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Technical Report

MOBILE4
Exhaust Emission Factors and Inspection/Maintenance Benefits for Passenger Cars

By

Edward L. Glover
David J. Brzezinski

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NOTICE

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Technical Support Staff
Emission Control Technology Division
Office of Mobile Sources
Office of Air and Radiation
U. S. Environmental Protection Agency

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1.0 INTRODUCTION

The MOBILE4 Tech IV Credit Model is used to estimate the emission factor equations, the effects of Inspection and Maintenance (I/M) programs, and the bag fraction equations for 1981 and later passenger cars. The model's results are then stored in the EPA MOBILE4 emission factor model. This report describes the development, use, and results of the Tech IV model. It also documents the normalized bag fractions, high altitude emission factors, biennial I/M credits, and idle emission I/M credits used in MOBILE4.

MOBILE3, EPA's previous emission factor model, used a similar modeling approach. Details on this model can be found in the report "Tech IV Credit Model : Estimates for Emission Factors and Inspection and Maintenance Credits for 1981 and Later Vehicles for MOBILE3" (EPA-AA-IMG-85-6).

The technology used to meet the stringent emission standards beginning with the 1981 model year is continually being improved. For instance, many manufacturers have utilized closed-loop control since 1981; others, however, did not adopt it product-wide until more recently. Fuel injection use has also grown dramatically in the past few years. It has increased from 8.5% of fleet sales in 1981, to 81.1% in 1988, and is projected to comprise 95.7% of the 1992 model year.

In the Tech IV Model, the fleet is separated into three technology groups. They are open loop vehicles (OL) - including both carbureted and fuel injected vehicles, closed-loop carbureted vehicles (CARB), and closed-loop fuel injected vehicles (FI). The data were separated into the three technology groups for several reasons. The open and closed-loop vehicles were separated because of large differences in emission levels. Also, the open and closed-loop systems are technically very different. They generally utilize completely different principles to control emissions and engine functions and when they fail it is frequently in a different manner. Repairing vehicles of these two technologies often requires different diagnostic procedures, tools, replacement parts, and expertise. The closed-loop vehicles were further divided into carbureted and fuel injected types. Overall, the emissions of these technologies did not differ greatly. However, they are technically quite different in their operation, failure mode, adjustment, and repairability. Also, the fuel injected technology is the more important one in terms of future emissions predictions, since it is rapidly dominating the market and will continue to do so in the future.

The MOBILE4 Tech IV Credit Model predicts the emission levels of each distinct technology separately and then combines the results based on the fraction of the vehicle fleet which uses each technology in each model year group.

The sample of passenger cars is also separated into two model year groups. These two groups are the 1981 and 1982 model year cars and the 1983 and later model year cars. The differences in these groups are largely the result of CO waivers granted to most 1981 and 1982 cars and the gradual improvement of closed-loop technology throughout the 1980's.

The MOBILE3 version of the Tech IV Credit Model divided the sample into three emission level categories. For the MOBILE4 Tech IV Credit Model these categories have been modified and expanded to include a fourth category. They are 1) passing FTP, 2) marginal emitters, 3) high emitters, and 4) super emitters.

The general approach of the MOBILE4 Tech IV Model is to obtain statistical information about the emission levels of each category by emission standard and technology and to predict the emission levels of that category at any specified age measured by mileage. All categories are then weighted together based on their predicted size in each model year group.

The emission reduction credits allowed inspection and maintenance (I/M) programs for inspection of 1981 and newer passenger cars are also estimated using the Tech IV model. Successful inspection and maintenance programs, as their name implies, are the result of two factors: identification of high emitting vehicles through failure of an emissions test, and proper repair of these vehicles. Data on both of these aspects of I/M have been collected, analyzed by EPA, and included in the model.

2.0 EMISSION FACTORS

2.1 Fleet Description

2.1.1 EPA Emission Factors Surveillance Database

The database was created from data collected in EPA's in-use emission factor surveillance program. The cars in this program were randomly recruited and thoroughly emission tested. The data from these vehicles were used to calculate the emission factors, the percent of excess emissions identified by the I/M tests, and the bag fractions. This database consists of 1,697 light-duty vehicles with model years 1981 through 1986. It contains 659 1981 and 1982 vehicles certified to the 7.0 gram CO standard. These vehicles were included because they were so numerous; however, their use was restricted to modeling only the 1981 and 1982 model years.

All the vehicles in the sample were examined for emissions systems tampering. However, not all forms of tampering yield significant exhaust emissions increases. Tampering of the air pump system, catalyst removal, misfueling of catalyst equipped cars with leaded gasoline, and EGR system disablements were considered reasons for removal from the database. There were 89 vehicles identified with such tampering in the EPA surveillance database. All of them were removed. Table 2-1b provides a distribution and shows the average excess emissions due to tampering among tampering types and model years for the vehicles which were removed.

MOBILE4 adjusts the emission levels predicted by the Tech IV Credit Model to reflect the emission impact of tampering separately. The emission values which are part of this calculation are displayed in the row entitled MOBILE4 (See footnote at the bottom of Table 2-1b).

Three major technology divisions were used for modeling the emissions of passenger cars. These were:

- o Closed-loop carbureted (CARB)
- o Closed-loop fuel-injected (FI)
  (both MFI and TBI)
- o Open-loop carbureted and fuel-injected (OL)

Table 2-1a shows the distribution of the database, excluding tampered vehicles, by model year, technology, and CO certification standard.

Table 2-1a

Distribution by Technology and Model Year

Model Year	Closed Loop				Open Loop		All
	Carbureted		FI				
	3.4	7.0	3.4	7.0	3.4	7.0	
1981	253	344	33	8	196	145	979
1982	7	60	13	64	17	38	199
1983	57	-	168	-	47	-	272
1984	0	-	64	-	0	-	64
1985	68	-	52	-	16	-	136
1986	25	-	22	-	0	-	47
TOTAL	410	404	352	72	276	183	1697

Table 2-1b
Distribution and Average Emissions
of Tampered Vehicles by Model Year

	Air Pump Tampering			
Model Year	N	HC	CO	NOx
1981	19	1.28	30.72	0.33
1982	8	2.35	29.72	0.34
1983	0	-	-	-
1984*	0	-	-	-
1985	0	-	-	-
1986	1	0.00	0.00	0.00
All	28	1.61	30.47	0.34
MOBILE4**	-	1.55	30.13	-

	Fuel Inlet Tampering			
Model Year	N	HC	CO	NOx
1981	52	0.33	4.25	0.34
1982	3	0.05	1.55	0.23
1983	2	0.00	0.06	0.00
1984	1	0.00	0.00	0.00
1985	1	0.00	0.00	0.00
1986	0	-	-	-
All	59	0.32	3.92	0.34
MOBILE4**	-	2.14	15.68	1.55

	Catalyst Tampering			
Model Year	N	HC	CO	NOx
1981	1	6.45	172.6	0.00
1982	1	3.23	19.7	1.35
1983	0	-	-	-
1984	0	-	-	-
1985	0	-	-	-
1986	0	-	-	-
All	2	4.84	96.1	1.35
MOBILE4**	-	2.74	22.8	1.55

* The small number of tampered vehicles in later model years reflects the EPA policy of generally rejecting tampered vehicles from the in-use testing program.

** The MOBILE4 numbers are the basic 50,000 mile emission rates for 1981 vehicles from Table 2-14 of this report plus the excess added by MOBILE4 per tampered vehicle for a given tampering type. This provides a point of comparison to the test data on the tampered vehicles which were removed from the analysis. The final MOBILE4 number for all the vehicles in a model year is the product of the tampering excess and the tampering rate plus the basic emission rate.

2.1.2 Technology Distribution Projections

Most information about the mix of the technologies was taken directly from actual sales data provided by the manufacturers. For model years not yet produced, and for recent model years where sales information is not yet available, projections of the future technology mix were needed. All estimates for 1987 and later model years were based on 1986 model year actual CAFE sales data, modified by sales fraction projections provided by most of the major manufacturers. CAFE sales projections (General Label) were generally not used, except for some engine families introduced after the 1986 model year.

Some general rules for estimating the technology distribution were used:

- The 1988 model year distribution is estimated using the actual total 1986 sales for those carbureted engines still available in 1988. New carbureted engines for 1988 assume the sales projected by the manufacturer for that engine in 1988.

- All carbureted engines remaining in 1988 which are not the largest or the smallest engine offered by a manufacturer are assumed to convert to fuel injection by the 1992 model year.

- Engines with both carbureted and fuel injected versions are assumed to convert sooner than engines that are strictly carbureted. Engines with larger fuel injected version sales than carbureted sales estimated for 1988, are assumed to drop the carbureted version for the 1990 model year. Others discontinue the carbureted version for the 1991 model year.

- Manufacturer market share is assumed to remain fixed at 1986 model year levels.

- Engine sales in each size are assumed to remain fixed at 1986 model year levels.

- None of the carbureted engines that were available in 1988 are assumed to be completely converted to fuel injected before the 1990 model year. However, carbureted sales are assumed to drop linearly between 1988 and 1990.

- The projected 1992 distribution is assumed to continue indefinitely.

The technology projections used in calculating the weighted emission values are given in Table 2-2 below.

Table 2-2

Passenger Car (LDGV) MOBILE4
Technology Distribution by Model Year

Model Year	Technology Group: Closed-Loop CLS Fuel Injected	Technology Group: Closed-Loop CLS Carbureted	Technology Group: Open Loop
1981	0.084	0.635	0.281
1982	0.171	0.499	0.330
1983	0.303	0.456	0.241
1984	0.485	0.460	0.055
1985	0.545	0.393	0.062
1986	0.670	0.260	0.070
1987	0.747	0.239	0.014
1988	0.811	0.189	0.000
1989	0.837	0.163	0.000
1990	0.863	0.137	0.000
1991	0.916	0.084	0.000
1992	0.957	0.043	0.000

For exhaust emissions, TBI and PFI were not distinguished since no large differences in performance were noted in the data. The evaporative emissions portion and the temperature correction factor portion of MOBILE4 do distinguish TBI and PFI. Documentation for the non-exhaust portions of MOBILE4 will be provided elsewhere.

2.2 Emission Level Groupings

2.2.1 Description of Passing Emitters

A Passing emitter is defined as a vehicle which passes the FTP Certification standards for both HC and CO. The NOx emission value is not used in determining an emitter type. It is assumed instead that all vehicles comprise one NOx emitter category. For programming convenience these were referred to as "Passing" NOx emitters, although they may exceed the FTP standard for NOx. Also, I/M programs are assumed not to affect NOx emissions directly; therefore, no NOx I/M credits are produced. However, I/M programs help deter tampering which reduces NOx emissions slightly.

The emission levels and mileages of the Passing emitters in the surveillance database are shown below in Table 2-3 stratified by technology and model year. On average these vehicles are approximately 40% below their FTP standards for HC and the 1983 and later vehicles are approximately 30% below the

FTP CO standard. The passing vehicles make up about 46% of the surveillance database sample. The data indicate that for FTP passing vehicles there is very little emissions difference between technologies.

Table 2-3

Description of the Passing Emitters

Carbureted Vehicles

Model Year	Sample	HC	CO	NOx	Mile
1981	259	0.267	2.978	0.801	19,691
1982	54	0.256	2.859	0.729	6,695
1983	32	0.236	1.894	0.796	18,029
1984	0	-	-	-	-
1985	43	0.233	1.914	0.751	30,979
1986	20	0.227	1.838	0.678	23,221
ALL	408	0.258	2.709	0.780	19,203

Fuel Injected Vehicles

Model Year	Sample	HC	CO	NOx	Mile
1981	20	0.272	2.344	0.799	24,310
1982	47	0.257	3.376	0.679	31,417
1983	74	0.239	2.389	0.623	27,853
1984	21	0.245	2.347	0.788	17,933
1985	20	0.234	2.650	0.665	35,728
1986	16	0.263	2.059	0.608	30,706
ALL	198	0.249	2.614	0.675	28,315

Open Loop Vehicles

Model Year	Sample	HC	CO	NOx	Mile
1981	121	0.290	2.671	0.769	24,269
1982	37	0.265	2.827	0.748	3,017
1983	12	0.257	2.749	0.665	23,819
1984	0	-	-	-	-
1985	2	0.335	2.260	0.680	21,380
1986	0	-	-	-	-
ALL	172	0.283	2.705	0.756	19,632

When the fleet is at zero mileage, the model assumes most vehicles are Passing emitters (Further details are provided below). As the vehicles of a given model year accumulate mileage, the number of Passing emitters decreases and the number of other types of emitters grows. The decrease in the number of Passing emitters with increased mileage is the result of the increased number of failed emission control components. In addition, the emissions of Passing emitters are assumed to have a gradual deterioration due to normal use. This deterioration is calculated by regressing the emissions of the Passing emitters versus mileage. The deterioration and zero mile level are shown in Table 2-4 for each technology and model year group.

Since there were only 14, 1983 and newer open-loop vehicles in the sample, the deterioration rate of the 1981 and 1982 open-loop vehicles was assumed for the 1983 and newer vehicles as well. The zero-mile and deterioration rates for the other 1983+ technologies are based only on 1983 and later model year vehicles.

Table 2-4

Emission Levels of the Vehicles Passing FTP

MYR Group	Technology	N	Zero-Mile HC	Zero-Mile CO	Deterioration per 10k miles HC	Deterioration per 10k miles CO
1981-82	Carbureted	313	0.244	2.686	0.0122	0.156
1981-82	Fuel Injected	67	0.229	2.368	0.0111	0.239
1981-82	Open Loop	158	0.260	2.465	0.0124	0.126
1983+	Carbureted	95	0.192	1.619	0.0162	0.109
1983+	Fuel Injected	131	0.232	2.176	0.0039	0.078
1983+	Open Loop	14	0.240	2.385	0.0124	0.126

2.2.2 Description of Marginal Emitters

The Marginal emitter category is new for MOBILE4. It was added to better model the emission behavior of vehicles whose emissions are not enough to make them High emitters, yet which do not pass the FTP certification standards for one or both pollutants. Unlike the passing vehicles, most of these vehicles have some minor engine or emission control system problems which cause them to exceed FTP standards. It was also desirable to separate these vehicles in modeling the I/M benefits. Their behavior toward testing and repair is often quite different than that of the High emitters.

