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**HANDBOOK OF AIR POLLUTANT EMISSIONS
FROM TRANSPORTATION SYSTEMS**

by

Richard R. Cirillo and Thomas D. Wolsko

ARGONNE NATIONAL LABORATORY

CENTER FOR ENVIRONMENTAL STUDIES

MASTER

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Richard R. Cirillo and Thomas D. Wolsko

Center for Environmental Studies

December 1973

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*Part of Environmental Impact of Transportation Systems Program conducted under subcontract number 31-109-38-2517 with the Illinois Institute for Environmental Quality.

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TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT	9
1.0 INTRODUCTION	9
2.0 MOTOR VEHICLES	11
2.1 MODEL YEAR EMISSION FACTORS	12
2.1.1 Light Duty Gasoline-powered Vehicles	12
2.1.2 Light Duty Diesel-powered Vehicles	17
2.1.3 Heavy Duty Gasoline-powered Vehicles	18
2.1.4 Heavy Duty Diesel-powered Vehicles	26
2.1.5 Cold Start Effects	27
2.1.6 Crankcase and Evaporative Emissions	39
2.1.7 Modal Emissions	43
2.1.8 Gaseous-fueled Vehicles	46
2.1.9 Motorcycles	49
2.2 EMISSION FACTOR ADJUSTMENTS	50
2.2.1 Deterioration	50
2.2.2 Speed	58
2.3 REGIONAL AND LOCAL EFFECTS	60
2.3.1 Local Travel Distribution	60
2.3.2 Vehicle Class Mix	64
2.3.3 Retrofit Program	65
2.4 MOTOR VEHICLE EMISSION FACTOR COMPUTATION	67
2.4.1 Calculation Procedure	67
2.4.2 Emission Factor Computer Program	69
2.5 SAMPLE PROBLEMS	77
2.5.1 Urban Central Business District	77
2.5.2 Urban Expressway	84
2.5.3 Suburban Shopping Center Complex	86
3.0 RAILROAD LOCOMOTIVES	89
4.0 AIRCRAFT	93
4.1 AIRPORT ACTIVITY LEVELS	95
4.2 AIRPORT EMISSION FACTORS	98
4.3 SAMPLE RESULTS	104

TABLE OF CONTENTS (cond.)

	<u>Page</u>
5.0 WATERBORNE VESSELS	106
5.1 INBOARD-POWERED VESSELS	106
5.2 OUTBOARD-POWERED VESSELS	107
APPENDIX A - TREFACT Program Listing	108
APPENDIX B - Motor Vehicle Emission Factor Tables	121
ACKNOWLEDGMENTS	178
REFERENCES	179

List of Figures

<u>No.</u>	<u>Title</u>	<u>Page</u>
2.1	1975 Federal Test Procedure Urban Driving Schedule	15
2.2	Heavy Duty Gasoline-powered Vehicle Emissions by Gross Vehicle Weight	22
2.3	Schematic of Heavy Duty Gasoline-powered Vehicle Emissions by Percent Power	23
2.4	Light Duty Gasoline-powered Vehicle CO Emissions vs Time .	28
2.5	Light Duty Gasoline-powered Vehicle Exhaust CO Deterioration	53
2.6	Light Duty Gasoline-powered Vehicle Exhaust HC Deterioration	54
2.7	Light Duty Gasoline-powered Vehicle Exhaust NO _x Deterioration	55
2.8	Heavy Duty Gasoline-powered Vehicle Exhaust Deterioration	57
2.9	Average Speed Correction Factors	59
2.10	TREFACT Input Data Deck Structure	70
4.1	Schematic of Sources of Airport Air Pollutant Emissions. .	94

List of Tables

<u>No.</u>	<u>Title</u>	<u>Page</u>
2.1	Exhaust Emission Factors for Light Duty Gasoline-powered Vehicles	13
2.2	Particulate and Sulfur Oxide Emission Factors for Light Duty Gasoline-powered Vehicles	17
2.3	Exhaust Emission Factors for Light Duty Diesel-powered Vehicles	18
2.4	9-Mode Federal Test Procedure for Heavy Duty Gasoline-powered Vehicles	19
2.5	Exhaust Emission Factors for Heavy Duty Gasoline-powered Vehicles	20
2.6	Particulate and Sulfur Oxide Emission Factors for Heavy Duty Gasoline-powered Vehicles	20
2.7	Motor Vehicle Manufacturers Association Heavy Duty Vehicle Weight Classification	24
2.8	Exhaust Emission Factors by Vehicle Weight Class for Heavy Duty Gasoline-powered Vehicles	25
2.9	Exhaust Emission Factors for Heavy Duty Diesel-powered Vehicles	27
2.10	Cold Start Ratios for Light Duty Gasoline-powered Vehicles	32
2.11	Cold Start Emission Factors for Light Duty Gasoline-powered Vehicles	33
2.12	Hot Operating Emission Factors for Light Duty Gasoline-powered Vehicles	34
2.13	Cold Start Ratios for Heavy Duty Gasoline-powered Vehicles	36
2.14	Cold Start Emission Factors for Heavy Duty Gasoline-powered Vehicles	37
2.15	Crankcase Hydrocarbon Emission Factors for Gasoline-powered Vehicles	40
2.16	Fuel Evaporative Hydrocarbon Emission Factors for Gasoline-powered Vehicles	41

List of Tables (Contd.)

<u>No.</u>	<u>Title</u>	<u>Page</u>
2.17	Fuel Evaporative Hydrocarbon Emission Factors for Gasoline-powered Vehicles by Source	42
2.18	Acceleration/Deceleration Modes and Driving Sequence	44
2.19	Light Duty Gasoline-powered Vehicle Modal Emission Ratios	45
2.20	Light Duty Gaseous-fuel-powered Vehicle Exhaust Emission Factors	47
2.21	Heavy Duty Gaseous-fuel-powered Vehicle Exhaust Emission Factors	48
2.22	Motorcycle Emission Factors	49
2.23	Exhaust Deterioration Factors for Light Duty Gasoline-powered Vehicles	51
2.24	Exhaust Deterioration Factors for Heavy Duty Gasoline-powered Vehicles	56
2.25	U.S. National Vehicle Age Distribution	61
2.26	Cook County, Illinois, Vehicle Age Distribution	61
2.27	U.S. National Average Rate of Miles Driven	62
2.28	Mileage Accumulation Fractions	64
2.29	U.S. National Vehicle Class Distribution	65
3.1	Railroad Locomotive Emission Factors	90
3.2	U.S. National Average Locomotive Emission Factors	91
3.3	Electric Rail System Emission Factors	92
4.1	Aircraft Classification Scheme	96
4.2	Service Times of Aircraft Ground Service Vehicles	97
4.3	Aircraft Landing-Takeoff Cycle Emission Factors	99

List of Tables (Contd.)

<u>No.</u>	<u>Title</u>	<u>Page</u>
4.4	Aircraft Modal Emission Factors	100
4.5	Typical Time-in-mode for Landing-Takeoff Cycle at a Metropolitan Airport	102
4.6	Aircraft Time-in-mode, O'Hare International Airport	102
4.7	Ground Service Vehicle Emission Factors	103
4.8	Airport Heating Plant Emission Factors	104
4.9	O'Hare Airport Emissions, 1972	105
4.10	Aircraft Emissions by Mode of LTO Cycle, O'Hare Airport 1972	105
5.1	Inboard-powered Waterborne Vessel Emission Factors.	106
5.2	Outboard-powered Waterborne Vessel Emission Factors	107

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ABSTRACT

This report describes procedures for estimating the rate of air pollutant emissions from transportation systems. Emission factors and computation techniques for motor vehicles, railroad locomotives, aircraft, and waterborne vessels are presented.

The major emphasis is on motor vehicle emission computations and data on model year emission rates, control device deterioration, and vehicle speed adjustments is given. Procedures for separating the cold start, computing evaporative emissions by source, and developing modewise emission factors are presented. TREFACT, a computer program designed to calculate motor vehicle emission factors, is described.

Emission factors for diesel and electric railroad locomotives are presented and discussed. Aircraft emissions are described in the context of total airport emissions. Emission factors for both inboard- and outboard-powered waterborne vessels are presented.

1.0 INTRODUCTION

Transportation systems are responsible for a significant amount of the air pollution in the U.S. and many other countries around the world. Since transportation is a vital element of the structure of any society, it is not possible to control its emissions by bringing the system to a halt. Air quality management officials must devise alternative schemes of maintaining acceptable levels of environmental quality while enabling both the transportation system and the society it serves to function.

The purpose of this report is to outline procedures that may be used to estimate the rate of air pollutant emissions from transportation systems. The report is intended for use by air pollution control agency officials, transportation planners, and anyone with the need to develop quantitative estimates of air pollutant emission rates. It is written on the assumption that even a reader with only a marginal background in transport-generated air pollution will be able to generate adequate estimates of emissions. For the more knowledgeable reader, it represents the latest available data and computation routines being utilized.

This report is a revision of a previous document prepared for the Illinois Institute for Environmental Quality.^{1*} It contains the most recent transportation emission data published by the U.S. Environmental Protection Agency,^{2,3} and is intended to be more detailed and instructive than the USEPA documents. The major focus will be on emissions from motor vehicles, since these sources are the largest contributors to transportation air pollution. Additional sections will deal with emissions from rail vehicles, aircraft, and ships and river vessels.

*Superscript numbers refer to references listed at the back of the report.

2.0 MOTOR VEHICLES

Motor vehicles (automobiles, trucks, buses, etc.) are far and away the largest source of transportation air pollutant emissions. The majority of emissions come from gasoline-powered motor vehicles. When gasoline is mixed with air in proper proportions, a combustible mixture is formed. The proportion of air to gasoline can vary from 8 to 1 up to 20 to 1. Even at a stoichiometric air-fuel ratio, combustion is not 100% complete in real engines. As a result of the incomplete combustion, by-products, which are considered to be pollutants, are formed. This situation is characteristic of any combustion process using fossil fuels (e.g., electricity generation, space heating, industrial manufacturing).

The formula for fuel combustion is shown in Eq. 2.1. Carbon dioxide, water vapor, and free hydrogen, oxygen, and nitrogen make up the bulk of the products of combustion, but carbon monoxide (CO), oxides of nitrogen (NO, NO₂), and unburned hydrocarbons (HC) are also produced. More than 200 unburned hydrocarbons have been detected in automobile exhausts, with the majority coming from the unburned fuel-air mixture released in the exhaust gases. Carbon monoxide emissions result from incomplete combustion due to insufficient oxygen in the fuel-air mixture. Nitrogen oxides result from the combustion of the free nitrogen present in the air.

Because of the many different types of vehicles and their different ages and degrees of operating efficiency, emissions vary widely from vehicle to vehicle. In addition, the vehicle operating cycle is an important determinant of pollutant emissions. Cold starts, acceleration, speed, deceleration, starts and stops are some parts of the cycle that affect emissions. Ambient temperature also has an effect on vehicle emissions.

Emission factors, therefore, represent an average over many different vehicle types and operating conditions. The following sections will outline several of the more important considerations. First, distinctions will be

made between different types of vehicles (e.g., light and heavy duty vehicles, gasoline-engine-driven and diesel-driven, etc.). Emission factors will be presented for different model years of these vehicles to reflect the imposition of successively more stringent federal and local regulations on emission rates. Next, techniques will be described that will account for different speed conditions and emission-control-device deterioration. Finally, methods for averaging emission factors to reflect the characteristics of the local vehicle population under consideration will be outlined.

2.1 MODEL YEAR EMISSION FACTORS

In making the distinction between various motor vehicle types, the following definitions are employed.

Light duty vehicle - any motor vehicle designed primarily for the transportation of property and rated at 6,000 pounds gross vehicle weight (GVW) or less, or designed primarily for the transportation of people and having a capacity of 12 persons or less. This includes almost all passenger automobiles and small trucks (pickups, panel vans, etc.). This class can be divided into light duty gasoline-powered vehicles and diesel-powered vehicles.

Heavy duty vehicle - any motor vehicle designed primarily for transportation of property and rated at more than 6,000 pounds GVW or designed primarily for transportation of people and having a capacity of more than 12 persons. This includes large trucks and buses. This class is also divided into gasoline-powered and diesel-powered vehicles.

2.1.1 Light Duty Gasoline-powered Vehicles

Table 2.1 gives the exhaust emission factors for light duty vehicles. The test cycle on which they are based is described in this section.

In previous publications^{1,4} light duty vehicle emissions were expressed in terms of what is called the 1972 Federal Test Procedure (FTP), which is outlined in the Federal Register.⁵ This procedure involves the measurement of mass emissions as the vehicle is subjected to a driving cycle that is representative of a typical urban pattern. The test includes a "cold start," which is achieved by allowing the vehicle to stand—or soak—

TABLE 2.1. Exhaust Emission Factors for Light Duty Gasoline-powered Vehicles
1975 Federal Test Procedure, No Deterioration
(All Emissions in Grams/Vehicle-Mile)

Model Year	Low Altitude (<3500 ft)			High Altitude (≥3500 ft)			California		
	CO	HC	NO _x	CO	HC	NO _x	CO	HC	NO _x
1960	87	8.8	3.6	130	10.0	1.9	87	8.8	3.6
1961	87	8.8	3.6	130	10.0	1.9	87	8.8	3.6
1962	87	8.8	3.6	130	10.0	1.9	87	8.8	3.6
1963	87	8.8	3.6	130	10.0	1.9	87	8.8	3.6
1964	87	8.8	3.6	130	10.0	1.9	87	8.8	3.6
1965	87	8.8	3.6	130	10.0	1.9	87	8.8	3.6
1966	87	8.8	3.6	130	10.0	1.9	51	6.0	3.4
1967	87	8.8	3.6	130	10.0	1.9	50	4.6	3.4
1968	46	4.5	4.3	74	6.0	2.2	46	4.5	4.3
1969	39	4.4	5.5	48	5.4	2.6	39	4.4	5.5
1970	36	3.6	5.1	72	6.1	2.8	36	3.6	5.1
1971	34	2.9	4.8	75	5.3	3.1	34	2.9	3.5
1972	19	2.7	4.8	42	4.9	3.1	19	2.7	3.5
1973	19	2.7	2.3	42	4.9	1.4	19	2.7	2.3
1974	19	2.7	2.3	42	4.9	1.4	19	2.7	2.3
1975	12.5	1.3	2.2	20.0	1.8	1.4	2.8	0.33	1.1
1976	1.8	0.23	1.6	1.8	0.23	1.3	1.8	0.23	1.1
1977	1.8	0.23	0.31	1.8	0.23	0.31	1.8	0.23	0.31
1978	1.8	0.23	0.31	1.8	0.23	0.31	1.8	0.23	0.31
1979	1.8	0.23	0.31	1.8	0.23	0.31	1.8	0.23	0.31
1980	1.8	0.23	0.31	1.8	0.23	0.31	1.8	0.23	0.31

for a minimum of 12 hours at an ambient temperature of between 68° and 86°F before starting the driving cycle. The entire cycle covers 7.5 miles and takes 23 minutes to run, the average speed being 19.6 mph. It includes some 18 accelerate-cruise-decelerate sequences with several idling periods interspersed. The emissions are collected in a sample bag using a constant volume sampling (CVS) technique. The measured pollutant concentration in the bag is then converted to mass units and is expressed in grams of pollutant emitted per vehicle-mile. This is an average for the entire test cycle.

A great deal of criticism was leveled at this testing technique because of the cold start feature. In most automobiles a disproportionately large fraction of the emissions come from the first minutes of vehicle operation before the engine has had a chance to warm up and reach thermal equilibrium. This disproportionate fraction is further accentuated in later model years, where emission control devices must reach an elevated operating temperature before becoming fully effective. The main thrust of the argument was that not all vehicle trips begin with a cold start and that the 1972 FTP therefore resulted in an overestimate of emissions over the length of a typical vehicle trip. Also, the argument ran, any cold start emissions should be assigned to the locale of the trip origin and not spread over the entire trip length.

To correct these deficiencies the U.S. Environmental Protection Agency introduced a modification to the 1972 FTP. This new test, referred to as the 1975 Federal Test Procedure, involves a segment added on to the 1972 FTP and is also documented in the Federal Register.⁶ After the completion of the original 23-minute test cycle, the vehicle engine is shut off and allowed to stand for 10 minutes. It is then restarted and the first 505 seconds of the test procedure is repeated. The emissions are collected in three separate sample bags. The first, called the cold transient bag, contains the emissions from the first 505 seconds of the test, which includes the cold start. The second, called the stabilized bag, contains the emissions from 505 seconds to the end of the first 23-minute cycle. The third, called the hot transient bag, contains the emissions from the repeated 505 seconds, which includes the hot start after the 10-minute soak. A plot of speed vs time for the entire 1975 test procedure is given in Fig. 2.1. To obtain the test-cycle emission factor, the pollutant mass computed for the cold and hot bags are weighted

Fig. 2.1. 1975 Federal Test Procedure Urban Driving Schedule

and combined with the mass computed for the stabilized bag. This total is then divided by the 7.5-mile length of one test cycle. The computation is given in Eq. 2.2.

$$\begin{array}{l} \text{1975 FTP} \\ \text{Emission Factor} = (0.43 Y_{ct} + 0.57 Y_{ht} + Y_s)/7.5 \\ \text{gms/vehicle-mile} \end{array} \quad (2.2)$$

where

$$\begin{array}{ll} Y_{ct} & = \text{mass emissions as calculated from the cold transient bag [grams]} \\ Y_{ht} & = \text{mass emissions as calculated from the hot transient bag [grams]} \\ Y_s & = \text{mass emissions as calculated from the stabilized bag [grams]} \end{array}$$

This computation is applied to carbon monoxide, hydrocarbons, and nitrogen oxides. The weighting factors 0.43 and 0.57 indicate the EPA's estimate that only 43% of the vehicle trips begin with a cold start. This emission factor therefore accounts for the criticism that not all trips start with a cold engine, but does not enable a spatial distribution of the cold start emissions to be made. This will be discussed in more detail later.

The exhaust emission factors for each model year light duty gasoline-powered vehicle given on Table 2.1 are computed on the basis of the 1975 FTP and represent the most recent data published by the USEPA.² The factors are for new vehicles; that is, no deterioration of the control devices is accounted for.

The distinction between "high altitude" and "low altitude" in the emission factors comes as the result of an extensive USEPA motor vehicle emission surveillance program.^{7,8} The changes in emission rates with altitude are attributed to the enriched fuel metering schedules required to match the lower atmospheric pressure at high altitudes. For computation purposes EPA has defined "high altitude" to be 3,500 feet and above.

A distinction is made for California vehicles as a result of the earlier promulgation of some standards for vehicles in that State.

The emission factors reflect the interim CO and HC standards for 1975 as proposed by the USEPA on July 2, 1973⁹ and the interim NO_x standards for 1976 proposed on August 21, 1973.¹⁰

Light duty cars and trucks are not considered to be major sources of sulfur oxide or particulate emissions. Nevertheless, for the sake of

completeness, these emission factors are presented on Table 2.2.² No federal emission standards have yet been proposed for the control of these pollutants from motor vehicles; hence the emission factors are the same for all model years and all areas.

TABLE 2.2. Particulate and Sulfur Oxide Emission
Factors for Light Duty Gasoline-powered Vehicles
(All Emissions in Grams/Vehicle-Mile)

	Particulate		Sulfur Oxides
	Exhaust	Tire Wear	
All model years all areas	0.34	0.20	0.13

Recently the USEPA has announced¹¹ that it will treat light duty trucks separately from light duty automobiles. The emission standard for 1975 model year light duty trucks is approximately 33% higher for CO and HC, and the same for NO_x, as the standard for light duty automobiles. To date no separate emission factors have been developed for light duty trucks, and they will therefore be treated as light duty vehicles, together with automobiles, here.

2.1.2 Light Duty Diesel-powered Vehicles

There are in the U.S. today a small number of light duty diesel-powered automobiles. About 8,000 of the 10 million cars sold in the U.S. every year are diesels.¹²

The diesel power plant is an inherently low CO- and HC-producing engine compared to a gasoline-powered engine. The NO_x emission rates are slightly lower. For these reasons the use of diesel engines has been given serious consideration by manufacturers in complying with the Federal emission control program. There are, however, some disadvantages to diesels, which must be considered. Diesel engines are generally heavy and require more costly materials in their construction because of the high pressures in the combustion chambers. Also, the driveability performance of a diesel engine is different than that of a gasoline engine. In truck applications the engine is run over a very narrow rpm range, while vehicle speed is adjusted by as many as 15 forward gears. Clearly, this type of operation is not readily acceptable to the average automobile driver. To date only one

manufacturer, Mercedes Benz, is marketing diesel-powered automobiles in the U.S. The price of that vehicle puts it well into the luxury car class.

Emission factors for light duty diesels are given in Table 2.3, as compiled by the USEPA.² The factors are based on limited data, but will serve to estimate the emission contribution. No data on deterioration rates or changes in emissions with vehicle speed is available.

TABLE 2.3. Exhaust Emission Factors for Light Duty Diesel-powered Vehicles
1975 Federal Test Procedure
(All Emissions in Grams/Vehicle-Mile)

Model Year	CO	HC	NO _x	Particulate	SO _x
1960-1975	1.7	.45	1.6	.73	.63
1976-1990	1.7	.45	.4	.73	.63

2.1.3 Heavy Duty Gasoline-powered Vehicles

The Federal Test Procedures for heavy duty gasoline-powered vehicles are substantially different than those for their light duty counterparts. The following paragraphs indicate some of the differences.

- Heavy duty vehicle engines are tested on an engine dynamometer and are not installed in a vehicle.
- The test cycle for heavy duty engines involves nine engine operating modes with a different time-in-mode and weighting factor for each. The cycle is given in Table 2.4. A complete test run for an engine involves a one-hour soak period at a temperature between 68° and 86°F, an engine start and idle (1000-2000 rpm) for 5 minutes, and four 9-mode cycles. The sampling system is not started until after the 5-minute idle, so the engine is always warm during the test. The cold start is not included in the heavy duty vehicle test.
- The emission standards for the 1970-73 model years for heavy duty vehicles are expressed in terms of pollutant concentration rather than pollutant mass per mile. For 1974 the standard is expressed in grams per brake horsepower-hour.

TABLE 2.4. 9-Mode Federal Test Procedure for
Heavy Duty Gasoline-powered Vehicles

Sequence No.	Mode	Manifold Vacuum ("Hg)	Time-in- Mode (Secs)	Weighting Factors	
				Model Yrs (1970-73)	Model Yr (1974)
1	Idle	-	70	.036	.232
2	Cruise	16	23	.089	.077
3	Part throttle acceleration	10	44	.257	.147
4	Cruise	16	23	.089	.077
5	Part throttle deceleration	19	17	.047	.057
6	Cruise	16	23	.089	.077
7	Full Load	3	34	.283	.113
8	Cruise	16	23	.089	.077
9	Closed throttle	-	43	.021	.143

The implications, therefore, are that heavy duty vehicle certification procedure results are not directly applicable to the computation of regional emission rates without some modification of the data. The primary change needed is an expression of the emission rates in grams/vehicle-mile. This can be done if a constant volume sampler is used to measure exhaust emissions, thus enabling the computation of pollutant mass emission rates to be made. Also, the 9-mode FTP is recognized¹³ as producing high NO_x and low CO emission rates compared to tests on vehicles operated over a road course. Thus some compensation for this effect must be made.

The USEPA has published heavy duty vehicle emission rates based on road tests and the 9-mode FTP and expressed in grams/vehicle mile.² These are given on Table 2.5 and represent a weighted average of vehicle sizes and types. The distinctions between low altitude, high altitude, and California are the same as for light duty vehicles. No deterioration has been included.

Table 2.6 gives the particulate and sulfur oxide emission factors for heavy duty gasoline-powered vehicles. The tire wear particulate emissions are based on automobile studies, since no truck data is available. The exhaust emission factors are based on a fuel consumption rate of 8.4 miles/

TABLE 2.5. Exhaust Emission Factors for Heavy Duty Gasoline-powered Vehicles
No Deterioration

(All Emissions in Grams/Vehicle-Mile)

Model Year	Low Altitude (<3500 ft)			High Altitude (≥3500 ft)			California		
	CO	HC	NO _x	CO	HC	NO _x	CO	HC	NO _x
1960-69	140	17	9.4	210	19	5.0	140	17	9.4
1970	130	16	9.2	190	18	4.9	130	16	9.2
1971	130	16	9.2	190	18	4.9	130	16	9.2
1972	130	16	9.2	190	18	4.9	130	13	9.2
1973	130	16	9.2	190	18	4.9	130	13	9.2
1974	130	13	9.2	190	15	4.9	130	13	9.2
1975	130	13	9.2	190	15	4.9	81	4.1	2.8
1976-80	130	13	9.2	190	15	4.9	81	4.1	2.8

TABLE 2.6. Particulate and Sulfur Oxide Emission Factors
for Heavy Duty Gasoline-powered Vehicles

(All Emissions in Grams/Vehicle-Mile)

	Particulate		Sulfur Oxides
	Exhaust	Tire Wear	
All Model Years	.65 ^a	.20	.26 ^b

^aBased on fuel consumption of 8.4 mi/gal.

^bBased on fuel consumption of 8.4 mi/gal, 0.4% sulfur content fuel, and fuel density of 6.1 lb/gal.

gallon. To use a different rate, one need only multiply the given emission factor by the ratio of 8.4 miles/gallon to the new fuel consumption.

An additional refinement can be made to the heavy duty emission factors upon inspection of the results of a recently completed EPA-sponsored surveillance of heavy duty gasoline-powered trucks conducted by the Southwest Research Institute (SwRI).¹³ In this study, a fleet of 145 trucks in regular commercial use was tested via the 9-mode FTP. Also, a group of 25 trucks was tested over a road route in addition to the FTP. Emissions were measured with a constant volume sampler (similar to the CVS used in light duty vehicle tests), which enabled the pollutant mass emissions to be computed. For the tests the unit of expression was grams of pollutant emitted/pound of fuel consumed. This can be converted to grams/vehicle-mile by multiplying by the fuel consumption rate (gallons/mile) and the fuel density (6.24 pounds/gallon). The fuel consumption rate is determined from the road test results on the 25-truck group.

The fleet of test trucks was made up of several makes, models, vehicle types, and vehicle gross weights in order to determine if any trend existed. Much attention has been focused on the dependence of heavy duty vehicle emissions on gross vehicle weight (GVW). Previous publications^{1,14} have declared that no GVW distinction could be made due to inconclusive data. Even in this latest study, a strict GVW dependence cannot be determined. If, however, one is slightly more careful about determining the manner in which emissions vary with vehicle size, a useful correlation can be made.

The Motor Vehicle Manufacturers Association has grouped heavy duty vehicles into 8 categories.¹⁵ They are given in Table 2.7. If a graph is made of the emissions from the tests on the 170-truck fleet, a trend is indicated with GVW, but it is not monotonic. Such a graph, using the 9-mode FTP test results, is shown in Figure 2.2. This behavior can be explained in principle by the results of some previous work on heavy duty vehicles.¹⁶ The load placed on an engine has a substantial effect on the emission rate. For CO and HC the emissions vs %-power curve is upwardly concave, with the highest emissions occurring at zero and 100% loads. For NO_x the opposite is true; highest emissions occur at 40-70% power, with the minimums at zero and 100% loads. Figure 2.3 is a schematic drawing of such a curve. The emission rate, therefore, is heavily dependent on the portion of the power curve where the vehicle spends most of its operating time.

Fig. 2.2. Heavy Duty Gasoline-powered Vehicle Emissions by Gross Vehicle Weight

Fig. 2.3. Schematic of Heavy Duty Gasoline-powered Vehicle Emissions by Percent Power

TABLE 2.7. Motor Vehicle Manufacturers Association
Heavy Duty Vehicle Weight Classification

Category	GVW ~lbs
1	≤ 6000
2	6001-10000
3	10001-14000
4	14001-16000
5	16001-19500
6	19501-26000
7	26001-33000
	> 33000

In general, engine size does not increase in direct proportion to GVW. This means that vehicles with smaller engine/vehicle size ratios will operate more at high power settings (further to the right on Fig. 2.3) than will those with larger ratios. The result is a distortion of the emissions vs GVW curve. It is also possible that a given GVW category would have a higher emission rate than the next highest weight category because its engine/vehicle size ratio forces operation higher on the power curve. This, in fact, is demonstrated on Fig. 2.2. The conclusion to be drawn from this qualitative analysis is that GVW does not alone influence emission rates.

There is, nevertheless, a trend of higher emissions for larger vehicle sizes as indicated on Fig. 2.2. In the estimation of regional motor vehicle emissions, this trend should be accounted for. Ingalls and Springer¹³ suggest an aggregation of GVW categories to reflect the emission trend with vehicle type and size. Three classes, referred to as small, intermediate, and large, are used. The first includes vehicles of GVW from 6001 lb to 16,000 lb (Categories 2, 3, 4 on Table 2.7). Category 1 vehicles with GVW less than 6000 lb are not included here, since, by definition, they are light duty vehicles. The second includes all vehicles over 33,000 lb (Category 8). Truck tractors by themselves generally have a GVW that would put them in the intermediate category. However, when a trailer is connected, the gross combined weight (GCW) is almost always above 33,000 lb. Hence the tractors have been included in the third category here.

