FTP tests obtained from public vehicle recruitment programs, there is some concern that low vehicle recruitment acceptance rates (typically less than 25%) in these programs may introduce recruitment bias. Whether such bias results in overestimation or underestimation of the true emissions deterioration is a matter of debate. This section addresses this issue, describes the methodology for adjusting emission factor estimates to account for bias, and presents the results.

Most of the 1990 and later model year vehicle data for this analysis were supplied by the domestic automobile manufacturers (the AAMA dataset). The manufacturers have expressed the opinion in FACA meetings and MOBILE6 workshops that owners of vehicles experiencing problems would be more likely to respond to the manufacturers' recruitment efforts, especially considering that repairs were included as an incentive to participate. The AAMA dataset is also composed of vehicles tested when they were roughly 2-3 years of age, when gross emitters should be few in number and any recruitment bias influence should be minimal.

Most of the pre-1990 data were collected by EPA; the average age of the vehicles was roughly 3-5 years at the time of testing. In this case, tampered vehicles or vehicles with problems should be greater in number, but owners may be more reluctant to participate in a program run by a regulatory agency, resulting in an underestimation of high emitters. The California Air Resources Board (CARB) has tested this hypothesis by comparing estimates from its CALIMFAC emissions inventory model, which are based on surveillance programs similar to those run by EPA, with emissions obtained from a California Pilot Project fleet with a high (60%) vehicle capture rate. In general, the comparison showed that the modeled estimates tend to underestimate emissions in older model year vehicles and slightly overestimate the emissions of newer vehicles. CARB developed high emitter adjustment factors (HECFs) for use in its EMFAC model to account for these discrepancies.

EPA developed high emitter correction factors using IM240 data collected in Dayton, Ohio during 1996-97. Like other inspection and maintenance (I/M) data, these form a large sample of vehicles within their geographical region, and are considerably less subject to sources of bias found in non-mandatory programs. The data and their translation to running LA4 estimates are described in more detail in a separate document[4].

Because of problems with the Ohio data odometer readings, the data were condensed to their mean running LA4 values by age, which then were associated with the corresponding region-specific mileage accumulations obtained from 1995 Nationwide Personal Transportation Survey (NPTS) data. After smoothing these values in the manner required for use in MOBILE6, these points were graphed with the emission rates fitted from the FTP data as described in Section 4. For each pollutant and within each model year/technology group, the difference between the Ohio mean and FTP-based fit was computed. These values were regressed through the origin against mileage. (The line was forced through the origin so that at zero miles the difference is zero.) Finally, the fitted differences were added to the fitted FTP-based values to obtain corrected values.

---

[4]Enns, P., E. Glover, P. Carey and M. Sklar, "Analysis of Emissions Deterioration Using Ohio and Wisconsin IM240 Data," Report Number M6.EXH.002, October, 1998.

In a few model year/technology groups, the Ohio adjustment is negative and, when applied to the deterioration line, causes negative deterioration. For these cases, deterioration is held equal to zero up to the mileage at which the adjusted emissions exceed the low mileage constant level.

Figures 1 and 2 illustrate how the adjusted and original values compare for each model year/technology group as a function of mileage for the car sample. Ninety-five percent confidence bands for the unadjusted lines are drawn to help judge the impact of the corrections. If the adjusted values fall inside these bands, it suggests that the Ohio IM240 data agrees fairly closely with the FTP data, i.e., bias is not a large problem. Otherwise, the recruitment bias is more serious. The graphs show varying levels of disagreement between the two data sources. In these graphs, the mileage interval for a given set of lines corresponds to the average mileages assigned in the NPTS survey to the model years for that group of vehicles. For example, the 1990 to 1993 cars range in mileage from about 45,000 to 70,000. Thus, the graphs show line fits for those vehicles in that interval.

Figures 3 to 9 present emission estimates for each model year/technology group as a function of mileage both with and without the high emitter correction factors for cars and trucks. For MOBILE6, deterioration estimates with the high emitter corrections will be used.

6.0 RESULTS

Results for each vehicle type/model year/technology group are presented in Tables 3 and 4. Included are the slopes and intercepts of the constrained and unconstrained regression lines, low mileage emissions and mileage intervals for each line segment. Table 3, described in Section 4, gives the unadjusted slopes. Applying the adjustment factors effectively changes the line segment slopes. The high emitter correction factors and the corresponding adjusted slopes are displayed in Table 4.

Shown below is a sample calculation of running emissions. It illustrates how the model coefficients given in Table 4 are used.

Example: Calculate HC running emissions for a 1985 model year FI-equipped car with: a) 15,000 miles, b) 75,000 miles, and c) 125,000 miles.

From Table 4:

a) At 15,000 miles, mileage<first corner, therefore:

Running (g/mile) = ZML + (First Slope * Mileage)
= 0.1479 + (0.0000*15)
= 0.1479 g/mile

b) At 75,000 miles, first corner<mileage<second corner, therefore:

Running (g/mile) = ZML + (First Slope * First Corner) +
(Second Slope) * (Mileage - First Corner)
= 0.1479 + (0.0000*18.89) + (0.0078)*(75-18.89)
= 0.5855 g/mile

c) At 125,000 miles, mileage>second corner, therefore:

Running (g/mile) = ZML + (First Slope * First Corner) +
(Second Slope) * (Second Corner - First Corner) +
(Third Slope) * (Mileage - Second Corner)
= 0.1479 + (0.0000*18.89) + (0.0078)*(81.38-18.89) +
(0.0059)*(125-81.38)
= 0.8927 g/mile

7.0 RESPONSE TO COMMENTS FROM PEER AND STAKEHOLDER REVIEW

(1) "MOBILE6 Determination of Running Emissions as a Function of Mileage for 1981 - 1993 Model Year Light-Duty Cars and Trucks", and (2) "Analysis of Emissions Deterioration Using Ohio and Wisconsin IM240 Data"

Comment #37 (AAMA) June 5, 1997

Comment: "EPA did not describe, however, how they intend to estimate deterioration for current and future technology vehicles, particularly Tier I and LEV-type vehicles with extended durability (100K) and onboard diagnostic controls."

EPA's Response: *EPA's estimates of future technology vehicle emission factors can be found in documents M6.EXH.007 and M6.EXH.009. The first document discusses the HC and NOx emission factors and the second paper discusses the CO emission factors.*

Comment: "AAMA differs significantly with the EPA on its approach to estimate in-use exhaust emissions and deterioration. EPA should not base in-use emission rates used in MOBILE6 on I/M240 results, for the following reasons:

1. EPA has not demonstrated sufficient correlation between the I/M240 and FTP.

2. EPA has little control over vehicle test fuel, preconditioning, or temperature at which I/M240 tests are conducted. The methods used by EPA in MOBILE5 to correct I/M240 results for temperature and fuel effects are questionable.

3. The use of the I/M240 results along with dubious correlation equations and correction factors for fuels and temperature very likely result in EPA arriving at emission rates for current and future vehicles that are significantly different than the California Air Resources Board's (ARB) emission rates for exactly the same vehicles. If this is the case, then EPA must explain why these emission rates are so different than ARB's emission rates. If EPA is convinced that the I/M240 must be used, then EPA should convince ARB to estimate emission rates in the same way, so that some consistency in emission rates on identical vehicles is achieved."

EPA's Response*:*

1. *Emission results from the IM240 exhaust emission test procedure were not used directly to estimate the emissions of vehicles using the FTP. The IM240 was used primarily to assure that recruitment bias in the FTP testing did not affect the overall emission deterioration estimate. Adjustments were made to the IM240 results in order to approximate FTP emission levels, however, these emission levels are never used to estimate FTP emission levels for MOBILE6 directly.*

2. *The adjustments to IM240 results for preconditioning, fuel and temperature effects are applied only as an attempt to reduce, not eliminate, the effect of these parameters. EPA feels that the application of these adjustments improved the credibility of the overall analysis.*

3. *EPA does feel that the emission estimates for similar future vehicles in California and in the federal fleet should be comparable. However, since the specific rules related to new vehicle certification federally and in California are not identical, there is room for disagreement on the emission impact of the new rules. EPA and California are sharing data and methods so that EPA is confident that, once all factors have been considered by both groups, that the differences between EPA's and California's estimates of emissions from future vehicles will be negligible.*

Comment:: "EPA should not base FTP emission rates on fast-pass I/M240 data, for the same reasons as above. AAMA believes there will be a weak correlation between fast-pass data and full I/M 240 data, and a weak correlation between full I/M240 data and the FTP. FTP values developed from fast-pass data and these two weak correlations will be subject to a high degree of error."

EPA's Response*: EPA admits that the relationship between the fast pass IM240 test and the FTP test is not well characterized in the work and may possess a low level of correlation. This would be particularly true for high emitting vehicles or vehicles which possess intermittent emission problems. Fortunately, in the case of high emitting vehicles (Ohio failures), no fast pass results were used since all failures automatically received a full IM240 test.*

Comment: "The automakers submitted extensive in-use FTP data to the EPA a year ago which show that emission rates of 1990-1994 vehicles are significantly less than MOBILE5 estimates, furthermore the data do not show any accelerated deterioration after 50,000 miles as EPA now assumes. The emission rates developed from this data were similar to ARB's emission rates for the same vehicles. Data were submitted on over 2,000 cars and 900 light duty trucks. This data was not mentioned by EPA in the Workshop. This data significantly adds to the EPA data on the same model years, and should give EPA a much larger database to analyze for MOBILE6. AAMA urges that the MOBILE6 emission rates should be based on all available FTP testing of vehicles by various sources, including EPA, ARB, and the Industry."