For consistency, the Marginal emitters were split into the same technology groups and model year groups as the Passing emitters. The three technology groups were all open loop, closed loop carbureted, and closed loop fuel injected. The model year groups were 1981-82 and 1983 and later.

The EPA surveillance database contains 735 Marginal emitting vehicles. This corresponds to 43% of the sample. On average these vehicles exceed HC FTP standards by about 20% However, the average fuel injected marginal vehicle did not exceed the HC FTP standards, indicating that many of these vehicles are CO-only failures. It also demonstrates that on average, Marginal fuel injected vehicles emit less than carbureted. The average 1983 and later Marginal emitting vehicle in the sample exceeded its CO FTP standard by approximately 40%.

The corresponding emission levels for the Marginal emitters in the surveillance database are shown in Table 2-5.

Emissions data from the Marginal vehicles are used to create three input parameters to the MOBILE4 Tech IV Model. These are the deterioration in the emission level, the initial emission level, and the growth rate of the Marginal emitter category. The first two parameters are obtained from a linear least squares regression of the HC and CO emissions data of the Marginal vehicles. The zero-mile intercept is used as the initial emissions level and the slope of the regression represents the gradual deterioration that a Marginal emitting vehicle would undergo with normal use and maintenance. These parameters are shown in Table 2-6 by technology and model year group.

The growth rate of the Marginal emitter category is the rate at which Passing vehicles turn into Marginals, or the rate at which vehicles become FTP failures. These parameters were developed by coding all marginal emitting vehicles which passed as a zero and all failing vehicles as a one. The coded data of ones and zeroes were then divided by technology and model year group and regressed versus mileage using least squares. The FTP failure rate regression parameters which were obtained are displayed in Table 2-7 for each technology and model year group.

2.2.3 Description of High Emitters

For MOBILE4, High emitters are defined in a statistical manner. The sample was first separated into the same technology and model year groups as the Passing and Marginal vehicles. For each of these groups, the logarithmic distribution of the emissions was computed. A High emitter was

Table 2-5

Description of the Marginal Emitters

Carbureted Vehicles

Model Year	Sample	HC	CO	NOx	Mile
1981	255	0.565	6.832	1.010	43,398
1982	9	0.767	9.193	0.914	76,829
1983	19	0.552	4.996	1.142	37,720
1984	0	-	-	-	-
1985	18	0.329	4.934	0.852	32,752
1986	5	0.238	5.038	0.434	25,989
ALL	306	0.551	6.646	0.997	43,118

Fuel Injected Vehicles

Model Year	Sample	HC	CO	NOx	Mile
1981	16	0.482	5.821	1.375	42,255
1982	13	0.481	6.569	1.324	54,158
1983	79	0.352	4.823	0.729	34,255
1984	35	0.355	4.705	0.840	30,504
1985	29	0.420	4.181	0.738	36,429
1986	4	0.470	4.030	0.410	27,095
ALL	176	0.388	4.895	0.848	35,901

Open Loop Vehicles

Model Year	Sample	HC	CO	NOx	Mile
1981	190	0.525	7.336	0.795	41,640
1982	15	0.500	6.890	0.637	21,087
1983	35	0.398	4.881	0.652	24,190
1984	0	-	-	-	-
1985	13	0.522	5.952	0.615	33,891
1986	0	-	-	-	-
ALL	253	0.506	6.899	0.757	37,609

Table 2-6

Emission Levels of the Marginal Emitters

MYR Group	Technology	N	Zero-Mile HC	Zero-Mile CO	Deterioration per 10k miles HC	Deterioration per 10k miles CO
1981-82	Carbureted	264	0.533	5.358	0.0087	0.349
1981-82	Fuel Injected	29	0.428	5.333	0.0113	0.173
1981-82	Open Loop	205	0.468	6.818	0.0137	0.121
1983+	Carbureted	42	0.348	4.600	0.0207	0.109
1983+	Fuel Injected	147	0.367	4.361	0.0008	0.085
1983+	Open Loop	48	0.370	4.880	0.0230	0.108

Table 2-7

Rate of FTP Failures per 10,000 Miles

MYR Group	Technology	Zero-Mile	Growth	@50K
1981-82	Carbureted	0.2079	0.09537	0.685
1981-82	Fuel Injected	0.1056	0.07877	0.499
1981-82	Open Loop	0.3548	0.07322	0.721
1983+	Carbureted	0.0889	0.09479	0.563
1983+	Fuel Injected	0.3598	0.06729	0.696
1983+	Open Loop	0.7025	0.02835	0.844

judged to be any vehicle whose HC or CO emissions were more than two standard deviations from the log mean of the sample. Table 2-8 gives the actual HC and CO cutpoints, for each technology and group, that determine the lower boundary of the High emitter category. To prevent outliers from being classified as High emitters, an upper bound was established at 150 g/mile CO and 10 g/mile HC.

Table 2-8

Definition of a High Emitter

MYR Group	Technology	FTP (gm/mi) HC	FTP (gm/mi) CO
1981-82	Carbureted	1.175	17.411
1981-82	Fuel Injected	0.725	10.499
1981-82	Open Loop	1.112	21.638
1983+	Carbureted	0.815	10.398
1983+	Fuel Injected	0.965	10.558
1983+	Open Loop	0.837	10.139

Table 2-9 presents the zero-mile levels and deterioration rates of the High emitters. The emissions of the High emitters are assumed to deteriorate at the same rate as Marginal emitters of the same model year group and technology. The zero-mile level was calculated using the average emissions of the Highs and the deterioration rates of the Marginals for each technology and model year group. The method was to subtract from the average emission level of the Highs the product of the deterioration rate and the average mileage of those High emitters. The deterioration and zero-mile levels of the High emitters are shown in Table 2-9.

Table 2-9

Emission Levels of the High Emitters

MYR Group	Technology	N	Zero-Mile HC	Zero-Mile CO	Deterioration per 10k miles HC	Deterioration per 10k miles CO
1981-82	Carbureted	80	2.198	33.659	0.0087	0.349
1981-82	Fuel Injected	22	0.861	11.901	0.0113	0.173
1981-82	Open Loop	33	2.179	31.933	0.0137	0.121
1983+	Carbureted	13	0.954	13.197	0.0207	0.109
1983+	Fuel Injected	26	1.260	13.789	0.0008	0.085
1983+	Open Loop	2	2.123	32.014	0.0230	0.108

For the MOBILE4 Tech IV Model, data on High emitters are used to create two other parameters. These are the growth in the High emitter category at low mileage and the accelerated growth in the High emitters after 50,000 miles - the "kink." It is assumed that no High emitters exist at zero miles, but that vehicles start to become High emitters as soon as they are driven. The proportion of High emitters then increases for a given model year at a linear rate until it reaches 50,000 miles. After 50,000 miles, the rate of occurrence of High emitters increases. This increase might be due to such factors as loss of warranty coverage or generally poor maintenance given to used cars by second owners.

The increased rate in the number of High emitters for all technologies and model years was calculated using the following methodology.

1. The fraction of High emitters was found in the sample of vehicles which had less than 50,000 miles.

2. The average mileage of all the cars in the sample which had less than 50,000 was calculated. This sample was formed by combining both model year groups and the three technology groups. A more disaggregated approach would have been preferred, however, insufficient data above 50,000 miles for all the groups prevented it.

3. The rate of increase of High emitters per 10,000 miles was calculated by dividing the fraction of High emitters by the average mileage.

4. Using the rate developed in step 3 and assuming that at zero miles there were no Highs, the number of Highs at 50,000 miles was calculated.

5. The fraction of High emitters was found in the sample of vehicles which had more than 50,000 miles.

6. The average mileage of all the cars in the sample which had more than 50,000 miles was calculated.

7. The mileage beyond 50,000 miles was determined by subracting 50,000 from the average mileage.

8. The increase in High emitters was determined by subtracting the number of High emitters predicted at 50,000 miles (from Step 4) from the fraction of High emitters among vehicles with more than 50,000 miles.

9. The increase in High emitters was divided by the mileage beyond 50,000 to determine the rate of increase for High emitters after 50,000 miles.

10. The rate of increase after 50,000 miles was divided by the rate for vehicles before 50,000 miles to give the adjustment factor for the accelerated growth.

11. This is the "kink" and its calculated value is 3.1.

The growth in the number of High emitters up to 50,000 miles is shown for each technology and model year group in Table 2-10.

Table 2-10

Growth in the Number of
High Emitters per 10,000 Miles

MYR Group	Technology	Growth
1981-82	Carbureted	0.016257
1981-82	Fuel Injected	0.022202
1981-82	Open Loop	0.011799
1983+	Carbureted	0.023528
1983+	Fuel Injected	0.015340
1983+	Open Loop	0.008304

2.2.4 Description of Super Emitters

There are nine vehicles in the EPA surveillance database which exceed either 150 g/mile CO or 10 g/mile HC. The repair databases, as discussed in Section 3.3.1, provided an additional eight vehicles which met these critera. These vehicles are outliers and are classified as Super emitters. All seventeen vehicles had closed-loop systems. Thirteen of the vehicles were carbureted and four were fuel injected. A list of the seventeen vehicles, their emission levels, mileage, and a brief description are presented in Table 2-11. Since there were only four fuel injected vehicles, they were combined with the other thirteen carbureted Super emitters to determine the average emissions of a Super emitter.

Table 2-11

Description of the Super Emitters

Veh #	MYR	Make	Std	Fuel	Mileage	HC	CO	NOx
58*	1981	PONT	3.4	CARB	5,710	8.88	204.56	0.33
408*	1981	CHEV	7.0	CARB	25,440	24.86	134.62	0.23
462*	1981	PONT	7.0	CARB	30,740	10.55	254.87	0.24
5206*	1982	CHEV	7.0	CARB	80,050	58.31	302.21	0.57
5238*	1984	CHRY	3.4	TBI	30,340	7.66	154.50	0.31
6045*	1984	FORD	3.4	TBI	55,720	12.53	41.99	0.70
5045*	1982	OLDS	7.0	CARB	94,321	3.39	152.08	0.20
3139*	1981	MERC	3.4	CARB	50,740	12.24	178.88	0.94
109	1981	OLDS	3.4	CARB	29,266	10.30	179.85	0.73
272	1981	BUIC	3.4	CARB	70,147	7.11	152.36	2.74
274	1981	AUDI	3.4	MFI	27,574	5.39	207.52	0.19
305	1981	CHEV	7.0	CARB	115,833	6.27	165.64	0.43
329	1981	PONT	7.0	CARB	71,004	9.69	209.78	0.78
5144*	1981	BUIC	7.0	CARB	52,126	11.57	20.64	0.73
423	1984	CHRY	3.4	MFI	6,523	8.89	189.11	0.19
629	1982	PONT	7.0	CARB	67,522	28.50	58.28	1.23
1107	1984	PONT	3.4	CARB	44,424	16.49	312.55	0.73
ALL					50,440	14.27	171.73	0.66

* Indicates a vehicle from the Emission Factor Database.

Analysis of the Super emitters showed that the extremely high emissions result from failure of the closed-loop control system. A bad oxygen sensor or a malfunctioning electronic control unit can often be the problem.. Additionally, many Super emitters suffer from problems which vehicle tune-ups often address such as dirty air filters, worn plugs, bad distributor, etc.

Only one growth rate for all closed-loop technology vehicles was calculated for Super emitters. Only the surveillance database was used for determining the rate of occurrence of Super emitters. Therefore, only nine of the seventeen Super emitters identified in all sources are used. The first step in finding the growth rate of Super emitters was to calculate the fraction of Supers in the sample. The fraction was then divided by the average mileage of the sample to obtain the rate of occurrence of Super emitters per 10,000 miles.

The methodology assumes that no Super emitters exist at zero miles. Also, the rate of occurrence of Supers is assumed to increase linearly with mileage. Unlike the high emitters, the rate of increase is not assumed to change after 50,000 miles.

The calculation is:

$$\frac{\text{Number of Supers}}{\text{Number of Closed-loop Vehicles in the Sample}} \Big/ \text{Average Mileage of the Closed-loop Sample in 10K} = \text{Growth of Supers}$$

or:

$$(9 / 1238) / 3.3332 = 0.00218 = \text{Growth of Supers}$$

2.3 General Methodology

The estimates of the vehicle emissions are weighted sums of the separate emission contributions of Passing, Marginal, High, and Super emitters. The equation is in the form:

$$\begin{aligned} E(M) = {} & (1-W_m-W_h-W_s) * (ZM_p+DF_p*M) \\ & + W_m*(ZM_m + DF_m*M) + W_h*(ZM_h+DF_h*M) \\ & + W_s*ZM_s \end{aligned} \qquad (1)$$

A set of three estimates, in the form of equation (1), is generated. The three estimates represent the three technologies of carbureted, fuel injected, and open loop. They are then weighted together using the technology distribution fractions found in Table 2-2 to produce a weighted emission value (WEV).

Mathematically, the form is:

$WEV = \Sigma E_i(M)$ where i = technology type

For each model year, the weighted emission values are calculated for twenty different vehicle mileage points over the life of a vehicle. Each point is the average mileage that the in-use vehicle fleet, of that model year, has at a given age. Table 2-13 displays the twenty average mileage points, the vehicle miles traveled fraction (VMT), and the corresponding vehicle ages. The VMT fraction is the fraction of total travel which the vehicles of a given age perform in a year. For example, the vehicles which are two years old, on average, make up 12% of the total light-duty vehicle VMT.