Table 2.8 gives the emission factors for heavy duty gasoline-powered vehicles from the SwRI study and broken down by the three GVW aggregate classes. The data has been adjusted to be compatible with the test procedure

TABLE 2.8. Exhaust Emission Factors by Vehicle Weight Class for Heavy Duty Gasoline-powered Vehicles
No Deterioration

(All Emissions in Grams/Vehicle-Mile)

	Model Year	Low Altitude (<3500 ft)			High Altitude (≥3500 ft)			California		
		CO	HC	NO _x	CO	HC	NO _x	CO	HC	NO _x
GVW 6001- 16,000 lbs.	1960-69	108.5	13.1	9.4	162.8	14.6	5.0	108.5	13.1	9.4
	1970	100.8	12.3	9.2	147.3	13.9	4.9	100.8	12.3	9.2
	1971	100.8	12.3	9.2	147.3	13.9	4.9	100.8	12.3	9.2
	1972	100.8	12.3	9.2	147.3	13.9	4.9	100.8	10.0	9.2
	1973	100.8	12.3	9.2	147.3	13.9	4.9	100.8	10.0	9.2
	1974	100.8	10.0	9.2	147.3	11.6	4.9	100.8	10.0	9.2
	1975	100.8	10.0	9.2	147.3	11.6	4.9	62.8	3.2	2.8
	1976-80	100.8	10.0	9.2	147.3	11.6	4.9	62.8	3.2	2.8
GVW 16,001- 33,000 lbs.	1960-69	146.2	20.2	9.6	219.2	22.6	5.1	146.2	20.2	9.6
	1970	135.7	19.0	9.4	198.4	21.4	5.0	135.7	19.0	9.4
	1971	135.7	19.0	9.4	198.4	21.4	5.0	135.7	19.0	9.4
	1972	135.7	19.0	9.4	198.4	21.4	5.0	135.7	15.4	9.4
	1973	135.7	19.0	9.4	198.4	21.4	5.0	135.7	15.4	9.4
	1974	135.7	15.4	9.4	198.4	17.8	5.0	135.7	15.4	9.4
	1975	135.7	15.4	9.4	198.4	17.8	5.0	84.6	4.9	2.9
	1976-80	135.7	15.4	9.4	198.4	17.8	5.0	84.6	4.9	2.9
GVW ≥ 33,000 lbs ^a	1960-69	271.3	29.0	9.3	407.0	32.4	5.0	271.3	29.0	9.3
	1970	251.9	27.3	9.1	368.2	30.7	4.9	251.9	27.3	9.1
	1971	251.9	27.3	9.1	368.2	30.7	4.9	251.9	27.3	9.1
	1972	251.9	27.3	9.1	368.2	30.7	4.9	251.9	22.2	9.1
	1973	251.9	27.3	9.1	368.2	30.7	4.9	251.9	22.2	9.1
	1974	251.9	22.2	9.1	368.2	25.6	4.9	251.9	22.2	9.1
	1975	251.9	22.2	9.1	368.2	25.6	4.9	157.0	7.0	2.8
	1976-80	251.9	22.2	9.1	368.2	25.6	4.9	157.0	7.0	2.8

^aIncludes truck tractors with GVW <3000 lbs but with gross combined weight (GCW) >33000 lb.

used in the USEPA data. It can be seen that there is a rather marked distinction between the classes with respect to CO and HC emissions. The NO_x emissions are virtually unchanged. The distinctions made for low altitude, high altitude and California are based on a proportional ratio to the different area emissions from the USEPA data. This was necessary since the SwRI work was done at only one altitude level. In addition, the SwRI work used vehicle model years between 1970-72. Prior work with pre-1970 vehicles¹⁴ used different test procedures and is not readily usable for the purposes here. The GVW-dependent emission factors for other model years were therefore based on a ratio proportional to the USEPA data. In all cases no deterioration has been included.

It should be emphasized that even though the data shows an emissions trend with GVW, this is not strictly the case. It is more a function of the engine/vehicle size matching, as previously discussed. The GVW breakdown is used here only because this is the form of data most readily available for regional emission estimates and because this breakdown gives a measure of the emission trend with vehicle size.

The use of the USEPA data or the SwRI data for GVW classes is dictated by the information available on vehicle class distribution.

A distinction of particulate and sulfur oxide emissions by vehicle GVW is not available.

2.1.4 Heavy Duty Diesel-powered Vehicles

Although diesel trucks represent a small percentage (.6%) of the motor vehicles in the U.S., their emissions are quite high, and they may actually make up a large fraction of the vehicles on a particular road. Basic emission factors for diesel trucks and buses are given in Table 2.9. The emission factors distinguish between pre-1970 and post-1970 diesel engines. This change in emissions came as a result of the addition of a new needle valve injector that reduced the amount of fuel that can be burned. The result of this engine modification was to decrease the level of hydrocarbon and carbon monoxide emissions, but the improved engine combustion efficiency is reflected in the increase in nitrogen oxide emissions.

The emission factors are dependent upon fuel usage. To convert emissions to a per-vehicle-mile scale, a fuel consumption rate of 3 mi/gal has been assumed for diesel trucks and buses.

TABLE 2.9. Exhaust Emission Factors for Heavy Duty Diesel-powered Vehicles
(All Emissions in Grams/Vehicle-Mile)

Model Year	All Areas				
	CO	HC	NO _x	Particulates	SO _x ^a
1960-1969	49.2	9.8	51.5	2.0	4.1
1970-1990	32.5	3.8	76.4	2.0	4.1

Note: Emissions based on 3 mi/gal fuel consumption

^aBased on 0.2% sulfur content fuel.

2.1.5 Cold Start Effects

As stated previously, when the gasoline engine in a light duty vehicle is allowed to reach ambient temperature, the air pollutant emission rate will be high during the first few minutes after it is started. This rate tapers off dramatically after the first 2-4 minutes of operation, as shown on Fig. 2.4. This phenomenon is referred to as a "cold start," and is a result of having to supply the engine with a fuel-rich mixture (choking) until a sustaining thermal equilibrium is reached. With the introduction of 1976 emission controls on light duty vehicles, the effect is even more pronounced because the control equipment itself is required to reach an operating temperature before becoming fully effective.

The cold start phenomenon is demonstrated in the CO and HC emission rates. The fuel-rich mixture results in a relatively inefficient combustion process, which generates the large quantities of CO and unburned hydrocarbons. The nitrogen oxides emission rate does not show a cold start effect, since NO_x emissions increase only at elevated combustion temperatures.

Several suggestions have been made to cope with the cold start problem. The simplest means is to reduce the choking time ("quick choke"). This has the disadvantage of causing the vehicle to stall or stumble along until full thermal equilibrium is reached. Another alternative is to employ a dual fuel system using a clean-burning fuel such as liquefied petroleum gas (LPG) or liquefied natural gas (LNG) until the control devices come up to operating temperature. Still another suggestion is to preheat the control devices either electrically or with a gas-fired burner before starting the vehicle. All of these techniques have distinct disadvantages and indicate the complexity of solving the cold start problem.

Fig. 2.4. Light Duty Gasoline-powered Vehicle CO Emissions vs Time

In terms of estimating regional air pollutant emissions from motor vehicles, the cold start phenomenon is of special significance. It has been mentioned previously that with regard to light duty vehicles, the USEPA has attempted to cope with the problem by developing a certification procedure (1975 FTP), which approximates the fraction of vehicle trips that include a cold start. The cold start is computed into the emission factor with a 0.43 weighting factor, while the hot start has an 0.57 weighting factor. The rationale behind the weighting factors is that only 43% of the vehicle trips begin with a cold start. While this procedure may be adequate for emission estimates over large regions, it is inadequate for estimating emissions on small scales. The reason is that the 1975 FTP emission factor in grams/vehicle-mile has the effect of spreading the cold start emissions over the entire certification trip length of 7.5 miles. In actuality, the cold start emission occurs over only the first mile or less of operation of the vehicle. The 1975 FTP factors, where the emission estimate is being made with a spatial resolution of less than 7.5 miles, are clearly inadequate.

Several examples could be given of how the cold start effect could distort an emission estimate. Assume that one wishes to compute emissions from vehicles where the region under study is broken down into square-mile grids. If the average trip length was 1 mile or less, then the 1975 FTP emission factor would be satisfactory since the cold start and the warmed-up operation emissions would occur in the same grid square or, at least, in adjacent grid squares. If, on the other hand, the average trip length was say 7.5 miles, then this emission factor would have the effect of distributing the cold start emissions to the origin grid, the destination grid, and all intermediate grids.

Another example would be the computation of emissions from an expressway. None of the vehicles have a cold start associated with their operation there. To use the 1975 FTP emission factors would have the result of substantially over-estimating the emission rates.

To overcome the problems resulting from the cold start phenomenon, some method must be devised to separate the cold start emissions from the hot operating emissions. For light duty vehicles, the 1975 FTP provides a means of making this separation. The exhaust emissions measured in the cold transient bag and the hot transient bag represent the same driving modes,

differing only by the amount of time the engine is allowed to soak prior to starting the run; for the cold transient bag it is 12 hours, for the hot transient bag it is 10 minutes after the completion of the initial 23-minute test run. The difference in pollutant mass between the cold transient bag and the hot transient bag will then represent the emissions resulting from a cold start. The hot operating emission factor can be developed by combining the mass emissions from the hot transient bag and the stabilized bag and dividing by the 7.5-mile test distance. This, in effect, assumes that the average vehicle trip includes a hot start. Equation 2.3 indicates this computation procedure. The symbolism is the same as in Sec. 2.1.1.

$$\begin{aligned} \text{Cold Start Emissions} &= Y_{ct} - Y_{ht} \quad [\text{grams/cold start}] \\ \text{Hot Operating Emissions} &= \frac{Y_{ht} + Y_s}{7.5} \quad \text{grams/vehicle-mile} \end{aligned} \quad (2.3)$$

In applying this procedure to separate out the cold start from the 1975 FTP emission factors, the results of the USEPA surveillance of automobiles in 6 cities⁷ can be used. The data collected in this program included the mass emissions for each of the three segments of the 1975 FTP for vehicles of model years 1957-1971. Since the data was collected from vehicles in use, it reflects some deterioration of the control equipment, and hence is not completely consistent with the new car emission factors. To overcome this, the assumption can be made that the proportion of cold start emissions to hot operating emissions remains the same as the vehicle ages. A "cold start ratio" can then be formed, which, when applied to new car emission factors, will yield the cold start emissions from a new vehicle. The cold start ratio as used here is defined by Eq. 2.4.

$$\begin{aligned} \text{Cold start Ratio for} & \\ \text{Light Duty Vehicles} & R_{LDV} = \frac{Y_{ct} - Y_{ht}}{.43Y_{ct} + .57Y_{ht} + Y_s} \end{aligned} \quad (2.4)$$

The denominator of this ratio is the 1975 FTP emission factor expressed in grams; hence, to obtain the new car cold start emissions Eq. 2.5 is used.

$$\begin{aligned} \text{New Car Cold} & \\ \text{Start Emissions} & = R_{LDV} \times \left[\begin{array}{l} \text{1975 FTP New Car} \\ \text{Emission Factor} \\ \text{(from Table 2.1)} \end{array} \right] \times 7.5 \quad (2.5) \\ \text{[grams]} & \end{aligned}$$

All of the quantities on the right-hand side of Eq. 2.4 are computed from the Six-Cities Study for 1960-71 years. For model years 1972-75 (1972-74 in California) the same ratio as the 1971 model year is used because of a lack of experimental test data. Test data on prototype catalyst-equipped vehicles generated by General Motors¹⁷ is used for 1976 and later model years (1975 in California). Using the definition of the hot operating emission factor from Eq. 2.3 and some algebraic manipulation, the hot factor can be determined by Eq. 2.6.

$$\begin{array}{l} \text{New Car Hot Operating} \\ \text{Emission Factor} \\ \text{[grams/vehicle-mile]} \end{array} = (1 - .43R_{LDV}) \times \left[\begin{array}{l} \text{1975 FTP New Car} \\ \text{Emission Factor} \\ \text{(from Table 2.1)} \end{array} \right] \quad (2.6)$$

It should be noted that this cold start ratio is not the same as the "fraction of emissions that occurs during the cold start" figure that has been used in a good deal of previous work. In fact, this ratio is not a fraction at all because of the weighting factors used in the denominator. R_{LDV} can, and does, have values in excess of unity.

Table 2.10 gives the cold start ratios for each model year as computed from the Six-Cities results and the GM data. The low altitude ratios were computed as an average of the results from Chicago, St. Louis, Houston, Washington (D.C.), and Los Angeles (excluding 1966 and 1967 model years). The high altitude ratios were computed from the Denver results and the California ratios for 1966 and 1967 model years from the Los Angeles results. Table 2.11 gives the cold start emission factors resulting from the application of the ratios to the 1975 FTP emission factors. Table 2.12 gives the corresponding hot operating emission factors.

It can be seen that the general trend is toward higher cold start ratios for both CO and HC, with the most dramatic change in the 1976 model year (1975 in California) when the catalytic converters will be introduced. This is a result of the need for the newer emission control devices to reach an operating temperature before becoming fully effective. The high cold start ratios further accentuate the need for properly separating the cold start from the hot operating emissions.

For heavy duty gasoline-powered vehicles, the 9-mode FTP and the road tests do not by themselves enable one to separate out the cold start emissions,

TABLE 2.10. Cold Start Ratios for Light Duty Gasoline-powered Vehicles
 (R_{LVD})

Model Year	Low Altitude (<3500 ft)		High Altitude (≥ 3500 ft)		California	
	CO	HC	CO	HC	CO	HC
1960-1965	.175	.163	.138	.199	.175	.163
1966	.175	.163	.138	.199	.349	.198
1967	.175	.163	.138	.199	.372	.291
1968	.274	.227	.220	.334	.274	.227
1969	.347	.263	.372	.396	.347	.263
1970	.305	.229	.285	.297	.305	.229
1971	.322	.221	.237	.358	.322	.221
1972	.322	.221	.237	.358	.322	.221
1973	.322	.221	.237	.358	.322	.221
1974	.322	.221	.237	.358	.322	.221
1975	.322	.221	.237	.358	1.369	.556
1976	1.369	.556	1.369	.556	1.369	.556
1977-1980	1.369	.556	1.369	.556	1.369	.556

TABLE 2.11. Cold Start Emission Factors for
Light Duty Gasoline-powered Vehicles
(All Emissions in Grams)

Model Year	Low Altitude (<3500 ft)		High Altitude (≥ 3500 ft)		California	
	CO	HC	CO	HC	CO	HC
1960-1965	114.2	10.8	134.6	14.9	114.2	10.8
1966	114.2	10.8	134.6	14.9	133.5	8.9
1967	114.2	10.8	134.6	14.9	139.5	10.0
1968	94.5	7.7	122.1	15.0	94.5	7.8
1969	101.5	8.7	133.9	16.0	101.5	8.7
1970	82.4	6.2	153.9	13.6	82.4	6.2
1971	82.1	4.8	133.3	14.2	82.1	4.8
1972	45.9	4.5	74.7	13.2	45.9	4.5
1973	45.9	4.5	74.7	13.2	45.9	4.5
1974	45.9	4.5	74.7	13.2	45.9	4.5
1975	30.2	2.2	35.6	4.8	28.7	1.4
1976	18.5	1.0	18.5	1.0	18.5	1.0
1977-1980	18.5	1.0	18.5	1.0	18.5	1.0

TABLE 2.12. Hot Operating Emission Factors for
Light Duty Gasoline-powered Vehicles
(All Emissions in Grams/Vehicle-Mile)

Model Year	Low Altitude (<3500 ft)		High Altitude (≥ 3500 ft)		California	
	CO	HC	CO	HC	CO	HC
1960-1965	80.5	8.2	122.3	9.1	80.5	8.2
1966	80.5	8.2	122.3	9.1	43.3	5.5
1967	80.5	8.2	122.3	9.1	42.0	4.0
1968	40.6	4.1	67.0	5.1	40.6	4.1
1969	33.2	3.9	40.3	4.5	33.2	3.9
1970	31.3	3.2	63.2	5.3	31.3	3.3
1971	29.3	2.6	67.4	4.5	29.3	2.6
1972	16.4	2.4	37.7	4.1	16.4	2.4
1973	16.4	2.4	37.7	4.1	16.4	2.4
1974	16.4	2.4	37.7	4.1	16.4	2.4
1975	10.8	1.2	18.0	1.5	1.2	0.3
1976	0.7	0.2	0.7	0.2	0.7	0.2
1977-1980	0.7	0.2	0.7	0.2	0.7	0.2

since the tests are always run with the engine warm. The Southwest Research Institute study¹³ did, however, run the 9-mode FTP from both a warm start and a cold start (12-hour soak) to investigate the differences. The tests were made on 26 trucks and as such represent only limited data. The general conclusion made by Southwest Research was that the 9-mode FTP was not sensitive to the cold start. It is possible, nevertheless, to form a cold start ratio for heavy duty vehicles from the data. The ratio is obtained by taking the difference between the cold start and the warm start FTP emission results and dividing by the warm start 9-mode FTP emission factor, expressed in grams, over a 7.5 mile distance. This distance is arbitrarily chosen to correspond to that for light duty vehicles, since the 9-mode FTP does not have an actual distance associated with it. Equation 2.7 illustrates the computation.

$$\begin{array}{l} \text{Cold Start Ratio for} \\ \text{Heavy Duty Vehicles} \end{array} R_{\text{HDV}} = \frac{Y_{\text{cold}} - Y_{\text{warm}}}{\text{EF}_{9\text{-mode}} \times 7.5} \quad (2.7)$$

Y_{cold} is the emission in grams from the 9-mode FTP run from a cold start condition; Y_{warm} is for the same test run from the standard warm start; $\text{EF}_{9\text{-mode}}$ is the emission factor in grams/vehicle-mile for the 9-mode FTP run from the standard warm start. All of the quantities on the right-hand side of Eq. 2.7 are computed from the SwRI study. As this data covers only 1970-71 model years, it is assumed that the ratios will be the same for all model years, since the past and projected future control equipment does not display the same wide variation as for light-duty vehicles. In addition, the data was collected on in-use vehicles, and it will also be assumed that the ratio will not change with vehicle age.

This ratio can be applied to the published emission factors to obtain a heavy duty vehicle cold start emission. It is not necessary to compute a separate hot operating emission factor as with light duty vehicles, since the emission factor already represents warmed-up engine operation. Equation 2.8 demonstrates the application of this ratio.

$$\begin{array}{l} \text{New Heavy Duty Vehicle} \\ \text{Cold Start Emissions} \\ \text{[grams]} \end{array} = R_{\text{HDV}} \times \left[\begin{array}{l} \text{New Heavy Duty Vehicle} \\ \text{Emission Factor} \\ \text{(from Table 2.5 or 2.8)} \end{array} \right] \times 7.5 \quad (2.8)$$

Table 2.13 gives the cold start ratios as computed from the SwRI study. In addition to the overall value for heavy duty vehicles, the ratio has also been computed for the three GVW aggregate classes described previously. In all cases, distinctions between low altitude, high altitude, and California have not been made due to insufficient data. Table 2.14 gives the cold start emission factors resulting from the application of the ratios. The corresponding hot operating emission factors are simply those values on Tables 2.5 and 2.8.

In comparing these numbers with the light duty vehicle cold start ratios, it should be remembered that the heavy duty vehicle values represent the ratio of a cold start emission to an emission factor, which includes a weighted cold start and is therefore a larger number. If both could be put on the light duty vehicle basis, the heavy duty vehicle ratios would become smaller yet. The ratios are small to begin with and thus support the Ingalls and Springer conclusion that heavy duty vehicles are not faced with significant cold start problems. It is interesting to note that the smallest GVW class on Table 2.13 has the highest cold start ratio. This could be attributed to the closer similarity of engine type with light duty vehicles.

TABLE 2.13. Cold Start Ratios for Heavy Duty
Gasoline-powered Vehicles
(All Model Years, All Areas)

	CO	HC
All Heavy Duty Vehicles	.105	.142
GVW 6001-16000 lb	.238	.171
GVW 16001-33000 lb	.076	.139
GVW >33000 lb ^a	.033	.131

^aIncludes Truck Tractors.

No data is available on the cold start performance of either light duty or heavy duty diesel-powered vehicles.

As might be expected, the ambient temperature and the time a vehicle is left to stand before operation are two factors that affect the cold start performance of both light and heavy duty vehicles. Unfortunately, there is

TABLE 2.14. Cold Start Emission Factors for
Heavy Duty Gasoline-powered Vehicles
(All Emissions in Grams)

	Model Year	Low Altitude (<3500 ft)		High Altitude (≥ 3500 ft)		California	
		CO	HC	CO	HC	CO	HC
All Heavy Duty Vehicles	1960-69	110.3	18.1	165.4	20.2	110.3	18.1
	1970	102.4	17.0	149.6	19.2	102.4	17.0
	1971	102.4	17.0	149.6	19.2	102.4	17.0
	1972	102.4	17.0	149.6	19.2	102.4	13.9
	1973	102.4	17.0	149.6	19.2	102.4	13.9
	1974	102.4	13.8	149.6	16.0	102.4	13.9
	1975	102.4	13.8	149.6	16.0	63.8	4.4
	1976-80	102.4	13.8	149.6	16.0	63.8	4.4
GVW 6,001- 16,000 lb	1960-69	193.7	16.8	290.6	18.7	193.7	16.8
	1970	179.9	15.8	262.9	17.8	179.9	15.8
	1971	179.9	15.8	262.9	17.8	179.9	15.8
	1972	179.9	15.8	262.9	17.8	179.9	12.8
	1973	179.9	15.8	262.9	17.8	179.9	12.8
	1974	179.9	12.8	262.9	14.9	179.9	12.8
	1975	179.9	12.8	262.9	14.9	112.1	4.1
	1976-80	179.9	12.8	262.9	14.9	112.1	4.1
GVW 16,001- 33,000 lb	1960-69	83.3	21.1	124.9	23.6	83.3	21.1
	1970	77.3	19.8	113.1	22.3	77.3	19.8
	1971	77.3	19.8	113.1	22.3	77.3	19.8
	1972	77.3	19.8	113.1	22.3	77.3	16.1
	1973	77.3	19.8	113.1	22.3	77.3	16.1
	1974	77.3	16.1	113.1	18.6	77.3	16.1
	1975	77.3	16.1	113.1	18.6	48.2	5.1
	1976-80	77.3	16.1	113.1	18.6	48.2	5.1
GVW >33,000 lb	1960-69	67.1	28.5	100.7	31.8	67.1	28.5
	1970	62.3	26.8	91.1	30.2	62.3	26.8
	1971	62.3	26.8	91.1	30.2	62.3	26.8
	1972	62.3	26.8	91.1	30.2	62.3	21.8
	1973	62.3	26.8	91.1	30.2	62.3	21.8
	1974	62.3	21.8	91.1	25.2	62.3	21.8
	1975	62.3	21.8	91.1	25.2	38.9	6.9
	1976-80	62.3	21.8	91.1	25.2	38.9	6.9

little published data that would enable one to make an accurate quantitative measure of these factors, although some qualitative descriptions of these effects may prove useful.

A Workshop on the Influence of Cold Weather on Automobile Emissions was sponsored by Environment Canada in Ottawa on October 17-18, 1973. Preliminary unpublished data was presented by the Surveillance Branch of the USEPA's Mobile Source Pollution Control Program in Ann Arbor, Michigan, indicating that the reduction of the ambient temperature from 75° to 25°F results in an increase in CO and HC emissions by factors of 6 to 10 as measured by the 1975 FTP. NO_x emissions increase by a factor of 3. Work done by the Bartlesville Energy Research Center of the U.S. Bureau of Mines in Bartlesville, Oklahoma, also indicates an increase in CO and HC emission, but the increment is by a factor of 2 only. The NO_x emissions show little change. Both sets of results show that the biggest changes occur in the cold transient portion of the 1975 FTP, with relatively small changes in the hot transient and stabilized portions. The conclusion to be drawn from this is that the emission increase is primarily a result of the increased choke time required to bring the engine up to operating temperature. Once the engine is warm the colder ambient temperatures no longer influence the emission rate.

For vehicles equipped with catalytic converters, there appears to be an increase in CO and HC emissions as the test temperature is raised from 75° to 95°F. The preliminary conclusion is that the shorter choke time at the higher temperature results in an increase in catalyst "light-off" time (time to reach operating temperature), with the resulting increase in emissions. There is only a very small amount of data, however, and this conclusion cannot yet be fully validated.

Publication of all of the above data, as well as additional test data from the USEPA, the Bureau of Mines, and the Canadian Department of the Environment, is expected early in 1974.

With regard to the effect of vehicle soak time on emissions, the available data is even more sparse. To date, no significant test program has been undertaken to correlate the amount of time a vehicle soaks at a given ambient temperature with the cold start effect, and none is currently planned. The experiences of those who have conducted emission tests using the 1975 FTP indicate that for test temperatures between 76°-86°F the engine approaches

a cold start condition after standing 6-8 hours. (The official test procedure calls for a 12-hour soak.) There is little in the way of experience at other test temperatures.

One suggestion has been to use the engine cooldown rate, as measured by the oil and coolant temperature, to determine how close the engine is to a full cold start. To do this would require data on cooldown rates for many makes and models, much of which is available from manufacturers' tests, and even more data on the correlation between oil and coolant temperature and emissions, little of which is available.

Perhaps the simplest way to treat the problem is to assume that the CO and HC emission change resulting from soak time varies linearly between the 12-hour soak for the cold transient part of the 1975 FTP and the 10-minute soak of the hot transient. Thus a 12-hour soak would result in a 100% cold start, a 6-hour soak would result in a 50% cold start, and so forth. This cold start fraction could then be applied to the cold start emission factor to estimate emissions. It should be emphasized that this is only a first-order approximation to the situation and should be used for order of magnitude estimates only. In practice, the approach to full cold start would probably be faster than the linear approximation would indicate.

2.1.6 Crankcase and Evaporative Emissions

In addition to the vehicle exhaust, there are two other sources of hydrocarbon emissions. They are blowby from the crankcase and evaporation from the fuel system.

Crankcase blowby emissions result from fuel that escapes past the piston and is unburned. As such, it is strictly a hydrocarbon emission since no combustion has taken place. In 1963, federal regulation made it mandatory for light duty vehicles to be equipped with crankcase controls. Additional controls, which eliminated crankcase emissions altogether, were added in 1968. (In California, the first controls went into effect in 1961, with additional controls in 1964.) The control technique used is Positive Crankcase Ventilation (PCV), which recycles the blowby vapors to the intake manifold, the air cleaner, or both. Table 2.15 gives the crankcase emission factors published by the USEPA.² Diesel vehicles do not have a crankcase emission problem, since the mixture in the cylinder on the compression stroke contains no fuel.

TABLE 2.15. Crankcase Hydrocarbon Emission Factors
for Gasoline-powered Vehicles
(All Emissions in Grams/Vehicle-Mile)

Model Year	All Areas Except California		California	
	Light Duty Vehicles	Heavy Duty Vehicles	Light Duty Vehicles	Heavy Duty Vehicles
1960	4.1	5.2	4.1	5.2
1961	4.1	5.2	0.8	5.2
1962	4.1	5.2	0.8	5.2
1963	0.8	5.2	0.8	5.2
1964	0.8	5.2	0.	0.
1965	0.8	5.2	0.	0.
1966	0.8	5.2	0.	0.
1967	0.8	5.2	0.	0.
1968-1990	0.	0.	0.	0.

Fuel evaporative emissions are not easy to control, since they are emitted from all of the points in the fuel system that are vented to the atmosphere. The most important of these are the fuel tank and the carburetor. The emission rate depends on the fuel volatility, liquid surface area and ambient temperature.

The federal test procedure for light duty vehicle evaporative losses⁶ is based on measuring emissions during three distinct types of vehicle test conditions. The first is called the "diurnal breathing loss test." In this sequence the fuel in the gas tank is heated from 60° to 84°F in the space of one hour while the evaporated vapors are collected in a canister. This test is designed to simulate evaporative emissions resulting from the vehicle's being subjected to a diurnal temperature fluctuation.

The second test condition is called the "running loss test." The vehicle is run through the 1975 FTP cycle while the evaporated vapors from the fuel system are collected. This is designed to measure the emissions resulting from evaporation while the vehicle is in operation.

The third test condition is called the "hot soak test." After the completion of the running loss test, as described above, the vehicle is

allowed to stand for a period of one hour with the hood down while the evaporated vapors are collected. This is designed to measure losses that result when the vehicle is parked and the hot engine is turned off.

Table 2.16 gives the evaporative emissions published by the USEPA² expressed in grams/vehicle-mile. These can be converted to grams/test simply by multiplying by the 7.5-mile distance over which the test results have been spread.

TABLE 2.16. Fuel Evaporative Hydrocarbon Emission Factors
for Gasoline-powered Vehicles
(All Emissions in Grams/Vehicle-Mile)

Model Year	All Areas Except California		California	
	Light Duty Vehicles	Heavy Duty Vehicles	Light Duty Vehicles	Heavy Duty Vehicles
1960-1969	3.0	3.0	3.0	3.0
1970	3.0	3.0	0.5	3.0
1971	0.5	3.0	0.5	3.0
1972	0.2	3.0	0.2	3.0
1973-1990	0.2	3.0	0.2	0.2

In making evaporative emission calculations, one would like to compute the losses from each of the three tests separately. This would improve the spatial resolution of the emission calculation and is analogous to the separation of the cold start. Unfortunately, the data available is not sufficient to make a rigorous separation, although some reasonable approximations can be made. As part of the Six-Cities Surveillance Study,⁸ light duty vehicle evaporative emissions for the diurnal breathing loss test and the hot soak test were run separately using the SHED (Sealed Housing for Evaporative Determinations) technique. In this procedure, the vehicle is in a sealed enclosure during the test, which permits the collection of all the evaporated vapors. In the federal test procedure all of the evaporative tests are run with the fuel system external vents connected to a collection canister that is weighed to get the mass emissions. Since all of the possible points of fuel evaporation, including things such as ill-fitted gaskets, cannot be accounted for by this technique, there is a tendency to underestimate total vehicle evaporative emissions.

Table 2.17 gives the diurnal loss and hot soak loss test results from the Six-Cities study. No running loss tests were made. The data has been extended beyond the 1971 model year by assuming that the reduction in emissions as measured by the Federal Procedure will be the same as that measured by the SHED technique. In addition, the high altitude data has been extended to other model years in the same manner. (The Six-Cities data for Denver was collected on 1970-71 controlled vehicles only.) For heavy duty vehicles, the light duty vehicle emission rates were used in the same manner as in the USEPA data.

TABLE 2.17. Fuel Evaporative Hydrocarbon Emission Factors
for Gasoline-powered Vehicles by Source^a
(All Emissions in Grams)

Model Year	Low Altitude (<3500 ft)		High Altitude (≥3500 ft)		California	
	Diurnal Loss	Hot Soak Loss	Diurnal Loss	Hot Soak Loss	Diurnal Loss	Hot Soak Loss
1960-69	26.0	14.7	75.3	46.7	26.0	14.7
L 1970	26.0	14.7	75.3	46.7	16.3	10.9
D 1971	16.3	10.9	47.2	34.8	16.3	10.9
V 1972	6.5	4.4	18.9	13.9	6.5	4.4
1973-90	6.5	4.4	18.9	13.9	6.5	4.4
H 1960-72	26.0	14.7	75.3	46.7	26.0	14.7
D 1973-90	26.0	14.7	75.3	46.7	6.5	4.4
V						

^aMeasured by SHED technique.

In making evaporative emission computations, one is forced to choose either the USEPA data on Table 2.16 or the Six-Cities data on Table 2.17, since the two are not compatible. The particular problem under study will dictate the choice. If, for example, the problem involves the computation of emission factors for an urban street, the USEPA data should be used, since the emission factors represent those occurring while the vehicle is in operation. If, on the other hand, the problem involves a large parking lot (or other complex source) where vehicles will be subjected to significant soak times but relatively short travel distances, then the Six-Cities data should be used. In the latter case, no running evaporative emissions are included in the calculation.

2.1.7 Modal Emissions

The 1975 FTP for light duty vehicles involves a series of driving patterns that are designed to represent typical urban conditions. Although it is acknowledged that this pattern can vary substantially from area to area, the emission factors based on this cycle are generally adequate to represent regional motor vehicle emissions. There are, however, special circumstances in which the 1975 FTP emission factors can be substantially in error. For example, a typical driving pattern in the City of Fairbanks, Alaska, involves an engine warmup at idle of the order of 30-45 minutes. In addition, on most short trips the engine is left idling to keep it warm in the very cold ambient temperatures. In this situation the 1975 FTP does not adequately account for the extensive amount of idling time.