EPA's Response: The EPA acknowledges the receipt of these data and their use in characterizing in-use emission behavior. The FTP test data provide by these various sources became the backbone of the MOBILE6 emission factors. It was used almost exclusively to characterize the normal and high emitter emission levels. It was also the basis for the average emission calculation presented in reports M6.EXH.001 and M6.STE.002.

Comment: "100K and Useful Life Effects: For purposes of certification, under Section 206 (Clean Air Act), emission standards were established for useful life extended to 10 years or 100,000 miles. EPA needs to explicitly incorporate the effect of this added requirement in the MOBILE model as this was not done in MOBILE5."

EPA's Response*: The MOBILE6 1981-1993 model year emission factors were empirically developed from the FTP and Ohio datasets, and no assumptions were added to account for extended useful life. However, the 1994 and later vehicle modeling was less empirical in nature, and contains factors that account for the extension of the useful life from 50,000 miles to 100,000 miles.*

Comment #56 (J.F. KOWALCZYK, State of Oregon) Dec. 19, 1997

Comment:: "It is recommended that EPA go through the precise calculations to make the adjustment to mobile 6 based on Ohio I/M data and 1995 NPTS data as outlined above. Additionally, EPA should use the 1995 NPTS mileage factors in the final mobile 6 model which may necessitate speeding up the Acurex work. The 1995 NPTS data is clearly more up-to-date and most likely more accurate than the 1990 data. Regional specific NPTS mileage data should be used as there appears to be significant differences between regions.

I also recommend that CARB's revised EMFAC model, which according to Mark Carlock should be available in January, be analyzed against mobile 6 and that full harmonization between the two models be sought or, at the very least, a believable explanation of the difference be provided."

***EPA's Response**: The final analysis by Acurex used in MOBILE6 included the 1995 Nationwide Personal Transportation Survey (NPTS) database. As suggested, the regional NPTS results were used for estimating mileage accumulations in the analysis of the Ohio I/M data.*

We have attempted to coordinate with California as much as possible when constructing MOBILE6, including sharing of data and analysis. We have met repeatedly with California Air Resource staff during the development of MOBILE6 to share ideas. Some aspects of the California fleet, however, are unique to California and will not be identical in the federal (non-California) fleet.

Comment #58 (Data Analysis team, In-Use Deterioration and Modeling Workgroups) January 14, 1998

Comment: EPA should consider a broad range of mass emissions databases, including those reviewed by the Team and those which EPA has said it is still seeking to obtain and/or analyze (e.g., more complete Ohio IM240 data, California Pilot I/M Program data). EPA should report to the Team at a later date its proposal for the role of each data base in revising MOBILE, groupings of model year, technology, model year/technology, emitter categories, etc. The team wishes to review and discuss EPA's draft revision of the in-use deterioration estimates in the MOBILE model.

***EPA Response**: EPA agrees that the data summarized in the workgroup report are enough to warrant a serious reassessment of the MOBILE5a emissions. EPA has considered the data during that reassessment. EPA has presented interim analyses to the Workgroup for review, including the model year/technology groupings chosen, and the role of each data base in revising MOBILE. The documentation for the proposed in-use deterioration estimates will be provided to the Workgroup for review.*

Comment: EPA should acknowledge the overestimation that results when predicting future evaporative emissions based on current experience and existing technology.

***EPA Response:** EPA agrees that cars meeting the new evaporative test procedures and standards should be modeled as being lower emitting in-use than previous cars. This was in fact the case in MOBILE5, but the size of the difference is worthy of reconsideration. The reconsideration ought to start with an understanding of the causes of high evaporative emissions in the older cars, and then apply an* *understanding of how changes in design and materials would affect those causes.*

Comment: EPA should take an active role in obtaining high quality data from state IM240 programs.

EPA Response: *EPA has obtained state IM240 data from Colorado, Arizona, Wisconsin, and Ohio. Effort in 1998 is limited due to staff time and resource constraints; however, we remain interested in encouraging and perhaps financially supporting better preconditioning, more full IM240 tests, and more careful recording of vehicle information, on a sizable sample of vehicles.*

Comment: An Auto/Oil hot soak pilot study has been conducted. In addition, CRC has conducted a real time diurnal study that will measure 24 hour diurnal emissions from 151 vehicles. EPA is also conducting a diurnal emission study. The results of these analyses should be reviewed when available to provide insight into evaporative emissions deterioration.

EPA Response*: EPA plans to use these data along with the data collected under EPA sponsorship*.

Comment #83 (Rick Barrett, CDPHE) July 28, 1999

Comment: The 60-day comment period is not sufficient to complete the review of MOBILE 6 documents.

EPA Response*: We agree that due to the simultaneous posting of large amounts of MOBILE6 documents that a 60-day comment period may not be sufficient time to complete a thorough review of the MOBILE6 documents. As such, we have accepted comments for several months following the original 60-day deadlines.*

Comment: "there is likely still an under prediction in both the frequency and projected emissions levels of high emitters in the proposed Mobile 6 estimates."

EPA Response*:*

EPA does not believe that the emission factors and high emitter frequency contained in MOBILE6 seriously under or over predict (within a reasonable statistical range) the emission results that have been collected from vehicles or will likely be collected from typical vehicle emission testing. This conclusion is backed up by considerable laboratory and in-use IM240 testings, and by recent repeat testing of vehicles (multiple tests over a long period of time).

However, it doesn't necessarily mean that the emission factors based on dynamometer tests exactly match either individual vehicle behavior or even fleet behavior in the 'real world'. Vehicle emission testing has confirmed that individual vehicle emission behavior is highly variable. Thus, any individual vehicle or small sample of vehicles may have results which are considerably different that these averages. Also, the 'real world' may contain factors that greatly affect emissions which have not been accounted for in the MOBILE6 modeling due to testing and experimentation resource limits.

Comment: The EPA has several documents related to the Tier 0 and Tier 1 vehicles, as well as I/M effects, which show the high emitting vehicles have a constant average emission rate with respect to age or mileage. CDPHE staff believes this assumption does not make sense. As a result of an audit of Colorado's I/M program conducted last year by Environ, vehicles identified as failures, and then repaired, were deteriorating at a faster rate than the remainder of the fleet. In addition an analysis of Colorado's data conducted by Peter McClintock has shown that high emitters average emissions do increase with age. CDPHE staff believes EPA should reevaluate these assumptions based on I/M data where the emissions performance of the same vehicles can be tracked through multiple inspection cycles.

EPA Response: *The assumption of zero deterioration of High emitters was made because absolutely no correlation could be found in the data (FTP and a limited sample of Ohio I/M data) that indicated that it is a function of mileage or age. Thus, the assumption of a constant emission level with respect to mileage or age is the most prudent assumption to make. The engineering rationale for this assumption is that the more serious emission related problems are not necessarily more likely to occur at high mileage than at low mileage. However, the large observed variance of the high emitter level does suggest that a variety of emission related problems occur, and that they can occur at any mileage (few problem occur under 20,000 miles, though). The rising High emitter fraction with mileage also implies that the frequency of High emitter appearance increases with mileage.*

Comment: The CDPHE staff feels that EPA has made reasonable assumptions regarding the effectiveness of OBD systems and motorist response to OBD MIL indications.

EPA Response: *Thanks*.

Comment #85 (Joel Schwartz, California Inspection & Maintenance Review Committee) August 3, 1999

Comment: Data biases should be examined and corrected: Some cars never get tested. Some motorists prepare for the test by setting up their car to pass the test without making substantive repairs. And some motorists make substantive repairs to their cars in preparation for the test. Either (1) validate the IM240 test-lane data against data collected in random roadside pullovers or by remote sensing, or (2) use roadside or RSD data to generate the emission factors for the model. Base RSD credits on more representative RSD data and encourage the use of the CRC best practices for collection of high-quality RSD data.

EPA Response:

(Also s*ee responses #1 and #20 of section 7 of M6.IM.001)*

The remote sensing device (RSD) has the potential to collect massive amounts of in-use data that could potentially be used for the development of emission factor models or the confirmation of emission factor models. Unfortunately, at the time of data collection and analysis, high quality RSD data in large quantities were not available for use. Also, the quality and applicability of use of RSD data is frequently dependent on the actions of individual operators and the specific test locations. Improper siting of the RSD units can lead to results which are not representative of overall vehicle operation (100% ramp siting for example), or do not measure a random sample of the vehicle population.