Table 2-13

Age and Mileage Distribution

Age	Mileage	VMT Fraction	Age	Mileage	VMT Fraction
1	13,118	0.030	11	115,172	0.043
2	26,058	0.120	12	122,594	0.038
3	38,298	0.111	13	129,615	0.033
4	49,876	0.099	14	136,257	0.028
5	60,829	0.088	15	142,540	0.024
6	71,190	0.078	16	148,483	0.020
7	80,991	0.068	17	154,104	0.017
8	90,262	0.060	18	159,421	0.013
9	99,031	0.054	19	164,451	0.010
10	107,326	0.048	20	169,209	0.019
					1.000

For each model year, the twenty technology weighted emission values are regressed versus mileage to produce an emission factor. Since the data for HC and CO emission points are non-linear due to the "kink," two linear regressions are performed. The first regression is done on the data points which have mileages from zero to 50,000 miles. This produces the zero mile level and the first deterioration factor. The second regression is computed on the data points which have mileages greater than 50,000 miles. The deterioration of this regression becomes the second deterioration. The second regression is constrained to be equal at the 50,000 point of the first regression. Both regressions are weighted by the VMT fraction contribution of each age (see Table 2-13). This allows each emission point to be weighted by the amount of travel that actually happens at that age. The NOx weighted emission factors are calculated in a manner analogous to the HC and CO emission numbers. The difference is that the NOx regression is not split at 50,000 miles but has only a single deterioration factor for all mileages. This approach was used because there were no high NOx emitters.

2.4 Emission Factor Results

The final HC, CO, and NOx emission factors for light-duty vehicles are shown in Table 2-14. These numbers are used in the MOBILE4 computer model to predict the exhaust emissions of 1981 and later cars.

Table 2-14

MOBILE4 Exhaust Emission Factors

Model Year	HC (gm/mi) ZML	DET	DET2	50k	100k
1981	.308	.079	.108	0.70	1.24
1982	.305	.074	.101	0.68	1.18
1983	.257	.062	.085	0.57	0.99
1984	.242	.067	.088	0.58	1.01
1985	.254	.063	.084	0.57	0.99
1986	.265	.060	.081	0.56	0.97
1987	.264	.060	.081	0.56	0.97
1988	.267	.059	.080	0.56	0.96
1989	.269	.059	.079	0.56	0.96
1990	.271	.058	.078	0.56	0.95
1991	.275	.057	.077	0.56	0.95
1992+	.278	.056	.076	0.56	0.94

Model Year	CO (gm/mi) ZML	DET	DET2	50k	100k
1981	3.378	1.147	1.765	9.11	17.94
1982	3.376	1.079	1.616	8.77	16.85
1983	2.731	0.760	1.013	6.53	11.60
1984	2.431	0.840	1.052	6.63	11.89
1985	2.611	0.803	1.014	6.63	11.70
1986	2.764	0.771	0.982	6.62	11.53
1987	2.720	0.786	0.983	6.65	11.57
1988	2.757	0.780	0.973	6.66	11.52
1989	2.785	0.774	0.967	6.66	11.49
1990	2.813	0.769	0.961	6.66	11.46
1991	2.870	0.757	0.949	6.66	11.40
1992+	2.915	0.748	0.939	6.66	11.35

Model Year	NOx (gm/mi) ZML	DET	DET2	50k	100k
1981	0.651	0.067		0.98	1.32
1982	0.633	0.071		0.99	1.34
1983	0.632	0.039		0.83	1.02
1984	0.663	0.035		0.84	1.02
1985	0.651	0.035		0.83	1.00
1986	0.641	0.035		0.82	1.00
1987	0.647	0.034		0.82	0.99
1988	0.646	0.034		0.82	0.98
1989	0.644	0.034		0.81	0.98
1990	0.642	0.034		0.81	0.98
1991	0.638	0.034		0.81	0.98
1992+	0.635	0.034		0.80	0.97

3.0 INSPECTION AND MAINTENANCE BENEFITS

Three I/M tests are modeled by the MOBILE4 Tech IV Credit Model. They are the Idle test, the 2500/Idle test, and the Loaded/Idle test performed on a dynamometer. The I/M tests are much more likely to fail High and Super emitting cars than Marginal or Passing emitters. This fact is used in I/M programs to identify vehicles which most need repair and produce the greatest emission benefits.

The MOBILE4 Tech IV Credit Model only uses the cutpoints of 1.2% CO and 220 ppm HC. The previous Tech IV Credit Model for MOBILE3 also produced I/M credits for the cutpoints of 0.5% CO and 100 ppm HC, and 3.0% and 300 ppm HC. These cutpoints were dropped because they were rarely used by state I/M programs.

The I/M credits produced by the MOBILE4 Tech IV Credit Model are the product of identification effectiveness of a particular I/M test (IDR) and the effectiveness of repair after identifying a failing vehicle. The EPA surveillance database was used to generate the IDR's for each test and emitter type. A separate repair effectiveness database was used to estimate the effect of repairing each emitter type after it failed the I/M procedure.

3.1 Short Test Data

The Idle test tailpipe emission levels were gathered mainly from the second idle in neutral of the four-mode test procedure. In this procedure the vehicle is tested at curb idle, then with the idle speed held at 2500 rpm for up to 30 seconds, then at curb idle again, and finally at curb idle with the vehicle transmission in drive with the brake on for vehicles with automatic transmissions. The second idle measured in this procedure best simulates a preconditioned Idle test procedure.

The 2500/Idle test data for this analysis were derived mainly from the same four-mode test procedure. In this case the emissions sampled at 2500 rpm and from the second idle in neutral are used. Vehicles must pass both the 2500 rpm and idle modes of this test. For MOBILE4 the I/M credit is based on a different definition of the 2500/Idle test than in MOBILE3. In the new definition, the CO cutpoint of 1.2% is applied during the idle portion of the test but not during the 2500 rpm test portion. The additional 2500 rpm benefits of the 2500/Idle test over the idle test alone are therefore based only on the HC cutpoint of 220 ppm. This change reduces the amount of emission credit given the 2500/Idle test. This change in the 2500/Idle test procedure is being promoted by EPA to reduce problems with testing vehicles which purge their evaporative canisters at 2500 rpm. Many of these vehicles tend to fail the CO cutpoint during the 2500 rpm portion of the test even though the FTP emissions are low.

Restart test procedure results were substituted for the above four-mode test data for all vehicles manufactured by the Ford Motor Company in the sample with restart procedure results. The Restart test is a modified 2500/Idle test in which the vehicle ignition is turned off and then restarted prior to the 2500 rpm portion of the test, and is required for Ford vehicles to be eligible for warranty coverage.

The data on the Loaded/Idle test procedure came primarily from some limited testing done on 1981, 1982 and 1983 model year vehicles. Where Loaded/Idle data were not available, the 2500/Idle data were substituted. The Loaded/Idle test procedure consisted of a 30 MPH cruise with a 9.0 hp load for 30 seconds followed by a 30 second idle period. Emissions are sampled during both modes and vehicles must pass both the loaded and idle modes of this test.

3.2 Identification Rates

Table 3-1 below displays the distribution in the EPA surveillance database of emitter type versus technology. These vehicles were used to generate the I/M identification of excess emissions rates (IDR's) as well as the emission factors. The tampered vehicles are shown for illustration only. They were not used in the analysis to create the I/M benefits.

Table 3-1

Emitter Category vs. Technology
in the EPA Surveillance Database

Sample	CARB	FI	OL	Total
Pass FTP	408	198	172	778
Marg	306	176	253	735
High	93	48	34	175
Super	6	2	0	8
Tampered	53	12	24	89
Total	866	436	483	1785

One vehicle, a Super emitter, was eliminated from the sample for purposes of determining short test identification rates. This vehicle, number 5206, was determined to have unreliable short test results making it impossible to determine if the vehicle would be correctly identified. Since it was a Super emitter, any determination would greatly effect the emission reduction estimates for short tests. Eliminating this vehicle from the identification rate sample avoids any effect this vehicle would have without reducing the confidence in the results using the remaining vehicles in the sample.

Table 3-2 shows the failure distribution by emitter type for the Idle test, the 2500/Idle test and the Loaded/Idle test in the EPA Surveillance Database. Note that the I/M short test failure rate increases with increased FTP emissions. Also, that tampered vehicles tend to fail at a higher rate than the fleet as a whole, but not as much as the vehicles classified as High emitters.

Table 3-2

Identification Rate Database

	Idle Test			2500/Idle Test			Loaded/Idle Test		
Sample	Pass	Fail	% Fail	Pass	Fail	% Fail	Pass	Fail	% Fail
Pass	768	10	1.3	766	12	1.5	763	15	1.9
Marginal	709	26	3.5	707	28	3.8	699	36	4.9
High	128	47	26.9	123	52	29.7	112	63	36.0
Super	3	5	62.5	3	5	62.5	2	6	75.0
Tampered	77	12	13.5	76	13	14.6	73	16	18.0
Total	1685	100	5.6	1675	110	6.2	1649	136	7.6

Table 3-2 presents the raw I/M failure rates for various I/M short tests. These rates were easily calculated by dividing the number of failures by the sample size. It shows that a high percent of the failures are high emitters.

The MOBILE4 Tech IV Model, however, uses a measure of the total emissions of the vehicles identified by the short test to quantify the impact of I/M. This IDR is usually greater than the simple failure rate shown in Table 3-2 and can be different for HC and CO. The IDR better reflects the fact that short tests usually identify the worst emitting vehicles in any grouping. For MOBILE4, the IDR was determined as the fraction of the emissions in excess of certification standards.

Table 3-3 shows there to be large differences between the IDR's of High emitters and Marginal emitters. For example, the High emitters make up about 10% of the sample; however, it is these vehicles at which I/M programs are targeted and which contribute the bulk of the emissions reductions. Also, the IDR's of the High and Super emitting fuel injected vehicles are considerably lower than the corresponding ones for carbureted or open-loop vehicles. The primary cause of this phenomenon is the low failure rate of fuel injected vehicles compared to carbureted vehicles, even among High emitting vehicles.

Vehicles passing the FTP, by definition, have no excess emissions. Therefore, the IDR for Passing vehicles is zero in all cases. The IDR for Super vehicles were determined from the combined carbureted and fuel injected sample of eight Super emitting vehicles.

Table 3-3

Identification Rates For Excess Emissions

Carbureted Vehicles

	Idle Test		2500/Idle Test		Loaded/Idle Test	
	HC	CO	HC	CO	HC	CO
Pass FTP	0.00	0.00	0.00	0.00	0.00	0.00
Marginal	3.34	1.51	3.34	1.51	5.71	5.36
High	35.74	41.24	42.90	49.90	53.99	63.76
Super	55.26	71.72	55.26	71.72	58.63	84.90

Fuel Injected Vehicles

	Idle Test		2500/Idle Test		Loaded/Idle Test	
	HC	CO	HC	CO	HC	CO
Pass FTP	0.00	0.00	0.00	0.00	0.00	0.00
Marginal	7.46	8.33	8.30	8.60	11.29	12.54
High	15.57	23.74	18.93	25.80	18.93	25.80
Super	55.26	71.72	55.26	71.72	58.63	84.90

Open Loop Vehicles

	Idle Test		2500/Idle Test		Loaded/Idle Test	
	HC	CO	HC	CO	HC	CO
Pass FTP	0.00	0.00	0.00	0.00	0.00	0.00
Marginal	3.80	4.86	5.20	6.90	4.55	9.25
High	60.61	61.14	71.57	77.47	66.22	75.82
Super	-	-	-	-	-	-

3.3 Repair Effects from I/M

In the MOBILE3 Tech IV Credit Model, the I/M benefits were based on the assumption that High and Super emitters would fail the I/M test and a certain percentage of the excess emissions would be identified and repaired. It was assumed that this repair would reduce the emissions of a High emitting vehicle to those of the average Normal emitting vehicle. This assumption was necessary because there were insufficient data available to show the effect of failing an I/M test and receiving repairs to pass it.

3.3.1 Repair Database

Prior to the development of the MOBILE4 Tech IV Model, testing programs were conducted with vehicles which went through the I/M process and were repaired by either commercial garage mechanics or by EPA contractor mechanics. Data collected from these programs allow the modeling of repair effectiveness for the MOBILE4 Tech IV Model. Table 3-4 shows the distribution of the repair effects by testing program type. Approximately half of the repair effectiveness database is composed of vehicles which are in the EPA Surveillance Database and had before and after repairs and emission tests. Approximately, one quarter of the vehicles were recruited after they failed the Maryland or Washington, D.C. I/M programs and were repaired by EPA contractor mechanics or garage mechanics in Washington D.C. to pass the I/M test. The other 25% of the vehicles were involved in an extensive I/M evaluation program conducted by the California Air Resources Board. The results from this program may be the most representative of actual field conditions in decentralized programs, since the vehicles were tested and repaired in commercial garage facilities.

Table 3-4

The Distribution of Repair Database
Vehicles by Emissions Testing Program

Program	# of Vehicles	%
EF80	34	4.7
EF82	280	38.7
MI82	28	3.9
SP82	8	1.1
IM83	184	25.4
CALI87	190	26.2
ALL	724	100.0

Tables 3-5 and 3-6 show the distribution of vehicles in the repair database by model year, technology, and emitter category. As Table 3-5 shows, 51 1980 model year vehicles from California were included in the database and in the analysis of repair effects. These vehicles were included because they were certified to California's strict 1980 standards. They also used technology which was similar to what was on Federally certified 1981 model year vehicles.

Table 3-5

Distribution of Repair Database
Vehicles by Model Year and Technology

Model Year	Technology Type CARB	FI	OL
1980*	42	9	0
1981	242	20	106
1982	50	38	17
1983	37	55	26
1984	26	25	8
1985	5	9	2
1986	0	7	0
	402	163	159

* Includes only California cars.

Table 3-6

Distribution of Repair Database
Vehicles by Emitter Category and Technology

Emitter Type	Technology Type CARB	FI	OL
Pass FTP	48	23	13
Marg	161	40	75
High	177	91	71
Super	16	9	0
ALL	402	163	159

3.3.2 Emission Reduction from Repairs

Table 3-7 displays the emission reductions from repairing vehicles which failed the initial idle test but passed after repairs. The data show that the emissions from failing Highs can be reduced more than 50% as a result of I/M repairs. The benefit of repairing Marginal and Passing emitters which fail I/M drops off sharply, with emissions actually increasing after repairing vehicles under certification standards in many cases. Table 3-8 displays analogous results for vehicles which fail the 2500/Idle test.