To help meet the need for more specific information on vehicle emissions, the Six-Cities Surveillance Study^{7,8} measured emission rates in a variety of vehicle operating modes. These modes included idle, steady state cruising speeds of 15, 30, 45, and 60 mph, and various acceleration and deceleration rates. Table 2.18, reproduced from that report, lists the acceleration/deceleration test conditions. All of the data was collected using a constant volume sampler that permitted the measurement of mass emission rates.

To put the Six-Cities information into a form that is compatible with the published USEPA data, it can be assumed that the ratio of the emissions, during any mode, to the 1975 FTP emission rate is constant with vehicle model year. This permits the generation of a full set of modal emission factors. Table 2.19 gives the ratio of the modal emission rate to the 1975 FTP emission rate for light duty gasoline-powered vehicles. Application of these ratios to the data on Table 2.1 will give model emission factors for any model year. No modal emission data was available for heavy duty gasoline- or diesel-powered vehicles.

With this information, it is possible to "build up" an emission factor that will represent a very specific micro-scale problem. If, for example, one wished to evaluate the air quality impact of installing traffic lights at a given intersection, it would be possible, given sufficient vehicle operation data, to simulate the emission characteristics of deceleration to stop, idle, and acceleration to speed of the vehicles passing through the intersection.

TABLE 2.18. Acceleration/Deceleration Modes and Driving Sequence

MODE			TIME IN MODE (sec)	AVERAGE SPEED (mph)	AVERAGE ACCEL- ERATION RATE (mph/sec)	DISTANCE (miles)
NO.	TYPE	SPEED RANGE (mph)				
1	ACCEL	0-30	12	18.05	2.50	0.0602
2	DECEL	30-0	16	16.66	-1.88	0.0741
3	ACCEL	0-15	8	9.04	1.88	0.0201
4	ACCEL	15-30	11	23.07	1.36	0.0705
5	ACCEL	30-45	13	37.65	1.15	0.1360
6	DECEL	45-30	12	38.05	-1.25	0.1268
7	ACCEL	30-60	17	45.80	1.76	0.2163
8	DECEL	60-45	12	53.01	-1.25	0.1716
9	ACCEL	45-60	14	52.54	1.07	0.2043
10	DECEL	60-15	30	40.40	-1.50	0.3367
11	ACCEL	15-60	26	43.42	1.73	0.3136
12	DECEL	60-0	21	33.83	-2.86	0.1973
13	ACCEL	0-60	32	38.24	1.88	0.3313
14	DECEL	60-30	23	46.86	-1.30	0.2994
15	DECEL	30-15	9	23.18	-1.67	0.0579
16	DECEL	15-0	8	7.81	-1.88	0.0173
17	ACCEL	0-45	22	28.85	2.05	0.1759
18	DECEL	45-15	16	31.33	-1.88	0.1392
19	ACCEL	15-45	18	30.55	1.67	0.1528
20	DECEL	45-0	19	24.72	-2.37	0.1304
21	ACCEL	0-60	25	38.28	2.40	0.2654
22	DECEL	60-0	28	33.88	-2.14	0.2634
23	ACCEL	0-30	15	17.73	2.00	0.0737
24	ACCEL	30-60	25	45.14	1.20	0.3134
25	DECEL	60-30	18	47.23	-1.67	0.2362
26	DECEL	30-0	10	15.99	-3.00	0.0444
27	ACCEL	0-60	38	38.01	1.58	0.4009
28	DECEL	60-0	35	33.87	-1.71	0.3293
29	ACCEL	0-30	18	17.73	1.67	0.0886
30	ACCEL	30-60	21	45.27	1.43	0.2599
31	DECEL	60-30	14	46.63	-2.14	0.1813
32	DECEL	30-0	13	16.40	-2.31	0.0592

TABLE 2.19. Light Duty Gasoline-powered Vehicle Modal Emission Ratios

Mode	Modal Ratio ^a					
	Low Altitude and California			High Altitude		
	CO	HC	NO _x	CO	HC	NO _x
Idle ^b	.225	.197	.027	.153	.172	.054
Steady State Speed (mph)						
15	.936	.750	.182	.771	.706	.373
30	.417	.439	.486	.465	.436	.686
45	.386	.426	1.022	.503	.459	1.377
60	.396	.419	1.542	.634	.451	2.027
Acceleration/ Deceleration Sequences						
1	1.686	1.733	2.743	2.424	1.479	2.063
2	0.650	0.823	0.559	0.616	0.699	0.673
3	2.647	2.379	1.554	2.431	1.933	1.121
4	1.009	0.970	1.821	1.319	0.850	1.525
5	0.628	0.691	2.015	1.178	0.652	1.884
6	0.309	0.412	0.583	0.335	0.350	0.808
7	1.258	0.881	2.161	2.053	0.874	1.704
8	0.330	0.426	0.753	0.405	0.408	1.256
9	0.630	0.661	2.185	1.308	0.652	2.198
10	0.382	0.617	0.607	0.424	0.548	1.032
11	1.130	0.896	2.379	2.255	0.967	1.570
12	0.446	0.720	0.704	0.505	0.652	1.211
13	1.151	1.014	2.719	2.220	1.106	1.794
14	0.352	0.529	0.559	0.434	0.513	0.987
15	0.513	0.632	0.389	0.508	0.582	0.583
16	1.926	1.718	0.583	1.602	1.514	0.583
17	1.295	1.146	2.403	2.361	1.176	1.570
18	0.447	0.573	0.486	0.471	0.513	0.718
19	1.136	0.984	2.209	2.035	0.978	1.391
20	0.573	0.735	0.534	0.591	0.676	0.763
21	1.642	1.160	2.452	2.791	1.211	1.391
22	0.466	0.749	0.583	0.563	0.664	0.987
23	1.671	1.630	2.379	2.474	1.572	1.749
24	0.801	0.720	2.209	1.628	0.734	1.525
25	0.341	0.500	0.583	0.450	0.419	1.032
26	0.807	0.940	0.534	0.735	0.827	0.808
27	0.978	0.896	2.500	1.925	0.943	1.704
28	0.482	0.735	0.534	0.558	0.664	0.987
29	1.581	1.469	2.015	2.100	1.339	1.749
30	1.056	0.779	2.136	1.913	0.885	1.435
31	0.340	0.470	0.631	0.446	0.431	1.077
32	0.846	0.970	0.510	0.729	0.885	0.673

^aEmissions in mode/Emissions in 1975 FTP (grams/vehicle-mile/ grams/vehicle-mile).^bGrams/minute/ grams/vehicle-mile.

The detailed description of modal emission patterns is useful only when there is sufficient data on vehicle operating modes. This, in general, confines its use to localized situations where the data collection problem is manageable.

2.1.8 Gaseous-fueled Vehicles

The conversion of motor vehicles to gaseous fuels has received increased attention in recent years as a means of meeting federal motor vehicle emission standards. Besides their natural tendency to reduce maintenance on internal combustion engines, gaseous fuels can come close to meeting emission standards without the use of additional control devices.

Three forms of gaseous fuel are in use in the U.S. today. They are liquefied petroleum gas (LPG), compressed natural gas (CNG), and liquefied natural gas (LNG). LPG is far and away the most frequently used as a motor vehicle fuel. All three have also been used in stationary combustion applications.

The conversion of a motor vehicle to burn a gaseous fuel involves the installation of a special heavy gauge steel tank to handle the high pressures required to achieve acceptable storage space (150 psig for LPG, 2000 psig for LNG at 70°F), installation of shut-off valves and special fuel lines, and replacement of the carburetor with a flow valve and pressure regulator. The conversion can be made in several hours and the system can be removed from a vehicle when it is retired from service and installed on another vehicle. In addition, the vehicle can be made to run on both gaseous fuel and conventional gasoline with the switchover being made by the driver.

Because gaseous fuels are always introduced into the engine in a vapor state, their burning characteristics are much cleaner, resulting in less carbon and sludge buildup on the cylinders, on the spark plugs, and in the engine oil. This makes for a much improved maintenance picture and would make conversion attractive, even without emission standards. For example, it has been reported¹⁸ that converted taxis have gone 16,000 miles between oil changes and 50,000 miles between spark plug changes, and have had a total operating cost of 1.75 cents/mile, compared to 2.33 cents/mile for comparable gasoline-powered taxis.

From an emissions standpoint, one of the biggest advantages of gaseous fuels is that the vehicle does not have to be run with an enriched fuel

mixture during starting and warmup. Hence, a sizeable part of the cold start problem is eliminated. On the basis of the 1975 FTP, the biggest emission reductions come in the CO and HC emission rates. The NO_x rates are also reduced but not as dramatically. The USEPA has published emission factor data for gaseous-fueled vehicles,² and these are given on Tables 2.20 and 2.21. These factors are based on in-use vehicles and hence have deterioration already incorporated. No separate deterioration factors or speed correction factors have been developed. The LPG and LPG/Dual Fuel emission factors have been separated, since the dual fuel system requires some compromise of optimum emission levels to achieve this fuel flexibility.

TABLE 2.20. Light Duty Gaseous-fuel-powered Vehicle Exhaust Emission Factors
1975 Federal Test Procedure, Deterioration Included
(All Emissions in Grams/Vehicle-Mile)

Fuel	Model Year	CO	HC	NO _x
LPG	1960-69	11.0	1.80	3.2
	1970	3.4	.67	2.8
	1971	3.4	.67	2.8
	1972	3.4	.67	2.8
	1973 ^a	3.4	.67	-
	1974 ^a	3.4	.67	-
LPG/ Dual Fuel	1960-69	7.8	2.40	3.4
	1970	7.8	2.40	3.4
	1971	7.8	2.40	3.4
	1972	7.8	2.40	3.4
	1973 ^a	7.8	2.40	-
	1974 ^a	7.8	2.40	-
CNG/ Dual Fuel	1960-69	9.2	1.50	2.8
	1970	9.2	1.50	2.8
	1971	9.2	1.50	2.8
	1972	9.2	1.50	2.8
	1973 ^a	9.2	1.50	-
	1974 ^a	9.2	1.50	-

^aBased on the assumption that 1973-74 model year vehicles will exhibit the same emission characteristics (except for NO_x) as 1972 vehicles.

TABLE 2.21. Heavy Duty Gaseous-fuel-powered Vehicle Exhaust Emission Factors
Deterioration Included
(All Emissions in Grams/Vehicle-Mile)

Fuel	Model Year	CO	HC	NO _x
LPG	All model years	4.2	2.4	2.8
CNG/ Dual Fuel	All model years	7.5	2.2	5.8

The light duty vehicle emission factors are presented for 1974 and earlier model years only. The USEPA has estimated that 1973 and 1974 emission factors for CO and HC will be essentially the same as the 1972 model year, but the NO_x emissions may differ. No attempt has been made to project 1975 and later emission factors, because the gaseous fuel emissions are very close to not meeting the standards. They would require some additional control equipment in order to comply, and such equipment is not currently planned. For heavy duty vehicles the standards would permit the use of gaseous fuels alone beyond 1974.

In utilizing gaseous-fueled vehicles as a means of regional motor vehicle emission reduction, some constraints must be kept in mind. The special safety precautions required for the handling of LPG, CNG, and LNG dictate the location of fuel distributors in relatively remote locations. This creates an availability problem if the average motorist is to use this fuel. The storage by the user of gaseous fuels in large quantities overcomes the availability problem, but makes the system feasible only for fleet operations (e.g., taxi fleets, municipal vehicles; delivery truck fleets; etc.). These operators are also in a better position to take advantage of the transferability from one vehicle to another of the conversion equipment. In a recent position paper the USEPA stated:

The conversion of existing vehicles to gaseous motor fuels is recommended for fleet-operated vehicles in those metropolitan areas in which (a) logistical and economic considerations are favorable in terms of availability of fuel and conversion equipment, and (b) where major air pollution problems are attributable to the use of motor vehicles. Those vehicles likely to receive maximum usage prior to being phased out of use should be converted first. Except on the above terms, conversion of vehicles to gaseous fuel is not warranted at this time for purposes of air pollution control.¹⁹

In addition, it cautioned against diverting natural gas supplies away from other users (e.g., utilities, space heating), which would have the effect of increasing the use of high-sulfur- and high-particulate-producing fuels.

2.1.9 Motorcycles

Motorcycles are not, in general, considered in the estimation of regional motor vehicle emissions. In certain special cases where they operate in large numbers, it may be necessary to include their effects. For this reason motorcycle data is included here.

In 1970 there were 2,815,000 motorcycles registered in the U.S. They traveled on the average 3,600 miles/year with an average fuel consumption of 75 miles/gallon.²⁰ Approximately 38% of the motorcycles are equipped with 2-stroke air-cooled engines, with the remaining 62% equipped with 4-stroke engines.

The USEPA has published emission factors for motorcycles,² and these are given in Table 2.22. The exhaust emission factors are based on the 1975 FTP. The crankcase emissions for 2-stroke engines are not included, since these vehicles use crankcase induction systems that eliminate crankcase losses. The evaporative hydrocarbon emissions are diurnal breathing losses only. Deterioration and speed correction data are not available.

TABLE 2.22. Motorcycle Emission Factors
(All Emissions in Grams/Vehicle-Mile)

	2-stroke Engine	4-stroke Engine
Exhaust Emissions		
CO	27.	33.
HC	16.	2.9
NO _x	0.12	0.24
Particulates	0.33	0.046
Sulfur Oxides	0.038	0.022
Crankcase HC Emissions	-	0.60
Evaporative HC Emissions (Diurnal Breathing Loss)	.36	.36

2.2 EMISSION FACTOR ADJUSTMENTS

The emission factors presented in Sec. 2.1 reflect motor vehicle operation under certain specified conditions. When these conditions are not met, then some adjustment is necessary. Two specific adjustments will be discussed in this section: emission control device deterioration and vehicle speed.

2.2.1. Deterioration

Motor vehicle engine emission control devices deteriorate with use. The result is a higher emission rate that should be accounted for when making regional emission estimates. Deterioration factors have been developed by the USEPA² for exhaust CO, HC, and NO_x. These factors, when applied to the new vehicle emission rates, will correct the rates to account for vehicle use. Table 2.23 lists the factors for light duty gasoline-powered vehicles. The variation in deterioration rates with model year reflects the different emission control devices employed; uncontrolled vehicles have deterioration factors of 1.0.

It can be seen that the CO and HC deterioration factors increase substantially with the introduction of catalytic converters in the 1976 model year (1975 in California). Similarly, the NO_x deterioration rates increase sharply with the introduction of NO_x control devices in 1977. This rapid deterioration of control equipment has been one of the biggest problems faced by manufacturers in meeting the emission standards.

The deterioration factors in Table 2.23 are a function, in this case, of vehicle age, as a convenience for the computation at any given calendar year. Actually, the deterioration factors are vehicle-mileage rather than vehicle-age dependent. This distinction becomes important when computations are made for vehicles accumulating a lot of mileage in a short time period (e.g., taxicabs, which can travel in excess of 60,000 miles per year). The deterioration factors would, therefore, be more generally applicable if expressed in terms of mileage rather than age. The factors can be converted to a mileage dependence by applying a scale transformation using mileage accumulation data from the Federal Highway Works Administration.²¹ Figures 2.5-2.7 represent the deterioration rates plotted as mileage-dependent using the data of Table 2.23. Note that the deterioration rates go to 1.0 at a cumulative mileage of 4000 miles, because the deterioration factors as defined by the USEPA are normalized with respect to the 4000-mile emission rate.

TABLE 2.23. Exhaust Deterioration Factors for Light Duty Gasoline-powered Vehicles

Vehicle			All Areas Except California									
Age →			0	1	2	3	4	5	6	7	8	9 +
CO	M	1960-67	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	o	1968	1.00	1.24	1.35	1.41	1.47	1.53	1.58	1.63	1.67	1.72
	d	1969	1.00	1.42	1.53	1.59	1.63	1.68	1.71	1.75	1.79	1.82
	e	1970	1.00	1.18	1.32	1.38	1.40	1.44	1.47	1.50	1.51	1.56
	l	1971	1.00	1.18	1.32	1.38	1.40	1.44	1.47	1.50	1.51	1.56
		1972	1.00	1.18	1.32	1.38	1.40	1.44	1.47	1.50	1.51	1.56
	Y	1973	1.00	1.18	1.32	1.38	1.40	1.44	1.47	1.50	1.51	1.56
	e	1974	1.00	1.18	1.32	1.38	1.40	1.44	1.47	1.50	1.51	1.56
	a	1975	1.00	1.04	1.30	1.36	1.43	1.44	1.49	1.56	1.63	1.69
	r	1976-90	1.00	1.16	1.34	1.50	1.62	1.75	1.88	2.00	2.10	2.22
HC	M	1960-57	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	o	1968	1.00	1.12	1.18	1.21	1.23	1.26	1.28	1.30	1.32	1.35
	d	1969	1.00	1.10	1.16	1.18	1.21	1.23	1.25	1.28	1.29	1.31
	e	1970	1.00	1.05	1.10	1.13	1.15	1.17	1.20	1.22	1.24	1.26
	l	1971	1.00	1.05	1.10	1.13	1.15	1.17	1.20	1.22	1.24	1.26
		1972	1.00	1.05	1.10	1.13	1.15	1.17	1.20	1.22	1.24	1.26
	Y	1973	1.00	1.05	1.10	1.13	1.15	1.17	1.20	1.22	1.24	1.26
	e	1974	1.00	1.05	1.10	1.13	1.15	1.17	1.20	1.22	1.24	1.26
	a	1975	1.00	1.00	1.13	1.22	1.29	1.37	1.43	1.50	1.56	1.63
	r	1976-90	1.00	1.14	1.30	1.44	1.55	1.67	1.77	1.88	1.96	2.07
NO _x	M	1960-72	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	o	1973	1.00	1.11	1.18	1.20	1.21	1.22	1.23	1.24	1.25	1.26
	d	1974	1.00	1.11	1.18	1.20	1.21	1.22	1.23	1.24	1.25	1.26
	e	1975	1.00	1.00	1.18	1.23	1.23	1.41	1.45	1.45	1.45	1.45
	l	1976	1.00	1.03	1.07	1.10	1.13	1.17	1.19	1.21	1.24	1.26
	Yr	1977-90	1.00	1.17	1.37	1.53	1.67	1.82	1.94	2.06	2.17	2.32

TABLE 2.23. Exhaust Deterioration Factors for Light Duty Gasoline-powered Vehicles (Contd.)

C a l i f o r n i a											
Same as above except as indicated below											
Vehicle Age →		0	1	2	3	4	5	6	7	8	9 +
CO	M 1966	1.00	1.13	1.21	1.24	1.25	1.28	1.29	1.31	1.32	1.34
	o 1967	1.00	1.11	1.18	1.23	1.29	1.35	1.40	1.46	1.50	1.56
	d 1975	1.00	1.16	1.34	1.50	1.62	1.75	1.88	2.00	2.10	2.22
HC	e l 1966	1.00	1.14	1.22	1.25	1.27	1.29	1.30	1.32	1.35	1.35
	1967	1.00	1.07	1.10	1.12	1.14	1.15	1.17	1.18	1.20	1.21
	Y 1975	1.00	1.14	1.30	1.44	1.55	1.67	1.77	1.88	1.96	2.07
NO _x	e a 1971-74	1.00	1.11	1.18	1.20	1.21	1.22	1.23	1.24	1.25	1.26
	r 1975	1.00	1.03	1.07	1.10	1.13	1.17	1.19	1.21	1.24	1.26

Fig. 2.5. Light Duty Gasoline-powered Vehicle Exhaust CO Deterioration 5

Fig. 2.6. Light Duty Gasoline-powered Vehicle Exhaust HC Deterioration

Fig. 2.7. Light Duty Gasoline-powered Vehicle Exhaust NO_x Deterioration.

The age-dependent and mileage-dependent deterioration factors are applied to exhaust emissions only. They are to be used on the 1975 FTP emission factors and the modal emission factors. Crankcase and evaporative emissions were not included in the development of these deterioration rates. In the situation where the cold start is separated from the hot operating emission rate, the deterioration factor must be applied to both parts, since it has been developed on the basis of the 1975 FTP that includes a weighted cold start.

For heavy duty vehicles there is little actual data on deterioration of control equipment. Kircher and Armstrong³ recommend that light duty vehicle deterioration for CO and HC be used for the 1975 and later California vehicles only. No NO_x deterioration is used. All other heavy duty vehicles have deterioration factors of 1.0, since emission standards have not required the use of control equipment subject to significant deterioration. The age-dependent deterioration factors are given on Table 2.24 and the mileage-dependent factors on Fig. 2.8.

For diesel-powered light and heavy duty vehicles, no deterioration is used due to a lack of data. For gaseous-fueled vehicles the deterioration is already included in the emission factors. For motorcycles, no deterioration is used.

TABLE 2.24. Exhaust Deterioration Factors
for Heavy Duty Gasoline-powered Vehicles

		California Only									
		Vehicle Age (Years)									
		0	1	2	3	4	5	6	7	8	9 & older
1975 and later model years only	CO	1.00	1.24	1.35	1.43	1.50	1.57	1.63	1.69	1.73	1.77
	HC	1.00	1.12	1.18	1.22	1.25	1.28	1.30	1.33	1.36	1.38
	NO _x	1.00	1.11	1.18	1.20	1.22	1.23	1.24	1.25	1.27	1.28

Fig. 2.8. Heavy Duty Gasoline-powered Vehicle Exhaust Deterioration

2.2.2 Speed

The emission factors based on the 1975 FTP are at an average vehicle speed of 19.6 mph. In general, the emissions of CO and HC tend to increase with decreasing vehicle speed due to inefficient engine operation at low power settings. Conversely, the NO_x emission rate increases with increasing vehicle speed as the engine operates higher on the power curve. These changes in emission rate can be significant and, hence, the emission factors should be adjusted to reflect different vehicle speeds. Figure 2.9 gives the speed adjustment curves as published by the USEPA² for light duty vehicles. These correction factors are to be applied to the 1975 FTP emission factor. In the situations where the cold start is separated out, the speed correction applies only to the hot operating emission rate.

The curves of Fig. 2.9 can be expressed algebraically and are given in Eq. 2.9.

$$\begin{aligned} \text{CO speed correction factor} &= 12.5 [\text{Speed (mph)}]^{-0.845} \\ \text{HC speed correction factor} &= 7.0 [\text{Speed (mph)}]^{-0.649} \\ \text{NO}_x \text{ speed correction factor} &= 1.0 + 0.01262 [\text{Speed (mph)} - 19.6] \end{aligned} \quad (2.9)$$

Several points need to be emphasized about these speed-adjustment factors. First, the speed referred to is an average route speed over the test cycle. This is not the same as a cruising speed. The test sequence, as previously described, includes many stop-and-start cycles over which the speed is averaged. Second, the lowest speed for which actual data exists is 15 mph; the highest is 60 mph. Speed corrections outside these ranges are extrapolations. In the low speed range, this extrapolation is very approximate since the slope of the curve is very steep.

For heavy duty gasoline-powered vehicles, there is no speed correction data available, so the light duty factors are used. For diesel-powered vehicles, there is no speed correction since the engine is operated over a limited rpm range with gear shifts providing the vehicle speed range. For gaseous-fueled vehicles and motorcycles, no speed adjustment is used.

Fig. 2.9. Average Speed Correction Factors

2.3 REGIONAL AND LOCAL EFFECTS

Three area-specific modifications to the emission factor computation procedure will be discussed here. The first is the use of the local distribution of vehicle miles traveled by vehicle age. The second is the use of a vehicle class mix. The third is the incorporation of a vehicle retrofit program into a region's control program.

2.3.1 Local Travel Distribution

As can be seen from the previous sections, motor vehicle emissions vary significantly with model year and age. Therefore, in order to accurately estimate the total air pollutant emission rate, it is necessary to determine how much each vehicle age group contributes to the total vehicle miles traveled (VMT) in the area under consideration. Two pieces of information are necessary to make this determination: the vehicle age distribution and the average rate of travel of each age group.

The vehicle age distribution can be obtained from local motor vehicle registration files. Care must be taken to be consistent when using this data for any given calendar year. If it is desired to compute an emission factor for mid-year, then the registration data must be mid-year. This means that the next year's model vehicles (generally introduced in October) are not included. If, however, it is desired to compute an emission factor for year-end, then the next year's model must be included in the data. In most instances the available registration data is for July 1, hence excluding the next year's models. (It is important to note that the National Ambient Air Quality Standards are scheduled to be met in July, 1975. This means that the mid-year registration data must be used in developing emission factors for that time period.)

Table 2.25 gives the U.S. national average vehicle age distribution for light and heavy duty vehicles.² Table 2.26 gives the vehicle registration data for Cook County, Illinois, including the City of Chicago. It is interesting to note that the metropolitan Chicago region has an age distribution that is more skewed toward the newer vehicles. This means that such an area will benefit more quickly from the federal motor vehicle emission control program than will the nation as a whole. Such a conclusion is significant when planning for local compliance with the air quality standards.

TABLE 2.25. U.S. National Vehicle Age Distribution
(Data as of July 1)

Vehicle Age (Years)	Fraction of Vehicles in Use	
	Light Duty Vehicles	Heavy Duty Vehicles
0	.078	.071
1	.116	.106
2	.110	.087
3	.098	.081
4	.106	.084
5	.106	.076
6	.088	.065
7	.078	.055
8	.063	.047
9	.041	.035
10	.035	.037
11	.021	.033
12 and older	.060	.223
	<u>1.000</u>	<u>1.000</u>

TABLE 2.26. Cook County, Illinois, Vehicle Age Distribution
(Data as of July 1)

Vehicle Age (Years)	Fraction of Vehicles in Use	
	Passenger Cars	Trucks
0	.1163	.0825
1	.1444	.1292
2	.1307	.1042
3	.1124	.1081
4	.1090	.1024
5	.1047	.0921
6	.0815	.0660
7	.0671	.0610
8	.0523	.0503
9	.0296	.0343
10	.0230	.0361
11	.0101	.0275
12	.0042	.0157
13	.0147	.0158
14	-	.0154
15 and older	-	.0594
	<u>1.0000</u>	<u>1.0000</u>

The average rate of travel of each age group is available from data gathered by the Federal Highway Works Administration²¹ and the Census Bureau.²² Table 2.27 gives the national data as used by the USEPA.² It is important to note that in weighting the emission contribution of each group, it is the rate of mileage accumulation rather than the absolute accumulated mileage that is the significant factor. Hence the correct interpretation of Table 2.27 is that in July, 1975, for example, a 1975 model year vehicle is zero years old and is being used at the rate of 15,900 miles per year, although its actual cumulative mileage at that time is substantially less.

TABLE 2.27. U.S. National Average Rate of Miles Driven

Vehicle Age (Years)	Rate of mileage accrual (miles/year)	
	Light Duty Vehicles	Heavy Duty Vehicles
0	15900	17200
1	15000	17200
2	14000	15800
3	13100	15800
4	12200	13000
5	11300	13000
6	10300	11000
7	9400	11000
8	8500	9000
9	7600	9000
10	6700	5500
11	6700	5500
12	6700	5500
13	6700	5500
14	6700	5500
15 and older	6700	5500

The registration data and the rate of travel data are used together to develop a weighting factor for each model year. The weight factor is given by Eq. 2.10.

$$P_n = \frac{V_n \times D_n}{\sum_{n=0}^{16} (V_n \times D_n)} \quad (2.10)$$

where:

- n = Calendar year - model year
- P_n = Percentage of vehicle miles traveled by vehicles n years old
- V_n = Fraction of total vehicles of age n years from registration data (Table 2.25 or Table 2.26)
- D_n = Average rate of mileage accumulation of vehicles of age n (Table 2.27)

Note that n is defined so as to exclude the next year's model; that is, this calculation is set to operate on mid-year registration data. To do a year-end calculation, one need only redefine $n = \text{calendar year} - \text{model year} + 1$.

One other point may be made with reference to the annual rate of mileage accrual. It has been previously stated that vehicle deterioration factors are mileage dependent rather than vehicle age dependent. In situations where vehicle age data and mileage accrual rate data are available, the two can be combined to generate the total cumulative mileage of any model year with the addition of one other piece of information. It is necessary to know how much of the current year's mileage has been accumulated at the time the calculation is made. For example, if the calculation is made in mid-year 1975, then a 1975 model year vehicle is accruing at the rate of 15,900 miles per year, but by July, 1975, has accrued only a fraction of that mileage. Thus the cumulative mileage on which the deterioration factor is based is some fraction of 15,900 miles. Similarly, a 1972 model year vehicle in July, 1975 is a 3-year old vehicle and would have a cumulative mileage of 15,900 (accrued during its first year of service, 1972) + 15,000 (accrued during its second year, 1973) + 14,000 (accrued during its third year, 1974) + $f \times 13,100$ (accrued during the current year, 1975) miles. The value of f is the fraction of the current year's mileage that has been accrued up to July 1975. In general, the computation of cumulative mileage is given by Eq. 2.11.

$$CM_n = \sum_{i=0}^{n-1} D_i + D_n \times f_n \quad (2.11)$$

CM_n is the cumulative mileage of vehicles n years old, where $n = \text{calendar year} - \text{model year}$ for mid-year calculations and $n = \text{calendar year} - \text{model year} + 1$ for year-end calculations, as described before.

D_n is the rate of mileage accrual of a vehicle n years old and f_n is the fraction of the current year's mileage that has been accrued at the time of the calculation.

Based on new car sales²⁰ the average new vehicle is 4.5 months old in July of the calendar year that is the same as the model year. In December the vehicle is 8.6 months old, while the next year's model is 1.7 months old. The average new truck is 4.4 months old in July of the calendar year that is the same as the model year.¹⁵ In December the vehicle is 8.6 months old, while the next year's model is 1.0 months old. If it is assumed that the rate of mileage accrual is constant over the year, then values of f_n can be computed for mid-year and year-end calculations. These are given in Table 2.28.

TABLE 2.28. Mileage Accumulation Fractions

Vehicle Age (Years)	Fraction of the Current Year's Mileage Accumulated (f_n)			
	Light Duty Vehicles		Heavy Duty Vehicles	
	Mid-Year	Year-End	Mid-Year	Year-End
0	.38	.09 ^a	.37	.09 ^a
1	.30	.72	.30	.72
2	.30	.72	.30	.72
3 and older	.30	.72	.30	.72

^a In year-end calculations a zero-year old vehicle is the next year's model.

2.3.2 Vehicle Class Mix

The distribution of vehicle types is a significant factor in determining regional motor vehicle emission rates. In most cases passenger cars far outnumber all other vehicle types. However, there may be special situations in which other vehicle classes will predominate.

Table 2.29 gives the U.S. national vehicle class distribution, using the gross vehicle weight classification scheme previously developed for heavy duty vehicles. Light duty diesel-powered vehicles, gaseous-fueled vehicles, and motorcycles are not included here.