Comment: Base model assumptions on real-world data from vehicle emissions and human behavior studies, and not on incorrect pre-conceptions about the way people, vehicles, or programs ought to behave. EPA should provide justification for "Engineer Assumptions". I/M "Saw-Tooth" does not represent real I/M programs. Human behavior should explicitly included in the model. Real-world data should drive evaporative emissions calculation. RSD benefits are contingent on incorrect assumptions about effectiveness of scheduled I/M programs

***EPA Response**:*

(Also s*ee Response #20 of section 7 of M6.IM.001)*

The RSD benefits have been removed from the MOBILE6 model.

Comment: MOBILE should not be used for regulatory purposes until it has been appropriately validated. Include multiple internal validation checks so users can ensure that MOBILE's output jibes with real-world measurements, both overall and in detail. Make real-world measurements, rather than MOBILE predictions, the final arbiter of the emissions reduction credit attributed to an I/M program.

EPA Response*: The process for using a model such as the MOBILE model series for regulatory purposes rather than conducting a multitude of elaborate and expensive studies of 'real world' emissions has been established through Federal regulation over several decades. Until this process has been changed, the need for MOBILE6 will continue.*

<u>Comment #87 (Alison Pollack, Till Stoeckenius and Cuong Tran, Environ) August 18, 1999</u>

Comment: Comments from Peter McClintock of Applied Analysis (7/4/1999) and Tom Wenzel of Lawrence Berkeley National Laboratory.

EPA Response*:* Are these comments answered or addressed? Comments from Peter McClintock of Applied Analysis (7/4/1999 conversion of IM240 to running LA4 and 6/25/1999 memo to Phil Lorang regarding change vehicle registration patterns)

Comment: Fast Pass time is incorrectly included in the regression during conversion of fast pass to full IM240 using Wisconsin data. Fast pass time (variable name FSEC in EPA regressions) is assumed to be linearly related to the log of fast pass emissions.

EPA Response*: It would seem logical that the fast pass time would be a significant variable in the correlation between fast pass IM240 and the Full IM240. It's exclusion would clearly be a mistake. Only Phil Enns can definitively answer this question. However, it is my understanding that he double checked all of his regression equations, and found and corrected any errors that may have been present.*

Comment: Use of the logarithmic transformation is inappropriate and reduces the effects of the high emitters, leading to underprediction of emissions.

EPA Response*: Because of the highly skewed nature of vehicle emission data, a logarithmic transformation was necessary in-order to perform standard least-squares regression analysis. In order to overcome any possible under-prediction of emissions, an additive and positive logarithmic transformation factor was added to the regression equation. It has the effect of increasing the average emissions and restoring the effect of high emitters.   It is a valid and fairly commonly used statistical transformation.*

Comment: We recommend that EPA review the proposed approach for estimating MOBILE6 deterioration rates, taking into account the comments received, and revise the data bases and modeling methods accordingly. In addition, we recommend that EPA perform sensitivity and uncertainty analyses to guide further data collection efforts. In addition, as stated above, we recommend that EPA make all data sets *readily* publicly available, and also that full regression statistics be provided for any regression models using in the development of these and other MOBILE6 emission factors.

***EPA Response**: Throughout this process EPA has reviewed all comments and revised our methodology when appropriate. All non confidential or non proprietary data sets will be made public for subsequent analysis, and most regression models will also be available as part of the report.*

Comment #89 (Robert Slott, Consultant) August 23, 1999

Comment: "... large data sets of random full IM240 measurements exist in a number of states. These data sets should be used to get a first approximation of deterioration rates in each of these states." "Analysis of remote sensing measurements, corrected for vehicle specific power, should be developed to give more realistic on-road deterioration."

***EPA Response**: Data from IM240 testing done in Ohio and Wisconsin was used in MOBILE6 to adjust the deterioration of the national average fleet estimates in MOBILE6. Time and resources were not available to do a more extensive review of the available IM240 testing results from other States. There was not a sufficient consensus on how to interpret remote sensing measurements in order to use them for estimating on-road deterioration for MOBILE6. The appropriate use of remote sensing will be considered as a part of future EPA model development.*

