Appendix G

SAMPLE CALCULATION OF MOTOR VEHICLE EMISSIONS

This appendix presents procedures for calculating emission factors in a step-by-step manner. Although most users of motor vehicle emission factors would rely on computerized calculations (such as those performed by MOBILE5), this sample calculation should prove useful to those just becoming familiar with the methodologies presented in this document.

The January 1, 1995 hydrocarbon (HC) emissions of light-duty gasoline vehicles (LDGVs) are computed in the sample calculation. All of the eight vehicle types discussed in Chapters 1-8 of this document should be included in a complete inventory of motor vehicle HC emission sources. For each vehicle type, the exhaust emission factors are calculated with the equations presented in the corresponding chapter. Each resultant exhaust emission factor is first multiplied by the VMT fraction of the respective vehicle type to give a weighted exhaust emission factor. The weighted figures are then summed to give the average grams-per-mile exhaust emission levels for the entire highway mobile source fleet. For HC emission estimates, the crankcase and five other sources of evaporative HC emissions (i.e., hot soak, diurnal, running loss, resting loss, and refueling emissions) are also calculated. These are all added to the exhaust HC emission estimates to provide total vehicular HC emissions.

G.1 Data Requirements

Before determining what data are required, the user should review the standard conditions under which vehicles are tested (discussed in section .A.1 of each chapter) to ascertain if and to what degree these conditions differ from the conditions of interest for the intended application of the results. The modeler will generally want to specify different values than those used herein for ambient temperature, average traffic speed, and vehicle operating mode fractions.

In particular, the user will typically wish to consider use of the following locality-specific data:

1. Daily minimum and maximum ambient temperatures in degrees Fahrenheit.
2. Fractions of January 1 travel, by model year, for each vehicle type (determined from registration distributions by age and annual mileage accumulation rates by age).
3. The VMT mix (fractions of total VMT accumulated by each vehicle type).
4. Percent of VMT in cold-start and hot-start operating modes for light-duty gas vehicles, light-duty gas trucks, and motorcycles.
5. The calendar year of evaluation (emission factors can be calculated as of January 1 or July 1 of the year specified).
6. The level of in-use fuel volatility (now generally regulated during the summer ozone season).

G.2 Conditions for the Sample HC Emissions Calculation

For this sample calculation, the following conditions are assumed:

1. Daily minimum and maximum ambient temperatures are 60° and 84°F, respectively.
2. National statistical data on average fleet annual mileage accumulation rates and vehicle registration by model year are used.
3. The total HC emissions (as opposed to nonmethane HC) are calculated for the average speed of 30 mph.
4. The percentages of VMT in the cold start, stabilized, and hot start operating modes are 40%, 30%, and 30% respectively, for light-duty vehicles (both catalyst and non-catalyst).
5. The calendar year of evaluation is 1995.
6. There are no inspection and maintenance (I/M) or anti-tampering programs in operation.
7. Fuel volatility is at the certification level of 9.0 psi Reid vapor pressure (RVP).
8. All other conditions match the standard vehicle test conditions.

G.3 Calculation of Exhaust Emission Factors

The equations for calculation of exhaust HC emission factors for LDGVs are discussed in Chapter 1.

Since the user levels in air-conditioning usage ($ACCF_{ipt}$), extra load ($XLCF_{ip}$), trailer towing ($TWCF_{ip}$), and humidity for NOx (HCF) are assumed to match those of the basic test conditions, these variables are each set equal to 1.0. As these are multiplicative correction factors to the basic exhaust emission rate, these will have no impact on the results in this sample calculation.

G.3.1 Basic Exhaust Emission Levels (BER)

The basic exhaust emission levels for LDGVs are the emission levels measured in grams per mile under the assumed standard test conditions. The HC exhaust emission levels on January 1, 1988 are listed in Table G-1. The model-year-specific emission factors for selected calendar years between 1985 and 2020 are presented in Appendix H, Tables VT.11A.R, VT.11B.R, and VT.11C.R (for HC, CO, and NOx respectively), where VT = vehicle type and R = region (1=low or 2=high altitude).

In MOBILE5, an adjustment to the basic emission rates to account for the effects of industry-average commercial gasoline is included in the BERs. This adjustment is primarily to account for the sulfur level of gasoline; while certification fuel used in most laboratory testing has a maximum sulfur content of 50 parts per million (ppm), the average sulfur content of gasoline nationwide is approximately 339 ppm. This has the effect of slightly increasing the emission factors.