Table 3-7

Failed Initial Idle Test/Pass After Repair

Carbureted Vehicles

	N	HC Before	HC After	HC %Reduct	CO Before	CO After	CO %Reduct
Pass FTP	4	0.368	0.385	-4.62	5.120	5.333	-4.16
Marginal	34	0.806	0.645	19.98	9.205	7.136	22.48
High	53	2.858	1.398	51.08	50.939	21.895	57.02
Super	9	13.811	2.146	84.46	190.210	16.206	91.48

Fuel Injected Vehicles

	N	HC Before	HC After	HC %Reduct	CO Before	CO After	CO %Reduct
Pass FTP	3	0.260	0.300	15.38	3.443	4.330	-25.76
Marginal	9	0.455	0.333	26.81	6.535	4.443	32.01
High	24	2.358	0.936	60.31	47.898	15.163	68.34
Super	4	6.405	1.928	69.90	184.070	45.067	75.52

Open Loop Vehicles

	N	HC Before	HC After	HC %Reduct	CO Before	CO After	CO %Reduct
Pass FTP	0	-	-	-	-	-	-
Marginal	5	0.660	0.523	20.76	7.900	4.963	37.18
High	30	2.477	1.038	58.09	43.638	13.828	68.31
Super	0	-	-	-	-	-	-

Table 3-8

Failed Initial Two Speed Test/Passed After Repairs

Carbureted Vehicles

	N	HC Before	HC After	HC %Reduct	CO Before	CO After	CO %Reduct
Pass FTP	5	0.320	0.360	-12.50	4.303	5.530	-28.51
Marginal	38	0.739	0.591	20.03	8.661	6.780	21.72
High	58	2.833	1.189	58.03	49.632	17.789	64.16
Super	10	11.492	1.931	83.20	183.340	20.915	88.59

Fuel Injected Vehicles

	N	HC Before	HC After	HC %Reduct	CO Before	CO After	CO %Reduct
Pass FTP	3	0.220	0.265	-20.45	3.580	4.525	-26.40
Marginal	9	0.455	0.333	26.81	6.535	4.443	32.01
High	25	2.340	0.861	63.21	47.205	12.801	72.88
Super	4	6.547	0.603	90.79	192.02	5.033	97.38

Open Loop Vehicles

	N	HC Before	HC After	HC %Reduct	CO Before	CO After	CO %Reduct
Pass FTP	0	-	-	-	-	-	-
Marginal	6	0.643	0.550	14.46	11.385	7.958	30.10
High	31	2.506	0.966	61.45	43.749	11.821	72.98
Super	0	-	-	-	-	-	-

3.4 General Methodology

For MOBILE4, the effect of I/M immediately after an inspection/repair event is calculated by reducing the average emissions of the Super, High, and Marginal emitting vehicles stratified by technology, by a percentage which is the product of the IDR rate and the repair effectiveness. This product is multiplied by the weighted emission value to create a weighted I/M emission value for each technology. The I/M emission values for each technology are then weighted together using the technology distribution for each model year in Table 2-2. This produces intermediate I/M emission values for each pollutant, test type, model year and age. These emission values are compared to the corresponding non-I/M emission levels to produce the final I/M credits. This method is somewhat different from MOBILE3 where each pre-inspection point was calculated from the previous post-inspection point assuming an icreased rate of deterioration.

3.4.1 Annual I/M Credits

The individual credits are generated by comparing the emissions from all vehicles of a model year with and without the I/M program. Unfortunately, single emission values for both I/M and non-I/M cases cannot be used directly.

One problem is the distribution of ages within a model year. For example, if a program is evaluated in January, 1990, inspecting the 1988 model year vehicles, the age distribution of the 1988 model year vehicles would range from 2.25 years to 1.25 years. The vehicles between one and two years old have only been inspected once. Any vehicles two years and older should have already received their second inspection. For purposes of modeling, all vehicles are assumed to be inspected on the first anniversary of their purchase and periodically therafter, always on that same date. It is also assumed that sales of vehicles in a model year are evenly distributed and that all sales occur exactly in the 12 month period from October of the calendar year previous to the model year through September of the next year. In this example, 25% of the emissions on the evaluation date come from vehicles recently completing their second inspection and 75% of the emissions come from vehicles which have been inspected only once.

Another factor which is taken into account is the deterioration of the vehicles in between their yearly inspections and repairs. Existing evidence suggests that the type of problems which cause I/M failures can re-occur as often in the repaired vehicles as they do in the unrepaired fleet. It is assumed that the fleet, after repairs, will have the same emission deterioration as before repairs. On the other hand, there is no reason to suspect that replacement of components and other types of repairs performed on failed vehicles should be more susceptible to subsequent deterioration than in the non-I/M fleet. The available data from the California I/M Review Study are very limited, but suggest no unusual deterioration after repair. In MOBILE3 the deterioration between I/M cycles was calculated to be greater than or equal to the non-I/M deterioration.

Figure 3-1 shows how the distribution of a model year by individual age and the deterioration are incorporated to produce the I/M credits for each age for a given model year. The upper line is an example of an emission factor found in Table 2-14. It is the emission factor regression equation without I/M effects. The lower "sawtooth" figure is the I/M line. The "sawtooth" illustrates the effect of I/M inspection and repair and the subsequent deterioration of the fleet. All deterioration slopes are parallel. The repair effect is represented by the sudden drop in emission level at each anniversary. This drop is the product of the identification rates shown in Table 3-3 and the repair effectiveness in Tables 3-7 and 3-8. Details on these rates can be found in previous sections. The heavy shaded portions of the lines illustrate how an I/M credit for the given model year at age two is produced. MOBILE4 always chooses January 1st as the evaluation date. The vehicles sold from October through December are represented by the short line segment to the right of the two year anniversary point, representing vehicles in the model year that are older than two years. The longer line segment to the left of the anniversary point represents the vehicles sold from January through September, which are still less than two years old at the evaluation date. The weighted average of each segment is calculated and the percent difference between the two weighted averages is computed. This percent difference is the I/M credit.

3.4.2 Biennial I/M Credits

The weighted emission values after an inspection/repair event with and without biennial I/M are the same as those for annual I/M. The only difference is that the biennial I/M values are applied every other year and that there is consequently a longer period of deterioration between I/M inspections and repairs. Figures 3-2 and 3-3 are analogous to Figure 3-1. Figure 3-2 is an example of a 1-3-5 biennial program in which a vehicle is first inspected when it is one year old and then every two years thereafter. Figure 3-3 illustrates a 2-4-6 biennial program which begins when a vehicle is two years old and inspects it every other year. The differences are small for a fleet that has a full complement of vehicle ages. The final biennial credits used in MOBILE4 are the average of these two program types. This adequately represents either the 1-3-5 or the 2-4-6 plan, or any mixed biennial program in which half of each model year is inspected during each calendar year.

3.4.3 Idle I/M Credits

The previous emission factor model (MOBILE3) included idle emission factors in grams/hour but not I/M credits at idle. For MOBILE4 it was desired to include I/M credits at idle; however, very little data were available to evaluate the effect of I/M on idle emissions. Therefore, the FTP I/M Credits, as discussed in previous sections, are applied in MOBILE4 to the idle emission factors to calculate an I/M impact.

4.0 NORMALIZED BAG FRACTIONS

The basic exhaust emission level of a vehicle is a composite derived by VMT-weighting the vehicle's cold start, stabilized, and hot start emissions. A weighting factor of 20.6% is used for cold start, 52.1% for stabilized, and 27.3% for hot start. These are the weightings of the three "bags" of the Federal Test Procedure (FTP). These bag correction factors are used in MOBILE4 to adjust the emissions for cold/hot operation. The bag correction factors are used to separate the basic emission rate (BER) into cold start, stabilized and hot start operation emission levels. This correction factor is defined as:

The basic exhaust emission rate for one of the operating modes (cold,stabilized,hot) is expressed as:

$$BER_i = BER_{ftp} * CF(mile) \qquad (1)$$

Where:
- BER_i is the basic exhaust rate for an individual bag of the FTP.
- BER_{ftp} is composite FTP emission factor
- CF(mile) is the overall bag correction factor, which is a function of mileage.

The correction factor CF(mile) is represented in the form:

$$CF(mile) = A_i + B_i * M \qquad (2)$$

A_i = The zero-mile bag correction factor for bag i.
B_i = The deterioration bag correction factor for bag i.
M = The mileage, in 10,000 mile increments (mile/10,000).

The correction factor equation can also be displayed in terms of the zero-mile and deterioration levels. For 1981 and newer model year gasoline fueled passenger cars, the model produces a zero-mile level and deterioration rate for vehicles with mileage less than 50,000 and a second deterioration rate for vehicles with greater than 50,000 miles. The zero-mile and deterioration rates are calculated for each model year, FTP bag, and pollutant (HC and CO only ; NOx does not have the second deterioration).

The form of the equation when the mileage is less than 50,000 is:

$$A_i + B_i*M = (ZM_i+DR_i*M) / (ZM_{ftp}+DR_{ftp}*M) \quad (3)$$

Where:

ZM_i = The zero-mile coefficient for bag i (calculated by the emission factor model).
DR_i = The first deterioration rate (0-50K miles) for bag i.
ZM_{ftp} = The zero-mile coefficient for the composite FTP This coefficient is constructed from a weighted average of the three FTP bags.
DR_{ftp} = The deterioration rate (0-50K miles) for the composite FTP. This coefficient is also constructed from a weighted average of the three FTP bags.
M = The mileage, expressed in 10K increments (mile/10,000) up to 50,000 miles.

Equation 3 can be separated and the following four equations are the result.

$$A_i = ZM_i / (ZM_{ftp} + DR_{ftp} * M) \quad (4)$$

or

$$A_i = (ZM_i/ZM_{ftp}) / (1 + (DR_{ftp}/ZM_{ftp})*M)) \quad (5)$$

$$B_i*M = (DR_i*M) / (ZM_{ftp} + DR_{ftp}*M) \quad (6)$$

or

$$B_i*M = (DR_i/ZM_{ftp}) / (1 + (DR_{ftp}/ZM_{ftp})*M) \quad (7)$$

The bag correction factors for vehicles with mileages greater than 50,000 are similar to the previous ones. The equations are the same except ZM_i is now ZM_{i50k}, ZM_{ftp} is ZM_{ftp50k}, DR_i is now DR_{i50k} and DR_{ftp} is now DR_{ftp50k}. Also, the variable (M) is the mileage greater than 50,000 miles.

$$A_{i50k} + B_{i50k}*M = \frac{(ZM_{i50k}+DR_{i50k}*M)}{(ZM_{ftp50k}+DR_{ftp50k}*M)} \quad (8)$$

The variables ZM_{isok} and ZM_{ftpsok} are not zero-mile levels but the 50,000 mile emission levels of bag i and the composite FTP emission level for a given pollutant. The variables (DR_{isok}) and (DR_{ftpsok}) are the rates of deterioration in emissions which vehicles experience after 50,000 miles in bag i and the composite FTP emissions respectively. The bag fraction equations for vehicles with mileages greater than 50,000 are then:

$$A_{isok} = \frac{(ZM_{isok} / ZM_{ftpsok})}{(1 + (DR_{ftpsok} / ZM_{ftp})*M))} \quad (9)$$

and

$$B_{isok} = \frac{(DR_{isok}/ZM_{ftp})}{(1 + (DR_{ftp}/ZM_{ftp})*M)} \quad (10)$$

The bag correction factors can also be represented as normalized bag fractions. In this form the three correction factors sum to 1.0 and are used in MOBILE4. Mathematically the equation is:

$$1.0 = (vmf_i*(A_i + B_i*M)/(A_{ftp} + B_{ftp}*M)) \quad (11)$$

where vmf_i is the percent of the vehicle miles traveled (vmt) contributed by each of the three modes - cold start, hot stabilized, and hot start. The default values for the three percents are 20.6%, 52.1%, and 27.3% respectively. In the MOBILE4 model these percentages can also be entered by the user in the scenario record.

Equation (11) can be expanded to:

$$1.0 = \frac{w*(A_1+B_1*M) + (1-w-x)*(A_2+B_2*M) + x*(A_3+B_3*M)}{A_{ftp} + B_{ftp} * M}$$

where vmf_i becomes variables (w), (x) or (1-w-x). Variable (w) is the fraction of the miles a vehicle travels in cold start (default = 0.206). Variable (x) is the fraction traveled in the hot start mode (default = 0.273) and remaining fraction (1-w-x) is the fraction of hot-stabilized travel (default = 0.521).

The three normalized bag fractions are the terms of this equation. For example, the normalized fraction for bag one for mileage under 50,000 miles is:

$$BF_1 = w*(A_1 + B_1*M) / (A_{ftp} + B_{ftp}*M) \quad (13)$$

For bags two and three the equations are:

$$BF_2 = w*(A_2 + B_2*M) / (A_{ftp} + B_{ftp}*M) \quad (14)$$

and

$$BF_3 = w*(A_3 + B_3*M) / (A_{ftp} + B_{ftp}*M) \quad (15)$$

Normalized bag fractions for mileages over 50,000 miles are generated in an analogous manner substituting A_{i50k}, B_{i50k}, A_{ftp50k} and B_{ftp50k} for the appropriate variable.

5.0 HIGH ALTITUDE

5.1 Emission Factors

The number of vehicles available for analysis which were tested at high altitudes make an analysis, like the one performed for low altitude passenger cars, impossible. In addition, changes in the standards for high altitude areas make further division of the database necessary. Passenger cars must now meet the same emissions standards at all altitudes.

As a result, the modeling approach was simplified. It is assumed that passenger cars emissions at high altitude will deteriorate at the same rate as low altitude vehicles. Analysis of the limited high altitude sample supports this concept for low mileages. Average emission levels and mileages were determined for each model year. The small samples of 1983 and 1984 model year vehicles were combined. Using the low altitude emission deterioration rates and the high altitude mean emissions and mileages, the zero mile emission levels were determined. If this emission level was less than the low altitude prediction, the high altitude emissison level was set to the low altitude prediction. The 1986 and newer model years use the results of the combined 1984 and 1985 sample.