Figure 1: RUNNING LA4: FTP−BASED MOBILE6 and OHIO IM240 ADJUSTMENTS
1981−93 FUEL INJECTION CARS

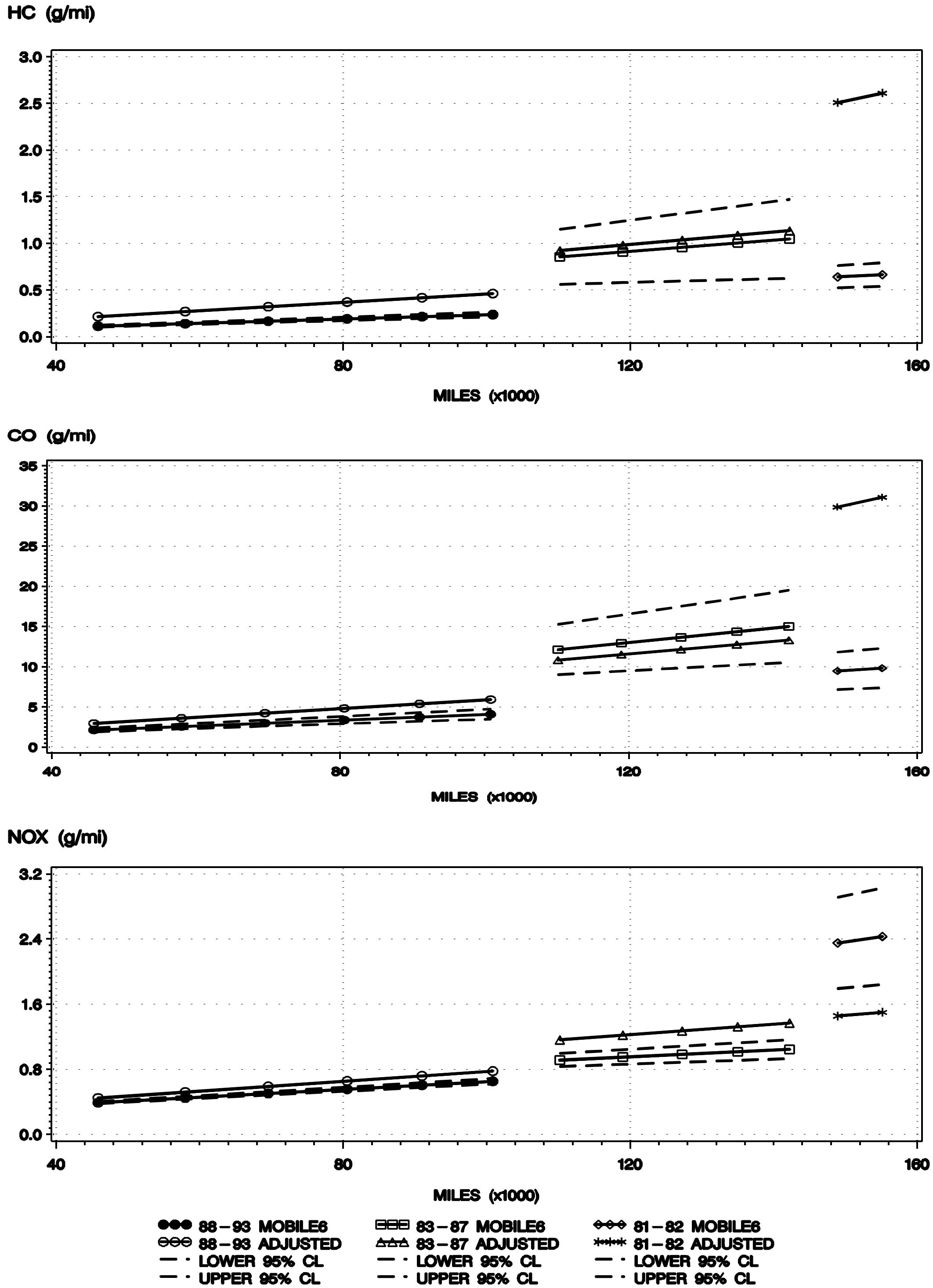

Figure 2: RUNNING LA4: FTP-BASED MOBILE6 and OHIO IM240 ADJUSTMENTS
1981-88 CARBURETED CARS

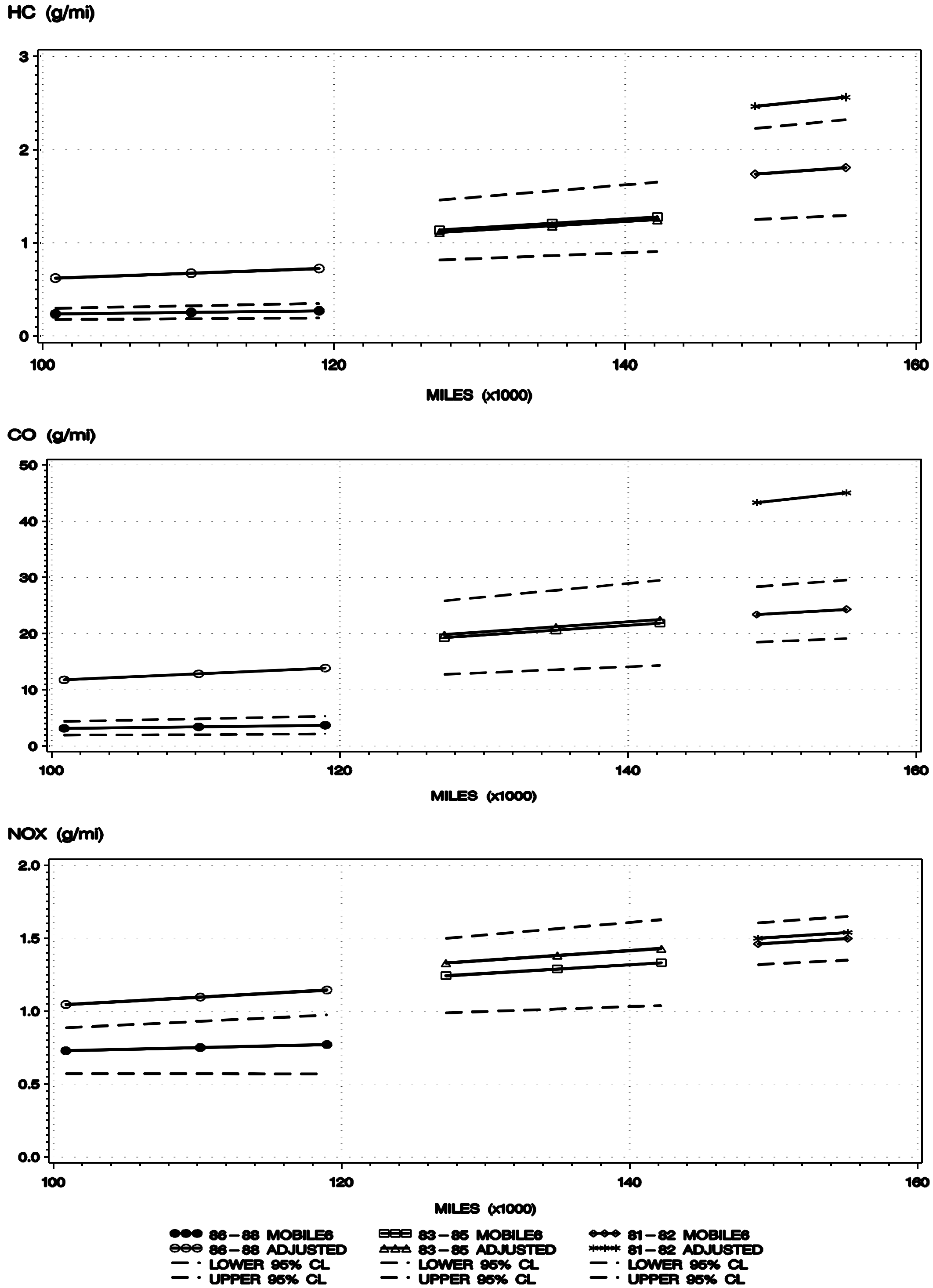

Figure 3: FTP-BASED MOBILE6 PROJECTIONS and OHIO IM240 ADJUSTMENTS
RUNNING LA4, 1988-93 PFI CARS

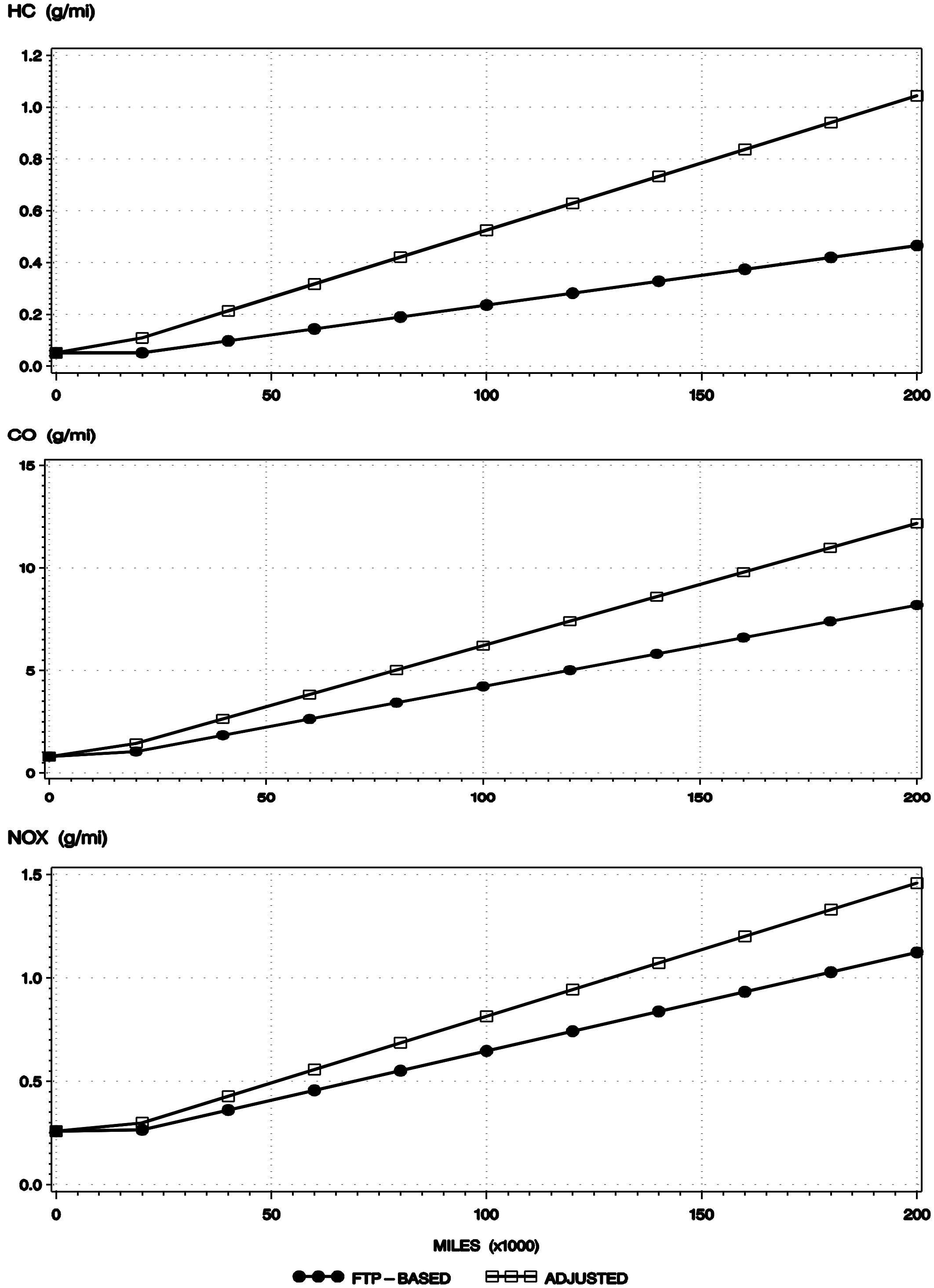

Figure 4: FTP-BASED MOBILE6 PROJECTIONS and OHIO IM240 ADJUSTMENTS
RUNNING LA4, 1988-93 TBI CARS

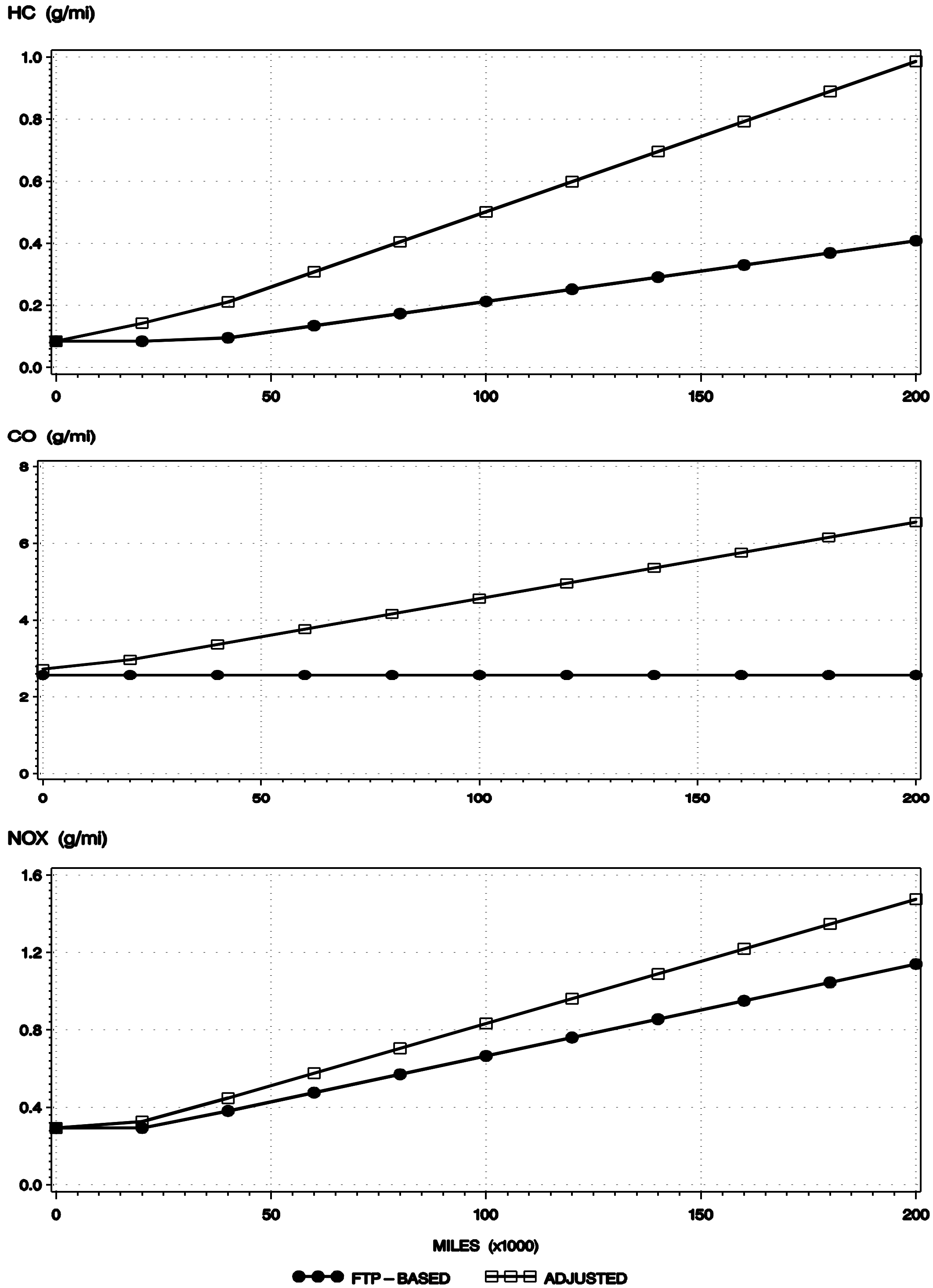

Figure 5: FTP-BASED MOBILE6 PROJECTIONS and OHIO IM240 ADJUSTMENTS
RUNNING LA4, 1986-93 CARB CARS

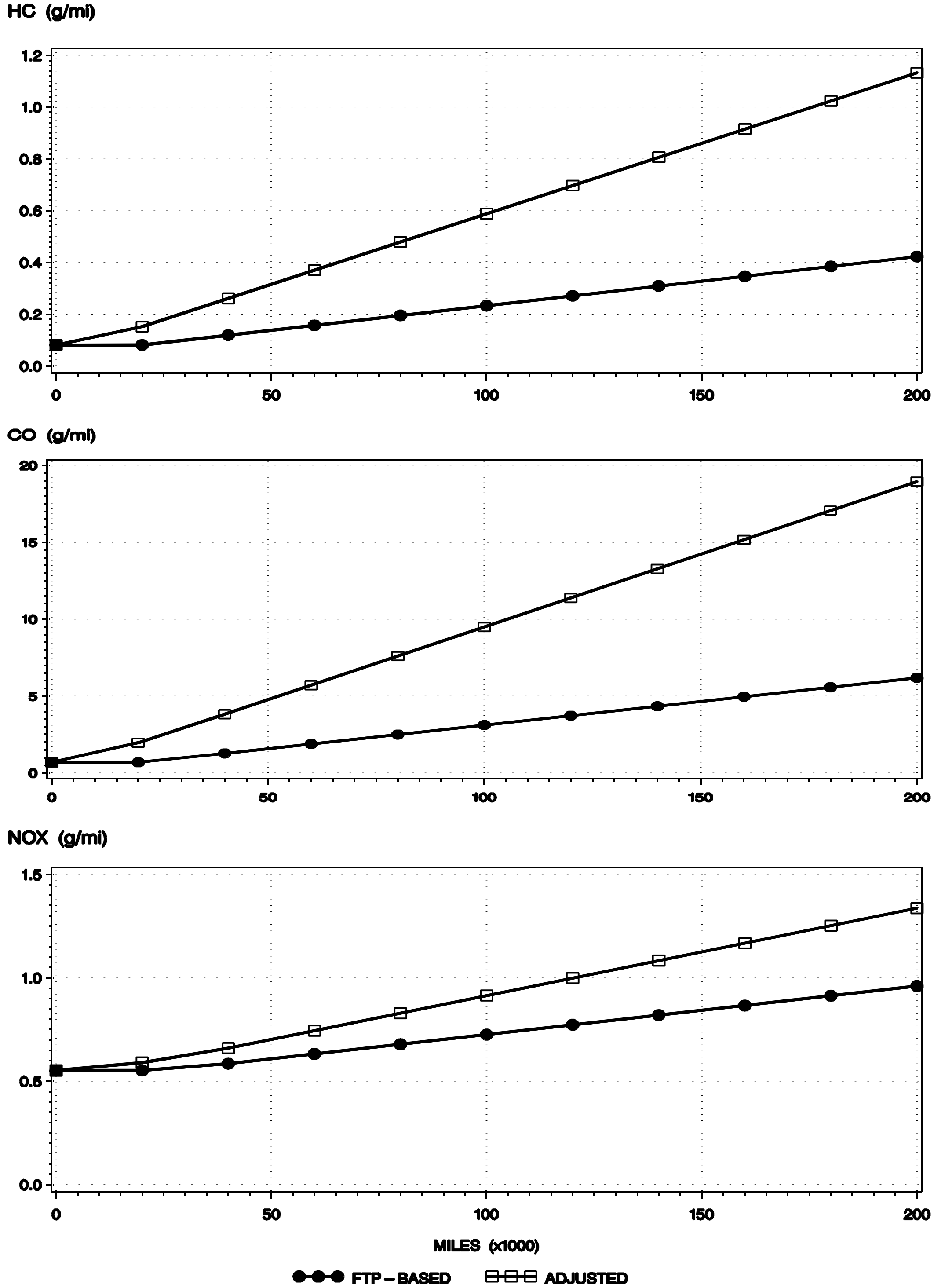

Figure 6: FTP-BASED MOBILE6 PROJECTIONS and OHIO IM240 ADJUSTMENTS
RUNNING LA4, 1983-87 FI CARS

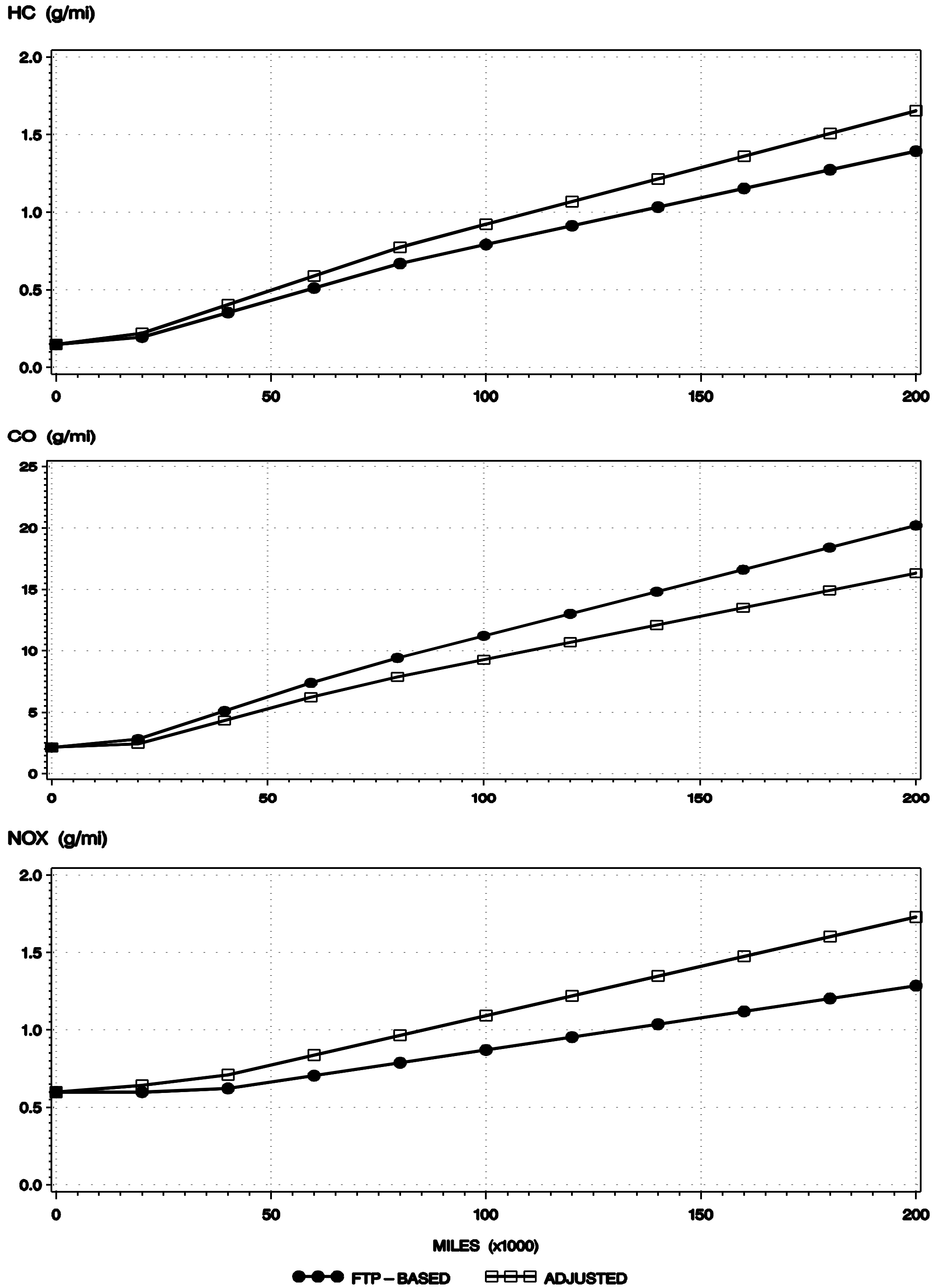

Figure 7: FTP-BASED MOBILE6 PROJECTIONS and OHIO IM240 ADJUSTMENTS
RUNNING LA4, 1983-85 CARB CARS

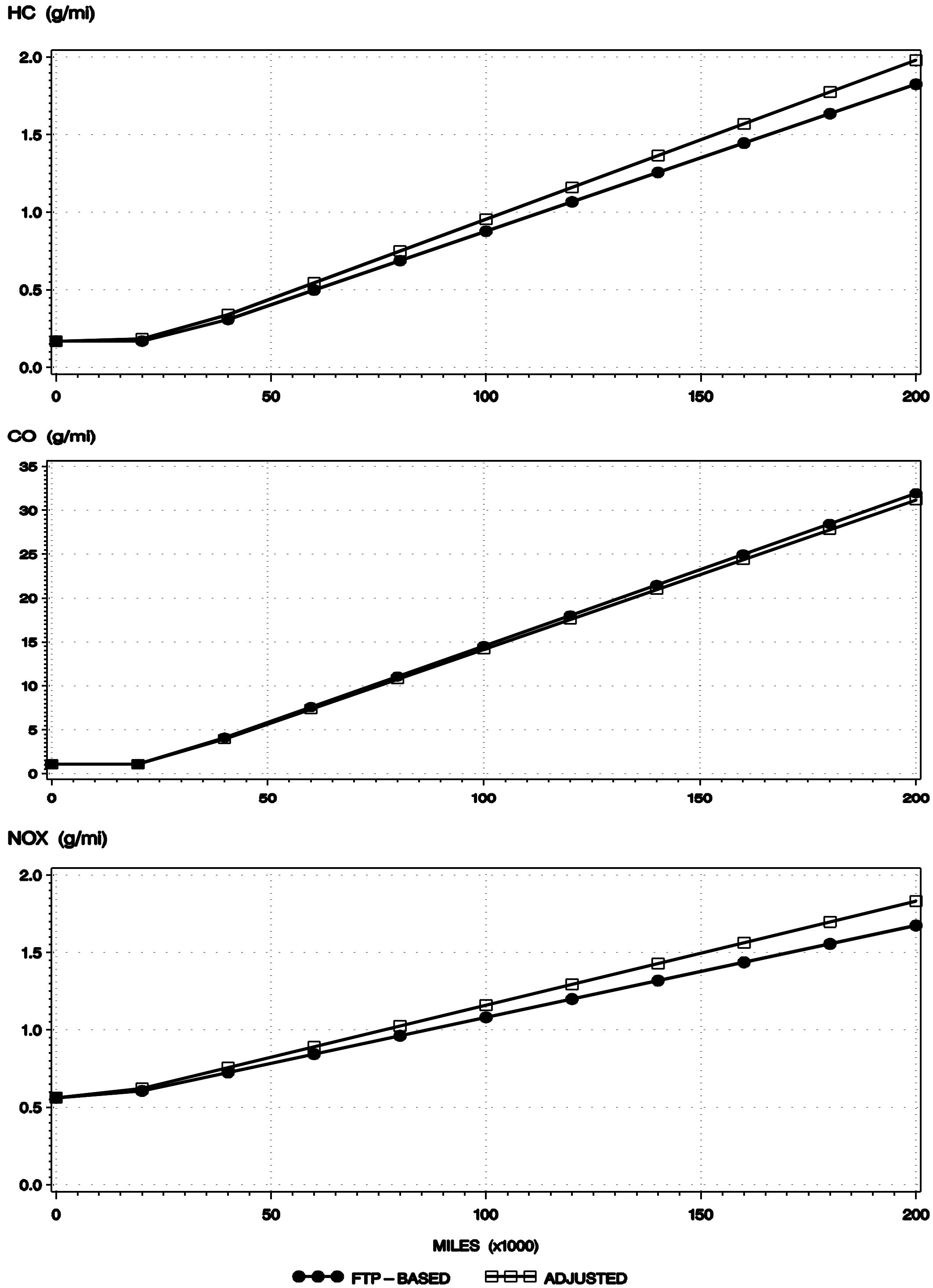

**Figure 8: FTP-BASED MOBILE6 PROJECTIONS and OHIO IM240 ADJUSTMENTS
RUNNING LA4, 1981-82 FI CARS**

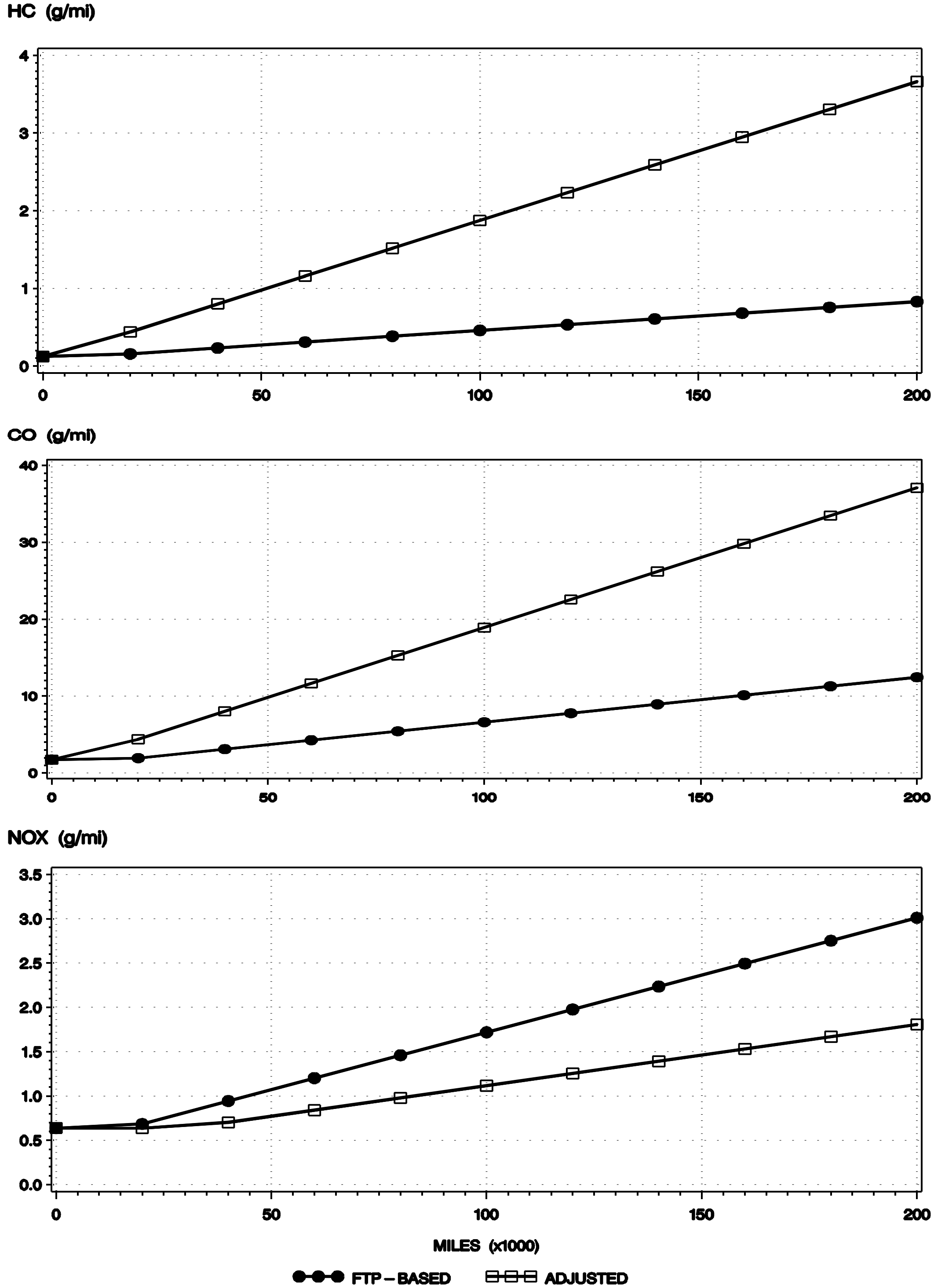

Figure 9: FTP-BASED MOBILE6 PROJECTIONS and OHIO IM240 ADJUSTMENTS