G.3.2 Operating-Mode/Temperature Correction Factor (OMTCF)

The operating-mode/temperature correction factor can be calculated manually using the generalized equations in Chapter 1. The OMTCF values listed below in Table G-1 are calculated in MOBILE5 for a cold start/stabilized/hot start mix of 40%/30%/30%, and an ambient temperature of 78.1°F (representing a trip- and emission-weighted average temperature for a day with 60°F minimum and 84°F maximum temperatures).

G.3.3 Tampering Offset (OMTTAM)

The effects of tampering (i.e., the rate of each type of tampering and the associated emission impact) on each model year's emission rate are estimated and corrected for temperature and operating mode, as also listed in Table G-1.

G.3.4 Speed Correction Factor (SALCHF)

The average speed assumed in this example is 30 mph. The speed correction factors, used to correct emissions estimates from the average FTP speed of 19.6 mph and the modeled average speed of 30 mph, are shown in the fifth column (captioned "SALHCF") of Table G-1. If any of the additional correction factors (AC use, trailer towing and extra load) were used in this example, this would be the point at which they are applied (that is, the value of SALHCF would include not only the speed correction factor but also the AC, trailer towing, and extra load corrections).

G.3.5 Travel Weighting Fractions (TFs)

To calculate the fraction of annual travel by model year, the model year fractions of in-use vehicles are weighted on the basis of annual rate of mileage accumulation. In many cases, locality-specific data on automobile use and registration are readily available. In general, local data should always be used whenever possible. But for this sample calculation, the national data on average fractions of annual travel are used. (These national average values are presented in Appendix H, Tables R.VT.5, where R = region and VT = vehicle type.) These travel weighting fractions or TF values, which are also listed in Table G-1, are used to weight the individual model year emission factors which are then summed to yield a fleet number.

G.3.6 Calculated Exhaust Emission Factors

The final step in the calculation of the exhaust HC emission factor for LDGVs is to multiply the basic emission rate (BER) by the operating mode/temperature correction factor (OMTCF), add the tampering offset (OMTTAM), and then multiply this sum by the speed correction factor (SALCHF) and travel fraction (TF). This procedure is shown in Table G-1. The emission factor is expressed in units of grams per vehicle mile traveled.

If the pollutant were CO or NOx, no further calculations would be needed to estimate the total emission factor, as these pollutants are emitted only in the form of exhaust (tailpipe) emissions. For

HC emission estimates, the additional calculations discussed in sections G.3.7 to G.3.9 also need to be performed to account for non-exhaust sources of emissions.

G.3.7 Crankcase and Evaporative HC Emission Levels (CCEVERT)

To calculate the crankcase and evaporative HC emission level, estimates of the model year crankcase emissions (CC), tampering offsets, hot soak (HS) and diurnal (DI) emissions, and tampering effects are needed. The estimated evaporative and crankcase emissions are shown in Table G-2. The model year fractions of annual travel (TF), same as in section G.3.5, are also needed for the calculations.

G.3.8 Refueling, Running Loss, and Resting Loss HC Emission Levels

The estimated refueling and running loss emissions are shown in Table G-2. Also needed for the calculations are the model year fractions of annual travel (TF), same as in section G.3.5.

G.3.9 Total HC Emission Factors

The sum of the emission factors derived in sections G.3.6 through G.3.8 gives the total HC emission factor, which equals (exhaust + evap + refueling + running loss + resting loss) = (1.412 + 0.317 + 0.173 + 0.292 + 0.065) = 2.25 grams/mile in this sample calculation.