TABLE 2.29. U.S. National Vehicle Class Distribution

Vehicle Class	Fraction of Population
Passenger Car	.821
Light Duty Truck (< 6000 lb GVW)	.100
Heavy Duty Gasoline-Powered Vehicles	
6001-16000 lb GVW	.045
16001-33000 lb GVW	.018
> 33000 lb GVW	.010
Heavy Duty Diesel-Powered Vehicles	.006

2.3.3 Retrofit Program

In recent years some attention has been focused on the use of a program of motor vehicle retrofits to enable special problem regions to meet the national ambient air quality standards. The program would involve the installation of emission control equipment on in-use vehicles that were manufactured prior to the stringent emission standards. For light-duty vehicles this would affect primarily pre-1968 model years; for heavy duty vehicles it would affect pre-1970 model years. In addition, it has been suggested in some areas that even some of the earlier controlled vehicles be retrofitted with more efficient control equipment.

The USEPA has published a report²³ summarizing several studies on the viability of alternative retrofit schemes. The data presented will not be repeated here, except to indicate how the retrofit would be included in the emission factor computation scheme.

The most straightforward approach to incorporating retrofit effects would be to replace the affected model year emission factors of Section 2.1 with retrofitted factors. Unfortunately, most of the data has been collected on other than the 1975 FTP. The alternative approach is to assume that the percent emission reduction, as a result of retrofit, measured by another test procedure will be the same as that measured by the 1975 FTP. There is no data to verify the accuracy of this assumption, but it appears to be intuitively correct, at least to a first order approximation, provided the test procedure is not highly unusual. The modified emission factor can then be computed by Eq. 2.12.

$$\left[\begin{array}{l} \text{1975 FTP Emission} \\ \text{Factor, Including} \\ \text{Retrofit} \end{array} \right] = \left[\begin{array}{l} \text{1975 FTP Emission} \\ \text{Factor Prior to} \\ \text{Retrofit} \\ \text{(From Table 2.1)} \end{array} \right] \times \left[\begin{array}{l} \% \text{ Reduction} \\ \text{1. - in Emissions} \\ \text{as a result} \\ \text{of Retrofit} \end{array} \right] \quad (2.12)$$

The % reduction is derived from the USEPA program. Obviously, the best results are obtained when the test procedure used to determine % reduction is closest to the 1975 FTP (e.g., the 1972 FTP).

2.4 MOTOR VEHICLE EMISSION FACTOR COMPUTATION

In calculating the contribution of motor vehicles to the rate of air pollutant emissions in a region, one must determine the parameters that represent local conditions and select from the previously presented data to generate an emission factor.

2.4.1 Calculation Procedure

The calculation scheme is straightforward and involves selecting the desired calendar year of computation and the basic model year emission factors. These factors are corrected for deterioration and speed, as described in Sec. 2.2, and are then weighted according to the local and regional effects as described in Sec. 2.3.

The basic equation used for exhaust emissions is Eq. 2.13.

$$(E_{j\ell})_y = \sum_{\substack{n=0 \\ m=y-16 \\ n=16}}^{m=y} Y_{jml} \times D_{jml} \times S_{j\ell} \times P_{jn} \quad (2.13)$$

where $(E_{j\ell})_y$ is the exhaust emission factor in calendar year y . The subscript j counts vehicle class (auto, heavy duty truck, etc.), and ℓ counts pollutant type (CO, HC, NO_x, etc.). This factor is in grams/vehicle-mile.

Y_{jml} is the exhaust emission factor of model year m . The subscripts, j and ℓ , are as above. Data for this variable are presented in Sec. 2.1. If the 1975 FTP data are used for Y_{jml} , then Eq. 2.13 is used as is. If the cold start is separated out, then the values of Y_{jml} used must be the hot operating factors only. The cold start emission factors are computed differently, and they will be discussed later. If retrofit considerations are to be included, then the modifications, as discussed in Sec. 2.3.3, are made to the appropriate values of Y_{jml} .

D_{jml} is the exhaust emission deterioration factor for model year m when it is n years old. The values of j and ℓ are as above. It should be noted that the subscript n varies, along with m , and is not independent. The deterioration factors are permitted to extend only to vehicles 16 years old, or less. This time factor is selected arbitrarily and is primarily

a result of data availability. Data for deterioration factors are given in Sec. 2.2.1, and either age- or mileage-dependent factors can be used.

$S_{j\ell}$ is the speed adjustment factor for pollutant ℓ . As previously indicated, there is no variation with model year.

P_{jn} is the percentage vehicle miles traveled by vehicles of n years old. The subscript j is for vehicle classes as above. The procedure for computing P_{jn} is given in Sec. 2.3.1. In Eq. 2.13, it is assumed that the calculation will be made on mid-year registration data. If year-end calculations are desired, then the bounds of variation of subscript n are changed to $n = y-15$ and $n = y+1$. This means that the next year's model vehicle is included and is treated as a zero year old vehicle. The current year's model is then treated as a one year old vehicle.

When doing cold start computations, Eq. 2.14 is used.

$$(CS_{j\ell})_y = \sum_{\substack{n=0 \\ m=y \\ m=y-16 \\ n=16}}^{n=0} YCS_{jmn\ell} \times D_{jmn\ell} \times P_{jn} \quad (2.14)$$

where $(CS_{j\ell})_y$ is the cold start emission in calendar year y and $YCS_{jmn\ell}$ is the cold start emission of model year m . Both have the units of grams. All other variables are as before. The important feature is that the speed correction has been eliminated, since it does not apply to cold starts.

Crankcase hydrocarbon emissions are computed using Eq. 2.15.

$$(CR_j)_y = \sum_{\substack{n=0 \\ m=y \\ m=y-16 \\ n=16}}^{n=0} C_{jmn} \times P_{jn} \quad (2.15)$$

where $(CR_j)_y$ is the crankcase HC emission in calendar year y and C_{jmn} is the crankcase emission of model year m . The other variables are as above. No speed or deterioration corrections are applied to the crankcase emissions. The units are grams/vehicle-mile.

Evaporative hydrocarbon emissions are computed by Eq. 2.16.

$$(EV_{ji})_y = \sum_{\substack{n=0 \\ m=y \\ m=y-16 \\ n=16}} V_{jmi} \times P_{jn} \quad (2.16)$$

where $(EV_{ji})_y$ is the evaporative emission factor in calendar year y . The subscript i is for the different emission sources (diurnal, running loss, hot soak). The units for the diurnal and hot soak are grams; for the running loss it is grams/vehicle-mile. V_{jmi} is the model year m evaporative emission factor from source i . All other variables are as before.

2.4.2 Emission Factor Computer Program

Although the computation scheme is straightforward it can be tedious. Hence a computer program, TREFACT, has been written to relieve this burden. The version of TREFACT described here is a modification of that discussed in Ref. 1. The major changes include the incorporation of the new emission data presented in the previous sections and a modification to the input routines to minimize the necessary input data. The new program input structure will be described here. A complete listing of TREFACT can be found in Appendix A. Appendix B contains tables of some of the more frequently used emission factors computed using the TREFACT program. Fig. 2.10 gives the comprehensive structure of the data input deck for TREFACT. Although the deck appears large, any or all of the data cards may be eliminated by choosing from data that is already included in the program. Hence, the input deck may be reduced to only the Title Card, Basic Option Card, and Yearly Calculation Option Cards if all the data in the program were to be used.

TITLE CARD (9A8)

This card permits the user to identify the output. It is printed at the top of the final emission factor table.

BASIC OPTION CARD (11I3)

This card selects options which are carried through the entire computer run. Any change would require a separate run.

Fig. 2.10. TREFACT Input Data Deck Structure

After reading this card, arrays will be set up which contain the exhaust emission factors, deterioration factors, crankcase and evaporative emission factors, and cold start ratios for model years 1960-1990. Also, arrays containing vehicle registration and annual travel and vehicle class weighting factors will be initialized. This will be done for CO, HC, and NO_x and for six vehicle classes. Automobiles are assigned to Class 1, light duty trucks (less than 6000 lbs GVW) to Class 2, heavy duty gasoline-powered vehicles of GVW 6001-16000 lbs, 16001-33000 lbs, greater than 33000 lbs to Classes 3-5 respectively, and heavy duty diesel-powered vehicles to Class 6. These classes can be changed to represent any other type of vehicle provided the appropriate new data is input.

<u>Variable</u>	<u>Columns</u>	<u>Meaning</u>
IAREA	1-3	=1 Low altitude data will be selected =2 High altitude data will be selected. =3 California data will be selected.
IAUTO	4-6	=0 New class 1 exhaust emission factors will be input on following cards. =1 Automobile emission factors corresponding to IAREA will be selected from Table 2.1.
ILDIT	7-9	=0 New class 2 exhaust emission factors will be input on following cards. =1 Light duty truck emission factors corresponding to IAREA will be selected from Table 2.1.
IHDV	10-12	=0 New class 3-5 exhaust emission factors will be input on following cards. =1 Heavy duty gasoline-powered vehicle emission factors corresponding to IAREA will be selected with no GVW dependence from Table 2.5. =2 Heavy duty gasoline-powered vehicle emission factors will be selected using the GVW dependence from Table 2.8.
IDIESL	13-15	=0 New class 6 exhaust emission factors will be input on following cards. =1 Heavy duty diesel-powered vehicle emission factors will be selected from Table 2.9.

<u>Variable</u>	<u>Columns</u>	<u>Meaning</u>
IDET	16-18	=0 New exhaust emission deterioration factors will be input for all six vehicle classes on the following cards. =1 Age-dependent deterioration factors corresponding to IAREA will be selected for all 6 vehicle classes from Tables 2.23 and 2.24. =2 Mileage-dependent deterioration factors corresponding to IAREA will be selected for all 6 vehicle classes from Figures 2.5-2.8.
ICRNK	19-21	=0 New crankcase emission factors will be input for all 6 vehicle classes on following cards. =1 Factors corresponding to IAREA will be selected for all 6 classes from Table 2.15.
IEVAP	22-24	=0 New evaporative emission factors will be input for all 6 vehicle classes on following cards. =1 Factors corresponding to IAREA will be selected for all 6 vehicle classes with no breakdown by evaporative source from Table 2.16. =2 Factors corresponding to IAREA will be selected for all 6 vehicle classes using a breakdown by evaporative source from Table 2.17.
ICLDST	25-27	=0 New coldstart ratios will be input for all 6 vehicle classes on following cards. =1 Ratios corresponding to IAREA will be selected for all 6 vehicle classes from Tables 2.10 and 2.13.
IATT	28-30	=0 New vehicle registration and average annual rate of travel data will be input on following cards. =1 Data will be selected for all 6 vehicle classes from Tables 2.25, 2.27, and 2.28.
IWTFTR	31-33	=0 New vehicle class weighting factors will be input on following cards. =1 Factors will be obtained from Table 2.29.

CLASS 1 EMISSION FACTOR CARDS (9F8.0)

These cards are input only if the parameter IAUTO=0 on the Basic Option Card. The first four cards contain CO emission factors for Class 1 vehicles for model years 1960-1990. The next 4 cards contain HC emission factors. The next 4 cards contain NO_x emission factors.

<u>Variable</u>	<u>Meaning</u>
BYEFCO(1,M)	CO emission factor for Class 1 vehicles. M=1-31 for model years 1960-1990.
BYEFHC(1,M)	HC emission factor for Class 1 vehicles.
BYEFNO(1,M)	NO _x emission factor for Class 1 vehicles.

CLASS 2 EMISSION FACTOR CARDS (9F8.0)

These cards are input only if the parameter ILDT=0 on the Basic Option Card. The order is the same as for Class 1 vehicles: 4 cards for CO emission factors for model years 1960-1990, 4 for HC, 4 for NO_x. The first subscript of the variables is 2: BYEFCO(2,M), BYEFHC(2,M), BYEFNO(2,M) where M designates model year.

CLASS 3-5 EMISSION FACTOR CARDS (9F8.0)

These cards are input only if the parameter IHDV=0 on the Basic Option Card. The order is the same as for Class 1 vehicles with the first 12 cards corresponding to Class 3, the next 12 to Class 4, the next 12 to Class 5. The first subscript of the variables BYEFCO, BYEFHC, BYEFNO is 3 for the first 12 cards, 4 for the next 12, and 5 for the next 12.

CLASS 6 EMISSION FACTOR CARDS (9F8.0)

These cards are input only if the parameter IDIESL=0 on the Basic Option Card. The order is the same as for Class 1 vehicles. The first subscript of the variables BYEFCO, BYEFHC, BYEFNO is 6.

EXHAUST EMISSION DETERIORATION FACTOR CARDS (16F8.0)

These cards are input only if the parameter IDET=0 on the Basic Option Card. There are 93 cards for each vehicle class and all 6 vehicle classes are input. For each class the first 3 cards are for model year 1960 and contain deterioration factors for CO, HC, and NO_x respectively. The 16 entries on each card correspond to the deterioration factor for vehicle ages 0 to 15 years. The next three cards are for model year 1961 (CO,HC,NO_x) and so on through model year 1990.

The large number of cards required to modify the deterioration factors makes this procedure unwieldy at best. If it is desired to use different deterioration factors it is suggested that consideration be given to modifying the program itself to suit the specific needs.

<u>Variable</u>	<u>Meaning</u>
DETCO(J,M,N)	CO deterioration factor. N=1-16 for vehicle ages 0-15 years. M=1-31 for model years 1960-1990. J=1-6 for six vehicle classes.
DETHC(J,M,N)	HC deterioration factor.
DETNO(J,M,N)	NO _x deterioration factor.

CRANKCASE EMISSION FACTOR CARDS (9F8.0)

These cards are input only if the parameter ICRNK=0 on the Basic Option Card. The first 4 cards contain crankcase HC emission factors for Class 1 vehicles for model years 1960-1990. The next 4 are for Class 2, the next 12 for Classes 3-5 respectively, and the last 4 are for Class 6.

<u>Variable</u>	<u>Meaning</u>
CREF(J,M)	Crankcase emission factor. M=1-31 for model years 1960-1990. J=1-6 for six vehicle classes.

EVAPORATIVE EMISSION FACTOR CARDS (9F8.0)

These cards are input only if the parameter IIEVAP=0 on the Basic Option Card. There are 12 cards for each vehicle class and all 6 classes are input. For each class the first 4 cards are diurnal breathing loss HC emission factors for model years 1960-1990, the next 4 cards are running loss emission factors, and the next 4 cards are hot soak emission factors.

<u>Variable</u>	<u>Meaning</u>
EVEF(J,M,K)	Evaporative emission factors. K=1-3 for diurnal breathing loss, running loss, and hot soak loss respectively. M=1-31 for model years 1960-1990. J=1-6 for six vehicle classes.

COLD START RATIO CARDS (9F8.0)

These cards are input only if the parameter ICLDST=0 on the Basic Option Card. There are 8 cards for each vehicle class and all 6 classes are input. For each class the first 4 cards are CO cold start ratios for model years 1960-1990 and the next 4 cards are HC cold start ratios.

<u>Variable</u>	<u>Meaning</u>
RCSCO(J,M)	CO cold start ratio. M=1-31 for model years 1960-1990. J=1-6 for six vehicle classes.
RCSHC(J,M)	HC cold start ratio.

VEHICLE REGISTRATION AND ANNUAL TRAVEL CARDS (9F8.0)

These cards are input only if the parameter IAAT=0 on the Basic Option Card. There are 6 cards for each vehicle class and all 6 classes are input. For each class the first 2 cards are registration data for vehicle ages 0-15 years, the next 2 cards are rate of mileage accrual for vehicle ages 0-15 years, and the next two cards are the fraction of the current year's mileage accumulated at the time of the computation for vehicle ages 0-15 years (see Section 2.3.1 for detailed descriptions).

<u>Variable</u>	<u>Meaning</u>
REGIS(N,J)	Vehicle registration (fraction of vehicles in use). N=1-16 for vehicle ages 0-15 years. J=1-6 for six vehicle classes.
AAT(N,J)	Average rate of mileage accrual.
PAAT(N,J)	Fraction of current year's mileage accumulated at the time of the computation.

VEHICLE CLASS WEIGHT FACTORS (6F8.0)

This card is input only if the parameter IWTFTFTR=0 on the Basic Option Card. The 6 values on the card are the weight factors for the six vehicle classes.

<u>Variable</u>	<u>Meaning</u>
WFCTR(J)	Fraction of vehicles in class J. J=1-6 for six vehicle classes.

YEARLY CALCULATION OPTION CARD (4I6,F6.2)

This card will select options which are carried through a single calculation. Several of these cards may be included in one computer run to expedite the desired results.

<u>Variable</u>	<u>Columns</u>	<u>Meaning</u>
YEAR	1-6	Calendar year between 1960 and 1990 for which the computation will be carried out.
ITIME	7-12	=0 Calculation will be carried out as of mid-year. =1 Calculation will be carried as of year end.
RTROFT	13-18	Retrofit parameter. =0 No retrofit considerations will be included. =1 Retrofit will be considered but no new data will be used. =-1 Retrofit will be considered. New data will be input on following cards. For retrofit cases RTROFT must be -1 the first time retrofit is calculated and whenever changes in the retrofit parameters are made.
CLDSTR	19-24	=0 No cold start computation will be made. =1 Cold start emissions will be computed.
SPEED	25-30	Average route speed at which the calculation will be made.

RETROFIT DATA CARDS (9F8.0)

These cards are input only if the parameter RTROFT=-1 on the preceding Yearly Calculation Option Card. There are 12 cards for each vehicle class and all 6 vehicle classes are input. For each class the first 4 cards are the CO retrofit data for model years 1960-1990, the next 4 cards are the HC retrofit data, and the next four are the NO_x retrofit data.

<u>Variable</u>	<u>Meaning</u>
RTROCO(J,M)	Fractional reduction in CO emissions as a result of retrofit. M=1-31 for model years 1960-1990. J=1-6 for 6 vehicle classes.
RTROHC(J,M)	Fractional reduction in HC emissions as a result of retrofit.
RTRONO(J,M)	Fractional reduction in NO _x emissions as a result of retrofit.

2.5 SAMPLE PROBLEMS

The computation of regional motor vehicle emissions involves the collection and manipulation of a large amount of traffic information. As with the emission factor computation, the calculations are straightforward with the major difficulty being the selection of the proper data to use. Ref. 1 describes a computer program, TREMISS, which used a traffic simulation of the Chicago metropolitan area, developed by the Chicago Area Transportation Study (CATS), to compute motor vehicle emissions. That program has been slightly modified to handle the new speed correction factors presented in this document. Otherwise, TREMISS is unchanged from the documentation presented in Ref. 1 and will not be discussed further here.

Since TREMISS or any other emission computation program relies on the user to choose emission factors which are appropriate to the situation under study, several sample problems are included here to illustrate the choices which must be made. Tables of the most frequently used emission factors are presented in Appendix B to enable hand calculations to be made. If a particular problem under study requires parameters which differ from those used in generating the tables, then TREFACT can be rerun to compute new emission factors.

2.5.1 Urban Central Business District

Problem: Compute the emissions from motor vehicles operating in the Chicago central business district (CBD) in mid-1975.

Information Needed: Total vehicle miles traveled (VMT) in the CBD, average vehicle speed, vehicle class distribution, and number of vehicle cold starts.

The total vehicle miles traveled in the CBD can be obtained from traffic counts or from a traffic simulation model. For Chicago, the Department of Streets and Sanitation conducts regular traffic counts which, if projected to 1975, give a total of 250,000 vehicles entering the CBD per day. The CATS traffic simulation model gives the number of vehicle miles traveled in each of 12 quarter-square-mile zones in the CBD. These are further broken down by arterial and freeway road types. The CBD total, projected for 1975, is 1,175,900 VMT per day (237,200 freeway and 938,700 arterial).

The average vehicle speed in the CBD can also be obtained from traffic counts or from a traffic simulation model. The CATS model gives the average vehicle speed as 41 mph for freeway roads and 11 mph for arterial roadways in the Chicago CBD.

The vehicle class distribution is obtained from actual traffic observations. Assume that the breakdown was observed to be 85% automobiles, 7% light duty trucks, 7% heavy duty trucks, and 1% diesel tractor-trailers.

Assume that no information is available on the number of vehicle cold starts.

With the data already presented it is possible to estimate emissions from the CBD.

Step 1 Select basic motor vehicle emission factors.

For this case the data from Table B.11 is used. This is selected because the computation is for mid-year 1975, the table has been generated with Cook County vehicle registration data, no cold start information is available, no heavy duty vehicle distribution by GVW is available, and evaporative emissions will be treated as running losses since no vehicle origin or soak time data is available.

Step 2 Determine the speed correction factors.

For this case the speed corrections involve a change from 19.6 mph (the speed from Table B.11) to 11 mph for arterial roadways and to 41 mph for freeway roads. From Eq. 2.9 or Fig. 2.9 the speed correction factors are the following:

	<u>CO</u>	<u>HC</u>	<u>NO_x</u>
11 mph	1.65	1.48	0.90
41 mph	.52	.63	1.25

These correction factors are for automobiles and light and heavy duty trucks. Diesel tractor-trailers have a speed correction of 1.0.

A word of caution is required here when computing speed correction factors. Because of the non-linearity of the CO and HC correction factor equations, the computation of an average speed and then the computation of a speed correction factor based on that average is not equivalent to determining the speed correction factor for each speed considered and then computing an average speed correction factor. Thus, for the CBD problem, to average the arterial and freeway speed and compute a single average speed correction factor from that would not be the same as computing and applying a separate speed correction factor for both. Although the differences between the two methods are often small, there are occasions where the variation is large. The USEPA recommends² the determination of the separate speed correction factors first and then the computation of an overall average correction factor. This procedure will be followed here. Thus a single set of speed correction factors for the CBD problem can be obtained by weighting the previously determined factors by the VMT.

$$S_{CO} = \frac{(1.65) (938,700) + (0.52) (237,200)}{1,175,900} = 1.42$$

$$S_{HC} = \frac{(1.48) (938,700) + (0.63) (237,200)}{1,175,900} = 1.31$$

$$S_{NO_x} = \frac{(0.90) (938,700) + (1.25) (237,200)}{1,175,900} = 0.97$$

(It may be noted that if the speed-average-first method were used, the average speed in the CBD would be 17.0 mph resulting in speed correction factors of 1.15, 1.11, and 0.97 for CO, HC, and NO_x respectively. The NO_x factor is the same because the NO_x equation is linear.)

Step 3 Compute emissions.

For each vehicle class the exhaust emissions are computed as follows:

$$\begin{array}{ccccccc} \text{Total VMT} & & \text{Fraction of VMT} & & \text{Emission Factor} & & \text{Speed} \\ \text{(vehicle-miles/day)}^x & & \text{by Class} & & \text{at 19.6 mph} & & \text{Correction} \\ & & & & \text{(grams/vehicle-mile)} & & \text{Factor} \\ & & & & & & \\ & & & & = \text{Emissions} & & \\ & & & & \text{(grams/day)} & & \end{array}$$

CO

Autos	1,175,900	x .85	x 38.37	x 1.42	= 54,459,000
Light Duty Trucks	1,175,900	x .07	x 38.37	x 1.42	= 4,485,000
Heavy Duty Trucks	1,175,900	x .07	x 132.45	x 1.42	= 15,482,000
Diesel Tractor-Trailers	1,175,900	x .01	x 36.59	x 1.00	= 430,000
CO Total					74,856,000
(grams/day)					

HC

Autos	1,175,900	x .85	x 3.67	x 1.31	= 4,805,000
Light Duty Trucks	1,175,900	x .07	x 3.67	x 1.31	= 396,000
Heavy Duty Trucks	1,175,900	x .07	x 15.38	x 1.31	= 1,658,000
Diesel Tractor-Trailers	1,175,900	x .01	x 5.27	x 1.00	= 62,000
HC Total					6,921,000
(grams/day)					

NO_x

Autos	1,175,900	x .85	x 3.66	x 0.97	= 3,548,000
Light Duty Trucks	1,175,900	x .07	x 3.66	x 0.97	= 292,000
Heavy Duty Trucks	1,175,900	x .07	x 9.25	x 0.97	= 739,000
Diesel Tractor-Trailers	1,175,900	x .01	x 70.30	x 1.00	= 827,000
NO _x Total					5,406,000
(grams/day)					

For crankcase and evaporative emissions, the computation is similar except that there is no speed correction.

HC Crankcase and Evaporative

Autos	1,175,900	x .85	x 1.16	= 1,159,000
Light Duty Trucks	1,175,900	x .07	x 1.16	= 95,000
Heavy Duty Trucks	1,175,900	x .07	x 3.70	= 305,000
Diesel Tractor Trailers	1,175,900	x .01	x 0.00	= 0
Crankcase & Evaporative Total				1,559,000
(grams/day)				

Thus, the motor vehicle emissions in the Chicago CBD amount to 74,856 kgms/day of CO, 8,480 kgms/day of HC, and 5,406 kgms/day of NO_x.

The above estimate of emissions can be refined if some additional information is available. For example, assume that data is available that indicates there are 100,000 work-to-home trip origins per day, 20,000 home-to-work trip origins per day, and 75,000 miscellaneous trip origins per day in the CBD. Also, assume that traffic data indicates that of the 7% of the VMT that are traveled by heavy duty vehicles, 5% are by small delivery trucks, 1% are by intermediate size trucks, and 1% are by large trucks. In addition, of the 85% of the VMT by autos 20% are by taxis.

Step 1 Select basic motor vehicle emission factors.

Now, since data on vehicle origins is available, cold start computations can be made. Also, heavy duty vehicle GVW information is available. Thus, emission factors are selected from Table B.38.

For taxis, a separate emission factor must be developed, since they are newer in model year and have accumulated more mileage than the average auto. For the purposes of this computation, assume that the following taxi information is available:

<u>Taxi Age</u>	<u>Fraction of Vehicles in Use</u>	<u>Rate of Mileage Accumulation</u>	<u>Cumulative Mileage at Mid-Year</u>
0 years	.5	80,000 mi/yr	30,400 miles
1	.3	60,000	98,000
2	.2	40,000	152,000

With this information it is possible to determine the percentage of annual travel by each age group, p_n (see Sec. 2.3.1), and the deterioration factors (see Figs. 2.5 - 2.7). They are as follows:

<u>Taxi Age</u>	<u>Model Year</u>	<u>P_n</u>	<u>Deterioration Factors</u>		
			<u>CO</u>	<u>HC</u>	<u>NO_x</u>
0 years	1975	.61	1.22	1.09	1.12
1	1974	.27	1.50	1.23	1.25
2	1973	.12	1.56	1.26	1.26

Since taxis are run almost continuously, the model year emission factors should be for hot operation only. These are selected from Table 2.12 (Table 2.1 for NO_x) and are weighted by the p_n values as in Eq. 2.10.

$$\begin{aligned} \text{Taxi CO} \\ \text{Hot Operating} &= (.61)(10.8)(1.22) + (.27)(16.4)(1.50) + (.12)(16.4)(1.56) \\ \text{Emission Factor} &= 17.75 \frac{\text{gms}}{\text{mile}} \end{aligned}$$

$$\begin{aligned} \text{Taxi HC} \\ \text{Hot Operating} &= (.61)(1.2)(1.09) + (.27)(2.4)(1.23) + (.12)(2.4)(1.26) \\ \text{Emission Factor} &= 1.96 \frac{\text{gms}}{\text{mile}} \end{aligned}$$

$$\begin{aligned} \text{Taxi NO}_x \\ \text{Emission Factor} &= (.61)(2.2)(1.12) + (.27)(2.3)(1.25) + (.12)(2.3)(1.26) \\ &= 2.63 \frac{\text{gms}}{\text{mile}} \end{aligned}$$

The crankcase emissions are zero (Table 2.13) and the evaporative emissions will be treated as running losses, since no data on taxi soak times is available. From Table 2.16 the evaporative emissions are the same for all three model years and equal 0.2 grams/mile.

Step 2 Determine speed corrections.

The speed corrections are the same as computed before.

Step 3 Compute emissions.

The computation for exhaust emissions is the same as before and is illustrated below for CO only.

CO

Autos	1,175,900 x .65 x 33.58 x 1.42 =	36,446,000
Taxis	1,175,900 x .20 x 17.75 x 1.42 =	5,928,000
Light Duty Trucks	1,175,900 x .07 x 33.58 x 1.42 =	3,925,000
Heavy Duty Trucks		
Small Delivery	1,175,900 x .05 x 102.69 x 1.42 =	8,573,000
Intermediate	1,175,900 x .01 x 138.27 x 1.42 =	2,309,000
Large	1,175,900 x .01 x 256.66 x 1.42 =	4,286,000
Diesel Tractor-Trailers	1,175,900 x .01 x 36.59 x 1.00 =	430,000
CO Exhaust Total (grams/day)		61,897,000

For exhaust hydrocarbons the rate is 5,956,000 grams/day and for exhaust NO_x the rate is 5,173,000 grams/day. The above emission rates are for vehicle hot operation only. To these the cold start emissions must be added. The 20,000 home-to-work trip origins per day will be assumed to be all automobiles and all with a full cold start. The 100,000 work-to-home trip origins will be assumed to be all automobiles. The soak time for these autos is on the order of 8 hours which is somewhat less than the 12 hour full cold start soak time. Depending on the ambient temperature this difference could be inconsequential (if it is very cold out) or could reduce the cold start emission (if it is very hot out). Since no good data on the effects of ambient temperatures and soak times is available, it will be assumed that the work-to-home trip results in a 90% cold start keeping in mind that this may be incorrect during ambient temperature extremes. The cold start emissions are calculated as follows using the data of Table B.38.

$$\text{CO Cold Start Emissions} = (20,000) (83.57) + (100,000) (83.57) (0.90) = 9,193,000 \text{ grams}$$

$$\text{HC Cold Start Emissions} = (20,000) (5.92) + (100,000) (5.92) (0.90) = 651,000 \text{ grams}$$

Note that no cold start contributions have been added for taxis or trucks. This is because these vehicles are assumed to be hot during their operation in the CBD. The miscellaneous origins are assumed to be hot starts.

It now remains to add the crankcase and evaporative hydrocarbon emissions. Crankcase emissions are computed as follows using the data on Table B.38.

$$\begin{aligned} \text{Crankcase HC Emissions} = 1,175,900 [& (.65) (0.09) + (.20) (0.0) + (.05) (.7) + (.01) (.7) \\ & + (.01) (.7) + (.01) (0.0)] = 126,000 \text{ grams} \end{aligned}$$

Evaporative hydrocarbon emission computations require some additional assumptions. For autos, there is information on soak times, hence the evaporative losses will be treated by source. The 100,000 work-to-home trip origins involved the bringing of a vehicle into the CBD where it experienced a hot soak; hence hot soak losses will be attributed to these origins. The temperature fluctuations during working hours is generally not enough to cause a

diurnal loss so this will not be included. The 20,000 home-to-work trip origins involve both a hot soak and an overnight soak which would cause a diurnal loss. Table B.38 will be used to determine these losses. For taxis, it has already been stated that the evaporative emissions will be treated as running losses. For trucks, no origin or soak data is available so the evaporative emissions will be treated as running losses and the data of Table B.12 will be used. The computation is illustrated as follows.