RUNNING LA4, 1981-82 CARB CARS

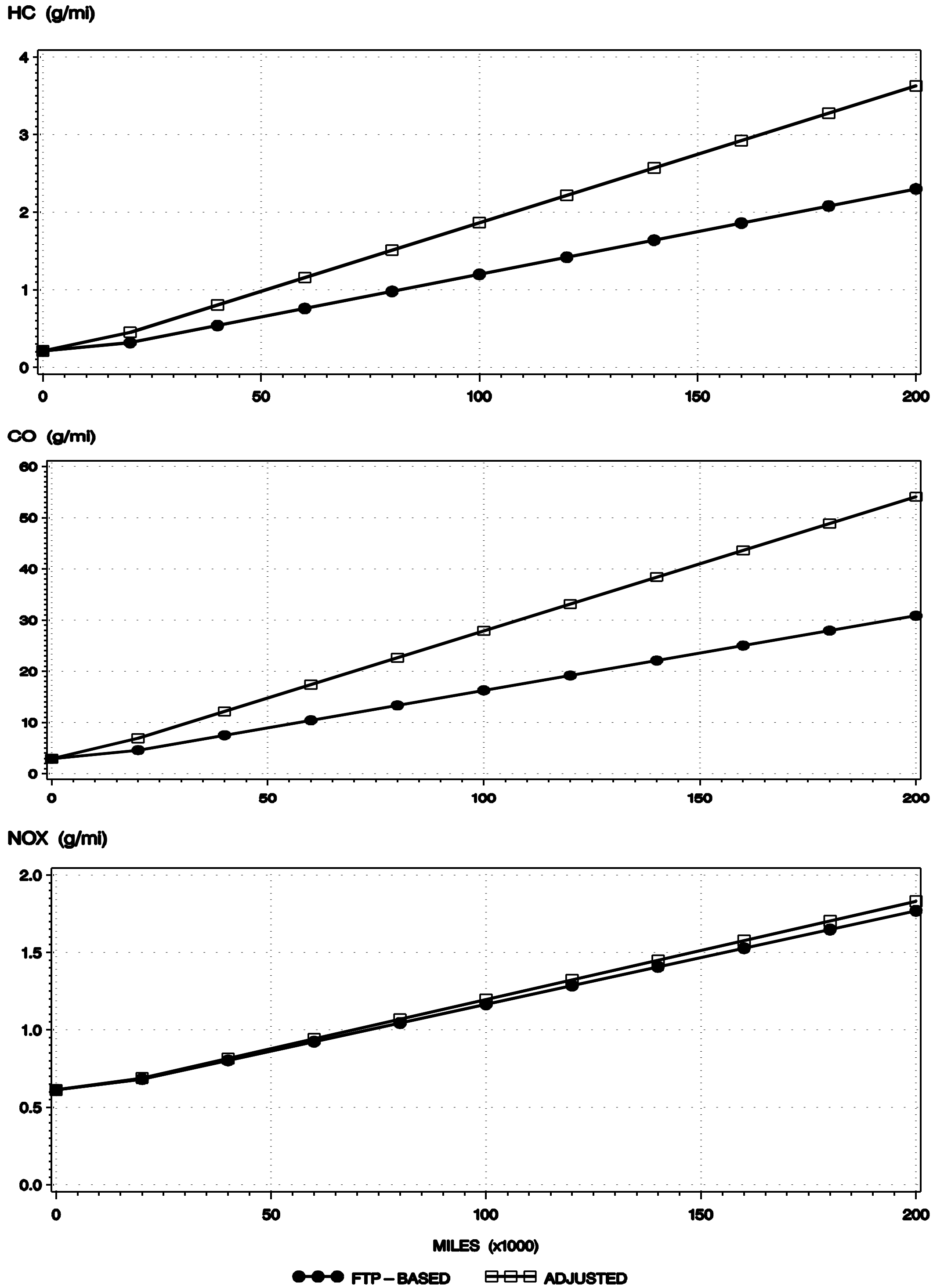

Table 1
Distribution of Vehicles by Model Year and Technology for the Combined FTP Dataset

	CARS					TRUCKS					
	TECHNOLOGY				SUB	TECHNOLOGY				SUB	
	CARB	OPLP	PFI	TBI	TOTAL	CARB	OPLP	PFI	TBI	TOTAL	TOTAL
81	657	367	29	15	1,068	.	124	.	.	124	1,192
82	71	71	8	74	224	.	45	.	.	45	269
83	57	63	62	127	309	3	8	.	.	11	320
84	30	5	35	46	116	22	26	1	.	49	165
85	74	24	66	56	220	30	33	6	13	82	302
86	34	7	92	60	193	9	14	41	23	87	280
87	17	1	106	76	200	.	.	4	6	10	210
88	15	.	113	69	197	.	.	.	.	.	197
89	22	.	103	38	163	.	.	.	.	.	163
90	.	.	250	160	410	.	.	1	144	145	555
91	.	.	426	91	517	.	.	144	141	285	802
92	.	.	347	57	404	.	.	92	92	184	588
93	.	.	366	29	395	.	.	93	90	183	578

TOTAL	977	538	2,003	898	4,416	64	250	382	509	1,205	5,621

Table 2
Mean Running LA4 and FTP Emission Levels by Model Year for Light-Duty Cars and Trucks for the Combined FTP Dataset

	CARS						TRUCKS					
MYR	HC_RUN	HCFTP	CO_RUN	COFTP	NOX_RUN	NOFTP	HC_RUN	HCFTP	CO_RUN	COFTP	NOX_RUN	NOFTP
81	0.421	0.706	6.489	9.667	0.795	0.897	0.759	1.275	10.876	18.158	1.662	1.752