Table G-1: Calculation of Exhaust HC Emission Factor* For LDGVs

Model Year(i)	BER	OMTCF	OMTTAM	SALHCF	TF	BEF**
1995	0.246	1.549	0.001	0.742	0.0237	0.0067
1994	0.330	1.458	0.007	0.742	0.1130	0.0409
1993	0.456	1.366	0.017	0.742	0.1123	0.0533
1992	0.558	1.310	0.026	0.742	0.1049	0.0589
1991	0.649	1.268	0.035	0.742	0.1017	0.0647
1990	1.009	1.178	0.046	0.748	0.0928	0.0857
1989	1.328	1.131	0.056	0.763	0.0835	0.0993
1988	1.583	1.102	0.066	0.777	0.0574	0.0807
1987	1.891	1.086	0.075	0.792	0.0484	0.0816
1986	2.239	1.076	0.089	0.801	0.0467	0.0934
1985	2.555	1.070	0.110	0.809	0.0430	0.0989
1984	2.771	1.060	0.120	0.797	0.0436	0.1062
1983	3.036	1.061	0.470	0.806	0.0357	0.1062
1982	3.363	1.108	0.515	0.798	0.0259	0.0877
1981	3.694	1.101	0.530	0.786	0.0157	0.0567
1980	3.738	1.378	1.445	0.684	0.0119	0.0537
1979	6.181	1.044	1.319	0.730	0.0085	0.0482
1978	6.377	1.043	1.319	0.730	0.0087	0.0506
1977	6.527	1.042	1.262	0.730	0.0061	0.0359
1976	6.702	1.041	1.306	0.717	0.0042	0.0249
1975	6.829	1.040	1.271	0.717	0.0030	0.0180
1974	6.087	1.013	0.202	0.706	0.0023	0.0103
1973	6.159	1.012	0.202	0.706	0.0018	0.0082
1972	6.227	1.011	0.067	0.795	0.0013	0.0066
≤1971	9.996	1.079	0.000	0.798	0.0040	0.0344
					Exhaust HC (g/mi) =	1.412

Notes:

* Ambient temperature 78.1°F; average traffic speed 30 mph; 40% cold start/30% hot start/ 30% stabilized operation; calendar year 1995 (as of January 1)

** BEF =(BER*OMTCF + OMTTAM) * SALHCF * TF

Table G-2: Calculation of Total HC Emissions Factor* for LDGVs

Model Year	BEF (exhaust)	Evap (CCEVRT)	Refuel. Loss	Run. Loss	Rest. Loss	TF	BEF + TF* (Evap + Refuel + Run. + Rest.)
1995	0.0067	0.110	0.170	0.193	0.038	0.0237	0.0188
1994	0.0409	0.112	0.170	0.194	0.039	0.1130	0.0991
1993	0.0533	0.121	0.170	0.195	0.041	0.1123	0.1125
1992	0.0589	0.129	0.170	0.196	0.043	0.1049	0.1153
1991	0.0647	0.137	0.169	0.197	0.050	0.1017	0.1209
1990	0.0857	0.174	0.167	0.238	0.052	0.0928	0.1443
1989	0.0993	0.221	0.165	0.276	0.056	0.0835	0.1593
1988	0.0807	0.253	0.162	0.311	0.064	0.0574	0.1260
1987	0.0816	0.306	0.164	0.345	0.069	0.0484	0.1244
1986	0.0934	0.348	0.166	0.377	0.085	0.0467	0.1390
1985	0.0989	0.404	0.171	0.408	0.092	0.0430	0.1451
1984	0.1062	0.454	0.176	0.436	0.101	0.0436	0.1571
1983	0.1062	0.510	0.179	0.464	0.105	0.0357	0.1511
1982	0.0877	0.565	0.179	0.489	0.112	0.0259	0.1225
1981	0.0567	0.620	0.186	0.514	0.121	0.0157	0.0793
1980	0.0537	1.007	0.198	0.537	0.128	0.0119	0.0760
1979	0.0482	1.073	0.229	0.558	0.135	0.0085	0.0652
1978	0.0506	1.141	0.233	0.579	0.143	0.0087	0.0688
1977	0.0359	2.167	0.251	0.598	0.151	0.0061	0.0552
1976	0.0249	2.268	0.264	0.617	0.160	0.0042	0.0388
1975	0.0180	2.371	0.292	0.634	0.169	0.0030	0.0284
1974	0.0103	2.477	0.322	0.651	0.179	0.0023	0.0186
1973	0.0082	2.588	0.322	0.666	0.189	0.0018	0.0150
1972	0.0066	2.701	0.317	0.681	0.200	0.0013	0.0117
≤1971	0.0344	3.913	0.319	1.156	0.211	0.0040	0.0568
HC (g/mi):**	1.412	0.317	0.173	0.292	0.065	--	2.249

Notes:

* Diurnal emissions based on 60° to 84°F, running and resting loss emissions corrected to 78.1°F; certification fuel volatility level of 9.0 psi; calendar year 1995 (as of January 1).

** BEF = ∑(Exh * TF), from previous table; intermediate sums under Evap, Refueling, Running loss, and Resting loss columns are also weighted by TF.