Autos	$100,000 \times 8.17 + 20,000 \times (13.37 + 8.17) = 1,248,000$		
Taxis	$1,175,900 \times .20 \times 0.20$	=	47,000
Light Duty Trucks	$1,175,900 \times .07 \times 1.07$	=	88,000
All Heavy Duty Trucks	$1,175,900 \times .07 \times 3.00$	=	247,000
Diesel Tractor-Trailers	$1,175,900 \times .01 \times 0.0$	=	0
Total evaporative HC losses (grams/day)			1,630,000

Thus by this refined computation the emissions in the CBD are computed to be 71,090 kgms/day CO, 8,363 kgms/day HC, and 5,173 kgms/day NO_x.

This illustrates the ability to make emission calculations for very complex conditions and is indicative of the wide range of situations which may be considered.

2.5.2 Urban Expressway

Problem: Compute the emissions resulting from an expressway scheduled to be completed in mid-1977.

Information Needed: Traffic volume, average vehicle speed, and vehicle class distribution.

Assume that the forecasted traffic volume is 40,000 vehicles per day, the average speed is 45 mph, and the class distribution is 75% autos, 8% small heavy duty trucks, 5% intermediate heavy duty trucks, 3% large heavy duty trucks, and 9% diesel tractor-trailers.

Step 1 Select basic motor vehicle emission factors.

For this case data from Table B.42 is used. This is selected because the computation is for mid-year 1977, the Cook County registration data is more representative of urban vehicle populations than is the national average,

only hot operating emissions will be used since all of the vehicles on the expressway can be assumed to have reached full operating temperature, and heavy duty vehicle GVW data is available. The evaporative emission factors will be taken from Table B.16 since the vehicles will have no soak times and the evaporative emissions will be treated as running losses.

Step 2 Determine the speed correction factors.

The speed corrections involve a change from 19.6 mph to 45 mph. From Eq. 2.9 or Fig. 2.9 the correction factors are 0.50 for CO, 0.58 for HC, and 1.26 for NO_x .

Step 3 Compute emissions.

The computation procedure for exhaust emissions is the same as in the urban CBD problem and is illustrated for CO only.

Autos	$40,000 \times .75 \times 20.82 \times 0.50$	=	312,000	grams/highway-mile per day
Heavy Duty Trucks				
Small	$40,000 \times .08 \times 101.84 \times 0.50$	=	163,000	
Intermediate	$40,000 \times .05 \times 137.11 \times 0.50$	=	137,000	
Large	$40,000 \times .03 \times 254.51 \times 0.50$	=	153,000	
Diesel Tractor-Trailers	$40,000 \times .09 \times 34.74 \times 1.00$	=	125,000	
	CO total		890,000	
	(grams/highway-mile per day)			

For hydrocarbons the emission rate is 112,000 grams/highway-mile per day.

For NO_x the emission rate is 443,000 grams/highway-mile per day.

Crankcase emissions are computed by the following:

$$\begin{aligned} \text{Crankcase HC} \\ \text{Emissions} &= 40,000 \times [(.75) (.02) + (.16) (.39) + (.09) (0.0)] = 3,100 \\ \text{(grams/mile-day)} \end{aligned}$$

Evaporative emissions are computed by the following:

$$\begin{aligned} \text{Evaporative HC} \\ \text{Emissions} &= 40,000 \times [(.75) (.60) + (.16) (3.00) + (.09) (0.0)] = 37,200 \\ \text{(grams/mile-day)} \end{aligned}$$

Thus, the highway will contribute 890 kgms/day of CO, 152.3 kgms/day of HC, and 443 kgms/day of NO_x for each mile of its length.

2.5.3 Suburban Shopping Center Complex

Problem: Compute the motor vehicle emissions from a suburban shopping center complex in mid-1973.

Information Needed: Traffic volume in the parking lot, average vehicle speeds, vehicle class distribution, and average vehicle standing time in the parking lot.

Assume that the following data is available on the shopping center. The building floor area is 100,000 sq ft; the parking lot size is 300,000 sq ft with 900 parking spaces; there are 4400 trips per day into and out of the lot; the average one-way trip distance is .15 miles; the average vehicle speed in the lot is 11 mph, but the congestion at the entrances and the picking up and letting off of passengers results in an average of 2 minutes of vehicle idling time on both inbound and outbound trips; the average auto is parked in the lot for 2.5 hours; the vehicle class distribution is 90% autos, 7% small delivery trucks (small heavy duty vehicles), and 3% intermediate size delivery trucks (intermediate heavy duty vehicles).

Step 1 Select basic emission factors.

The basic factors from Table B.34 will be used since the computation is for mid-1973, they reflect an urban/suburban vehicle population, the vehicles will be in a hot operating mode primarily, heavy duty vehicle distribution by GVW is available, and soak times are available for evaporative emission calculations. In addition to the above factors, the extensive idling time should be accounted for since the 1975 FTP does not include as much idle time. To generate an idle emission factor the idle ratio of Table 2.19 is applied to the 1975 FTP emission factor on Table B.33. Since the ratio is the same for all model years there is no need to compute an idle emission factor for each model year separately. The idle emission factor is computed as follows:

$$\begin{aligned}\text{CO Idle} & \\ \text{Emission Factor} &= 50.60 \times .225 = 11.39 \text{ grams/minute} \\ \text{HC Idle} & \\ \text{Emission Factor} &= 4.76 \times .197 = 0.94 \text{ grams/minute} \\ \text{NO}_x \text{ Idle} & \\ \text{Emission Factor} &= 4.25 \times .027 = 0.11 \text{ grams/minute}\end{aligned}$$

These factors are for autos only. No idle emission rates are available for heavy duty vehicles.

Step 2 Determine the speed correction factors.

For an average vehicle speed of 11 mph the speed corrections from Eq. 2.9 or Fig. 2.9 is 1.65 for CO, 1.48 for HC, and 0.90 for NO_x.

Step 3 Compute emissions.

The 4400 inbound and outbound trips involve hot vehicle operation. The exhaust emissions are computed in the same way as for the previous problems. The CO calculation is illustrated here.

CO

Autos	$4400 \times 0.15 \times .90 \times 44.81 \times 1.65$	$= 43,900 \frac{\text{grams}}{\text{day}}$
Heavy Duty Trucks		
Small	$4400 \times 0.15 \times .07 \times 104.23 \times 1.65$	$= 7,900$
Intermediate	$4400 \times 0.15 \times .03 \times 140.38 \times 1.65$	$= 4,600$
	CO total	56,400
	(grams/day)	

For hydrocarbons the emission rate is 5,300 grams/day and for NO_x the emission rate is 2,900 grams/day. The 2200 outbound trips involve a start after a 2.5 hour soak. The ambient temperature will determine how much of a full cold start is made by these vehicles. Lacking any good data, assume that there is a 21% cold start after the soak (linear change from the 1975 FTP 12 hour soak). Thus the cold start emissions can be computed using the data on Table B.34.

$$\text{CO Cold Start Emissions} = 2200 \times .9 \times 100.91 \times .21 = 42,000 \text{ grams}$$

$$\text{HC Cold Start Emissions} = 2200 \times .9 \times 7.35 \times .21 = 3,100 \text{ grams}$$

No cold start emissions are included for trucks.

The crankcase hydrocarbon emissions are computed as follows:

$$\text{Crankcase HC Emissions} = 4400 \times 0.15 \times [(.9) (.21) + (.1) (1.27)] = 200 \text{ grams}$$

The inbound auto trips have a hot soak associated with them and the hot soak evaporative emission will be assigned to these trips. There is insufficient parking time to allow for diurnal losses. Truck evaporative losses from the inbound and outbound trips will be treated as running losses. The evaporative emission calculation is as follows:

HC Evaporative Emissions

$$\begin{array}{llll} \text{Autos} & 2200 \times .9 \times 10.78 & = & 21,300 \text{ grams} \\ \text{Heavy Duty Trucks} & 4400 \times .15 \times .1 \times 3.0 & = & 200 \text{ grams} \end{array}$$

The last emission rate that must be computed is from the additional 2 minutes of idling for autos. Using the idle emission factors developed in Step 1 these rates are computed as follows:

$$\begin{array}{llll} \text{CO Idle Emissions} & 4400 \times .9 \times 11.39 \times 2 & = & 90,200 \text{ grams} \\ \text{HC Idle Emissions} & 4400 \times .9 \times 0.94 \times 2 & = & 7,500 \text{ grams} \\ \text{NO}_x \text{ Idle Emissions} & 4400 \times .9 \times 0.11 \times 2 & = & 900 \text{ grams} \end{array}$$

Thus the total emission rate for the shopping center is 188.6 kgms/day CO, 37.6 kgms/day HC, and 3.8 kgms/day NO_x.

3.0 RAILROAD LOCOMOTIVES

On a national basis railroad locomotives are not a significant source of air pollution. It has been estimated that the 25,000 diesel locomotives in the U.S. contribute 0.51% of the total emissions and 0.75% of the particulate emissions.²⁴ Despite this good position on the national scale, locomotives can present a significant problem on a local scale. For example, the communities adjacent to a heavily traveled right-of-way may experience degraded air quality as a result of railroad operations. For this reason emission factors for rail transportation systems are included here.

The operational cycle of railroad locomotives involves only eight throttle positions besides idle and dynamic brake. The rated horsepower of locomotives varies from 700 to 4000 hp. The smaller sizes are used for yard switch engines or local haul trains. The larger sizes are used for inter-city or transcontinental service. For the purposes of computing emission factors, locomotives are divided into two use categories: yard switch engines and road service engines. The yard switch engines are used to shunt cars around a railroad terminal or around an industrial freight siding. They do not usually achieve high speeds and often haul only a few cars at a time. Road service engines are used to haul intercity freight and passenger trains. Main-line freight locomotives average about 150,000 miles per year with some reaching 250,000 miles per year.

Both the yard switch and road service classes are further subdivided based on the engine configuration. Both categories use 2-stroke supercharged and 4-stroke diesel engines. Road service locomotives can also use a 2-stroke turbocharged engine. Emission factors for all five of these locomotive categories have been developed by the USEPA² and are given on Table 3.1.

The fuel consumption emission factors are used when information on fuel use is available. For example, for a commuter train pulling nine double-deck cars with 150 passengers per car the average fuel consumption would be about 3 gallons/mile.²⁵ This can be used to convert the emissions into a mass/train-mile analogous to the motor vehicle emissions.

TABLE 3.1 Railroad Locomotive Emission Factors

	Engine Category				
	2-Stroke Supercharged Yard Switch	4-Stroke Yard Switch	2-Stroke Supercharged Road Service	2-Stroke Turbocharged Road Service	4-Stroke Road Service
Fuel-Consumption Emission Factors (grams/gallon)					
CO	38	172	30	73	82
HC	86	66	67	13	45
NO _x	113	222	159	150	213
Work-Output Emission Factors (grams/horsepower- hour)					
CO	3.9	13.0	1.8	4.0	4.1
HC	8.9	5.0	4.0	0.7	2.2
NO _x	11.0	17.0	9.4	8.2	10.0

The work output emission factors require additional information about the engine. The work output can be calculated from Equation 3.1:

$$w = \ell p h \quad (3.1)$$

w is work output in horsepower-hours, ℓ is the load factor (the ratio of the average power produced during operation to the available power of the engine), p is the available power of the engine in horsepower, and h is the time spent at the given load factor ℓ in hours. A typical load factor for a yard switch engine is 0.06 and for a road service engine is 0.4.² These emission factors are useful when information on specific locomotives under study is available.

The USEPA has also published railroad locomotive emission factors for a weighted average engine population in the U.S. (approximately 70% of locomotives use 2-stroke engines). These are given on Table 3.2.

TABLE 3.2 U.S. National Average Locomotive Emission Factors

	CO	HC	NO _x	Particulates	Sulfur Oxides
Fuel-Consumption Emission Factors (grams/gallon)	59	43	168	11	26

Emissions from electrically-powered railroad locomotives are generally assumed to be zero. This is true along the operational right-of-way; nevertheless, electricity must be generated for these engines and the power plant has air pollution emissions associated with it. Some fraction of these emissions should be attributed to the electric rail system. It has been estimated that an urban commuter train made up of 10 cars with 80 passengers per car would consume 70kw-hr per train-mile.²⁵ A coal-fired power plant can generate approximately 2260 kw-hr per ton of coal assuming a coal heating value of 11,000 BTU/lb and a plant efficiency of 35%. This means that the train is responsible for the consumption of 0.031 tons of coal per train-mile. Emission factors for coal-fired power plants are available on a mass emission/ton of coal burned basis.² These can now be used to compute the emissions per train-mile. The choice of emission factors depends on the type of coal burned

and the state emission regulations under which the power plant is forced to operate. Table 3.3 gives the emission factors which result from assuming the use of bituminous coal and the emission regulations for the State of Illinois.

TABLE 3.3 Electric Rail System Emission Factors
(All Emissions in Grams/Train-Mile)

CO	HC	NO _x	Particulates	SO _x
14.1	4.2	253.1	30.9	557

This is a crude method of computing emissions attributable to electric rail transit. It should be used with caution and only for order-of-magnitude estimates.

4.0 AIRCRAFT

The estimation of air pollutant emissions from aircraft is a complex procedure because of the many interacting variables. Attention to aircraft emissions has been primarily focused on operations in and around airports, with little concern given to enroute emissions. The major exception to this is the effort currently being expended on studying the effects of supersonic transport (SST) operation on the upper atmosphere. Excluding this special case, aircraft emissions should be treated as a part of total airport emissions when attempting to quantify the air pollutant emission rate from this transportation system. A significant amount of work that details the procedures for estimating airport emissions has already been published.^{26,27} This will not be repeated here except in briefest form. The reader is referred to the cited references for further details.

Figure 4.1 is a schematic description of the various activities of a commercial air carrier airport that are likely to result in significant air pollutant emissions. The actual emission sources are indicated by circular figures on the diagram. Inspection of the figure indicates that each activity can be classified as an independently variable activity or a dependently variable activity. The primary independently variable activities (i.e., the boxes having no input arrows) are the passenger demand and the air cargo demand. All other activity levels can presumably be determined from this information. In practice, however, the aircraft activity level is a semi-independently variable activity. Though the activity is directly proportional to passenger and cargo demand, it is also dependent on external influences such as aircraft technology. The introduction of jumbo jets, wide-body jets, STOL aircraft, and SST's can change the activity level and mix, even though the passenger and cargo demand remains constant.

The dependently variable activities are the ground service vehicle activity and mix, the fuel storage and handling system, the engine test and maintenance facility, the building heating and air conditioning plant, and the access traffic activity and mix.

The estimation of emissions from each source is a two-step process. The first step is to quantify the activity level of the source, and the second is to choose and apply the appropriate emission factors. Activity levels at an

Fig. 4.1. Schematic of Sources of Airport Air Pollutant Emissions

existing airport can be determined by direct observation; for an airport in the planning stages, the projective techniques of Ref. 26 can be used.

4.1 AIRPORT ACTIVITY LEVELS

Aircraft activity is measured by the number of landing-takeoff (LTO) cycles made by each type of aircraft. An LTO cycle is generally defined to include the descent from 3500-ft altitude, touch down and rollout, taxi-in to the gate area where the engines are shut down, engine start, pushback from the gate, taxi-out to the end of the runway, takeoff, and climbout to 3500 ft. Data on the aircraft activity is available from flight schedules and runway-use logs for an existing airport or from projections based on the forecasted passenger demand for a proposed airport. Table 4.1 from Ref. 2 gives the aircraft classification scheme generally employed.

Ground service vehicle activity is tied directly to the aircraft activity. Table 4.2 gives the service vehicle time required by each aircraft type, as measured at Chicago's O'Hare International Airport.

Access traffic levels can be obtained from direct traffic counts or by a forecast based on passenger, visitor, and employee projections.²⁶

The size of the fuel storage and handling system, which results in evaporative hydrocarbon emissions, can be estimated by assuming a figure between 2700 and 3200 gallons of fuel pumped per aircraft LTO. The lower figure is based on O'Hare data and the higher figure on Los Angeles International data.

The activity level of engine test and maintenance depends on whether a major maintenance facility is located at the airport. For a major facility such as Los Angeles, a figure of 76 engine run-ups per 1000 LTOs per day is a good approximation. A minor test facility like the one at O'Hare would have only one or two engine run-ups per day.

The activity level of the heating and air conditioning plant is measured by the size of the terminal, hangar, and cargo buildings needed to meet the passenger, aircraft, and freight handling requirements of the airport.

TABLE 4.1. Aircraft Classification Scheme

Aircraft class	Representative aircraft	Engines per aircraft	Engine commonly used
Jumbo jet	Boeing 747	4	Pratt & Whitney JT-9D
	Lockheed L-1011	3	
	McDonald Douglas DC-10	3	
Long-range jet	Boeing 707	4	Pratt & Whitney JT-3D
	McDonald Douglas DC-8	4	
Medium-range jet	Boeing 727	3	Pratt & Whitney JT-8D
	Boeing 737	2	
	McDonald Douglas DC-9	2	
Air carrier turboprop	Convair 580	2	Allison 501-D13
	Electra L-188	4	
	Fairchild Hiller FH-227	2	
Business jet	Gates Learjet	2	General Electric CJ610
	Lockheed Jetstar	4	Pratt & Whitney JT-12A
General aviation turboprop			Pratt & Whitney PT-6A
General aviation piston	Cessna 210	1	Teledyne-Continental Ø-200
	Piper 32-300	1	Lycoming Ø-320
Piston transport	Douglas DC-6	4	Pratt & Whitney R-2800
Helicopter	Sikorsky S 61	2	General Electric CT-58
	Vertol 107	2	
Military transport			Allison T56A7
Military jet			General Electric J-79
			Continental J-69
Military piston			Curtiss-Wright R-1820

TABLE 4.2 Service Times of Aircraft Ground Service Vehicles

Aircraft Vehicle	Time in Vehicle-Minutes									
	B-747	DC-10	B-707	DC-8	B-727	DC-9	B-737	C-880	F-227	C-580
1. Tractor	155	148	66	98	66	48	85	40	55	50
2. Belt Loader	48	40	37	30	28	15	30	40	0	25
3. Container Loader	92	80	12	0	6	0	0	0	0	0
4. Cabin Service	24	25	12	15	12	0	15	0	0	0
5. Lavatory Truck	24	18	15	18	15	15	15	20	10	10
6. Water Truck	12	10	0	0	0	10	0	0	10	10
7. Food Truck	55	20	20	30	17	17	20	20	10	10
8. Fuel Truck	50	45	37	40	20	15	15	20	10	20
9. Tow Tractor	10	10	10	5	10	5	5	15	5	5
10. Conditioner ^a	0	0	30	30	0	0	0	0	0	0
11. Airstart ^b										
Transporting Engine	3	0	10	5	0	0	0	15	0	0
Diesel Power Unit	2	0	8	4	0	0	0	11	0	0
12. Ground Power Unit ^c										
Transporting Engine	0	0	9	0	0	0	0	35	0	0
Gasoline Power Unit	0	0	4	0	0	0	0	15	0	0
Diesel Power Unit	0	0	4	0	0	0	0	15	0	0
13. Transporter	19	0	10	0	3	0	0	0	0	0
14. Auxiliary Power Unit ^d	Yes	Yes	No	No	Yes	Yes	Yes	No	No	No

TABLE 4.2 (cont'd) Service Times of Aircraft Ground Service Vehicles

Footnotes:

- a. Normally used only in very hot or cold weather.
 - b. The airstart vehicle consists of a diesel generator mounted on the back of a truck. It is assumed that the truck engine runs continuously for the entire service time and the diesel generator runs for 75% of the time.
 - c. The ground power unit consists of a generator mounted on the back of a truck. It is assumed that the truck engine and the generator run continuously. About half of the generator units in service are diesel and the other half are gasoline engine. Hence, the generator service time is divided equally between a gasoline and diesel engine.
 - d. If an aircraft has an auxiliary power unit, it normally runs for the entire gate occupancy time. Its emissions are included in the aircraft calculations.
-

4.2 AIRPORT EMISSION FACTORS

Table 4.3 gives the aircraft emission factors published by the USEPA. These factors are based on a typical LTO cycle. While this procedure is adequate for generating order-of-magnitude estimates of aircraft emissions, it is not satisfactory for doing detailed calculations. To refine the computation, it is necessary to separate the LTO cycle into its different modes, gather data on the time spent in each mode at the airport under study, and use emission factors for each mode separately. In this way the peculiarities of an airport's layout and operational procedures can be properly accounted for. Table 4.4 gives the USEPA's modal emission factors and Table 4.5 outlines a typical LTO cycle breakdown.² Table 4.6 gives the LTO cycle breakdown for Chicago O'Hare.²⁶ It can be seen that there is a significant difference in the taxi-idle time. This is important since the bulk of CO and HC emissions from aircraft occur during taxi and idle conditions.

Table 4.7 gives the emission factors for ground service vehicles. The units are grams/hour since the activity is measured in vehicle-hours. Current motor vehicle emission standards do not apply to off-road vehicles, which category would include the ground service equipment. Hence, the emission factors represent uncontrolled vehicles.

Table 4.3 Aircraft Landing-Takeoff Cycle Emission Factors
(All Emissions in Kilograms/Engine-LTO Cycle)^a

Aircraft	CO	HC	NO _x	Particulates	Sulfur Oxides ^b
Jumbo jet	21.2	5.5	14.2	0.59	0.83
Long range jet	21.5	18.7	3.6	0.55	0.71
Medium range jet	7.71	2.2	4.6	0.19	0.46
Air carrier turboprop	3.0	1.3	1.1	0.49	0.18
Business jet	7.17	1.6	0.73	0.05	0.17
General aviation turboprop	1.4	0.5	0.54	0.09	0.08
General aviation piston	5.5	0.18	0.021	0.01	0.006
Piston transport	138.0	18.5	0.18	0.25	0.13
Helicopter	2.6	0.24	0.26	0.11	0.08
Military transport	2.6	1.2	1.0	0.49	0.19
Military jet	6.85	4.5	1.49	0.14	0.35
Military piston	69.0	9.3	0.09	0.13	0.04

^a To obtain aircraft emissions multiply the emission factors by the number of engines/aircraft.

^b Based on .05% sulfur content fuel.

TABLE 4.4 Aircraft Model Emission Factors (All Emissions in Kilograms/Hour per Engine)^a

Engine	Aircraft Application		Taxi-Idle	Takeoff	Climbout	Approach	Landing ^b
Pratt & Whitney JT-9D	Jumbo Jet	Part	1.0	1.7	1.8	1.0	1.17
		CO	46.30	3.76	5.31	14.80	31.05
		HC	12.40	1.34	1.20	1.36	7.98
		NO _x	2.75	327.00	208.00	24.50	84.05
General Electric CF6	Jumbo Jet	Part	0.02	0.24	0.24	0.20	0.10
		CO	23.50	3.04	2.99	8.44	16.18
		HC	7.00	0.59	0.59	0.86	4.48
		NO _x	1.63	245.00	151.00	78.50	72.34
Pratt & Whitney JT-3D	Long Range Jet	Part	0.20	3.7	3.9	3.6	1.58
		CO	49.40	5.60	6.94	18.00	33.86
		HC	44.70	2.11	2.23	3.56	27.90
		NO _x	0.649	67.10	43.60	9.89	18.08
Pratt & Whitney JT-3C	Long Range Jet	Part	0.18	2.9	2.8	1.5	1.04
		CO	42.00	4.10	7.26	22.20	29.74
		HC	41.80	0.388	0.405	3.75	25.77
		NO _x	1.13	54.00	38.40	10.50	15.32
Pratt & Whitney JT-4A	Long Range Jet	Part	0.54	9.5	9.1	2.7	3.04
		CO	28.50	8.53	8.30	11.90	21.05
		HC	29.40	0.306	0.576	1.74	17.99
		NO _x	1.23	107.00	70.30	16.30	29.03
General Electric CJ805	Long Range Jet	Part	0.59	6.8	6.8	2.3	2.35
		CO	28.90	13.20	13.10	19.40	23.61
		HC	12.40	0.252	0.264	1.10	7.68
		NO _x	0.712	50.30	33.60	8.07	13.79
Pratt & Whitney JT-8D	Medium Range Jet	Part	0.16	1.7	1.2	0.68	0.61
		CO	15.20	3.40	4.03	8.26	11.26
		HC	3.71	0.353	0.418	0.794	2.44
		NO _x	1.32	89.80	59.40	14.00	24.58

TABLE 4.4 Aircraft Modal Emission Factors (Contd.) (All Emissions in Kilograms/Hour per Engine)^a

Engine	Aircraft Application		Taxi-Idle	Takeoff	Climbout	Approach	Landing ^b
Rolls Royce Spey MK511	Medium Range Jet	Part	0.077	7.3	4.5	0.68	1.91
		CO	27.30	6.44	6.94	17.70	20.76
		HC	66.10	~0.00	0.110	1.91	39.97
		NO _x	0.385	69.4	52.20	13.80	19.10
Allison T-56-A15	Air Carrier Turboprop Military Transport	Part	0.73	1.7	1.4	1.4	1.07
		CO	3.96	1.71	1.54	1.58	3.04
		HC	3.35	0.200	0.181	0.148	2.08
		NO _x	0.560	12.70	10.10	3.32	3.92
Allison T-56-A7	Air Carrier Turboprop Military Transport	Part	0.73	1.7	1.4	1.4	1.07
		CO	6.94	0.975	1.37	1.66	4.66
		HC	2.93	0.195	0.216	0.235	1.84
		NO _x	0.980	10.40	9.62	3.53	3.65
Airesearch TPE-331	General Aviation Turboprop	Part	0.14	0.36	0.27	0.27	0.21
		CO	1.60	0.178	0.258	1.17	1.19
		HC	0.399	0.025	0.024	0.109	0.26
		NO _x	0.433	1.65	1.50	0.767	0.78
Teledyne/Continental O-200	General Aviation Piston	Part	NA ^c	NA	NA	NA	NA
		CO	3.41	24.80	24.80	10.80	9.73
		HC	0.097	0.327	0.327	0.172	0.16
		NO _x	0.004	0.117	0.117	0.024	0.03
Lycoming O-320	General Aviation Piston	Part	NA	NA	NA	NA	NA
		CO	5.03	32.20	29.80	11.00	12.51
		HC	0.161	0.676	0.594	0.225	0.29
		NO _x	0.006	0.097	0.170	0.023	0.03

^aTo obtain aircraft emissions, multiply the emission factors by the number of engines/aircraft.

^bComputed values.

^cNA - Not Available

TABLE 4.5. Typical Time-in-mode for Landing-Takeoff Cycle at a Metropolitan Airport

Aircraft	Time-in-mode, minutes				
	Taxi-idle	Takeoff	Climbout	Approach	Taxi-idle
Jumbo jet	19.00	0.70	2.20	4.00	7.00
Long range jet	19.00	0.70	2.20	4.00	7.00
Medium range jet	19.00	0.70	2.20	4.00	7.00
Air carrier turboprop	19.00	0.50	2.50	4.50	7.00
Business jet	6.50	0.40	0.50	1.60	6.50
General aviation turboprop	19.00	0.50	2.50	4.50	7.00
General aviation piston	12.00	0.30	4.98	6.00	4.00
Piston transport	6.50	0.60	5.00	4.60	6.50
Helicopter	3.50	0	6.50	6.50	3.50
Military transport	19.00	0.50	2.50	4.50	7.00
Military jet	6.50	0.40	0.50	1.60	6.50
Military piston	6.50	0.60	5.00	4.60	6.50

TABLE 4.6. Aircraft Time-in-mode, O'Hare International Airport

Aircraft Class	Time-in-mode, minutes						
	Inbound Taxi	Outbound Taxi	Idle	Landing	Takeoff	Approach	Climbout
Jumbo	7.2	7.2	4.2	0.6	0.5	3.0	1.9
Long Range	4.2	4.9	2.4	0.6	0.5	3.6	2.2
Medium Range	3.6	4.4	2.0	0.6	0.5	3.0	1.9
Short Range	3.6	4.4	2.0	0.6	0.5	4.5	3.6

TABLE 4.7. Ground Service Vehicle Emission Factors
(All Emissions in Grams/Hour)

Vehicle	CO	HC	NO _x	Particulates
1. Tractor	1800	400	103	3
2. Belt Loader	700	156	40	1
3. Container Loader	1750	391	100	3
4. Cabin Service	1500	335	86	3
5. Lavatory Truck	1500	335	86	3
6. Water Truck	1500	335	86	3
7. Food Truck	2000	446	114	4
8. Fuel Truck	1700	379	97	3
9. Tow Tractor	2350	525	134	4
10. Conditioner	1750	391	100	3
11. Airstart				
Transporting Engine	1400	312	80	3
Diesel Power Unit	1210	242	1266	93
12. Ground Power Unit				
Transporting Engine	2000	446	114	4
Gasoline Power Unit	5000	1116	285	9
Diesel Power Unit	1048	210	1096	81
13. Transporter	1500	335	86	3

Emission factors for access traffic have already been presented in the section on motor vehicles in this report.

Evaporative hydrocarbon emissions from the fuel storage and handling system can be estimated using an emission factor of .55 lb HC per 1000 gallons of fuel pumped.

The emission factors for engine test and maintenance are the same as aircraft engine emission factors. The engine test cycle can be represented by 18.75 minutes of idle and 6.25 minutes of approach power setting.²⁶

Emissions from the airport heating plant can be obtained by using the emission factors in Table 4.8.

TABLE 4.8. Airport Heating Plant Emission Factors

Pollutant	Emissions	
	Coal-Fired (kgms/ton of coal)	Oil-Fired (kgms/10 ³ gal of oil)
CO	.91	1.81
HC	.45	1.36
NO _x	6.80	18.14
Particulates	1.00	6.53
SO _x	17.96	65.32

4.3 SAMPLE RESULTS

Table 4.9 gives the results of an emission calculation for O'Hare International Airport.²⁶ The table demonstrates that while air craft are the prime source of emissions, the contributions from other sources are not negligible. The use of aircraft emissions alone would result in a severe underestimate of the air transportation system's impact on air quality. A surprisingly large part of the CO is contributed by the ground service vehicles. This may indicate the need for more stringent controls on such off-road vehicles.

Table 4.10 gives the aircraft emissions by mode for O'Hare. The extremely large fraction of CO and HC coming from the taxi-idle modes indicates that modification of ground operations to minimize taxi-idle time could effect a substantial improvement in air quality. There are, however, other logistical constraints on the use of this procedure. Tests are currently planned by the Federal Aviation Administration and the USEPA to determine the viability of modifying ground operations to improve air quality.