Table 5-1

High Altitude Sample

Model Year	Sample Size	Average Emissions (gm/mi) HC	CO	NOx	Average Mileage
1981	176	.633	13.522	.563	8,627
1982	149	.642	12.596	.815	26,451
Combined 1983-84	106	.338	4.399	.841	14,723

Table 5-2

Passenger Car (LDGV) High Altitude
Exhaust Emission Factors for MOBILE4

Model Year	HC (gm/mi) ZML	DET	DET2	50k	100k
1981	.565	.079	.108	0.96	1.50
1982	.446	.074	.101	0.82	1.32
1983	.269	.062	.085	0.58	1.00
1984	.242	.067	.088	0.57	1.01
1985	.254	.063	.084	0.57	0.99
1986	.265	.060	.081	0.56	0.97
1987	.264	.060	.081	0.56	0.97
1988	.267	.059	.080	0.56	0.96
1989	.269	.059	.079	0.56	0.96
1990	.271	.058	.078	0.56	0.95
1991	.275	.057	.077	0.56	0.95
1992+	.278	.056	.076	0.56	0.94

Model Year	CO (gm/mi) ZML	DET	DET2	50k	100k
1981	12.532	1.147	1.765	18.27	27.10
1982	9.742	1.079	1.616	15.14	23.22
1983	3.280	.760	1.013	7.08	12.15
1984	3.162	.840	1.052	7.36	12.62
1985	3.217	.803	1.014	7.23	12.30
1986	3.264	.771	.982	7.12	12.03
1987	3.242	.786	.983	7.17	12.09
1988	3.251	.780	.973	7.15	12.02
1989	3.259	.774	.967	7.13	11.97
1990	3.267	.769	.961	7.11	11.92
1991	3.284	.757	.949	7.07	11.82
1992+	3.298	.748	.939	7.04	11.74

Model Year	NOx (gm/mi) ZML	DET	50k	100k
1981	.505	.067	0.84	1.18
1982	.627	.071	0.98	1.34
1983	.784	.039	0.98	1.17
1984	.789	.035	0.96	1.14
1985	.789	.035	0.96	1.14
1986	.789	.035	0.96	1.14
1987	.791	.034	0.96	1.13
1988	.791	.034	0.96	1.13
1989	.791	.034	0.96	1.13
1990	.791	.034	0.96	1.13
1991	.791	.034	0.96	1.13
1992+	.791	.034	0.96	1.13

5.2 High Altitude I/M Credits

A separate model was not developed to generate high altitude I/M credits for model year vehicles 1981 and newer. However, since the technologies and emission levels at high and low altitudes are quite similar, it was assumed that the credits developed for low altitude could be applied directly to the high altitude emission estimates. Separate high altitude I/M credits are necessary for pre-1981 model year vehicles in MOBILE4.

5.3 High Altitude Bag Fractions

Different Bag Fractions for high altitude modeling were not developed for MOBILE4 because the technologies and emission levels for both altitudes are very similar. Therefore, the bag fractions developed for low altitude will be applied at high altitude.

MOBILE4
Exhaust Emission Factors and Inspection/Maintenance
Benefits for Passenger Cars