82	0.588	0.789	5.394	8.318	0.750	0.872	1.163	1.732	8.987	16.774	1.740	1.732
83	0.230	0.431	2.760	5.073	0.677	0.806	0.865	1.361	5.759	13.225	1.405	1.435
84	0.533	0.756	7.622	9.968	0.785	0.893	0.419	0.802	3.597	10.633	1.387	1.405
85	0.355	0.533	5.561	6.935	0.687	0.770	0.923	1.281	8.999	14.465	1.354	1.388

86	0.759	0.926	8.738	10.432	0.612	0.713	0.561	0.823	6.248	8.789	1.006	1.057
87	0.456	0.656	7.005	8.366	0.698	0.789	0.164	0.401	2.959	4.610	0.531	0.605
88	0.212	0.406	3.344	4.574	0.564	0.668	.	.	.	.	.	.
89	0.152	0.311	2.645	3.911	0.553	0.652	.	.	.	.	.	.
90	0.109	0.274	2.087	3.614	0.400	0.633	0.163	.	2.245	.	0.376	.
91	0.078	0.237	1.572	3.145	0.353	0.524	0.187	0.800	2.228	9.510	0.486	0.885
92	0.094	0.267	2.599	4.327	0.322	0.508	0.152	.	2.172	.	0.469	.
93	0.061	0.225	0.977	2.551	0.286	0.466	0.137	0.420	1.668	5.363	0.459	0.847

Table 3
Running Emission Deterioration Model Coefficients for HC (Unadjusted)

Light-Duty Cars

ModelYear/ Technology	ZML Mean Emissions (gr/m)	First Slope (gr/m/1000 m)	First Corner (1000 miles)	Second Slope (gr/m/1000 m)	Second Corner (1000 miles)	Third Slope (gr/m/1000 m)
88-93 PFI	0.0516	0.0000	20.03	0.0023	N/A	N/A