TABLE 4.9. O'Hare Airport Emissions, 1972
(All Emissions in Tons/Year)

	Aircraft	Ground Service Vehicles	Access Traffic	Heating Plants	Fuel Handling	Total	Density ^a Tons/Mi ² -Yr.
Part	542	23	34	511	-	1,110	112
CO	9,108	4,245	4,711	32	-	18,096	1,828
HC	5,377	942	821	32	582	7,754	783
NO _x	3,205	440	575	291	-	4,511	456

a. Based on 9.9 sq. mi. airport property.

TABLE 4.10. Aircraft Emissions by Mode of LTO Cycle, O'Hare Airport 1972

Pollutant	Mode	Percent of Emissions Coming from Mode					
		Taxi	Idle	Approach	Landing	Takeoff	Climbout
CO		61.3	29.1	5.5	2.1	0.4	1.6
HC		66.1	28.3	2.0	2.0	0.3	1.3
NO _x		4.4	4.6	16.7	6.0	18.4	49.9

5.0 WATERBORNE VESSELS

Concern about emissions from waterborne transportation systems has generally been focused on their impact on water quality. There are, however, situations where the air quality impact can be significant. Areas having substantial ocean or lake port facilities for commercial water transportation are likely to experience a high enough volume of shipping to have measurable air quality impact. Also, large recreational boating facilities are likely to attract enough pleasure craft to create local air quality degradation.

For the purpose of estimating the contribution of water transportation systems to the regional air pollution emission load, the USEPA has developed emission factors for inboard- and outboard-powered vessels.² The inboard vessel emission factors are representative of commercial shipping; the outboard vessel factors represent pleasure craft primarily.

5.1 INBOARD-POWERED VESSELS

Inboard-powered vessels can be divided into steamships and motorships. Steamships use a boiler to generate steam, which, in turn, drives a turbine to power the propellers. Motorships use internal combustion diesel engines. Emissions from both types of vessels occur while the ship is underway and while it is in berth. The in-berth emissions result from the necessity to provide power for the ship's lights, heat, pumps, refrigeration, loading equipment, etc. Table 5.1 gives the emission factors as published by the USEPA.

TABLE 5.1 Inboard-powered Waterborne Vessel Emission Factors

	CO	HC	NO _x	Particulates	Sulfur Oxides
Steamships					
Under way (gms/mi)	.91	90.7	2086	181.4	3220S ^a
In-Berth (kgms/day)	.036	4.1	90.7	6.8	138S ^a
Motorships					
Under way (gms/mi)	544	408	635	907	680
In-Berth (kgms/day)	20.8	14.9	22.7	7.5	19.5

a. S is the percent sulfur by weight in the fuel

5.2 OUTBOARD-POWERED VESSELS

There are approximately 7 million outboard motors in the U.S. today. They are predominately 2-stroke gasoline engines and have an average available horsepower of 25, with a range of 4 to 65. The emission factors published by the USEPA² permit the computation of emissions on a fuel-consumption or on a work-output basis. The USEPA gives an average work output of an outboard engine of 455 horsepower-hours per year (9.1 average horsepower produced x 50 hours of use per year).

TABLE 5.2 Outboard-powered Waterborne Vessel Emission Factors

	CO	HC	NO _x	Sulfur Oxides
Fuel-Consumption Emission Factors (grams/gallon)	1497	499	3	2.9
Work-Output Emission Factors (grams/hphr)	250	85	0.5	0.49

APPENDIX A - TREFACT Program Listing

The following is a program listing for TREFACT. The Job Control Language (JCL) cards for use with an IBM 360/195 computer have been included for reference.

```

//TREFACT JOB (F21130,10,2,2),'CIRILLO',MSGLEVEL=1,CLASS=A,REGION=320K
CIRILLO R 21130 84704-30190
/*PROCESS MAIN
/*PROCESS PRINT
/*PROCESS PUNCH
// EXEC FTXCLG
//FTX.SYSIN DD *
REAL*8 TITLE(10)
INTEGER YEAR, RTROFT, CLDSTR
DIMENSION BYEFCO(6,31), BYEFHC(6,31), BYEFNO(6,31),
A DETCO(6,31,16), DETHC(6,31,16), DETNO(6,31,16),
B RCSCO(6,31), RCHC(6,31),
C RTROCO(6,31), RTRHC(6,31), RTRNO(6,31),
D YEFCO(6,31), YEFHC(6,31), YEFNO(6,31),
E YEFCSO(6,31), YEFCHC(6,31),
F SCSO(6), SHC(6), SNO(6),
G CREF(6,31), EREF(6,31,3), REGIS(16,6), AAT(16,6), PAAT(16,6),
H SUM(6), PTRVL(6,16), WFCTR(6), WEVAP(3),
I EXEMI(6,3), CSCO(6), CSHC(6), CRANK(6), EVAP(6,3), Y(2)
DIMENSION FEXCO(31,3,3), FEXHC(31,3,3), FEXNO(31,3,3),
A HDVCO(31,3,3), HDVHC(31,3,3), HDVNO(31,3,3),
B FDEFCD(31), FDEFHC(31), FDEFNO(31),
C FDETCO(21,10,2), FDETHC(21,10,2), FDETNO(21,10,2),
D FCHDCO(16), FCHDHC(16), FCHDNO(16),
E FFCSCO(31,3), FFCSHC(31,3),
F HDCSCO(4), HDCSHC(4),
CM(10), FCRNK(31,2,2), FEVAP(31,2,2), SEV(31,3,2,3), CMH(16)
C USEPA EXHAUST EMISSION FACTORS -- 1960-1990 (GRAMS/VEHICLE-MILE)
C FIRST 31 VALUES ARE AUTOS, NEXT 31 ARE LIGHT DUTY TRUCKS, NEXT
C 31 ARE HEAVY DUTY GASOLINE-POWERED TRUCKS
DATA FEXCO/
A 8*87., 46., 39., 36., 34., 3*19., 12.5, 15*1.8, LOW CAR
B 8*87., 46., 39., 36., 34., 3*19., 12.5, 15*1.8, LOW LDT
C 10*140., 21*130., LOW HDV
D 8*130., 74., 48., 72., 75., 3*42., 20.0, 15*1.8, HIGH CAR
E 8*130., 74., 48., 72., 75., 3*42., 20.0, 15*1.8, HIGH LDT
F 10*210., 21*190., HIGH HDV
G 6*87., 51., 50., 46., 39., 36., 34., 3*19., 2.8, 15*1.8, CALI CAR
H 6*87., 51., 50., 46., 39., 36., 34., 3*19., 2.8, 15*1.8, CALI LDT
I 10*140., 5*130., 16*81./ CALI HDV
DATA FEXHC/
A 8*8.8, 4.5, 4.4, 3.6, 2.9, 3*2.7, 1.3, 15*.23, LOW CAR
B 8*8.8, 4.5, 4.4, 3.6, 2.9, 3*2.7, 1.3, 15*.23, LOW LDT
C 10*17., 4*16., 17*13., LOW HDV
D 8*10., 6.0, 5.4, 6.1, 5.3, 3*4.9, 1.8, 15*.23, HIGH CAR
E 8*10., 6.0, 5.4, 6.1, 5.3, 3*4.9, 1.8, 15*.23, HIGH LDT
F 10*19., 4*18., 17*15., HIGH HDV
G 6*8.8, 6.0, 4.6, 4.5, 4.4, 3.6, 2.9, 3*2.7, .33, 15*.23, CALI CAR
H 6*8.8, 6.0, 4.6, 4.5, 4.4, 3.6, 2.9, 3*2.7, .33, 15*.23, CALI LDT
I 10*17., 2*16., 3*13., 16*4.1/ CALI HDV
DATA FEXNO/
A 8*3.6, 4.3, 5.5, 5.1, 2*4.8, 2*2.3, 2.2, 1.6, 14*.31, LOW CAR
B 8*3.6, 4.3, 5.5, 5.1, 2*4.8, 2*2.3, 2.2, 1.6, 14*.31, LOW LDT
C 10*9.4, 21*9.2, LOW HDV
D 8*1.9, 2.2, 2.6, 2.8, 2*3.1, 2*1.4, 1.4, 1.3, 14*.31, HIGH CAR
E 8*1.9, 2.2, 2.6, 2.8, 2*3.1, 2*1.4, 1.4, 1.3, 14*.31, HIGH LDT
F 10*5.0, 21*4.9, HIGH HDV
G 6*3.6, 2*3.4, 4.3, 5.5, 5.1, 2*3.5, 2*2.3, 1.1, 1.1, 14*.31, CALI CAR
H 6*3.6, 2*3.4, 4.3, 5.5, 5.1, 2*3.5, 2*2.3, 1.1, 1.1, 14*.31, CALI LDT
I 10*9.4, 5*9.2, 16*2.8/ CALI HDV

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C USEPA DIESEL EMISSION FACTORS -- 1960-1990
 DATA FDEFCD/ 10*49.2, 21*32.5/
 DATA FDEFHC/ 10*9.84, 21*3.78/
 DATA FDEFND/ 10*51.5, 21*76.4/
 C HEAVY DUTY VEHICLE EXHAUST EMISSION FACTORS 1960-1990 SWRI STUDY, FEB 1973
 C FIRST 31 VALUES ARE FOR GVW 6000-16000 LBS
 C NEXT 31 VALUES ARE FOR GVW 16001-33000 LBS
 C NEXT 31 VALUES ARE FOR GVW GREATER THAN 33000 LBS
 DATA HDVCD/
 A 10*108.5, 21*100.8, 10*146.2, 21*135.7, 10*271.3, 21*251.9, LOW ALT
 B 10*162.8, 21*147.3, 10*219.2, 21*198.4, 10*407.0, 21*368.2, HIGH ALT
 C 10*108.5, 5*100.8, 16*62.8, 10*146.2, 5*135.7, 16*84.6, 10*271.3, CALIFORN
 D 5*251.9, 16*157.0/
 DATA HDVHC/
 A 10*13.1, 4*12.3, 17*10.0, 10*20.2, 4*19.0, 17*15.4, 10*29.0, 4*27.3, LOW ALT
 B 17*22.3, 10*14.6, 4*13.9, 17*11.6, 10*22.6, 4*21.4, 17*17.8, 10*32.4, HIGH ALT
 C 4*30.7, 17*25.6, 10*13.1, 2*12.3, 3*10.0, 16*3.2, 10*20.2, 2*19.0, CALIFORN
 D 3*15.4, 16*4.9, 10*29.0, 2*27.3, 3*22.2, 16*7.0/
 DATA HDVND/
 A 10*9.4, 21*9.2, 10*9.6, 21*9.4, 10*9.3, 21*9.1, LOW ALT
 B 10*5.0, 21*4.9, 10*5.1, 21*5.0, 10*5.0, 21*4.9, HIGH ALT
 C 10*9.4, 5*9.2, 16*2.8, 10*9.6, 5*9.4, 16*2.9, 10*9.3, 5*9.1, 16*2.8/ CALIFORN
 C COLD START RATIOS FOR LDV FROM 6-CITIES AND GM DATA 1960-1990
 DATA FFCSCD/ 8*.175, .274, .347, .305, 5*.322, 15*1.369, LOW ALT
 A 8*.138, .220, .372, .285, 5*.237, 15*1.369, HIGH ALT
 B 6*.175, .349, .372, .274, .347, .305, 4*.322, 16*1.369/ CALIFORN
 DATA FFCSHC/ 8*.163, .227, .263, .229, 5*.221, 15*0.556, LOW ALT
 A 8*.199, .334, .396, .297, 5*.358, 15*0.556, HIGH ALT
 B 6*.163, .198, .291, .227, .263, .229, 4*.221, 16*0.556/ CALIFORN
 C COLD START RATIOS FOR HDV FROM SWRI STUDY ALL MODEL YEARS AND AREAS
 C FIRST VALUE IS FOR ALL HDV, NEXT 3 ARE FOR GVW CLASSES
 DATA HDCSCD/ .105, .238, .076, .033/
 DATA HDCSHC/ .142, .171, .139, .131/
 C EPA CRANKCASE AND EVAPORATIVE EMISSIONS -- KIRCHER 1/12/73 1960-90 GMS/VMILE
 C FIRST 31 VALUES ARE LIGHT-DUTY, NEXT 31 ARE HEAVY-DUTY
 DATA FCRNK/ 3*4.1, 5*0.8, 23*0.0, 8*5.2, 23*0.0, LOW-HIGH
 A 4.1, 3*0.8, 27*0.0, 4*5.2, 27*0.0/ CALIFORN
 DATA FEVAP/ 11*3.0, 0.5, 19*0.2, 31*3.0, LOW-HIGH
 A 10*3.0, 2*0.5, 19*0.2, 13*3.0, 18*0.2/ CALIFORN
 C EVAPORATIVE EMISSION FACTORS BY SOURCE 1960-1990 6-CITIES STUDY
 C FIRST 31 VALUES ARE DIURNAL LOSS, NEXT 31 ARE RUNNING LOSS, NEXT
 C 31 ARE HOT SOAK LOSS
 DATA SEV/
 A 11*26.0, 16.3, 19*6.5, 31*0.0, 11*14.7, 10.9, 19*4.4, LOW LDV
 B 31*26.0, 31*0.0, 31*14.7, LOW HDV
 C 11*75.3, 47.2, 19*18.9, 31*0.0, 11*46.7, 34.8, 19*13.9, HIGH LDV
 D 31*75.3, 31*0.0, 31*46.7, HIGH HDV
 E 10*26.0, 2*16.3, 19*6.5, 31*0.0, 10*14.7, 2*10.9, 19*4.4, CALI LDV
 F 13*26.0, 18*6.5, 31*0.0, 13*14.7, 18*4.4/ CALI HDV
 C USEPA EXHAUST EMISSION DETERIORATION FACTORS 1960-1980 LIGHT DUTY
 C EACH SET OF 21 VALUES REPRESENTS THE AGE OF THE VEHICLE
 DATA FDETCO/ 21*1.00 , LO-HI 0
 A 8*1.0, 1.24, 1.42, 5*1.18 , 1.04, 5*1.16, LO-HI 1
 B 8*1.0, 1.35, 1.53, 5*1.32 , 1.30, 5*1.34, LO-HI 2
 C 8*1.0, 1.41, 1.59, 5*1.38 , 1.36, 5*1.50, LO-HI 3
 D 8*1.0, 1.47, 1.63, 5*1.40 , 1.43, 5*1.62, LO-HI 4
 E 8*1.0, 1.53, 1.68, 5*1.44 , 1.44, 5*1.75, LO-HI 5
 F 8*1.0, 1.58, 1.71, 5*1.47 , 1.49, 5*1.88, LO-HI 6
 G 8*1.0, 1.63, 1.75, 5*1.50 , 1.56, 5*2.00, LO-HI 7
 H 8*1.0, 1.67, 1.79, 5*1.51 , 1.63, 5*2.10, LO-HI 8

I 8*1.0, 1.72, 1.82, 5*1.56, 1.69, 5*2.22, LO-HI 9
 E21*1.00, 6*1.00, 1.13, 1.11, 1.24, 1.42, 5*1.18, 6*1.16, 6*1.00, 1.21, CALIFORN
 F1.18, 1.35, 1.53, 5*1.32, 6*1.34, 6*1.00, 1.24, 1.23, 1.41, 1.59, CALIFORN
 G5*1.38, 6*1.50, 6*1.00, 1.25, 1.29, 1.47, 1.63, 5*1.40, 6*1.62, CALIFORN
 H6*1.00, 1.28, 1.35, 1.53, 1.68, 5*1.44, 6*1.75, 6*1.00, 1.29, 1.40, 1.58, CALIFORN
 I1.71, 5*1.47, 6*1.88, 6*1.00, 1.31, 1.46, 1.63, 1.75, 5*1.50, 6*2.00, CALIFORN
 J6*1.00, 1.32, 1.50, 1.67, 1.79, 5*1.51, 6*2.10, 6*1.00, 1.34, 1.56, 1.72, CALIFORN
 K1.82, 5*1.56, 6*2.22/ CALIFORN
 DATA FDETHC/ 21*1.00, LO-HI 0
 A 8*1.0, 1.12, 1.10, 5*1.05, 1.00, 5*1.14, LO-HI 1
 B 8*1.0, 1.18, 1.16, 5*1.10, 1.13, 5*1.30, LO-HI 2
 C 8*1.0, 1.21, 1.18, 5*1.13, 1.22, 5*1.44, LO-HI 3
 D 8*1.0, 1.23, 1.21, 5*1.15, 1.29, 5*1.55, LO-HI 4
 E 8*1.0, 1.26, 1.23, 5*1.17, 1.37, 5*1.67, LO-HI 5
 F 8*1.0, 1.28, 1.25, 5*1.20, 1.43, 5*1.77, LO-HI 6
 G 8*1.0, 1.30, 1.28, 5*1.22, 1.50, 5*1.88, LO-HI 7
 H 8*1.0, 1.32, 1.29, 5*1.24, 1.56, 5*1.96, LO-HI 8
 I 8*1.0, 1.35, 1.31, 5*1.26, 1.63, 5*2.07, LO-HI 9
 E21*1.00, 6*1.00, 1.14, 1.07, 1.12, 1.10, 5*1.05, 6*1.14, 6*1.00, 1.22, CALIFORN
 F1.10, 1.18, 1.16, 5*1.10, 6*1.30, 6*1.00, 1.25, 1.12, 1.21, 1.18, 5*1.13, CALIFORN
 G6*1.44, 6*1.00, 1.27, 1.14, 1.23, 1.21, 5*1.15, 6*1.55, 6*1.00, 1.29, CALIFORN
 H1.15, 1.26, 1.23, 5*1.17, 6*1.67, 6*1.00, 1.30, 1.17, 1.28, 1.25, 5*1.20, CALIFORN
 I6*1.77, 6*1.00, 1.32, 1.18, 1.30, 1.28, 5*1.22, 6*1.88, 6*1.00, 1.35, CALIFORN
 J1.20, 1.32, 1.29, 5*1.24, 6*1.96, 6*1.00, 1.35, 1.21, 1.35, 1.31, 5*1.26, CALIFORN
 K6*2.07/ CALIFORN
 DATA FDETNO/ 21*1.00, LO-HI
 A 13*1.0, 2*1.11, 1.00, 1.03, 4*1.17, 13*1.0, 2*1.18, 1.18, 1.07, 4*1.37, LO-HI
 B 13*1.0, 2*1.20, 1.23, 1.10, 4*1.53, 13*1.0, 2*1.21, 1.23, 1.13, 4*1.67, LO-HI
 C 13*1.0, 2*1.22, 1.41, 1.17, 4*1.82, 13*1.0, 2*1.23, 1.45, 1.19, 4*1.94, LO-HI
 D 13*1.0, 2*1.24, 1.45, 1.21, 4*2.06, 13*1.0, 2*1.25, 1.45, 1.24, 4*2.17, LO-HI
 E 13*1.0, 2*1.26, 1.45, 1.26, 4*2.32, LO-HI
 F 21*1.00, CALIF
 G 11*1.0, 4*1.11, 2*1.03, 4*1.17, 11*1.0, 4*1.18, 2*1.07, 4*1.37, CALIF
 H 11*1.0, 4*1.20, 2*1.10, 4*1.53, 11*1.0, 4*1.21, 2*1.13, 4*1.67, CALIF
 I 11*1.0, 4*1.22, 2*1.17, 4*1.82, 11*1.0, 4*1.23, 2*1.19, 4*1.94, CALIF
 J 11*1.0, 4*1.24, 2*1.21, 4*2.06, 11*1.0, 4*1.25, 2*1.24, 4*2.17, CALIF
 K 11*1.0, 4*1.26, 2*1.26, 4*2.32/ CALIF
 DATA CM/ 4000., 20400., 35100., 48830., 61660., 73590., 84590.,
 A 94620., 103750., 111980./
 DATA FCHDCO/ 1.00, 1.24, 1.35, 1.43, 1.50, 1.57, 1.63, 1.69, CALI HDV
 A 1.73, 7*1.77/ CALI HDV
 DATA FCHDHC/ 1.00, 1.12, 1.18, 1.22, 1.25, 1.28, 1.30, 1.33, CALI HDV
 A 1.36, 7*1.38/ CALI HDV
 DATA FCHDNO/ 1.00, 1.11, 1.18, 1.20, 1.22, 1.23, 1.24, 1.25, CALI HDV
 A 1.27, 7*1.28/ CALI HDV
 DATA CMH/ 4000., 22360., 39140., 54940., 69900., 82900., 95300.,
 A 106300., 116700., 125700., 133650., 139150., 144650., 150150.,
 B 155650., 161150./
 C USEPA REGISTRATION (MID-YEAR) AND ANNUAL TRAVEL
 DATA REGIS/ .078, .116, .110, .098, .106, .106, .088, .078,
 A .063, .041, .035, .021, .060, 0., 0., 0., 1 AUTO
 B .078, .116, .110, .098, .106, .106, .088, .078, 1 AUTO
 C .063, .041, .035, .021, .060, 0., 0., 0., 2 LDT
 D .071, .106, .087, .081, .084, .076, .065, .055, 2 LDT
 E .047, .035, .037, .033, .223, 0., 0., 0., 3 HDV
 F .071, .106, .087, .081, .084, .076, .065, .055, 3 HDV
 G .047, .035, .037, .033, .223, 0., 0., 0., 4 HDV
 H .071, .106, .087, .081, .084, .076, .065, .055, 4 HDV
 I .047, .035, .037, .033, .223, 0., 0., 0., 5 HDV
 J .071, .106, .087, .081, .084, .076, .065, .055, 5 HDV
 6 DIES

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K .047, .035, .037, .033, .223, 0., 0., 0./ 6 DIES
DATA AAT/15900.,15000.,14000.,13100.,12200.,11300.,10300., 9400., 1 AUTO
A 8500., 7600., 6700., 6700., 6700., 6700., 6700., 6700., 1 AUTO
B 15900.,15000.,14000.,13100.,12200.,11300.,10300., 9400., 2 LDT
C 8500., 7600., 6700., 6700., 6700., 6700., 6700., 6700., 2 LDT
D 17200.,17200.,15800.,15800.,13000.,13000.,11000.,11000., 3 HDV
E 9000., 9000., 5500., 5500., 5500., 5500., 5500., 5500., 3 HDV
F 17200.,17200.,15800.,15800.,13000.,13000.,11000.,11000., 4 HDV
G 9000., 9000., 5500., 5500., 5500., 5500., 5500., 5500., 4 HDV
H 17200.,17200.,15800.,15800.,13000.,13000.,11000.,11000., 5 HDV
I 9000., 9000., 5500., 5500., 5500., 5500., 5500., 5500., 5 HDV
J 17200.,17200.,15800.,15800.,13000.,13000.,11000.,11000., 6 DIES
K 9000., 9000., 5500., 5500., 5500., 5500., 5500., 5500./ 6 DIES
DATA PAAT/ .38,15*.30, .38,15*.30, .37,15*.30, .37,15*.30, MID-YEAR
A .37,15*.30, .37,15*.30/ MID-YEAR
DATA WFCTR/ .821, .100, .045, .018, .010, .006/
DATA Y/ MID-YEAR, END-1/

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C
C***** READ TITLE AND BASIC OPTION CARD *****
READ(5,220) TITLE
READ(5,225) IAREA,IAUTO,ILDT,IHDV,IDIEST,IOET,ICRANK,IEVAP,ICLDST
,IAAT,IWTFTR
C***** INITIALIZE DATA ARRAYS *****
IF(IAUTO.EQ.0)GO TO 101
DO 1 M=1,31
BYEFCO(1,M) = FEXCO(M,1,IAREA)
BYEFHC(1,M) = FEXHC(M,1,IAREA)
BYEFNO(1,M) = FEXNO(M,1,IAREA)
1 CONTINUE
GO TO 2
101 READ(5,210)(BYEFCO(1,M),M=1,31)
READ(5,210)(BYEFHC(1,M),M=1,31)
READ(5,210)(BYEFNO(1,M),M=1,31)
2 IF(ILDT.EQ.0)GO TO 102
DO 3 M=1,31
BYEFCO(2,M) = FEXCO(M,2,IAREA)
BYEFHC(2,M) = FEXHC(M,2,IAREA)
BYEFNO(2,M) = FEXNO(M,2,IAREA)
3 CONTINUE
GO TO 4
102 READ(5,210)(BYEFCO(2,M),M=1,31)
READ(5,210)(BYEFHC(2,M),M=1,31)
READ(5,210)(BYEFNO(2,M),M=1,31)
4 IH=IHDV+1
GO TO(103,5,7),IH
5 DO 6 M=1,31
DO 6 J=3,5
BYEFCO(J,M) = FEXCO(M,3,IAREA)
BYEFHC(J,M) = FEXHC(M,3,IAREA)
BYEFNO(J,M) = FEXNO(M,3,IAREA)
6 CONTINUE
GO TO 8
7 DO 8 M=1,31
DO 8 J=3,5
BYEFCO(J,M) = HDVCO(M,J-2,IAREA)
BYEFHC(J,M) = HDVHC(M,J-2,IAREA)
BYEFNO(J,M) = HDVNO(M,J-2,IAREA)
8 CONTINUE
GO TO 9
103 DO 104 J=3,5

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      READ(5,210)(BYEFCO(J,M),M=1,31)
      READ(5,210)(BYEFHC(J,M),M=1,31)
      READ(5,210)(BYEFNO(J,M),M=1,31)
104 CONTINUE
      9 IF(IDIESL.EQ.0)GO TO 106
      DO 105 M=1,31
      BYEFCO(6,M) = FDEFCD(M)
      BYEFHC(6,M) = FDEFHC(M)
      BYEFNO(6,M) = FDEFNO(M)
105 CONTINUE
      GO TO 107
106 READ(5,210)(BYEFCO(6,M),M=1,31)
      READ(5,210)(BYEFHC(6,M),M=1,31)
      READ(5,210)(BYEFNO(6,M),M=1,31)
107 IDT=IDET+1
      IAD=MAXO(IAREA-1,1)
      GO TO(118,108,115),IDT
108 DO 111 J=1,2
      DO 110 N=1,10
      DO 109 M=1,21
      DETCO(J,M,N)=FDETCO(M,N,IAD)
      DETHC(J,M,N)=FDETHC(M,N,IAD)
      DETNO(J,M,N)=FDETNQ(M,N,IAD)
109 CONTINUE
      DO 110 M=22,31
      DETCO(J,M,N)=FDETCO(21,N,IAD)
      DETHC(J,M,N)=FDETHC(21,N,IAD)
      DETNO(J,M,N)=FDETNQ(21,N,IAD)
110 CONTINUE
      DO 111 N=11,16
      DO 111 M=1,31
      DETCO(J,M,N)=DETCO(J,M,10)
      DETHC(J,M,N)=DETHC(J,M,10)
      DETNO(J,M,N)=DETNO(J,M,10)
111 CONTINUE
      DO 112 J=3,6
      DO 112 N=1,16
      DO 112 M=1,31
      DETCO(J,M,N)=1.0
      DETHC(J,M,N)=1.0
      DETNO(J,M,N)=1.0
112 CONTINUE
      IF(IAREA.NE.3) GO TO 120
      DO 113 J=3,5
      DO 113 M=16,31
      DO 113 N=1,16
      DETCO(J,M,N) = FCHOCD(N)
      DETHC(J,M,N) = FCHOHC(N)
      DETNO(J,M,N) = FCHONQ(N)
113 CONTINUE
115 GO TO 120
C MILEAGE DEPENDANT DETERIORATION FACTORS WILL BE
C INITIALIZED AFTER REGISTRATION DATA IS INPUT
118 DO 119 J=1,6
      DO 119 M=1,31
      READ(5,230) (DETCO(J,M,N),N=1,16)
      READ(5,230) (DETHC(J,M,N),N=1,16)
      READ(5,230) (DETNO(J,M,N),N=1,16)
119 CONTINUE
120 IF(ICRNK.EQ.0)GO TO 122

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      DO 121 M=1,31
      CREF(1,M) = FCRNK(M,1,IAD)
      CREF(2,M) = FCRNK(M,1,IAD)
      CREF(3,M) = FCRNK(M,2,IAD)
      CREF(4,M) = FCRNK(M,2,IAD)
      CREF(5,M) = FCRNK(M,2,IAD)
      CREF(6,M) = 0.
121  CONTINUE
      GO TO 124
122  DO 123 J=1,6
      READ(5,210)(CREF(J,M),M=1,31)
123  CONTINUE
124  IEV=IEVAP+1
      GO TO(130,125,127),IEV
125  DO 126 M=1,31
      EVEF(1,M,2) = FEVAP(M,1,IAD)
      EVEF(2,M,2) = FEVAP(M,1,IAD)
      EVEF(3,M,2) = FEVAP(M,2,IAD)
      EVEF(4,M,2) = FEVAP(M,2,IAD)
      EVEF(5,M,2) = FEVAP(M,2,IAD)
      EVEF(6,M,2) = 0.
      DO 126 K=1,3,2
      DO 126 J=1,6
      EVEF(J,M,K) = 0.
126  CONTINUE
      GO TO 135
127  DO 129 M=1,31
      DO 129 K=1,3
      EVEF(1,M,K) = SEV(M,K,1,IAREA)
      EVEF(2,M,K) = SEV(M,K,1,IAREA)
      EVEF(3,M,K) = SEV(M,K,2,IAREA)
      EVEF(4,M,K) = SEV(M,K,2,IAREA)
      EVEF(5,M,K) = SEV(M,K,2,IAREA)
      EVEF(6,M,K) = 0.
129  CONTINUE
      GO TO 135
130  DO 131 J=1,6
      DO 131 K=1,3
      READ(5,210)(EVEF(J,M,K),M=1,31)
131  CONTINUE
135  IF(ICLDST.EQ.0)GO TO 140
      DO 139 M=1,31
      RCSCD(1,M) = FFCSCD(M,IAREA)
      RCSHC(1,M) = FFCSHC(M,IAREA)
      RCSCD(2,M) = FFCSCD(M,IAREA)
      RCSHC(2,M) = FFCSHC(M,IAREA)
      RCSCD(6,M) = 0.
      RCSHC(6,M) = 0.
      IF(IHGV.EQ.2)GO TO 137
      DO 136 J=3,5
      RCSCD(J,M) = HDCSCD(1)
      RCSHC(J,M) = HDCSHC(1)
136  CONTINUE
      GO TO 139
137  DO 138 J=3,5
      RCSCD(J,M) = HDCSCD(J-1)
      RCSHC(J,M) = HDCSHC(J-1)
138  CONTINUE
139  CONTINUE
      GO TO 142