Appendix

Program Code Listing

```
CC
CC..MOBILE4 I/M Credit Model for 1981 and newer LDGV
CC
CC..Program Main
CC
CC..COMMON Blocks and DIMENSION Statements
CC
      COMMON /DAT01/ MYR,ISTD,ITECH,IBAG,IP,IAGE,ICUT,ITST
      COMMON /DAT02/ AMIL(20),ODOM(20),TMILE(20),WGT(20)
      COMMON /DAT03/ PASS(20,3,2),EDGE(20,3,2),HIGH(20,3,2)
      COMMON /DAT04/ FAIL(20,3,2)
      COMMON /DAT05/ SN0(3,2),SM0(3,2)
      COMMON /DAT06/ FRAC(3,12)
      COMMON /DAT07/ ES0(2,4,3,2),EH0(2,4,3,2)
      COMMON /DAT08/ DM(2,4,3,2),DN(3,4,3,2)
      COMMON /DAT09/ ZMIL(2,4,3,2),CWO(2,4,20,3,2),CIMW(2,4,20,3,2,3)
      COMMON /DAT10/ EWO(2,4,20,12),EIMW(2,4,20,12,3),EZM(2,4,12)
      COMMON /DAT11/ CREDIT(2,20,12,3,4)
      COMMON /DAT12/ ZML(3,4,12),ZML1(3,4,12),ZML2(3,4,12)
      COMMON /DAT13/ BFZML1(3,4,12),BFDET1(3,4,12)
      COMMON /DAT14/ DET(3,4,12),DET1(3,4,12),DET2(3,4,12)
      COMMON /DAT16/ XSIDR(2,3,2,3),XHIDR(2,3,2,3)
      COMMON /DAT17/ RSUP(2,3,2,3),RHIG(2,3,2,3)
      COMMON /DAT18/ SUPER(20,3,2)
      COMMON /DAT19/ GM(3,2),GH(3,2),GS(3,2),BEND(3,2)
      COMMON /DAT20/ EM0(2,4,3,2),EN0(3,4,3,2)
      COMMON /DAT21/ BFDET2(3,4,12),BFZML2(3,4,12)
      COMMON /DAT22/ RMAR(2,3,2,3)
      COMMON /DAT24/ XMIDR(2,3,2,3)
CC
      INTEGER BI
C
      OPEN(1,FILE='BIENIAL')
      OPEN(7,FILE='ANNUAL')
      OPEN(8,FILE='EFAC')
      OPEN(9,FILE='BAGFRAC')
CC
CC..Inspection Frequency:
CC
CC..BI = 1 : 1/3/5 Biennial inspection schedule.
CC..BI = 2 : 2/4/6 Biennial inspection schedule.
CC..BI = 3 : Annual inspection schedule.
CC
      BI = 3
CC
CC
CC..Calculate the mileage accumulated in each one year interval.
CC
      AMIL(1) = ODOM(1)
CC
      DO 10 IAGE=2,20
        AMIL(IAGE) = ODOM(IAGE) - ODOM(IAGE-1)
   10 CONTINUE
CC
CC..CO standard ( 1: 1981,1982, 2: 1983 and newer )
CC
      DO 600 ISTD=1,2
CC
```

```
CC..ITECH indicates the technology type used in the vehicles.
CC
CC..ITECH = 1 : Closed-Loop, Carbureted
CC..ITECH = 2 : Closed-Loop, Fuel-Injected
CC..ITECH = 3 : Open-Loop, Any
CC
      DO 600 ITECH=1,3
CC
CC..Vehicle age in years
CC
      DO 600 IAGE=1,20
CC
      CALL SIZE
CC
CC..FTP Bag ( 1=FTP; 2=BAG1; 3=BAG2; 4=BAG3 )
CC
      DO 600 IBAG=1,4
CC
CC..Pollutant ( 1:HC, 2:CO )
CC
      DO 600 IP=1,2
CC
      CALL EMIT
      CALL IMEMIT
CC
  600 CONTINUE
CC
      CALL MYRSUB
      CALL REGR
      CALL JAN1
      CALL OUTPUT
CC
CC
      STOP
      END
```

```
      SUBROUTINE SIZE
CC
CC..This routine predicts the number of vehicles in each emission
CC..level category by technology and age.
CC
      COMMON /DAT01/ MYR,ISTD,ITECH,IBAG,IP,IAGE,ICUT,ITST
      COMMON /DAT02/ AMIL(20),ODOM(20),TMILE(20),WGT(20)
      COMMON /DAT03/ PASS(20,3,2),EDGE(20,3,2),HIGH(20,3,2)
      COMMON /DAT04/ FAIL(20,3,2)
      COMMON /DAT05/ SN0(3,2),SM0(3,2)
      COMMON /DAT18/ SUPER(20,3,2)
      COMMON /DAT19/ GM(3,2),GH(3,2),GS(3,2),BEND(3,2)
CC
CC..Estimate the number of FTP failures
CC
      FAIL(IAGE,ITECH,ISTD) = SM0(ITECH,ISTD)
     *                      + GM(ITECH,ISTD)*ODOM(IAGE)
      IF(FAIL(IAGE,ITECH,ISTD).GT.1.0) FAIL(IAGE,ITECH,ISTD)=1.0
CC
CC..Calculate the number of "HIGH" emitting vehicles
CC
      HIGH(IAGE,ITECH,ISTD) = GH(ITECH,ISTD) * ODOM(IAGE)
CC
CC.."BEND" is the change in the rate of occurrance of "HIGH"
CC..emitting vehicles assumed to occur at 50,000 miles.
CC
      IF(ODOM(IAGE-1).GT.5.0)
     * HIGH(IAGE,ITECH,ISTD) = HIGH(IAGE-1,ITECH,ISTD)
     *                 + BEND(ITECH,ISTD)*GH(ITECH,ISTD)*AMIL(IAGE)
      IF(HIGH(IAGE,ITECH,ISTD).GT.1.00) HIGH(IAGE,ITECH,ISTD) = 1.00
CC
CC..Calculates the number of "SUPER" emitting vehicles
CC
      SUPER(IAGE,ITECH,ISTD) = GS(ITECH,ISTD)*ODOM(IAGE)
      IF(SUPER(IAGE,ITECH,ISTD).GT.1.0) SUPER(IAGE,ITECH,ISTD)=1.0
CC
CC..Calculate the number of "MARGINAL" FTP failures
CC
      EDGE(IAGE,ITECH,ISTD) = FAIL(IAGE,ITECH,ISTD)
     *                      - HIGH(IAGE,ITECH,ISTD)
     *                      - SUPER(IAGE,ITECH,ISTD)
      IF(EDGE(IAGE,ITECH,ISTD).LT.0.0) EDGE(IAGE,ITECH,ISTD)=0.0
CC
CC..Calculate the number of remaining FTP passing vehicles
CC
      CHECK = HIGH(IAGE,ITECH,ISTD) + SUPER(IAGE,ITECH,ISTD)
      IF(CHECK.GT.1.0)
     *    HIGH(IAGE,ITECH,ISTD) = 1.0 - SUPER(IAGE,ITECH,ISTD)
CC
      PASS(IAGE,ITECH,ISTD) = 1.0
     *                      - EDGE(IAGE,ITECH,ISTD)
     *                      - HIGH(IAGE,ITECH,ISTD)
     *                      - SUPER(IAGE,ITECH,ISTD)
CC
      IF(IAGE.GT.1) GOTO 999
CC
CC..Calculates the remaining FTP passing vehicles at zero miles
CC
```

```
      SN0(ITECH,ISTD) = 1.0 - SM0(ITECH,ISTD)
CC
  999 RETURN
      END
```

```
      SUBROUTINE EMIT
CC
CC..This routine combines the emission levels of each emission
CC..category based on the predicted categroy size.
CC
      COMMON /DAT01/ MYR,ISTD,ITECH,IBAG,IP,IAGE,ICUT,ITST
      COMMON /DAT02/ AMIL(20),ODOM(20),TMILE(20),WGT(20)
      COMMON /DAT03/ PASS(20,3,2),EDGE(20,3,2),HIGH(20,3,2)
      COMMON /DAT05/ SN0(3,2),SM0(3,2)
      COMMON /DAT07/ ES0(2,4,3,2),EH0(2,4,3,2)
      COMMON /DAT08/ DM(2,4,3,2),DN(3,4,3,2)
      COMMON /DAT09/ ZMIL(2,4,3,2),CWO(2,4,20,3,2),CIMW(2,4,20,3,2,3)
      COMMON /DAT18/ SUPER(20,3,2)
      COMMON /DAT19/ GM(3,2),GH(3,2),GS(3,2),BEND(3,2)
      COMMON /DAT20/ EM0(2,4,3,2),EN0(3,4,3,2)
CC
      IF(IAGE.GT.1) GOTO 10
CC
CC..Emission levels at zero mileage point
CC
      ZMIL(IP,IBAG,ITECH,ISTD) =
     *    SM0(ITECH,ISTD) * EM0(IP,IBAG,ITECH,ISTD)
     *  + SN0(ITECH,ISTD) * EN0(IP,IBAG,ITECH,ISTD)
CC
CC..Emission levels by age
CC
   10 ES = ES0(IP,IBAG,ITECH,ISTD)
      EH = EH0(IP,IBAG,ITECH,ISTD)
     *   + ( DM(IP,IBAG,ITECH,ISTD)*ODOM(IAGE) )
      EM = EM0(IP,IBAG,ITECH,ISTD)
     *   + ( DM(IP,IBAG,ITECH,ISTD)*ODOM(IAGE) )
      EN = EN0(IP,IBAG,ITECH,ISTD)
     *   + ( DN(IP,IBAG,ITECH,ISTD)*ODOM(IAGE) )
CC
CC..Calculate the base (without I/M) composite emission levels by age
CC
      CWO(IP,IBAG,IAGE,ITECH,ISTD) =
     *   PASS(IAGE,ITECH,ISTD) * EN
     * + EDGE(IAGE,ITECH,ISTD) * EM
     * + HIGH(IAGE,ITECH,ISTD) * EH
     * + SUPER(IAGE,ITECH,ISTD) * ES
CC
  999 RETURN
      END
```

```
      SUBROUTINE IMEMIT
CC
CC..This routine combines the emission levels of each emission
CC..category based on the predicted catagory size.
CC
      COMMON /DAT01/ MYR,ISTD,ITECH,IBAG,IP,IAGE,ICUT,ITST
      COMMON /DAT02/ AMIL(20),ODOM(20),TMILE(20),WGT(20)
      COMMON /DAT03/ PASS(20,3,2),EDGE(20,3,2),HIGH(20,3,2)
      COMMON /DAT07/ ES0(2,4,3,2),EH0(2,4,3,2)
      COMMON /DAT08/ DM(2,4,3,2),DN(3,4,3,2)
      COMMON /DAT09/ ZMIL(2,4,3,2),CWO(2,4,20,3,2),CIMW(2,4,20,3,2,3)
      COMMON /DAT16/ XSIDR(2,3,2,3),XHIDR(2,3,2,3)
      COMMON /DAT17/ RSUP(2,3,2,3),RHIG(2,3,2,3)
      COMMON /DAT18/ SUPER(20,3,2)
      COMMON /DAT20/ EM0(2,4,3,2),EN0(3,4,3,2)
      COMMON /DAT22/ RMAR(2,3,2,3)
      COMMON /DAT24/ XMIDR(2,3,2,3)
CC
CC..Non-I/M emission levels
CC
      ES2 = ES0(IP,IBAG,ITECH,ISTD)
      EH2 = EH0(IP,IBAG,ITECH,ISTD)
     *    + ( DM(IP,IBAG,ITECH,ISTD)*ODOM(IAGE) )
      EM2 = EM0(IP,IBAG,ITECH,ISTD)
     *    + ( DM(IP,IBAG,ITECH,ISTD)*ODOM(IAGE) )
      EN2 = EN0(IP,IBAG,ITECH,ISTD)
     *    + ( DN(IP,IBAG,ITECH,ISTD)*ODOM(IAGE) )
CC
CC..For each test type   ITEST = 1 : Idle Test
CC..                     ITEST = 2 : 2500/Idle Test
CC..                     ITEST = 3 : Loaded/Idle Test
CC
      DO 10 ITEST=1,3
CC
CC..The emissions of vehicles passing the short test are combined
CC..with the estimated emission levels of vehicles which are repaired.
CC
      EIMS = (XSIDR(IP,ITECH,ISTD,ITEST)*
     *             (ES2*(1-RSUP(IP,ITECH,ISTD,ITEST))))   +
     *             ((1 - XSIDR(IP,ITECH,ISTD,ITEST))*ES2)
CC
      EIMH = (XHIDR(IP,ITECH,ISTD,ITEST)*
     *             (EH2*(1-RHIG(IP,ITECH,ISTD,ITEST))))   +
     *             ((1 - XHIDR(IP,ITECH,ISTD,ITEST))*EH2)
CC
      EIMM = (XMIDR(IP,ITECH,ISTD,ITEST)*
     *             (EM2*(1-RMAR(IP,ITECH,ISTD,ITEST))))   +
     *             ((1 - XMIDR(IP,ITECH,ISTD,ITEST))*EM2)
CC
CC..Emission levels by age and by test
CC..Calculate the base (without I/M) composite emission levels by age
CC
      CIMW(IP,IBAG,IAGE,ITECH,ISTD,ITEST) =
     *   PASS(IAGE,ITECH,ISTD) * EN2
     * + EDGE(IAGE,ITECH,ISTD) * EIMM
     * + HIGH(IAGE,ITECH,ISTD) * EIMH
     * + SUPER(IAGE,ITECH,ISTD) * EIMS
CC
```

```
   10 CONTINUE
CC
  999 RETURN
      END
```

```
      SUBROUTINE MYRSUB
CC
CC..This section combines the technologies into
CC..model year emission levels.
CC
      COMMON /DAT01/ MYR,ISTD,ITECH,IBAG,IP,IAGE,ICUT,ITST
      COMMON /DAT06/ FRAC(3,12)
      COMMON /DAT09/ ZMIL(2,4,3,2),CWO(2,4,20,3,2),CIMW(2,4,20,3,2,3)
      COMMON /DAT10/ EWO(2,4,20,12),EIMW(2,4,20,12,3),EZM(2,4,12)
CC
CC..Loop by MYR, CO standard, technology, age, bag, & pollutant
CC
CC..The ITEST loops only for the I/M composite emission arrays
CC
CC
      DO 300 MYR=1,12
       ISTD=1
       IF(MYR.GE.3) ISTD=2
      DO 300 IP=1,2
      DO 300 IBAG=1,4
      DO 300 ITECH=1,3
CC
CC..Zero mile emission levels by model year
CC
      EZM(IP,IBAG,MYR) = EZM(IP,IBAG,MYR)
     * + FRAC(ITECH,MYR) * ZMIL(IP,IBAG,ITECH,ISTD)
CC
      DO 300 IAGE=1,20
CC
CC..Calculates the emission levels for
CC..January 1st dates from the emission levels by age.
CC..Since model year introduction is on October 1st, this
CC..requires a 75%/25% staggering.
CC
      EWO(IP,IBAG,IAGE,MYR) =
     *   EWO(IP,IBAG,IAGE,MYR)
     * + FRAC(ITECH,MYR) * CWO(IP,IBAG,IAGE,ITECH,ISTD)
CC
      DO 200 ITEST=1,3
CC
      EIMW(IP,IBAG,IAGE,MYR,ITEST) =
     *    EIMW(IP,IBAG,IAGE,MYR,ITEST)
     *  + FRAC(ITECH,MYR) * CIMW(IP,IBAG,IAGE,ITECH,ISTD,ITEST)
CC
CC
  200 CONTINUE
  300 CONTINUE
CC
  999 RETURN
      END
```

```
      SUBROUTINE REGR
CC
CC..This subroutine uses a weighted regression equation to
CC..linearize the emission level results for each model year.
CC
      COMMON /DAT01/ MYR,ISTD,ITECH,IBAG,IP,IAGE,ICUT,ITST
      COMMON /DAT02/ AMIL(20),ODOM(20),TMILE(20),WGT(20)
      COMMON /DAT06/ FRAC(3,12)
      COMMON /DAT07/ ES0(2,4,3,2),EH0(2,4,3,2)
      COMMON /DAT08/ DM(2,4,3,2),DN(3,4,3,2)
      COMMON /DAT10/ EWO(2,4,20,12),EIMW(2,4,20,12,3),EZM(2,4,12)
      COMMON /DAT12/ ZML(3,4,12),ZML1(3,4,12),ZML2(3,4,12)
      COMMON /DAT14/ DET(3,4,12),DET1(3,4,12),DET2(3,4,12)
      COMMON /DAT20/ EM0(2,4,3,2),EN0(3,4,3,2)
CC
      DO 40 MYR=1,12
      DO 40 IBAG=1,4
      DO 40 IP=1,2
CC
      SUMX  = 0.0
      SUMY  = 0.0
      SUMXY = 0.0
      SUMXX = 0.0
CC
      N = 5
CC
      DO 10 IAGE=1,N
CC
       IF(IAGE.EQ.1) EM = EZM(IP,IBAG,MYR)
       IF(IAGE.GT.1) EM = EWO(IP,IBAG,IAGE-1,MYR)
CC
       IF(IAGE.EQ.1) XM = 0.0
       IF(IAGE.GT.1) XM = ODOM(IAGE-1)
CC
       SUMX  = SUMX  +  XM
       SUMY  = SUMY  +  EM
       SUMXY = SUMXY +  (XM*EM)
       SUMXX = SUMXX +  (XM**2)
CC
   10 CONTINUE
CC
      SUM1 = N * SUMXY - SUMX * SUMY
      SUM2 = N * SUMXX - SUMX**2
      D1 =  SUM1 / SUM2
      Z1 =  (SUMY/N) - D1 * (SUMX/N)
CC
CC..Store the regression results
CC
      ZML1(IP,IBAG,MYR) = Z1
      DET1(IP,IBAG,MYR) = D1
      ZML2(IP,IBAG,MYR) = ZML1(IP,IBAG,MYR) + DET1(IP,IBAG,MYR)*5.0
CC
      IF(ZML1(IP,IBAG,MYR).GE.0.0) GO TO 30
CC
CC..If the emission level at zero miles is less than zero,
CC..then the regression is altered to intercept at zero.
CC
      ZML1(IP,IBAG,MYR) = 0.0
```

```
      DET1(IP,IBAG,MYR) = SUMXY / SUMXX
      ZML2(IP,IBAG,MYR) = ZML1(IP,IBAG,MYR) + DET1(IP,IBAG,MYR)*5.0
CC
   30 SUMX  = 0.0
      SUMY  = 0.0
      SUMXY = 0.0
      SUMXX = 0.0
CC
      M = 16
CC
      DO 20 IAGE=6,21
CC
       IF(IAGE.EQ.1) EM = EZM(IP,IBAG,MYR)
       IF(IAGE.GT.1) EM = EWO(IP,IBAG,IAGE-1,MYR)