88-93 TBI	0.0843	0.0000	34.39	0.0020	N/A	N/A
83-87 FI	0.1479	0.0000	14.10	0.0079	81.38	0.0060
86-93 CARB	0.0815	0.0000	19.83	0.0019	N/A	N/A
83-85 CARB	0.1691	0.0000	25.24	0.0095	N/A	N/A
81-82 FI	0.1240	0.0000	11.29	0.0038	70.55	0.0037
81-82 CARB	0.2108	0.0000	10.18	0.0110	N/A	N/A

Light-Duty Trucks

88-93 PFI	0.0932	0.0000	23.40	0.0025	N/A	N/A
88-93 TBI	0.0783	0.0000	16.24	0.0043	55.16	0.0042
84-93 CARB	0.2495	0.0000	22.03	0.0136	N/A	N/A
81-87 FI	0.2927	0.0000	29.38	0.0136	N/A	N/A
81-83 CARB	0.6587	0.0000	15.99	0.0110	N/A	N/A

Note: The first slope is zero, since it is assumed that the ZML emission rate is constant from zero miles to the first corner. For the cases with a single corner, the second slope is determined from the unconstrained regression and the corner occurs at the mileage where that line intersects the ZML mean emissions. For the case with two corners, the second slope was obtained using a regression line constrained to pass through the ZML mean emissions-mileage. The third slope is for the unconstrained regression line and applies at mileages above the second corner. (Unadjusted refers to estimates obtained using the FTP dataset only.)