```

```

140 DO 141 J=1,6
    READ(5,210)(RCSCD(J,M),M=1,31)
    READ(5,210)(RCSHC(J,M),M=1,31)
141 CONTINUE
142 IF(IAAT.NE.0)GO TO 144
    DO 143 J=1,6
        READ(5,210)(REGIS(N,J),N=1,16)
        READ(5,210)(AAT(N,J),N=1,16)
        READ(5,210)(PAAT(N,J),N=1,16)
143 CONTINUE
144 DO 145 J=1,6
    SUM(J)=0.0
    DO 145 N=1,16
        PTRVL(J,N)=REGIS(N,J)*AAT(N,J)
        SUM(J)=SUM(J)+PTRVL(J,N)
145 CONTINUE
    DO 146 J=1,6
        IF(SUM(J).EQ.0.) SUM(J)=1.0
        DO 146 N=1,16
            PTRVL(J,N)=PTRVL(J,N)/SUM(J)
146 CONTINUE
    IF(IWTFTR.NE.0)GO TO 147
    READ(5,210)(WFCTR(J),J=1,6)
147 CONTINUE
    IF(IDET.NE.2) GO TO 199
    DO 160 J=1,2
        XMILES=0.0
        DO 160 N=1,16
            XMILES=XMILES+AAT(N,J)
        XM = XMILES - AAT(N,J)*(1.-PAAT(N,J))
        DO 151 N1=1,10
            IF(XM.LE.CM(N1)) GO TO 154
151 CONTINUE
        DO 152 M=1,21
            DETCO(J,M,N) = FDETCO(M,10,IAD)
            DETHC(J,M,N) = FDETHC(M,10,IAD)
            DETNO(J,M,N) = FDETNO(M,10,IAD)
152 CONTINUE
        DO 153 M=22,31
            DETCO(J,M,N) = DETCO(J,21,N)
            DETHC(J,M,N) = DETHC(J,21,N)
            DETNO(J,M,N) = DETNO(J,21,N)
153 CONTINUE
        GO TO 160
154 IF(N1.NE.1)GO TO 156
        DO 155 M=1,31
            DETCO(J,M,N) = 1.0
            DETHC(J,M,N) = 1.0
            DETNO(J,M,N) = 1.0
155 CONTINUE
        GO TO 160
156 DO 157 M=1,21
            DETCO(J,M,N) = (FDETCO(M,N1,IAD)-FDETCO(M,N1-1,IAD))/
                (CM(N1)-CM(N1-1))*(XM-CM(N1-1)) + FDETCO(M,N1-1,IAD)
            DETHC(J,M,N) = (FDETHC(M,N1,IAD)-FDETHC(M,N1-1,IAD))/
                (CM(N1)-CM(N1-1))*(XM-CM(N1-1)) + FDETHC(M,N1-1,IAD)
            DETNO(J,M,N) = (FDETNO(M,N1,IAD)-FDETNO(M,N1-1,IAD))/
                (CM(N1)-CM(N1-1))*(XM-CM(N1-1)) + FDETNO(M,N1-1,IAD)
157 CONTINUE
        DO 158 M=22,31

```

```

      DETCO(J,M,N) = DETCO(J,21,N)
      DETHC(J,M,N) = DETHC(J,21,N)
      DETNO(J,M,N) = DETNO(J,21,N)
158 CONTINUE
160 CONTINUE
      DO 161 J=3,6
      DO 161 M=1,31
      DO 161 N=1,16
      DETCO(J,M,N) = 1.0
      DETHC(J,M,N) = 1.0
      DETNO(J,M,N) = 1.0
161 CONTINUE
      IF(IAREA.NE.3) GO TO 199
      DO 170 J=3,5
      XMILES = 0.0
      DO 170 N=1,16
      XMILES = XMILES + AAT(N,J)
      XM = XMILES * AAT(N,J)*(1.-PAAT(N,J))
      DO 162 N1=1,16
      IF(XM.LE.CMH(N1)) GO TO 164
162 CONTINUE
      DO 163 M=16,31
      DETCO(J,M,N) = FCHDCO(16)
      DETHC(J,M,N) = FCHDHC(16)
      DETNO(J,M,N) = FCHDNO(16)
163 CONTINUE
      GO TO 170
164 IF(N1.EQ.1) GO TO 170
      DO 165 M=16,31
      DETCO(J,M,N) = (FCHDCO(N1)-FCHDCO(N1-1))/(CMH(N1)-CMH(N1-1))
      * (XM-CMH(N1-1)) + FCHDCO(N1-1)
      DETHC(J,M,N) = (FCHDHC(N1)-FCHDHC(N1-1))/(CMH(N1)-CMH(N1-1))
      * (XM-CMH(N1-1)) + FCHDHC(N1-1)
      DETNO(J,M,N) = (FCHDNO(N1)-FCHDNO(N1-1))/(CMH(N1)-CMH(N1-1))
      * (XM-CMH(N1-1)) + FCHDNO(N1-1)
165 CONTINUE
170 CONTINUE
C
C***** WRITE OUT BASIC DATA SET *****
199 WRITE(6,1000) IAREA,IAUTO,ILOT,IHDV,IDIEST,IDET,ICRKN,IEVAP,
A ICLDST,IAAT,IWTFTR
      WRITE(6,1010) (J,J=1,6)
      WRITE(6,1011)
      IYR = 1960
      DO 300 M=1,31
      WRITE(6,1015) IYR,((BYEFGO(J,M),BYEFHC(J,M),BYEFNO(J,M)),J=1,6)
      IYR=IYR+1
300 CONTINUE
      DO 320 J=1,6
      N1=0
      WRITE(6,1020) J, N1,(N,N=1,15)
      IYR=1960
      DO 320 M=1,31
      WRITE(6,1022) IYR, (DETCO(J,M,N),N=1,16)
      WRITE(6,1024) (DETHC(J,M,N),N=1,16)
      WRITE(6,1026) (DETNO(J,M,N),N=1,16)
      IYR=IYR+1
320 CONTINUE
      WRITE(6,1030) (J,J=1,6)
      IYR=1960

```

```

      DO 330 M=1,31
      WRITE(6,1032) IYR, (CREF(J,M),J=1,6)
      IYR=IYR+1
330  CONTINUE
      WRITE(6,1040) (J,J=1,6)
      WRITE(6,1041)
      IYR=1960
      DO 340 M=1,31
      WRITE(6,1015) IYR, ((EVEF(J,M,K),K=1,3),J=1,6)
      IYR=IYR+1
340  CONTINUE
      WRITE(6,1050) (J,J=1,6)
      WRITE(6,1051)
      IYR=1960
      DO 350 M=1,31
      WRITE(6,1052) IYR, ((RCSCD(J,M),RCSHC(J,M)),J=1,6)
      IYR=IYR+1
350  CONTINUE
      WRITE(6,1060) (J,J=1,6)
      WRITE(6,1061)
      DO 360 N=1,16
      N1=N-1
      WRITE(6,1062) N1, ((REGIS(N,J),AAT(N,J),PAAT(N,J)),J=1,6)
360  CONTINUE
      WRITE(6,1070)
      WRITE(6,1072) ((J,WFCTR(J)),J=1,6)
1000 FORMAT(1H1, 'BASIC OPTIONS SELECTED FOR THIS RUN' / 1H , 5X,
A 'IAREA =', 12, 2X, 'IAUTO =', 12, 2X, 'ILDT =', 12, 2X,
B 'IHDV =', 12, 2X, 'IDIESL =', 12, 2X, 'IDET =', 12, 2X,
C 'ICRNK =', 12, 2X, 'IEVAP =', 12, 2X, 'ICLDST =', 12, 2X,
D 'IAAT =', 12, 2X, 'IWFCTR =', 12)
1010 FORMAT(1H0, 'MODEL YEAR EXHAUST EMISSION FACTORS' / 1H , 5X
A 6('-----', 11, '-----', 2X))
1011 FORMAT(1H , 5X, 6(3X, 'CO', 3X, 'HC', 3X, 'NOX', 5X))
1015 FORMAT(1H , 14, 1X, 6( F7.2, 2F6.2, 2X))
1020 FORMAT(1H1, 'CLASS', 12, ' EXHAUST DETERIORATION FACTORS' / 1H ,
A 'MOYR/AGE', 16(2X, 12, 2X) )
1022 FORMAT(1H0, 14, ' CO', 16F6.2)
1024 FORMAT(1H , 4X, ' HC', 16F6.2)
1026 FORMAT(1H , 4X, ' NOX', 16F6.2)
1030 FORMAT(1H1, 'MODEL YEAR CRANKCASE HC EMISSION FACTORS' / 1H ,
A 'MODYR', 6(5X, 11, 2X) )
1032 FORMAT(1H , 14, 1X, 6F8.2)
1040 FORMAT(1H1, 'MODEL YEAR EVAPORATIVE HC EMISSION FACTORS', / 1H ,
A 5X, 6('-----', 11, '-----', 2X))
1041 FORMAT(1H , 5X, 6(' DIUR RUN HTSK '))
1050 FORMAT(1H1, 'MODEL YEAR COLD START RATIOS', / 1H , 5X,
A 6('-----', 11, '-----', 2X) )
1051 FORMAT(1H , 5X, 6(3X, 'CO', 5X, 'HC', 4X))
1052 FORMAT(1H , 14, 1X, 6(F7.3, 2X))
1060 FORMAT(1H1, 'REGISTRATION AND ANNUAL TRAVEL' / 1H , 5X,
A 6('-----', 11, '-----', 2X))
1061 FORMAT(1H , 5X, 6(' REGIS AAT PAAT', 2X))
1062 FORMAT(1H , 14, 1X, 6(F6.3, F7.0, F6.3, 2X))
1070 FORMAT(1H0, // 1H0, 'VEHICLE CLASS WEIGHTING FACTORS')
1072 FORMAT(1H , 'CLASS ', 6(11, ' ', F6.3, 3X) )
C
C***** READ YEARLY CALCULATION OPTION CARD *****
10 READ(5,200,END=99)YEAR,ITIME,RTROFT,CLOSTR,SPEED
C***** CALCULATE EMISSION FACTORS *****

```

C. SPEED CORRECTION

```

SPDCO = 12.5 * ((SPEED)**(-0.845))
IF(SPEED.EQ.19.6) SPDCO = 1.0
SPDHC = 7.0 * ((SPEED)**(-0.649))
IF(SPEED.EQ.19.6) SPDHC = 1.0
SPONO = 1.0 + (SPEED-19.6)*0.01262
DO 11 J=1,5
  SCD(J)=SPDCO
  SHC(J)=SPDHC
  SNO(J)=SPONO

```

```

11 CONTINUE

```

```

  SCD(6)=1.0
  SHC(6)=1.0
  SNO(6)=1.0

```

C INITIALIZE YEARLY EMISSION FACTORS

```

DO 12 I = 1,31
  DO 12 K = 1,6
    YEFCD(K,I) = BYEFCD(K,I)
    YEFHC(K,I) = BYEFHC(K,I)
    YEFNO(K,I) = BYEFNO(K,I)

```

```

12 CONTINUE

```

```

  IF(RTROFT)21,25,23

```

```

21 DO 22 J=1,6

```

```

  READ(5,210)(RTROCD(J,M),M=1,31)

```

```

  READ(5,210)(RTROHC(J,M),M=1,31)

```

```

  READ(5,210)(RTRONO(J,M),M=1,31)

```

```

22 CONTINUE

```

```

23 DO 24 M=1,31

```

```

  DO 24 J=1,6

```

```

    YEFCD(J,M)=YEFCD(J,M)*(1.-RTROCD(J,M))

```

```

    YEFHC(J,M)=YEFHC(J,M)*(1.-RTROHC(J,M))

```

```

    YEFNO(J,M)=YEFNO(J,M)*(1.-RTRONO(J,M))

```

```

24 CONTINUE

```

```

25 DO 26 J=1,6

```

```

  CSCD(J)=0.0

```

```

  CSHC(J)=0.0

```

```

26 CONTINUE

```

```

30 IF(CLDSTR.EQ.0)GO TO 40

```

```

  DO 33 M=1,31

```

```

    DO 31 J=1,6

```

```

      YEFCSC(J,M)=YEFCD(J,M)*7.5*RCSCD(J,M)

```

```

      YEFCSH(J,M)=YEFHC(J,M)*7.5*RCSHC(J,M)

```

```

31 CONTINUE

```

```

    DO 32 J=1,2

```

```

      YEFCD(J,M)=YEFCD(J,M)*(1.-.43*RCSCD(J,M))

```

```

      YEFHC(J,M)=YEFHC(J,M)*(1.-.43*RCSHC(J,M))

```

```

32 CONTINUE

```

```

33 CONTINUE

```

```

  DO 35 J=1,6

```

```

    K=YEAR-1958+ITIME

```

```

    DO 35 N=1,16

```

```

      K=MAXO(K-1,1)

```

```

      CSCD(J)=CSCD(J)+PTRVL(J,N)*YEFCSC(J,K)*DETCO(J,K,N)

```

```

      CSHC(J)=CSHC(J)+PTRVL(J,N)*YEFCSH(J,K)*DETHC(J,K,N)

```

```

35 CONTINUE

```

```

40 DO 41 J=1,6

```

```

  DO 41 L=1,3

```

```

    EXEMI(J,L)=0.0

```

```

41 CONTINUE

```

```

  DO 42 J=1,6

```

```

      K=YEAR-1958+ITIME
      DO 42 N=1,16
      K=MAXO(K-1,1)
      EXEMI(J,1)=EXEMI(J,1)+YEFCD(J,K)*DETCO(J,K,N)*SCO(J)*PTRVL(J,N)
      EXEMI(J,2)=EXEMI(J,2)+YEFHC(J,K)*DETHC(J,K,N)*SHC(J)*PTRVL(J,N)
      EXEMI(J,3)=EXEMI(J,3)+YEFND(J,K)*DETND(J,K,N)*SND(J)*PTRVL(J,N)
42  CONTINUE
      DO 61 J=1,6
      CRANK(J)=0.0
      DO 61 I=1,3
      EVAP(J,I)=0.0
61  CONTINUE
      DO 62 J=1,6
      K=YEAR-1958+ITIME
      DO 62 N=1,16
      K=MAXO(K-1,1)
      CRANK(J)=CRANK(J)+CREF(J,K)*PTRVL(J,N)
      DO 62 I=1,3
      EVAP(J,I)=EVAP(J,I)+EVEF(J,K,I)*PTRVL(J,N)
62  CONTINUE
      WEXCO=0.0
      WEXHC=0.0
      WEXND=0.0
      WCSCO=0.0
      WCSHC=0.0
      WCRNK=0.0
      DO 81 I=1,3
      WEVAP(I)=0.0
81  CONTINUE
      DO 82 J=1,6
      WEXCO=WEXCO+EXEMI(J,1)*WFCTR(J)
      WEXHC=WEXHC+EXEMI(J,2)*WFCTR(J)
      WEXND=WEXND+EXEMI(J,3)*WFCTR(J)
      WCSCO=WCSCO+CSCO(J)*WFCTR(J)
      WCSHC=WCSHC+CSHC(J)*WFCTR(J)
      WCRNK=WCRNK+CRANK(J)*WFCTR(J)
      DO 82 I=1,3
      WEVAP(I)=WEVAP(I)+EVAP(J,I)*WFCTR(J)
82  CONTINUE
C
C*****
C  PRINT TABLE OF EMISSION FACTORS FOR YEAR 'YEAR'
C*****
96  WRITE(6,1100)TITLE
      IY=ITIME+1
      WRITE(6,1105)YEAR,Y(IY),SPEED,(J,J=1,6)
      IF(CLDSTR.EQ.0) WRITE(6,1110)
      IF(CLDSTR.NE.0) WRITE(6,1111)
      WRITE(6,1120)(EXEMI(J,1),J=1,6),WEXCO
      WRITE(6,1130)(EXEMI(J,2),J=1,6),WEXHC
      WRITE(6,1140)(EXEMI(J,3),J=1,6),WEXND
      IF (CLDSTR .NE. 0) WRITE(6,1160)CSCO,WCSKO,CSHC,WCSHC
      WRITE(6,1142)
      WRITE(6,1144) (EVAP(J,1),J=1,6), WEVAP(1)
      WRITE(6,1146) (EVAP(J,2),J=1,6), WEVAP(2)
      WRITE(6,1148) (EVAP(J,3),J=1,6), WEVAP(3)
      WRITE(6,1152)
      WRITE(6,1154) (CRANK(J),J=1,6), WCRNK
      IF (RTRQFT .NE. 0) WRITE(6,1150)
      GO TO 10

```

```

99 STOP
C
200 FORMAT(4I6,F6.2)
210 FORMAT(9F8.0)
220 FORMAT(10A8)
225 FORMAT(11I3)
230 FORMAT(16F5.0)
1100 FORMAT(1H1,11X,10A8)
1105 FORMAT(1H ,21X,'MOTOR VEHICLE EMISSION FACTORS FOR ',
A 14,1X,A4,'YEAR AT A SPEED OF ',F5.2,' MPH'/1H ,25X,
B 'CLASS',17,5I8)
1110 FORMAT(1H+,85X,'WEIGHTED'/1H ,17X,'EXHAUST EMISSIONS -- ',
A 'GRAMS/VEHICLE-MILE')
1111 FORMAT(1H+,85X,'WEIGHTED'/1H ,17X,'EXHAUST EMISSIONS -- ',
A 'GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY')
1120 FORMAT(1H ,13X,'CARBON MONOXIDE',3X,6F8.2,F14.2)
1130 FORMAT(1H ,13X,'HYDROCARBONS ',3X,6F8.2,F14.2)
1140 FORMAT(1H ,13X,'NITROGEN OXIDES',3X,6F8.2,F14.2)
1142 FORMAT(1H ,17X,'EVAPORATIVE HYDROCARBON EMISSIONS')
1144 FORMAT(1H ,13X,'DIURNAL (GRAMS)',2X,6F8.2,F14.2)
1146 FORMAT(1H ,13X,'RUNNING (GMS/MI)',2X,6F8.2,F14.2)
1148 FORMAT(1H ,13X,'HOT SOAK (GRAMS)',2X,6F8.2,F14.2)
1150 FORMAT(1H ,10X,'NOTE : RETROFIT INCLUDED')
1152 FORMAT(1H ,17X,'CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-
.MILE')
1154 FORMAT(1H ,31X,6F8.2,F14.2)
1160 FORMAT(1H ,17X,'COLD START EMISSIONS -- GRAMS'/
A 1H ,13X,'CARBON MONOXIDE',3X,6F8.2,F14.2/
B 1H ,13X,'HYDROCARBONS ',3X,6F8.2,F14.2)
C
END
/*

```


APPENDIX B - Motor Vehicle Emission Factor Tables

The following is a set of emission factor tables generated by the TREFACT program. The data are those that will be used most frequently.

The tables are divided into four basic sets each of which required a separate run on TREFACT. At the beginning of each set of tables is a listing of the data input cards used to generate that set. The sets are the following:

- Set 1 - Tables B.1 - B.26
Cook County vehicle registration data.
No GVW distinction of heavy duty gasoline-powered vehicles (Classes 3-5).
No separation of evaporative HC emissions by source (treated as running losses only).
- Set 2 - Tables B.27 - B.52
Cook County vehicle registration data.
GVW distinction of heavy duty vehicles.
Separation of evaporative emissions by source.
- Set 3 - Tables B.53 - B.78
U.S. national average vehicle registration data.
No GVW distinction of heavy duty vehicles.
No separation of evaporative emissions by source.
- Set 4 - Tables B.79 - B.104
U.S. national average vehicle registration data.
GVW distinction of heavy duty vehicles.
Separation of evaporative emissions by source.

Each set contains calculations for the years 1970-80, 1985, and 1990.

Also, each set contains exhaust emission computations for both a weighted cold start emission factor (1975 FTP) and separate emission factors for hot operation and a cold start.

Set 1 TREFACT
Input Data Deck

```

//GO,SYSIN DD *
***** COOK COUNTY REGISTRATION DATA *****
 1 1 1 1 1 1 1 1 1 0 1
.1163 .1444 .1307 .1124 .1090 .1047 .0815 .0671 .0523
.0296 .0230 .0101 .0042 .0149
15900. 15000. 14000. 13100. 12200. 11300. 10300. 9400. 8500.
7600. 6700. 6700. 6700. 6700. 6700. 6700.
.38 .30 .30 .30 .30 .30 .30 .30 .30
.30 .30 .30 .30 .30 .30 .30
.1163 .1444 .1307 .1124 .1090 .1047 .0815 .0671 .0523
.0296 .0230 .0101 .0042 .0149
15900. 15000. 14000. 13100. 12200. 11300. 10300. 9400. 8500.
7600. 6700. 6700. 6700. 6700. 6700. 6700.
.38 .30 .30 .30 .30 .30 .30 .30 .30
.30 .30 .30 .30 .30 .30 .30
.0825 .1292 .1042 .1081 .1024 .0921 .0660 .0610 .0503
.0343 .0361 .0275 .0157 .0158 .0154 .0594
17200. 17200. 15800. 15800. 13000. 13000. 11000. 11000. 9000.
9000. 5500. 5500. 5500. 5500. 5500. 5500.
.37 .30 .30 .30 .30 .30 .30 .30 .30
.30 .30 .30 .30 .30 .30 .30
.0825 .1292 .1042 .1081 .1024 .0921 .0660 .0610 .0503
.0343 .0361 .0275 .0157 .0158 .0154 .0594
17200. 17200. 15800. 15800. 13000. 13000. 11000. 11000. 9000.
9000. 5500. 5500. 5500. 5500. 5500. 5500.
.37 .30 .30 .30 .30 .30 .30 .30 .30
.30 .30 .30 .30 .30 .30 .30
.0825 .1292 .1042 .1081 .1024 .0921 .0660 .0610 .0503
.0343 .0361 .0275 .0157 .0158 .0154 .0594
17200. 17200. 15800. 15800. 13000. 13000. 11000. 11000. 9000.
9000. 5500. 5500. 5500. 5500. 5500. 5500.
.37 .30 .30 .30 .30 .30 .30 .30 .30
.30 .30 .30 .30 .30 .30 .30
1970 0 0 0 19.6
1970 0 0 1 19.6
1971 0 0 0 19.6
1971 0 0 1 19.6
1972 0 0 0 19.6
1972 0 0 1 19.6
1973 0 0 0 19.6
1973 0 0 1 19.6
1974 0 0 0 19.6
1974 0 0 1 19.6
1975 0 0 0 19.6
1975 0 0 1 19.6
1976 0 0 0 19.6
1976 0 0 1 19.6
1977 0 0 0 19.6
1977 0 0 1 19.6
1978 0 0 0 19.6
1978 0 0 1 19.6
1979 0 0 0 19.6
1979 0 0 1 19.6
1980 0 0 0 19.6
1980 0 0 1 19.6
1985 0 0 0 19.6
1985 0 0 1 19.6
1990 0 0 0 19.6
1990 0 0 1 19.6

```

TABLE B. 1							
***** COOK COUNTY REGISTRATION DATA *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1970 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	70.09	70.09	138.88	138.88	138.88	47.32	74.97
HYDROCARBONS	6.80	6.80	16.89	16.89	16.89	9.16	7.56
NITROGEN OXIDES	4.26	4.26	9.38	9.38	9.38	54.30	4.94
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	3.00	3.00	3.00	3.00	3.00	0.0	2.98
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.69	0.69	3.02	3.02	3.02	0.0	0.86

TABLE B. 2							
***** COOK COUNTY REGISTRATION DATA *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1970 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	63.40	63.40	138.88	138.88	138.88	47.32	68.81
HYDROCARBONS	6.25	6.25	16.89	16.89	16.89	9.16	7.05
NITROGEN OXIDES	4.26	4.26	9.38	9.38	9.38	54.30	4.94
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	116.67	116.67	109.36	109.36	109.36	0.0	115.43
HYDROCARBONS	9.60	9.60	17.99	17.99	17.99	0.0	10.16
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	3.00	3.00	3.00	3.00	3.00	0.0	2.98
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.69	0.69	3.02	3.02	3.02	0.0	0.86

TABLE B. 3

***** COOK COUNTY REGISTRATION DATA *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1971 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	64.51	64.51	137.11	137.11	137.11	44.38	69.69
HYDROCARBONS	6.08	6.08	16.71	16.71	16.71	8.09	6.87
NITROGEN OXIDES	4.41	4.41	9.34	9.34	9.34	58.69	5.10
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	2.62	2.62	3.00	3.00	3.00	0.0	2.64
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.48	0.48	2.32	2.32	2.32	0.0	0.61

TABLE B. 4

***** COOK COUNTY REGISTRATION DATA *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1971 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	57.93	57.93	137.11	137.11	137.11	44.38	63.63
HYDROCARBONS	5.58	5.58	16.71	16.71	16.71	8.09	6.40
NITROGEN OXIDES	4.41	4.41	9.34	9.34	9.34	58.69	5.10
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	114.77	114.77	107.98	107.98	107.98	0.0	113.58
HYDROCARBONS	8.83	8.83	17.80	17.80	17.30	0.0	9.44
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	2.62	2.62	3.00	3.00	3.00	0.0	2.64
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.48	0.48	2.32	2.32	2.32	0.0	0.61

TABLE B. 5

***** COOK COUNTY REGISTRATION DATA *****

MOTOR VEHICLE EMISSION FACTORS FOR 1972 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	57.61	57.61	135.81	135.81	135.81	42.20	63.22
HYDROCARBONS	5.37	5.37	16.58	16.58	16.58	7.30	6.20
NITROGEN OXIDES	4.52	4.52	9.32	9.32	9.32	61.94	5.21
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	2.14	2.14	3.00	3.00	3.00	0.0	2.19
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.33	0.33	1.77	1.77	1.77	0.0	0.43

TABLE B. 6

***** COOK COUNTY REGISTRATION DATA *****

MOTOR VEHICLE EMISSION FACTORS FOR 1972 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	51.39	51.39	135.81	135.81	135.81	42.20	57.50
HYDROCARBONS	4.91	4.91	16.58	16.58	16.58	7.30	5.78
NITROGEN OXIDES	4.52	4.52	9.32	9.32	9.32	61.94	5.21
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	108.39	108.39	106.95	106.95	106.95	0.0	107.64
HYDROCARBONS	8.02	8.02	17.66	17.66	17.66	0.0	8.67
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	2.14	2.14	3.00	3.00	3.00	0.0	2.19
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.33	0.33	1.77	1.77	1.77	0.0	0.43

TABLE R. 7

***** COOK COUNTY REGISTRATION DATA *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1973 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	50.60	50.60	134.46	134.46	134.46	39.94	56.66
HYDROCARBONS	4.76	4.76	16.45	16.45	16.45	6.48	5.62
NITROGEN OXIDES	4.25	4.25	9.29	9.29	9.29	65.31	4.98
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	1.72	1.72	3.00	3.00	3.00	0.0	1.80
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.21	0.21	1.27	1.27	1.27	0.0	0.29

TABLE R. 8

***** COOK COUNTY REGISTRATION DATA *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1973 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	44.81	44.81	134.46	134.46	134.46	39.94	51.33
HYDROCARBONS	4.34	4.34	16.45	16.45	16.45	6.48	5.24
NITROGEN OXIDES	4.25	4.25	9.29	9.29	9.29	65.31	4.98
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	100.91	100.91	105.88	105.88	105.88	0.0	100.67
HYDROCARBONS	7.35	7.35	17.51	17.51	17.51	0.0	8.05
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	1.72	1.72	3.00	3.00	3.00	0.0	1.80
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.21	0.21	1.27	1.27	1.27	0.0	0.29

TABLE B. 9

***** COOK COUNTY REGISTRATION DATA *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1974 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	44.46	44.46	133.40	133.40	133.40	38.18	50.92
HYDROCARBONS	4.27	4.27	16.00	16.00	16.00	5.84	5.14
NITROGEN OXIDES	3.93	3.93	9.27	9.27	9.27	67.93	4.71
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	1.37	1.37	3.00	3.00	3.00	0.0	1.48
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.14	0.14	0.98	0.98	0.98	0.0	0.20

TABLE B. 10

***** COOK COUNTY REGISTRATION DATA *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1974 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	39.12	39.12	133.40	133.40	133.40	38.18	45.99
HYDROCARBONS	3.89	3.89	16.00	16.00	16.00	5.84	4.78
NITROGEN OXIDES	3.93	3.93	9.27	9.27	9.27	67.93	4.71
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	93.24	93.24	105.05	105.05	105.05	0.0	93.54
HYDROCARBONS	6.78	6.78	17.04	17.04	17.04	0.0	7.49
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	1.37	1.37	3.00	3.00	3.00	0.0	1.48
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.14	0.14	0.98	0.98	0.98	0.0	0.20

TABLE B. 11

***** COOK COUNTY REGISTRATION DATA *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1975 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	38.37	38.37	132.45	132.45	132.45	36.59	45.23
HYDROCARBONS	3.67	3.67	15.38	15.38	15.38	5.27	4.53
NITROGEN OXIDES	3.66	3.66	9.25	9.25	9.25	70.30	4.46
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	1.07	1.07	3.00	3.00	3.00	0.0	1.20
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.09	0.09	0.70	0.70	0.70	0.0	0.14

TABLE B. 12

***** COOK COUNTY REGISTRATION DATA *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1975 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	33.58	33.58	132.45	132.45	132.45	36.59	40.82
HYDROCARBONS	3.33	3.33	15.38	15.38	15.38	5.27	4.22
NITROGEN OXIDES	3.66	3.66	9.25	9.25	9.25	70.30	4.46
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	83.57	83.57	104.31	104.31	104.31	0.0	84.58
HYDROCARBONS	5.92	5.92	16.38	16.38	16.38	0.0	6.64
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	1.07	1.07	3.00	3.00	3.00	0.0	1.20
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.09	0.09	0.70	0.70	0.70	0.0	0.14

TABLE B. 13

***** COOK COUNTY REGISTRATION DATA *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1976 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	30.92	30.92	131.88	131.88	131.88	35.63	38.32
HYDROCARBONS	2.94	2.94	14.93	14.93	14.93	4.92	3.82
NITROGEN OXIDES	3.29	3.29	9.24	9.24	9.24	71.73	4.14
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	0.79	0.79	3.00	3.00	3.00	0.0	0.95
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.04	0.04	0.51	0.51	0.51	0.0	0.07

TABLE B. 14

***** COOK COUNTY REGISTRATION DATA *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1976 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	26.82	26.82	131.88	131.88	131.88	35.63	34.54
HYDROCARBONS	2.66	2.66	14.93	14.93	14.93	4.92	3.57
NITROGEN OXIDES	3.29	3.29	9.24	9.24	9.24	71.73	4.14
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	71.51	71.51	103.85	103.85	103.85	0.0	73.44
HYDROCARBONS	4.90	4.90	15.90	15.90	15.90	0.0	5.67
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	0.79	0.79	3.00	3.00	3.00	0.0	0.95
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.04	0.04	0.51	0.51	0.51	0.0	0.07

TABLE B. 15

***** COOK COUNTY REGISTRATION DATA *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1977 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	24.29	24.29	131.34	131.34	131.34	34.74	32.16
HYDROCARBONS	2.33	2.33	14.47	14.47	14.47	4.59	3.23
NITROGEN OXIDES	2.78	2.78	9.23	9.23	9.23	73.05	3.67
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	0.60	0.60	3.00	3.00	3.00	0.0	0.77
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.02	0.02	0.39	0.39	0.39	0.0	0.05