CC
       IF(IAGE.EQ.1) XM = 0.0
       IF(IAGE.GT.1) XM = ODOM(IAGE-1)
CC
       SUMX  = SUMX  +  XM
       SUMY  = SUMY  +  EM
       SUMXY = SUMXY +  (XM*EM)
       SUMXX = SUMXX +  (XM**2)
CC
  20  CONTINUE
CC
      SUM1 = M * SUMXY - SUMX * SUMY
      SUM2 = M * SUMXX - SUMX**2
      D1 =  SUM1 / SUM2
      Z1 =  (SUMY/M) - D1 * (SUMX/M)
CC
CC..Store the regression results
CC
      DET2(IP,IBAG,MYR) = D1
CC
CC..Single Linear Regression
CC
      SUMX  = 0.0
      SUMY  = 0.0
      SUMXY = 0.0
      SUMXX = 0.0
C     SUMW  = 0.0
CC
      DO 60 IAGE=1,20
CC
       IF(IAGE.EQ.1) EM = EZM(IP,IBAG,MYR)
       IF(IAGE.GT.1) EM = EWO(IP,IBAG,IAGE-1,MYR)
CC
       IF(IAGE.EQ.1) XM = 0.0
       IF(IAGE.GT.1) XM = ODOM(IAGE-1)
CC
       SUMX  = SUMX  + ( WGT(IAGE) * XM )
       SUMY  = SUMY  + ( WGT(IAGE) * EM )
       SUMXY = SUMXY + ( WGT(IAGE) * (XM*EM))
       SUMXX = SUMXX + ( WGT(IAGE) * (XM**2))
CC
  60  CONTINUE
CC
      SUM1 = SUMXY - SUMX * SUMY
```

```
      SUM2 = SUMXX - SUMX**2
      D1 =  SUM1 / SUM2
      Z1 =  SUMY - D1 * SUMX
CC
CC..Store the regression results
CC
      ZML(IP,IBAG,MYR) = Z1
      DET(IP,IBAG,MYR) = D1
CC
      IF(ZML(IP,IBAG,MYR).GE.0.0) GO TO 40
CC
CC..If the emission level at zero miles is less than zero,
CC..then the regression is altered to intercept at zero.
CC
      ZML(IP,IBAG,MYR) = 0.0
      DET(IP,IBAG,MYR) = SUMXY / SUMXX
CC
   40 CONTINUE
CC
CC..Since the NOx emissions are not combined from emission level
CC..groups, the NOx emission factors can be calculated directly
CC..from the regressions.
CC
      IP=3
CC
      DO 50 MYR=1,12
       ISTD=1
       IF(MYR.GE.3) ISTD=2
      DO 50 IBAG=1,4
      DO 50 ITECH=1,3
CC
      ZML(IP,IBAG,MYR) = ZML(IP,IBAG,MYR) +
     *  EN0(IP,IBAG,ITECH,ISTD)*FRAC(ITECH,MYR)
CC
      DET(IP,IBAG,MYR) = DET(IP,IBAG,MYR) +
     *  DN(IP,IBAG,ITECH,ISTD)*FRAC(ITECH,MYR)
CC
      ZML1(IP,IBAG,MYR)=ZML(IP,IBAG,MYR)
      DET1(IP,IBAG,MYR)=DET(IP,IBAG,MYR)
      DET2(IP,IBAG,MYR)=DET(IP,IBAG,MYR)
CC
   50 CONTINUE
CC
      CALL BAGF
CC
  999 RETURN
      END
```

```
      SUBROUTINE BAGF
CC
CC..This routine calculates the bag fractions for hot/cold starts
CC
CC..Last Updated : November 15, 1988
CC
      COMMON /DAT01/ MYR,ISTD,ITECH,IBAG,IP,IAGE,ICUT,ITST
      COMMON /DAT12/ ZML(3,4,12),ZML1(3,4,12),ZML2(3,4,12)
      COMMON /DAT13/ BFZML1(3,4,12),BFDET1(3,4,12)
      COMMON /DAT14/ DET(3,4,12),DET1(3,4,12),DET2(3,4,12)
      COMMON /DAT21/ BFDET2(3,4,12),BFZML2(3,4,12)
CC
      DIMENSION BFRAC(4)
CC
      DATA BFRAC  / 1.000, 0.206, 0.521, 0.273 /
CC
      DO 20 IP=1,3
      DO 20 MYR=1,12
CC
       Z2 = 0.0
       Z3 = 0.0
       D2 = 0.0
       D3 = 0.0
CC
CC..Sum up the bag regression coeffs weighted by the FTP bag fractions
CC
      DO 10 IBAG=2,4
CC
       Z2 = Z2 + ZML1(IP,IBAG,MYR)  * BFRAC(IBAG)
       Z3 = Z3 + ZML2(IP,IBAG,MYR) * BFRAC(IBAG)
       D2 = D2 + DET1(IP,IBAG,MYR)  * BFRAC(IBAG)
       D3 = D3 + DET2(IP,IBAG,MYR) * BFRAC(IBAG)
CC
   10 CONTINUE
CC
CC..Set the combined FTP bag fraction to 1.00
CC
      BFZML1(IP,1,MYR)  = Z2 / Z2
      BFZML2(IP,1,MYR) = Z3 / Z2
      BFDET1(IP,1,MYR)  = D2 / Z2
      BFDET2(IP,1,MYR) = D3 / Z2
CC
CC..Divide each bag regression coeff by the weighted sum
CC
      DO 20 IBAG=2,4
CC
       BFZML1(IP,IBAG,MYR) = ZML1(IP,IBAG,MYR) / Z2
       BFZML2(IP,IBAG,MYR) = ZML2(IP,IBAG,MYR) / Z2
       BFDET1(IP,IBAG,MYR) = DET1(IP,IBAG,MYR) / Z2
       BFDET2(IP,IBAG,MYR) = DET2(IP,IBAG,MYR) / Z2
CC
   20 CONTINUE
CC
      RETURN
      END
```

```
      SUBROUTINE JAN1
CC
CC..This subroutine calculates the average emissions of each
CC..model year on January first.  It creates the I/M credits
CC..and passes them to OUTPUT.
CC
      COMMON /DAT02/ AMIL(20),ODOM(20),TMILE(20),WGT(20)
      COMMON /DAT10/ EWO(2,4,20,12),EIMW(2,4,20,12,3),EZM(2,4,12)
      COMMON /DAT11/ CREDIT(2,20,12,3,4)
      COMMON /DAT12/ ZML(3,4,12),ZML1(3,4,12),ZML2(3,4,12)
      COMMON /DAT14/ DET(3,4,12),DET1(3,4,12),DET2(3,4,12)
CC
      DIMENSION ANSWNO(2,20,12),ANSWIM(2,20,12,3,3)
      DIMENSION EPRED(2,4,20,12,3),PRED(2,4,20,12,3)
      DIMENSION SLOPE(2,12,21),ZERO(2,12,21)
CC
CC
      IBAG = 1
      DO 100 MYR  = 1,12
      DO 100 IP   = 1,2
CC
CC..The deteriorations before and after the "KINK" are transferred
CC..to the array SLOPE for each vehicle age.
CC
      DO 95 I = 1,20
CC
       IF(I.LE.4)  SLOPE(IP,MYR,I) = DET1(IP,IBAG,MYR)
       IF(I.GE.5)  SLOPE(IP,MYR,I) = DET2(IP,IBAG,MYR)
CC
       IF(I.LE.4)  ZERO(IP,MYR,I) = ZML1(IP,IBAG,MYR)
       IF(I.GE.5)  ZERO(IP,MYR,I) = ZML2(IP,IBAG,MYR) -
     *                              DET2(IP,IBAG,MYR)*5.0
CC
   95 CONTINUE
CC
CC..Computes the NON-I/M emission level by age, by pollutant,
CC..by bag, and by myr.
CC
      DO 100 IAGE = 1,19
CC
      IF(IAGE .GT. 1) GOTO 33
CC
CC..Vehicle age is one.
CC
      ANSWNO(IP,IAGE,MYR) =
     *.75*(ZERO(IP,MYR,IAGE) + SLOPE(IP,MYR,IAGE)*.625*ODOM(IAGE) ) +
     *.25*(ZERO(IP,MYR,IAGE+1) + SLOPE(IP,MYR,IAGE+1)*
     *        (.125*(ODOM(IAGE+1)-ODOM(IAGE))+ODOM(IAGE)) )
      GOTO 34
CC
CC..Vehicle age is greater than one.
CC
   33 ANSWNO(IP,IAGE,MYR) =
     *.75*(ZERO(IP,MYR,IAGE) + SLOPE(IP,MYR,IAGE) *
     *        (.625*(ODOM(IAGE)-ODOM(IAGE-1))+ODOM(IAGE-1)) )  +
     *.25*(ZERO(IP,MYR,IAGE+1) + SLOPE(IP,MYR,IAGE+1) *
     *        (.125*(ODOM(IAGE+1)-ODOM(IAGE))+ODOM(IAGE)) )
CC
```

```
CC..Compute the I/M emission level by age, by pollutant,
CC..by bag, by myr and by test for IAGE = 1.  The predicted emission
CC..level is from the regression equation and the actual model
CC..emission level points.
CC
   34 DO 100 ITEST=1,3
CC
      EPRED(IP,IBAG,IAGE,MYR,ITEST) =
     * 1 -  ((EWO(IP,IBAG,IAGE,MYR) - EIMW(IP,IBAG,IAGE,MYR,ITEST)) /
     *                      EWO(IP,IBAG,IAGE,MYR))
CC
      PRED(IP,IBAG,IAGE,MYR,ITEST) =
     *    (ZERO(IP,MYR,IAGE) + SLOPE(IP,MYR,IAGE)*ODOM(IAGE)) *
     *     EPRED(IP,IBAG,IAGE,MYR,ITEST)
CC
CC..Determine I/M credits for each inspection frequency.
CC
CC      ITYP = 1 : Annual
CC             2 : Biennial 1 - 3 - 5 - etc
CC             3 : Biennial 2 - 4 - 6 - etc
CC
      DO 110 ITYP = 1,3
CC
       IF(ITYP.GE.2) GOTO 60
CC
CC..Annual I/M Credits
CC
      IF(IAGE .GT. 1) GOTO 50
CC
      ANSWIM(IP,IAGE,MYR,ITEST,ITYP) =
     *  (.75*(.625*SLOPE(IP,MYR,IAGE)*ODOM(IAGE)  + ZERO(IP,MYR,IAGE)))
     * + .25*(PRED(IP,IBAG,IAGE,MYR,ITEST) + SLOPE(IP,MYR,IAGE+1)*
     *         (.125*(ODOM(IAGE+1)-ODOM(IAGE))) )
      GOTO 60
CC
   50 ANSWIM(IP,IAGE,MYR,ITEST,ITYP) =
     *.75*(PRED(IP,IBAG,IAGE-1,MYR,ITEST) +
     *  SLOPE(IP,MYR,IAGE) * (.625*(ODOM(IAGE)-ODOM(IAGE-1))) ) +
     *.25*(PRED(IP,IBAG,IAGE,MYR,ITEST) +
     *  SLOPE(IP,MYR,IAGE+1) * (.125*(ODOM(IAGE+1)-ODOM(IAGE))) )
CC
      GOTO 90
CC
CC..Biennial I/M Credits
CC
CC    IMODE =  1 :  Odd year
CC             2 :  Even year
CC
   60 IMODE = MOD(IAGE,2)
CC
CC..Biennial 1 - 3 - 5 - etc   1st Year Exception
CC..            same as no I/M first year
CC
      IF(ITYP .EQ. 2 .AND. IAGE .EQ. 1)
     *   ANSWIM(IP,IAGE,MYR,ITEST,ITYP) =
     *  (.75*(.625*SLOPE(IP,MYR,IAGE)*ODOM(IAGE)  + ZERO(IP,MYR,IAGE)))
     * + .25*(PRED(IP,IBAG,IAGE,MYR,ITEST) + SLOPE(IP,MYR,IAGE+1)*
     *         (.125*(ODOM(IAGE+1)-ODOM(IAGE))) )
```

```
CC
CC..Biennial 2 - 4 - 6 - etc   1st Year Exception
CC..           same as no I/M first year
CC
      IF(ITYP .EQ. 3 .AND. IAGE .EQ. 1)
     *  ANSWIM(IP,IAGE,MYR,ITEST,ITYP) =
     *   .75*(ZERO(IP,MYR,IAGE) + SLOPE(IP,MYR,IAGE)*.625*ODOM(IAGE))+
     *   .25*(ZERO(IP,MYR,IAGE) + SLOPE(IP,MYR,IAGE+1)*
     *  (.125*(ODOM(IAGE+1)-ODOM(IAGE))+ODOM(IAGE)) )
CC
CC..Biennial 2 - 4 - 6 - etc   2nd Year Exception
CC
      IF(ITYP .EQ. 3 .AND. IAGE .EQ. 2)
     *         ANSWIM(IP,IAGE,MYR,ITEST,ITYP) =
     *    .75*(ZERO(IP,MYR,IAGE) +
     *         SLOPE(IP,MYR,IAGE)*(ODOM(IAGE-1)) +
     *         SLOPE(IP,MYR,IAGE)*(.625*(ODOM(IAGE)-ODOM(IAGE-1)))) +
     *    .25*(PRED(IP,IBAG,IAGE,MYR,ITEST) +
     *         SLOPE(IP,MYR,IAGE+1)*.125*(ODOM(IAGE+1)-ODOM(IAGE)))
CC
      IF(IAGE.EQ.1 .OR. (ITYP.EQ.3 .AND. IAGE.EQ.2))  GOTO 90
CC
CC..The Principle Biennial Cases 1-3-5-etc and 2-4-6-etc
CC
CC..An Even Year for the 1-3-5 or An Odd Year for the 2-4-6
CC         There is no I/M inspection that year
CC
      IF((IMODE.EQ.1 .AND. ITYP.EQ.3) .OR. (IMODE.EQ.0.AND.ITYP.EQ.2))
     *        ANSWIM(IP,IAGE,MYR,ITEST,ITYP) =
     *   .75*(PRED(IP,IBAG,IAGE-1,MYR,ITEST) +
     *        SLOPE(IP,MYR,IAGE)*(.625*(ODOM(IAGE)-ODOM(IAGE-1)))) +
     *   .25*(PRED(IP,IBAG,IAGE-1,MYR,ITEST) +
     *        SLOPE(IP,MYR,IAGE)*(ODOM(IAGE)-ODOM(IAGE-1)) +
     *        SLOPE(IP,MYR,IAGE+1)*.125*(ODOM(IAGE+1)-ODOM(IAGE)))
CC
CC..An Odd Year for the 1-3-5 or An Even Year for the 2-4-6
CC..          There is an I/M inspection that year
CC
      IF((IMODE.EQ.0 .AND. ITYP.EQ.3) .OR. (IMODE.EQ.1.AND.ITYP.EQ.2))
     *        ANSWIM(IP,IAGE,MYR,ITEST,ITYP) =
     *    .75*(PRED(IP,IBAG,IAGE-2,MYR,ITEST) +
     *         SLOPE(IP,MYR,IAGE-1)*(ODOM(IAGE-1)-ODOM(IAGE-2)) +
     *         SLOPE(IP,MYR,IAGE)*(.625*(ODOM(IAGE)-ODOM(IAGE-1)))) +
     *    .25*(PRED(IP,IBAG,IAGE,MYR,ITEST)  +
     *         SLOPE(IP,MYR,IAGE+1)*(.125*(ODOM(IAGE+1)-ODOM(IAGE))))
CC
CC..Combined 1-3-5 and 2-4-6 biennial cases
CC
   90 CREDIT(IP,IAGE,MYR,ITEST,ITYP) =
     * (ANSWNO(IP,IAGE,MYR)-ANSWIM(IP,IAGE,MYR,ITEST,ITYP))
     *          / (ANSWNO(IP,IAGE,MYR))
CC
  110 CONTINUE
CC
CC..Store resulting I/M credits
CC
        CREDIT(IP,IAGE,MYR,ITEST,4) =
     *  (CREDIT(IP,IAGE,MYR,ITEST,2) + CREDIT(IP,IAGE,MYR,ITEST,3))/2
```

```
CC
  100 CONTINUE
CC
      RETURN
      END
```

```
      SUBROUTINE OUTPUT
CC
CC..Outputs results for emission factors, bag fractions and
CC..I/M credits.
CC
      COMMON /DAT11/ CREDIT(2,20,12,3,4)
      COMMON /DAT12/ ZML(3,4,12),ZML1(3,4,12),ZML2(3,4,12)
      COMMON /DAT13/ BFZML1(3,4,12),BFDET1(3,4,12)
      COMMON /DAT14/ DET(3,4,12),DET1(3,4,12),DET2(3,4,12)
      COMMON /DAT21/ BFDET2(3,4,12),BFZML2(3,4,12)
CC
      INTEGER ITEST,ICUTS,STD,IP,IBY,IBAG
      CHARACTER*4 LAB1(3)/'  HC',' CO',' NOX'/
      CHARACTER*4 LAB2(5)/'FTP ',
     *                   'BAG1',
     *                   'BAG2',
     *                   'BAG3',
     *                   'BAGI'/
CC
      NP = 3
      N1 = 1
      N3 = 3
CC
CC..Write out Annual I/M credits on Device #7
CC
      WRITE(7,102) N3
      DO 10 ITEST=1,3
      DO 10 MYR=1,12
        NYR=1980+MYR
      DO 10 IP=1,2
        WRITE(7,200) (CREDIT(IP,IAGE,MYR,ITEST,1),IAGE=1,19),
     *     NYR,LAB1(IP)
   10 CONTINUE
CC
CC..Write out Biennial I/M Credits on Device #1
CC
      WRITE(1,103) N3
      DO 130 ITEST=1,3
      DO 130 MYR=1,12
        NYR=1980+MYR
      DO 130 IP=1,2
        WRITE(1,200) (CREDIT(IP,IAGE,MYR,ITEST,4),IAGE=1,19),
     *     NYR,LAB1(IP)
  130 CONTINUE
CC
CC..Write out MOBILE4 Emission Facors on Device #8
CC
      WRITE(8,100) N1
      WRITE(8,600)
      DO 20 IP=1,NP
      WRITE(8,500)
      DO 20 MYR=1,12
      NYR=1980+MYR
      IBAG=1
      T50 = ZML1(IP,IBAG,MYR) + 5.0*DET1(IP,IBAG,MYR)
      T100 = T50 + 5.0*DET2(IP,IBAG,MYR)
      WRITE(8,300) NYR,LAB2(IBAG),LAB1(IP),
     *  ZML1(IP,IBAG,MYR),DET1(IP,IBAG,MYR),DET2(IP,IBAG,MYR),
```

```
     *   T50,T100,ZML(IP,IBAG,MYR),DET(IP,IBAG,MYR)
   20 CONTINUE
CC
CC..Write out bag fractions on Device #9
CC
      WRITE(9,101) N1
      DO 30 IP=1,3
      WRITE(9,500)
      DO 30 MYR=1,12
      NYR=1980+MYR
      WRITE(9,400) NYR,LAB1(IP),
     *(BFZML1(IP,IBAG,MYR),BFDET1(IP,IBAG,MYR),BFZML2(IP,IBAG,MYR),
     *                   BFDET2(IP,IBAG,MYR),IBAG=2,4),