Table 3 (cont.)
Running Emission Deterioration Model Coefficients for CO (Unadjusted)

Light-Duty Cars

ModelYear/ Technology	ZML Mean Emissions (gr/m)	First Slope (gr/m/1000 m)	First Corner (1000 miles)	Second Slope (gr/m/1000 m)	Second Corner (1000 miles)	Third Slope (gr/m/1000 m)
88-93 PFI	0.7983	0.0000	13.78	0.0397	N/A	N/A
88-93 TBI	2.5684	0.0000	N/A	N/A	N/A	N/A
83-87 FI	2.1416	0.0000	14.10	0.1142	69.78	0.0898
86-93 CARB	0.6910	0.0000	21.13	0.0307	N/A	N/A
83-85 CARB	1.0983	0.0000	22.69	0.1739	N/A	N/A
81-82 FI	1.7270	0.0000	16.62	0.0585	N/A	N/A
81-82 CARB	2.9361	0.0000	8.79	0.1494	15.02	0.1459

Light-Duty Trucks

88-93 PFI	0.9017	0.0000	16.80	0.0357	58.68	0.0297
88-93 TBI	1.1439	0.0000	17.54	0.0491	N/A	N/A
84-93 CARB	1.5384	0.0000	19.30	0.1986	N/A	N/A
81-87 FI	5.2337	0.0000	55.03	0.0644	N/A	N/A
81-83 CARB	9.0704	0.0000	18.86	0.0635	N/A	N/A

Note: The first slope is zero, since it is assumed that the ZML emission rate is constant from zero miles to the first corner. For the cases with a single corner, the second slope is determined from the unconstrained regression and the corner occurs at the mileage where that line intersects the ZML mean emissions. For the case with two corners, the second slope was obtained using a regression line constrained to pass through the ZML mean emissions-mileage. The third slope is for the unconstrained regression line and applies at mileages above the second corner. (Unadjusted refers to estimates obtained using the FTP dataset only.)

Table 3 (cont.)
Running Emission Deterioration Model Coefficients for NOx (Unadjusted)

Light-Duty Cars

ModelYear/ Technology	ZML Mean Emissions (gr/m)	First Slope (gr/m/1000 m)	First Corner (1000 miles)	Second Slope (gr/m/1000 m)	Second Corner (1000 miles)	Third Slope (gr/m/1000 m)
88-93 PFI	0.2582	0.0000	18.58	0.0048	N/A	N/A
88-93 TBI	0.2931	0.0000	21.55	0.0047	N/A	N/A
83-87 FI	0.5976	0.0000	34.25	0.0042	N/A	N/A
86-93 CARB	0.5522	0.0000	26.12	0.0023	N/A	N/A
83-85 CARB	0.5614	0.0000	12.52	0.0059	N/A	N/A
81-82 FI	0.6370	0.0000	16.36	0.0129	N/A	N/A
81-82 CARB	0.6121	0.0000	8.79	0.0063	17.00	0.0060

Light-Duty Trucks

88-93 PFI	0.3782	0.0000	21.20	0.0044	N/A	N/A
88-93 TBI	0.3346	0.0000	16.24	0.0040	55.16	0.0032
84-93 CARB	1.3234	0.0000	22.20	0.0040	N/A	N/A
81-87 FI	0.5388	0.0000	21.43	0.0084	N/A	N/A
81-83 CARB	1.6660	0.0000	N/A	N/A	N/A	N/A

Note: The first slope is zero, since it is assumed that the ZML emission rate is constant from zero miles to the first corner. For the cases with a single corner, the second slope is determined from the unconstrained regression and the corner occurs at the mileage where that line intersects the ZML mean emissions. For the case with two corners, the second slope was obtained using a regression line constrained to pass through the ZML mean emissions-mileage. The third slope is for the unconstrained regression line and applies at mileages above the second corner. (Unadjusted refers to estimates obtained using the FTP dataset only.)

Table 4
High Emitter Adjusted Running Emission Deterioration
Model Coefficients for HC

Light-Duty Cars

ModelYear/ Technology	ZML Mean Emissions (gr/m)	First Slope (gr/m/1000 m)	First Corner (1000 miles)	Second Slope (gr/m/1000 m)	Second Corner (1000 miles)	Third Slope (gr/m/1000 m)	Adjustment Additive (gr/m/1000m)
88-93 PFI	0.0516	0.0013	20.03	0.0036	N/A	N/A	0.0013
88-93 TBI	0.0843	0.0013	34.39	0.0033	N/A	N/A	0.0013
83-87 FI	0.1479	0.0000	18.89	0.0078	81.38	0.0059	-0.0001
86-93 CARB	0.0815	0.0039	19.83	0.0058	N/A	N/A	0.0039
83-85 CARB	0.1691	0.0003	25.24	0.0098	N/A	N/A	0.0003
81-82 FI	0.1240	0.0094	11.29	0.0132	70.55	0.0131	0.0094
81-82 CARB	0.2108	0.0048	10.18	0.0158	N/A	N/A	0.0048

Light-Duty Trucks

88-93 PFI	0.0932	0.0013	23.40	0.0038	N/A	N/A	0.0013
88-93 TBI	0.0783	0.0013	16.24	0.0056	55.16	0.0055	0.0013
84-93 CARB	0.2495	0.0000	36.01	0.0083	N/A	N/A	-0.0053
81-87 FI	0.2927	0.0000	40.58	0.0099	N/A	N/A	-0.0038
81-83 CARB	0.6587	0.0018	15.99	0.0127	N/A	N/A	0.0018

Note: Adjusted refers to estimates obtained using the high emitter correction factors. To obtain the adjusted values, the additive adjustments given in this table were applied to the unadjusted slopes in Table 3. Slope values of zero were assigned in cases where the additive adjustments would have resulted in negative deterioration.

Table 4 (cont.)
High Emitter Adjusted Running Emission Deterioration
Model Coefficients for CO

Light-Duty Cars

ModelYear/ Technology	ZML Mean Emissions (gr/m)	First Slope (gr/m/1000 m)	First Corner (1000 miles)	Second Slope (gr/m/1000 m)	Second Corner (1000 miles)	Third Slope (gr/m/1000 m)	Adjustment Additive (gr/m/1000m)
88-93 PFI	0.7983	0.0310	13.78	0.0707	N/A	N/A	0.0310
88-93 TBI	2.5684	0.0310	N/A	N/A	N/A	N/A	0.0310
83-87 FI	2.1416	0.0000	19.04	0.1091	69.78	0.0846	-0.0051
86-93 CARB	0.6910	0.0727	21.13	0.1034	N/A	N/A	0.0727
83-85 CARB	1.0983	0.0000	25.68	0.1537	N/A	N/A	-0.0203
81-82 FI	1.7270	0.1817	16.62	0.2401	N/A	N/A	0.1817
81-82 CARB	2.9361	0.1414	8.79	0.2908	15.02	0.2873	0.1414

Light-Duty Trucks

88-93 PFI	0.9017	0.0326	16.80	0.0683	58.68	0.0623	0.0326
88-93 TBI	1.1439	0.0326	17.54	0.0817	N/A	N/A	0.0326
84-93 CARB	1.5384	0.0000	28.90	0.1327	N/A	N/A	-0.0660
81-87 FI	5.2337	0.0545	55.03	0.1190	N/A	N/A	0.0545
81-83 CARB	9.0704	0.1040	18.86	0.1675	N/A	N/A	0.1040

Note: Adjusted refers to estimates obtained using the high emitter correction factors. To obtain the adjusted values, the additive adjustments given in this table were applied to the unadjusted slopes in Table 3. Slope values of zero were assigned in cases where the additive adjustments would have resulted in negative deterioration.

Table 4 (cont.)
High Emitter Adjusted Running Emission Deterioration
Model Coefficients for NOx

Light-Duty Cars

ModelYear/ Technology	ZML Mean Emissions (gr/m)	First Slope (gr/m/1000 m)	First Corner (1000 miles)	Second Slope (gr/m/1000 m)	Second Corner (1000 miles)	Third Slope (gr/m/1000 m)	Adjustment Additive (gr/m/1000m)
88-93 PFI	0.2582	0.0010	18.58	0.0058	N/A	N/A	0.0010
88-93 TBI	0.2931	0.0010	21.55	0.0058	N/A	N/A	0.0010
83-87 FI	0.5976	0.0023	34.25	0.0064	N/A	N/A	0.0023
86-93 CARB	0.5522	0.0021	26.12	0.0045	N/A	N/A	0.0021
83-85 CARB	0.5614	0.0003	12.52	0.0062	N/A	N/A	0.0003
81-82 FI	0.6370	0.0000	30.66	0.0069	N/A	N/A	-0.0060
81-82 CARB	0.6121	0.0003	8.79	0.0066	17.00	0.0063	0.0003

Light-Duty Trucks

88-93 PFI	0.3782	0.0002	21.20	0.0046	N/A	N/A	0.0002
88-93 TBI	0.3346	0.0002	16.24	0.0042	55.16	0.0034	0.0002
84-93 CARB	1.3234	0.0000	1754.24	0.0001	N/A	N/A	-0.0040
81-87 FI	0.5388	0.0000	32.21	0.0056	N/A	N/A	-0.0028
81-83 CARB	1.6660	0.0008	N/A	N/A	N/A	N/A	0.0008

Note: Adjusted refers to estimates obtained using the high emitter correction factors. To obtain the adjusted values, the additive adjustments given in this table were applied to the unadjusted slopes in Table 3. Slope values of zero were assigned in cases where the additive adjustments would have resulted in negative deterioration.