     * BFZML1(IP,1,MYR),BFDET1(IP,1,MYR),BFZML2(IP,1,MYR),
     *                BFDET2(IP,1,MYR)
   30 CONTINUE
CC
  100 FORMAT(I1,/,' **',/,
     *' ** MOBILE4 LDGV Emission Factors',
     *'  (February 1989) ',
     */,' **')
  101 FORMAT(I1,/,/,
     *' ** MOBILE4 LDGV Bag Fractions (February 1989)**',/,/,
     *23X,'Bag 1',20X,'Bag 2',25X,'Bag 3',25X,'FTP',/,
     *9X,4('    -------------------------'),/,
     *9X,4('    ZML1   DET1   ZML2   DET2'),/,
     *9X,4('    ----   ----   ----   ----'))
  102 FORMAT(I1,/,' **',/,
     *' ** MOBILE4 Annual I/M Credits (February 1989)',
     */,' **')
  103 FORMAT(I1,/,' **',/,
     *' ** MOBILE4 Biennial I/M Credits (February 1989)',
     */,' **')
  200 FORMAT(19F4.3,5X,I4,A4)
  600 FORMAT(29X,'  ZML ',3X,' DET1 ',18X,' DET2 ',18X,
     * '      @ 50k','     @100k',3X,'  ZML ',3X,'  DET ')
  300 FORMAT(
     * 1X,I4,' EF Equation : ',2A4,'=',
     * F6.3,' + ',F6.3,' * Mi/10k(<50K)',3X,
     * F6.3,' * Mi/10k(>50K)',3X,2F10.3,2(3X,F6.3))
  400 FORMAT(1X,I4,A4,16F7.4)
  500 FORMAT('-')
CC
      RETURN
      END
```

```
      BLOCK DATA BD01
CC
CC..This block data is used to initialize data arrays
CC
      COMMON /DAT10/ EWO(2,4,20,12),EIMW(2,4,20,12,3),EZM(2,4,12)
      COMMON /DAT12/ ZML(3,4,12),ZML1(3,4,12),ZML2(3,4,12)
      COMMON /DAT14/ DET(3,4,12),DET1(3,4,12),DET2(3,4,12)
CC
      DATA EWO  / 1920*0.0 /
      DATA EIMW / 5760*0.0 /
      DATA EZM  /   96*0.0 /
CC
      DATA ZML  / 144*0.0 /
      DATA ZML1 / 144*0.0 /
      DATA ZML2 / 144*0.0 /
CC
      DATA DET  / 144*0.0 /
      DATA DET1 / 144*0.0 /
      DATA DET2 / 144*0.0 /
CC
      END
```

```
      BLOCK DATA BD02
CC
CC..Emission Level Data Block
CC
      COMMON /DAT05/ SN0(3,2),SM0(3,2)
      COMMON /DAT07/ ES0(2,4,3,2),EH0(2,4,3,2)
      COMMON /DAT19/ GM(3,2),GH(3,2),GS(3,2),BEND(3,2)
CC
CC
CC..Change in the rate of increase in the number of HIGH emitters
CC..                  BEND(ITECH,ISTD)
CC
      DATA BEND / 6*3.1031 /
CC
CC..Growth in the number of SUPERS per 10,000 miles
CC..            GS(ITECH,ISTD)
CC
      DATA GS  / 6*.002180 /
CC
CC..Growth in the number of HIGHS per 10,000 miles
CC..            GH(ITECH,ISTD)
CC
CC                    CARB        FI         OPLP
      DATA GH /    .016257,    .022202,    .011799,
     *             .023528,    .015340,    .008304 /
CC
CC..Number of FTP failures at zero miles
CC..           SM0(ITECH,ISTD)
CC
      DATA SM0 /    .20788,     .10564,     .35484,
     *              .088884,    .35977,     .70248 /
CC
CC..Growth in the number of FTP failures per 10,000 miles
CC.. (Used to calculate the number of Marginal Emitters)
CC..                 GM(ITECH,ISTD)
CC
      DATA GM /    0.095371,   0.078771,   0.073221,
     *             0.094791,   0.067288,   0.028347  /
CC
CC..Average emissions of SUPERS (from 17 EF & IM vehicles)
CC..             ES0(IP,IBAG,ITECH,ISTD)
CC
      DATA ES0 /
CC..1981,1982 model year vehicles
     1 14.272, 171.732, 17.118,169.759,15.239,184.853,10.256,148.371,
     2 14.272, 171.732, 17.118,169.759,15.239,184.853,10.256,148.371,
     3  0.00,    0.00,   0.000,  0.000, 0.000,  0.000, 0.000,  0.000,
CC..1983 and newer model year vehicles
     1 14.272, 171.732, 17.118,169.759,15.239,184.853,10.256,148.371,
     2 14.272, 171.732, 17.118,169.759,15.239,184.853,10.256,148.371,
     3  0.00,    0.00,   0.000,  0.000, 0.000,  0.000, 0.000,  0.000 /
CC
CC..Emission Levels of HIGH Emitters at zero miles
CC..        EH0(IP,IBAG,ITECH,ISTD)
CC
      DATA EH0/
CC..1981,1982 model year vehicles
     * 2.1984, 33.659, 4.207,47.426,1.797,32.582,1.445,25.324,
```

```
      * 0.8610, 11.901, 1.883,30.409,0.568,06.391,0.601,06.749,
      * 2.1793, 31.933, 3.604,47.209,1.686,27.176,2.030,28.150,
CC..1983 and newer vehicles
      * 0.9543, 13.197, 2.769,32.539, .172, 5.854, .582,13.530,
      * 1.2596, 13.789, 2.226,29.151, .986, 9.183, .998,10.604,
      * 2.1224, 32.014, 3.961,54.979,1.532,24.740,1.839,26.080 /
CC
       END
```

```
      BLOCK DATA BD03
CC
CC..I/M effects block data (IDR & Repair Effects)
CC
      COMMON /DAT16/ XSIDR(2,3,2,3),XHIDR(2,3,2,3)
      COMMON /DAT17/ RSUP(2,3,2,3),RHIG(2,3,2,3)
      COMMON /DAT22/ RMAR(2,3,2,3)
      COMMON /DAT24/ XMIDR(2,3,2,3)
CC
CC..Emission level after repairs expressed as a fraction of
CC..the emission level before repairs.
CC
CC..                RSUP(IP,ITECH,ISTD,ITEST)
CC
       DATA RSUP/
CC..Idle test emission effect from repairs for SUPERS
     1       .851, .919, .699, .755, .000, .000,
     2       .851, .919, .699, .755, .000, .000,
CC..2500/Idle test emission effect of repairs for SUPERS
     1       .834, .892, .908, .974, .000, .000,
     2       .834, .892, .908, .974, .000, .000,
CC..Loaded/Idle test emission effect of repairs for SUPERS
     1       .834, .892, .908, .974, .000, .000,
     2       .834, .892, .908, .974, .000, .000/
CC
CC..                RHIG(IP,ITECH,ISTD,ITEST)
CC
       DATA RHIG/
CC..Idle test emission effect from repairs for HIGHS
     1       .514, .568, .603, .683, .561, .665,
     2       .514, .568, .603, .683, .561, .665,
CC..2500/Idle test emission effect of repairs for HIGHS
     1       .583, .639, .649, .749, .596, .725,
     2       .583, .639, .649, .749, .596, .725,
CC..Loaded/Idle test emission effect of repairs for HIGHS
     1       .583, .639, .649, .749, .596, .725,
     2       .583, .639, .649, .749, .596, .725 /
CC
CC..                RMAR(IP,ITECH,ISTD,ITEST)
CC
       DATA RMAR/
CC..Idle test emission effect from repairs for MARGINALS
     1       .209, .247, .268, .320, .208, .372,
     2       .209, .247, .268, .320, .208, .372,
CC..2500/Idle test emission effect of repairs for MARGINALS
     1       .206, .232, .268, .320, .145, .301,
     2       .206, .232, .268, .320, .145, .301,
CC..Loaded/Idle test emission effect of repairs for MARGINALS
     1       .206, .232, .268, .320, .145, .301,
     2       .206, .232, .268, .320, .145, .301 /
CC
CC..The fraction of excess emissions identified by the short
CC..test for each emission level group.
CC
CC..                XSIDR(IP,ITECH,ISTD,ITEST)
CC
       DATA XSIDR/
CC..Idle test identification rate for SUPERS
```

```
     1          .5526,.7172,.5526,.7172,.0,    .0,
     2          .5526,.7172,.5526,.7172,.0,    .0,
CC..2500/Idle test identification rate for SUPERS
     1          .5526,.7172,.5526,.7172,.0,    .0,
     2          .5526,.7172,.5526,.7172,.0,    .0,
CC..Loaded/Idle test identification rate for SUPERS
     1          .5863,.8490,.5863,.8490,.0,    .0,
     2          .5863,.8490,.5863,.8490,.0,    .0 /
CC
CC..                XHIDR(IP,ITECH,ISTD,ITEST)
CC
      DATA XHIDR/
CC..Idle test identification fraction for HIGHS
     1          .3574,.4124,.1557,.2374,.6061,.6114,
     2          .3574,.4124,.1557,.2374,.6061,.6114,
CC..2500/Idle test identification fraction for HIGHS
     1          .4290,.4990,.1893,.2580,.7157,.7747,
     2          .4290,.4990,.1893,.2580,.7157,.7747,
CC..Loaded/Idle test identification fraction for HIGHS
     1          .5399,.6376,.1893,.2580,.6622,.7582,
     2          .5399,.6376,.1893,.2580,.6622,.7582 /
CC
CC..                XMIDR(IP,ITECH,ISTD,ITEST)
CC
      DATA XMIDR/
CC..Idle test identification fraction for MARGINALS
     1          .0334,.0151,.0746,.0833,.0380,.0486,
     2          .0334,.0151,.0746,.0833,.0380,.0486,
CC..2500/Idle test identification fraction for MARGINALS
     1          .0334,.0151,.0830,.0860,.0520,.0690,
     2          .0334,.0151,.0830,.0860,.0520,.0690,
CC..Loaded/Idle test identification fraction for MARGINALS
     1          .0571,.0536,.1129,.1254,.0455,.0925,
     2          .0571,.0536,.1129,.1254,.0455,.0925 /
CC
      END
```

```
      BLOCK DATA BD04
CC
CC..Fleet Description Block
CC
      COMMON /DAT02/ AMIL(20),ODOM(20),TMILE(20),WGT(20)
      COMMON /DAT06/ FRAC(3,12)
CC
CC..Technology Sales Fractions Projections
CC..        FRAC(ITECH,MYR)
CC
      DATA FRAC /
CC      CARB   FI   OPLP
CC..1981 Model Year
     * .635, .084, .281,
CC..1982 Model Year
     * .499, .171, .330,
CC..1983 Model Year
     * .456, .303, .241,
CC..1984 Model Year
     * .460, .485, .055,
CC..1985 Model Year
     * .393, .545, .062,
CC..1986 Model Year
     * .260, .670, .070,
CC..1987 Model Year
     * .239, .747, .014,
CC..1988 Model Year
     * .189 ,.811, .000,
CC..1989 Model Year
     * .163, .837, .000,
CC..1990 Model Year
     * .137, .863, .000,
CC..1991 Model Year
     * .084, .916, .000,
CC..1992 and Newer Model Years
     * .043, .957, .000 /
CC
CC..Fleet January 1st VMT weighting factors (MOBILE4)
CC
      DATA WGT / 0.030, 0.120, 0.111, 0.099, 0.088,
     *           0.078, 0.068, 0.060, 0.054, 0.048,
     *           0.043, 0.038, 0.033, 0.028, 0.024,
     *           0.020, 0.017, 0.013, 0.010, 0.019/
CC
CC..Fleet average odometer mileage by vehicle age (MOBILE4)
CC
      DATA ODOM/ 1.3118, 2.6058, 3.8298, 4.9876, 6.0829,
     *           7.1190, 8.0991, 9.0262, 9.9031,10.7326,
     *          11.5172,12.2594,12.9615,13.6257,14.2540,
     *          14.8483,15.4104,15.9421,16.4451,16.9209/
CC
      END
```

```
      BLOCK DATA BD05
CC
CC..Emission Level Data Block
CC
      COMMON /DAT08/ DM(2,4,3,2),DN(3,4,3,2)
      COMMON /DAT20/ EM0(2,4,3,2),EN0(3,4,3,2)
CC
CC
CC..Emission level of MARGINALs at zero mileage
CC..            EM0(IP,IBAG,ITECH,ISTD)
CC
      DATA EM0/
CC..1981,1982 model year vehicles
     1 0.5333, 5.358, 1.321,15.34,.276,2.16,.426,3.89,
     2 0.4277, 5.333, 1.095,14.89,.222,2.66,.282,2.08,
     3 0.4684, 6.818,  .822,12.69,.310,3.35,.496,6.91,
CC..1983 and newer model year vehicles
     1 0.3482, 4.602, .889,15.81,.184,1.17,.245,3.48,
     2 0.3668, 4.360, .939, 9.76,.159,2.28,.293,3.97,
     3 0.3703, 4.881, .787,12.10,.200,1.32,.379,5.16 /
CC
CC..Emission deterioration MARGINALs per 10,000 miles
CC..              DM(IP,IBAG,ITECH,ISTD)
CC
      DATA DM/
CC..1981,1982 model year vehicles
     1 0.00871, 0.3490, .015, .812,.008, .223,.005, .238,
     2 0.01129, 0.1731, .000, .000,.012, .153,.025, .574,
     3 0.01372, 0.1211, .063,1.261,.002, .000,.000, .000,
CC..1983 and newer model year vehicles
     1 0.02071, 0.1089, .056, .056,.006, .000,.024, .118,
     2 0.00077, 0.0853, .000, .128,.007, .154,.000, .000,
     3 0.02295, 0.1080, .005, .000,.027, .233,.031, .336 /
CC
CC
CC..Emission level of vehicles passing FTP at zero mileage
CC..            EN0(IP,IBAG,ITECH,ISTD)
CC
      DATA EN0 /
CC..1981,1982 model year vehicles
     1 0.2437, 2.686, 0.6781, .66,8.45,1.2,.10, .64,.49,.20,2.19,.64,
     2 0.2288, 2.368, 0.4995, .70,5.74,.88,.09,1.38,.39,.14,1.69,.43,
     3 0.2600, 2.465, 0.6333, .57,7.19,.97,.15, .68,.50,.24,2.22,.64,
CC..1983 and newer model year vehicles
     1 0.1924, 1.619, 0.7030, .49,5.34,1.1,.09, .22,.52,.15,1.45,.76,
     2 0.2317, 2.176, 0.6322, .64,5.88,1.0,.09, .84,.48,.17,1.92,.63,
     3 0.2395, 2.385, 0.4893, .48,8.19,.60,.17, .24,.44,.25,2.12,.49 /
CC
CC..Emission deterioration of vehicles passing FTP per 10,000 miles
CC..                DN(IP,IBAG,ITECH,ISTD)
CC
      DATA DN /
CC..1981,1982 model year vehicles
     1 .01223, .1557, .0689, .019,.29,.06,.011,.14,.07,.011,.09,.09,
     2 .01106, .2391, .1358, .020,.68,.14,.009,.12,.12,.009,.14,.16,
     3 .01237, .1256, .0410, .047,.56,.03,.004,.04,.04,.002,.00,.05,
CC..1983 and newer model year vehicles
     1 .01615, .1089, .0340, .033,.28,.03,.011,.05,.03,.013,.10,.04,
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     2 .00387, .0781, .0338, .020,.05,.04,.002,.10,.02,.000,.05,.05,
     3 .01237, .1256, .0559, .023,.00,.07,.000,.23,.05,.000,.00,.05 /
CC
      END
```