TABLE B. 16

***** COOK COUNTY REGISTRATION DATA *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1977 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	20.82	20.82	131.34	131.34	131.34	34.74	28.97
HYDROCARBONS	2.10	2.10	14.47	14.47	14.47	4.59	3.02
NITROGEN OXIDES	2.78	2.78	9.23	9.23	9.23	73.05	3.67
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	60.53	60.53	103.43	103.43	103.43	0.0	63.30
HYDROCARBONS	4.04	4.04	15.41	15.41	15.41	0.0	4.84
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	0.60	0.60	3.00	3.00	3.00	0.0	0.77
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.02	0.02	0.39	0.39	0.39	0.0	0.05

TABLE B. 17

***** COOK COUNTY REGISTRATION DATA *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1978 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	18.67	18.67	130.99	130.99	130.99	34.15	26.96
HYDROCARBONS	1.84	1.84	14.12	14.12	14.12	4.38	2.75
NITROGEN OXIDES	2.23	2.23	9.22	9.22	9.22	73.95	3.17
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	0.45	0.45	3.00	3.00	3.00	0.0	0.63
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.01	0.01	0.30	0.30	0.30	0.0	0.03

TABLE B. 18

***** COOK COUNTY REGISTRATION DATA *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1978 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	15.74	15.74	130.99	130.99	130.99	34.15	24.27
HYDROCARBONS	1.65	1.65	14.12	14.12	14.12	4.38	2.57
NITROGEN OXIDES	2.23	2.23	9.22	9.22	9.22	73.95	3.17
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	51.02	51.02	103.15	103.15	103.15	0.0	54.52
HYDROCARBONS	3.34	3.34	15.04	15.04	15.04	0.0	4.18
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	0.45	0.45	3.00	3.00	3.00	0.0	0.63
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.01	0.01	0.30	0.30	0.30	0.0	0.03

TABLE B. 19

***** COOK COUNTY REGISTRATION DATA *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1979 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	14.34	14.34	130.74	130.74	130.74	33.74	22.96
HYDROCARBONS	1.45	1.45	13.81	13.81	13.81	4.23	2.37
NITROGEN OXIDES	1.78	1.78	9.21	9.21	9.21	74.56	2.76
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	0.34	0.34	3.00	3.00	3.00	0.0	0.53
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.01	0.01	0.24	0.24	0.24	0.0	0.03

TABLE B. 20

***** COOK COUNTY REGISTRATION DATA *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1979 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	11.83	11.83	130.74	130.74	130.74	33.74	20.64
HYDROCARBONS	1.29	1.29	13.81	13.81	13.81	4.23	2.22
NITROGEN OXIDES	1.78	1.78	9.21	9.21	9.21	74.56	2.76
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	43.87	43.87	102.96	102.96	102.96	0.0	47.92
HYDROCARBONS	2.80	2.80	14.71	14.71	14.71	0.0	3.66
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	0.34	0.34	3.00	3.00	3.00	0.0	0.53
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.01	0.01	0.24	0.24	0.24	0.0	0.03

TABLE B. 21

***** COOK COUNTY REGISTRATION DATA *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1980 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	10.71	10.71	130.58	130.58	130.58	33.47	19.59
HYDROCARBONS	1.12	1.12	13.62	13.62	13.62	4.13	2.05
NITROGEN OXIDES	1.46	1.46	9.21	9.21	9.21	74.95	2.46
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	0.28	0.28	3.00	3.00	3.00	0.0	0.48
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.01	0.01	0.21	0.21	0.21	0.0	0.02

TABLE B. 22

***** COOK COUNTY REGISTRATION DATA *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1980 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	8.54	8.54	130.58	130.58	130.58	33.47	17.60
HYDROCARBONS	0.99	0.99	13.62	13.62	13.62	4.13	1.93
NITROGEN OXIDES	1.46	1.46	9.21	9.21	9.21	74.95	2.46
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	37.82	37.82	102.83	102.83	102.83	0.0	42.34
HYDROCARBONS	2.36	2.36	14.51	14.51	14.51	0.0	3.23
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	0.28	0.28	3.00	3.00	3.00	0.0	0.48
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.01	0.01	0.21	0.21	0.21	0.0	0.02

TABLE B. 23

***** COOK COUNTY REGISTRATION DATA *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1985 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	3.29	3.29	130.00	130.00	130.00	32.50	12.72
HYDROCARBONS	0.40	0.40	13.14	13.14	13.14	3.78	1.35
NITROGEN OXIDES	0.58	0.58	9.20	9.20	9.20	76.40	1.66
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	0.20	0.20	3.00	3.00	3.00	0.0	0.40
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE B. 24

***** COOK COUNTY REGISTRATION DATA *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1985 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	1.69	1.69	130.00	130.00	130.00	32.50	11.24
HYDROCARBONS	0.31	0.31	13.14	13.14	13.14	3.78	1.27
NITROGEN OXIDES	0.58	0.58	9.20	9.20	9.20	76.40	1.66
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	28.06	28.06	102.38	102.38	102.38	0.0	33.31
HYDROCARBONS	1.45	1.45	13.99	13.99	13.99	0.0	2.35
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	0.20	0.20	3.00	3.00	3.00	0.0	0.40
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE B. 25

***** COOK COUNTY REGISTRATION DATA *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1990 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	2.67	2.67	130.00	130.00	130.00	32.50	12.15
HYDROCARBONS	0.33	0.33	13.00	13.00	13.00	3.78	1.27
NITROGEN OXIDES	0.47	0.47	9.20	9.20	9.20	76.40	1.56
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	0.20	0.20	3.00	3.00	3.00	0.0	0.40
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE B. 26

***** COOK COUNTY REGISTRATION DATA *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1990 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	1.10	1.10	130.00	130.00	130.00	32.50	10.70
HYDROCARBONS	0.25	0.25	13.00	13.00	13.00	3.78	1.20
NITROGEN OXIDES	0.47	0.47	9.20	9.20	9.20	76.40	1.56
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	27.45	27.45	102.38	102.38	102.38	0.0	32.75
HYDROCARBONS	1.37	1.37	13.85	13.85	13.85	0.0	2.27
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	0.20	0.20	3.00	3.00	3.00	0.0	0.40
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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***** COOK COUNTY REGISTRATION DATA -- HDV BY GVH. EVAP BY SOURCE *****

1	1	1	2	1	1	2	1	0	1
.1163	.1444	.1307	.1124	.1090	.1047	.0815	.0671	.0523	
.0296	.0230	.0101	.0042	.0149					
15900.	15000.	14000.	13100.	12200.	11300.	10300.	9400.	8500.	
7600.	6700.	6700.	6700.	6700.	6700.	6700.	6700.		
.30	.30	.30	.30	.30	.30	.30	.30	.30	
.30	.30	.30	.30	.30	.30	.30	.30		
.1163	.1444	.1307	.1124	.1090	.1047	.0815	.0671	.0523	
.0296	.0230	.0101	.0042	.0149					
15900.	15000.	14000.	13100.	12200.	11300.	10300.	9400.	8500.	
7600.	6700.	6700.	6700.	6700.	6700.	6700.	6700.		
.30	.30	.30	.30	.30	.30	.30	.30	.30	
.30	.30	.30	.30	.30	.30	.30	.30		
.0825	.1292	.1042	.1081	.1024	.0921	.0660	.0610	.0503	
.0343	.0361	.0275	.0157	.0158	.0154	.0594			
17200.	17200.	15800.	15800.	13000.	13000.	11000.	11000.	9000.	
9000.	5500.	5500.	5500.	5500.	5500.	5500.	5500.		
.37	.30	.30	.30	.30	.30	.30	.30	.30	
.30	.30	.30	.30	.30	.30	.30	.30		
.0825	.1292	.1042	.1081	.1024	.0921	.0660	.0610	.0503	
.0343	.0361	.0275	.0157	.0158	.0154	.0594			
17200.	17200.	15800.	15800.	13000.	13000.	11000.	11000.	9000.	
9000.	5500.	5500.	5500.	5500.	5500.	5500.	5500.		
.37	.30	.30	.30	.30	.30	.30	.30	.30	
.30	.30	.30	.30	.30	.30	.30	.30		
.0825	.1292	.1042	.1081	.1024	.0921	.0660	.0610	.0503	
.0343	.0361	.0275	.0157	.0158	.0154	.0594			
17200.	17200.	15800.	15800.	13000.	13000.	11000.	11000.	9000.	
9000.	5500.	5500.	5500.	5500.	5500.	5500.	5500.		
.37	.30	.30	.30	.30	.30	.30	.30	.30	
.30	.30	.30	.30	.30	.30	.30	.30		
.0825	.1292	.1042	.1081	.1024	.0921	.0660	.0610	.0503	
.0343	.0361	.0275	.0157	.0158	.0154	.0594			
17200.	17200.	15800.	15800.	13000.	13000.	11000.	11000.	9000.	
9000.	5500.	5500.	5500.	5500.	5500.	5500.	5500.		
.37	.30	.30	.30	.30	.30	.30	.30	.30	
.30	.30	.30	.30	.30	.30	.30	.30		
1970	0	0	0	19.6					
1970	0	0	1	19.6					
1971	0	0	0	19.6					
1971	0	0	1	19.6					
1972	0	0	0	19.6					
1972	0	0	1	19.6					
1973	0	0	0	19.6					
1973	0	0	1	19.6					
1974	0	0	0	19.6					
1974	0	0	1	19.6					
1975	0	0	0	19.6					
1975	0	0	1	19.6					
1976	0	0	0	19.6					
1976	0	0	1	19.6					
1977	0	0	0	19.6					
1977	0	0	1	19.6					
1978	0	0	0	19.6					
1978	0	0	1	19.6					
1979	0	0	0	19.6					
1979	0	0	1	19.6					
1980	0	0	0	19.6					
1980	0	0	1	19.6					
1985	0	0	0	19.6					
1985	0	0	1	19.6					
1990	0	0	0	19.6					
1990	0	0	1	19.6					

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TABLE B. 27

***** COOK COUNTY REGISTRATION DATA -- HDV BY GVW, EVAP BY SOURCE *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1970 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	70.09	70.09	107.63	145.02	269.12	47.32	74.98
HYDROCARBONS	6.80	6.80	13.01	20.06	28.81	9.16	7.56
NITROGEN OXIDES	4.26	4.26	9.38	9.58	9.28	54.30	4.94
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	26.00	26.00	26.00	26.00	26.00	0.0	25.84
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	14.70	14.70	14.70	14.70	14.70	0.0	14.61
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.69	0.69	3.02	3.02	3.02	0.0	0.86

TABLE B. 28

***** COOK COUNTY REGISTRATION DATA -- HDV BY GVW, EVAP BY SOURCE *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1970 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	63.40	63.40	107.63	145.02	269.12	47.32	68.82
HYDROCARBONS	6.25	6.25	13.01	20.06	28.81	9.16	7.05
NITROGEN OXIDES	4.26	4.26	9.38	9.58	9.28	54.30	4.94
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	116.67	116.67	192.13	82.66	66.61	0.0	118.25
HYDROCARBONS	9.60	9.60	16.69	20.92	28.30	0.0	10.25
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	26.00	26.00	26.00	26.00	26.00	0.0	25.84
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	14.70	14.70	14.70	14.70	14.70	0.0	14.61
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.69	0.69	3.02	3.02	3.02	0.0	0.86

TABLE B. 29

***** COOK COUNTY REGISTRATION DATA -- HDV BY GVW, EVAP BY SOURCE *****
 MOTOR VEHICLE EMISSION FACTORS FOR 1971 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	64.51	64.51	106.28	143.17	265.70	44.38	69.70
HYDROCARBONS	6.08	6.08	12.87	19.85	28.51	8.09	6.87
NITROGEN OXIDES	4.41	4.41	9.34	9.54	9.24	58.69	5.10
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	24.54	24.54	26.00	26.00	26.00	0.0	24.50
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	14.13	14.13	14.70	14.70	14.70	0.0	14.09
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.48	0.48	2.32	2.32	2.32	0.0	0.61

TABLE B. 30

***** COOK COUNTY REGISTRATION DATA -- HDV BY GVW, EVAP BY SOURCE *****
 MOTOR VEHICLE EMISSION FACTORS FOR 1971 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	57.93	57.93	106.28	143.17	265.70	44.38	63.64
HYDROCARBONS	5.58	5.58	12.87	19.85	28.51	8.09	6.41
NITROGEN OXIDES	4.41	4.41	9.34	9.54	9.24	58.69	5.10
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	114.77	114.77	189.71	81.61	65.76	0.0	116.37
HYDROCARBONS	8.83	8.83	16.50	20.70	28.01	0.0	9.53
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	24.54	24.54	26.00	26.00	26.00	0.0	24.50
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	14.13	14.13	14.70	14.70	14.70	0.0	14.09
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.48	0.48	2.32	2.32	2.32	0.0	0.61

TABLE B. 31

***** COOK COUNTY REGISTRATION DATA -- HDV BY GVW, EVAP BY SOURCE *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1972 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	57.61	57.61	105.27	141.80	263.17	42.20	63.23
HYDROCARBONS	5.37	5.37	12.76	19.70	28.29	7.30	6.20
NITROGEN OXIDES	4.52	4.52	9.32	9.52	9.22	61.94	5.21
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	21.37	21.37	26.00	26.00	26.00	0.0	21.58
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	12.49	12.49	14.70	14.70	14.70	0.0	12.57
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.33	0.33	1.77	1.77	1.77	0.0	0.43

TABLE B. 32

***** COOK COUNTY REGISTRATION DATA -- HDV BY GVW, EVAP BY SOURCE *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1972 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	51.39	51.39	105.27	141.80	263.17	42.20	57.51
HYDROCARBONS	4.91	4.91	12.76	19.70	28.29	7.30	5.78
NITROGEN OXIDES	4.52	4.52	9.32	9.52	9.22	61.94	5.21
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	108.39	108.39	187.91	80.83	65.13	0.0	110.39
HYDROCARBONS	8.02	8.02	16.37	20.53	27.79	0.0	8.77
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	21.37	21.37	26.00	26.00	26.00	0.0	21.58
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	12.49	12.49	14.70	14.70	14.70	0.0	12.57
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.33	0.33	1.77	1.77	1.77	0.0	0.43

TABLE B. 33

***** COOK COUNTY REGISTRATION DATA -- HDV BY GVW, EVAP BY SOURCE *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1973 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	50.60	50.60	104.23	140.38	260.54	39.94	56.66
HYDROCARBONS	4.76	4.76	12.66	19.53	28.06	6.48	5.63
NITROGEN OXIDES	4.25	4.25	9.29	9.49	9.19	65.31	4.98
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	18.20	18.20	26.00	26.00	26.00	0.0	18.66
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	10.78	10.78	14.70	14.70	14.70	0.0	11.00
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.21	0.21	1.27	1.27	1.27	0.0	0.29

TABLE B. 34

***** COOK COUNTY REGISTRATION DATA -- HDV BY GVW, EVAP BY SOURCE *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1973 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	44.81	44.81	104.23	140.38	260.54	39.94	51.33
HYDROCARBONS	4.34	4.34	12.66	19.53	28.06	6.48	5.24
NITROGEN OXIDES	4.25	4.25	9.29	9.49	9.19	65.31	4.98
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	100.91	100.91	186.05	80.02	64.48	0.0	103.39
HYDROCARBONS	7.35	7.35	16.23	20.36	27.57	0.0	8.14
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	18.20	18.20	26.00	26.00	26.00	0.0	18.66
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	10.78	10.78	14.70	14.70	14.70	0.0	11.00
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.21	0.21	1.27	1.27	1.27	0.0	0.29

TABLE B. 35

***** COOK COUNTY REGISTRATION DATA -- HDV BY GVW, EVAP BY SOURCE *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1974 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	44.46	44.46	103.42	139.27	258.50	38.18	50.93
HYDROCARBONS	4.27	4.27	12.31	19.00	27.32	5.84	5.14
NITROGEN OXIDES	3.93	3.93	9.27	9.47	9.17	67.93	4.71
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	15.59	15.59	26.00	26.00	26.00	0.0	16.26
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	9.36	9.36	14.70	14.70	14.70	0.0	9.69
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.14	0.14	0.98	0.98	0.98	0.0	0.20

TABLE B. 36

***** COOK COUNTY REGISTRATION DATA -- HDV BY GVW, EVAP BY SOURCE *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1974 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	39.12	39.12	103.42	139.27	258.50	38.18	46.00
HYDROCARBONS	3.89	3.89	12.31	19.00	27.32	5.84	4.78
NITROGEN OXIDES	3.93	3.93	9.27	9.47	9.17	67.93	4.71
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	93.24	93.24	184.60	79.38	63.98	0.0	96.25
HYDROCARBONS	6.78	6.78	15.79	19.81	26.84	0.0	7.58
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	15.59	15.59	26.00	26.00	26.00	0.0	16.26
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	9.36	9.36	14.70	14.70	14.70	0.0	9.69
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.14	0.14	0.98	0.98	0.98	0.0	0.20

TABLE B. 37

***** COOK COUNTY REGISTRATION DATA -- HDV BY GVW, EVAP BY SOURCE *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1975 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	38.37	38.37	102.69	138.27	256.65	36.59	45.24
HYDROCARBONS	3.67	3.67	11.83	18.26	26.27	5.27	4.53
NITROGEN OXIDES	3.66	3.66	9.25	9.45	9.15	70.30	4.47
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	13.37	13.37	26.00	26.00	26.00	0.0	14.21
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	8.17	8.17	14.70	14.70	14.70	0.0	8.60
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.09	0.09	0.70	0.70	0.70	0.0	0.14

TABLE B. 38

***** COOK COUNTY REGISTRATION DATA -- HDV BY GVW, EVAP BY SOURCE *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1975 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	33.58	33.58	102.69	138.27	256.66	36.59	40.83
HYDROCARBONS	3.33	3.33	11.83	18.26	26.27	5.27	4.22
NITROGEN OXIDES	3.66	3.66	9.25	9.45	9.15	70.30	4.47
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	83.57	83.57	183.30	78.82	63.52	0.0	87.27
HYDROCARBONS	5.92	5.92	15.17	19.03	25.31	0.0	6.73
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	13.37	13.37	26.00	26.00	26.00	0.0	14.21
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	8.17	8.17	14.70	14.70	14.70	0.0	8.60
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.09	0.09	0.70	0.70	0.70	0.0	0.14

TABLE B. 39

***** COOK COUNTY REGISTRATION DATA -- HDV BY GVW, EVAP BY SOURCE *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1976 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	30.92	30.92	102.24	137.67	255.54	35.63	38.32
HYDROCARBONS	2.94	2.94	11.49	17.72	25.52	4.92	3.83
NITROGEN OXIDES	3.29	3.29	9.24	9.44	9.14	71.73	4.14
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	11.38	11.38	26.00	26.00	26.00	0.0	12.38
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	7.11	7.11	14.70	14.70	14.70	0.0	7.62
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.04	0.04	0.51	0.51	0.51	0.0	0.07

TABLE B. 40

***** COOK COUNTY REGISTRATION DATA -- HDV BY GVW, EVAP BY SOURCE *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1976 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	26.82	26.82	102.24	137.67	255.54	35.63	34.55
HYDROCARBONS	2.66	2.66	11.49	17.72	25.52	4.92	3.57
NITROGEN OXIDES	3.29	3.29	9.24	9.44	9.14	71.73	4.14
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	71.51	71.51	182.51	78.47	63.25	0.0	76.12
HYDROCARBONS	4.90	4.90	14.73	18.47	25.08	0.0	5.75
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	11.38	11.38	26.00	26.00	26.00	0.0	12.38
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	7.11	7.11	14.70	14.70	14.70	0.0	7.62
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.04	0.04	0.51	0.51	0.51	0.0	0.07

TABLE B. 41

***** COOK COUNTY REGISTRATION DATA -- HDV BY GVW, EVAP BY SOURCE *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1977 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	24.29	24.29	101.84	137.11	254.51	34.74	32.17
HYDROCARBONS	2.33	2.33	11.13	17.17	24.76	4.59	3.23
NITROGEN OXIDES	2.78	2.78	9.23	9.43	9.13	73.05	3.68
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	9.78	9.78	26.00	26.00	26.00	0.0	10.90
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	6.22	6.22	14.70	14.70	14.70	0.0	6.80
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.02	0.02	0.39	0.39	0.39	0.0	0.05

TABLE B. 42

***** COOK COUNTY REGISTRATION DATA -- HDV BY GVW, EVAP BY SOURCE *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1977 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	20.82	20.82	101.84	137.11	254.51	34.74	28.98
HYDROCARBONS	2.10	2.10	11.13	17.17	24.76	4.59	3.02
NITROGEN OXIDES	2.78	2.78	9.23	9.43	9.13	73.05	3.68
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	60.53	60.53	181.78	78.15	62.99	0.0	65.97
HYDROCARBONS	4.04	4.04	14.28	17.89	24.32	0.0	4.93
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	9.78	9.78	26.00	26.00	26.00	0.0	10.90
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	6.22	6.22	14.70	14.70	14.70	0.0	6.80
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.02	0.02	0.39	0.39	0.39	0.0	0.05

TABLE B. 43

***** COOK COUNTY REGISTRATION DATA -- HDV BY GVW, EVAP BY SOURCE *****
 MOTOR VEHICLE EMISSION FACTORS FOR 1978 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	18.67	18.67	101.56	136.73	253.81	34.15	26.97
HYDROCARBONS	1.84	1.84	10.86	16.74	24.17	4.38	2.75
NITROGEN OXIDES	2.23	2.23	9.22	9.42	9.12	73.95	3.17
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	8.62	8.62	26.00	26.00	26.00	0.0	9.83
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	5.58	5.58	14.70	14.70	14.70	0.0	6.22
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.01	0.01	0.30	0.30	0.30	0.0	0.03

TABLE B. 44

***** COOK COUNTY REGISTRATION DATA -- HDV BY GVW, EVAP BY SOURCE *****
 MOTOR VEHICLE EMISSION FACTORS FOR 1978 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	15.74	15.74	101.56	136.73	253.81	34.15	24.27
HYDROCARBONS	1.65	1.65	10.86	16.74	24.17	4.38	2.57
NITROGEN OXIDES	2.23	2.23	9.22	9.42	9.12	73.95	3.17
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	51.02	51.02	181.28	77.94	62.82	0.0	57.18
HYDROCARBONS	3.34	3.34	13.93	17.45	23.74	0.0	4.26
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	8.62	8.62	26.00	26.00	26.00	0.0	9.83
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	5.58	5.58	14.70	14.70	14.70	0.0	6.22
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.01	0.01	0.30	0.30	0.30	0.0	0.03

TABLE B. 45

***** COOK COUNTY REGISTRATION DATA -- HDV BY GVW, EVAP BY SOURCE *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1979 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	14.34	14.34	101.37	136.48	253.34	33.74	22.96
HYDROCARBONS	1.45	1.45	10.62	16.37	23.65	4.23	2.37
NITROGEN OXIDES	1.78	1.78	9.21	9.41	9.11	74.56	2.76
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	7.76	7.76	26.00	26.00	25.00	0.0	9.05
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	5.12	5.12	14.70	14.70	14.70	0.0	5.78
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.01	0.01	0.24	0.24	0.24	0.0	0.03

TABLE B. 46

***** COOK COUNTY REGISTRATION DATA -- HDV BY GVW, EVAP BY SOURCE *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1979 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	11.83	11.83	101.37	136.48	253.34	33.74	20.65
HYDROCARBONS	1.29	1.29	10.62	16.37	23.65	4.23	2.22
NITROGEN OXIDES	1.78	1.78	9.21	9.41	9.11	74.56	2.76
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	43.87	43.87	180.95	77.79	62.70	0.0	50.57
HYDROCARBONS	2.80	2.80	13.62	17.07	23.24	0.0	3.73
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	7.76	7.76	26.00	26.00	26.00	0.0	9.05
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	5.12	5.12	14.70	14.70	14.70	0.0	5.78
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.01	0.01	0.24	0.24	0.24	0.0	0.03

TABLE B. 47

***** COOK COUNTY REGISTRATION DATA -- HDV BY GVW, EVAP BY SOURCE *****
 MOTOR VEHICLE EMISSION FACTORS FOR 1980 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	10.71	10.71	101.25	136.31	253.03	33.47	19.60
HYDROCARBONS	1.12	1.12	10.48	16.15	23.34	4.13	2.06
NITROGEN OXIDES	1.46	1.46	9.21	9.41	9.11	74.95	2.47
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	7.23	7.23	26.00	26.00	26.00	0.0	8.56
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	4.81	4.81	14.70	14.70	14.70	0.0	5.50
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.01	0.01	0.21	0.21	0.21	0.0	0.02

TABLE B. 48

***** COOK COUNTY REGISTRATION DATA -- HDV BY GVW, EVAP BY SOURCE *****
 MOTOR VEHICLE EMISSION FACTORS FOR 1980 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	8.54	8.54	101.25	136.31	253.03	33.47	17.60
HYDROCARBONS	0.99	0.99	10.48	16.15	23.34	4.13	1.93
NITROGEN OXIDES	1.46	1.46	9.21	9.41	9.11	74.95	2.47
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	37.82	37.82	180.73	77.70	62.63	0.0	44.99
HYDROCARBONS	2.36	2.36	13.44	16.83	22.93	0.0	3.31
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	7.23	7.23	26.00	26.00	26.00	0.0	8.56
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	4.81	4.81	14.70	14.70	14.70	0.0	5.50
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.01	0.01	0.21	0.21	0.21	0.0	0.02

TABLE B. 49

***** COOK COUNTY REGISTRATION DATA -- HDV BY GVW, EVAP BY SOURCE *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1985 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	3.29	3.29	100.80	135.70	251.90	32.50	12.73
HYDROCARBONS	0.40	0.40	10.11	15.57	22.53	3.78	1.35
NITROGEN OXIDES	0.58	0.58	9.20	9.40	9.10	76.40	1.66
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	6.50	6.50	26.00	26.00	25.00	0.0	7.88
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	4.40	4.40	14.70	14.70	14.70	0.0	5.13
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE B. 50

***** COOK COUNTY REGISTRATION DATA -- HDV BY GVW, EVAP BY SOURCE *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1985 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	1.69	1.69	100.80	135.70	251.90	32.50	11.25
HYDROCARBONS	0.31	0.31	10.11	15.57	22.53	3.78	1.27
NITROGEN OXIDES	0.58	0.58	9.20	9.40	9.10	76.40	1.66
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	28.06	28.06	179.93	77.35	62.35	0.0	35.95
HYDROCARBONS	1.45	1.45	12.96	16.23	22.14	0.0	2.43
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	6.50	6.50	26.00	26.00	26.00	0.0	7.88
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	4.40	4.40	14.70	14.70	14.70	0.0	5.13
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE B. 51

***** COOK COUNTY REGISTRATION DATA -- HDV BY GVW, EVAP BY SOURCE *****
 MOTOR VEHICLE EMISSION FACTORS FOR 1990 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	2.67	2.67	100.80	135.70	251.90	32.50	12.15
HYDROCARBONS	0.33	0.33	10.00	15.40	22.30	3.78	1.28
NITROGEN OXIDES	0.47	0.47	9.20	9.40	9.10	76.40	1.57
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	6.50	6.50	26.00	26.00	26.00	0.0	7.88
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	4.40	4.40	14.70	14.70	14.70	0.0	5.13
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE B. 52

***** COOK COUNTY REGISTRATION DATA -- HDV BY GVW, EVAP BY SOURCE *****
 MOTOR VEHICLE EMISSION FACTORS FOR 1990 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	1.10	1.10	100.80	135.70	251.90	32.50	10.71
HYDROCARBONS	0.25	0.25	10.00	15.40	22.30	3.78	1.20
NITROGEN OXIDES	0.47	0.47	9.20	9.40	9.10	76.40	1.57
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	27.45	27.45	179.93	77.35	62.35	0.0	35.39
HYDROCARBONS	1.37	1.37	12.83	16.05	21.91	0.0	2.35
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	6.50	6.50	26.00	26.00	26.00	0.0	7.88
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	4.40	4.40	14.70	14.70	14.70	0.0	5.13
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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***** U.S. NATIONAL AVERAGE DATA -- LOW ALTITUDE AREAS *****

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1990 0 0 0 19.6

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TABLE B. 53

***** U.S. NATIONAL AVERAGE DATA -- LOW ALTITUDE AREAS *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1970 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	73.45	73.45	138.93	138.93	138.93	47.42	78.07
HYDROCARBONS	7.18	7.18	16.89	16.89	16.89	9.19	7.90
NITROGEN OXIDES	4.14	4.14	9.38	9.38	9.38	54.16	4.82
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	3.00	3.00	3.00	3.00	3.00	0.0	2.98
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.95	0.95	3.19	3.19	3.19	0.0	1.11

TABLE B. 54

***** U.S. NATIONAL AVERAGE DATA -- LOW ALTITUDE AREAS *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1970 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	66.74	66.74	138.93	138.93	138.93	47.42	71.89
HYDROCARBONS	6.62	6.62	16.89	16.89	16.89	9.19	7.38
NITROGEN OXIDES	4.14	4.14	9.38	9.38	9.38	54.16	4.82
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	117.07	117.07	109.41	109.41	109.41	0.0	115.81
HYDROCARBONS	9.86	9.86	17.99	17.99	17.99	0.0	10.39
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	3.00	3.00	3.00	3.00	3.00	0.0	2.98
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.95	0.95	3.19	3.19	3.19	0.0	1.11

TABLE B. 55

***** U.S. NATIONAL AVERAGE DATA -- LOW ALTITUDE AREAS *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1971 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	63.51	68.51	137.34	137.34	137.34	44.76	73.39
HYDROCARBONS	6.55	6.55	16.73	16.73	16.73	8.23	7.30
NITROGEN OXIDES	4.29	4.29	9.35	9.35	9.35	58.12	4.98
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	2.73	2.73	3.00	3.00	3.00	0.0	2.73
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.71	0.71	2.61	2.61	2.61	0.0	0.84

TABLE B. 56

***** U.S. NATIONAL AVERAGE DATA -- LOW ALTITUDE AREAS *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1971 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	61.87	61.87	137.34	137.34	137.34	44.76	67.28
HYDROCARBONS	6.02	6.02	16.73	16.73	16.73	8.23	6.81
NITROGEN OXIDES	4.29	4.29	9.35	9.35	9.35	58.12	4.98
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	115.78	115.78	108.16	108.16	108.16	0.0	114.53
HYDROCARBONS	9.22	9.22	17.82	17.82	17.82	0.0	9.79
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	2.73	2.73	3.00	3.00	3.00	0.0	2.73
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.71	0.71	2.61	2.61	2.61	0.0	0.84

TABLE B. 57

***** U.S. NATIONAL AVERAGE DATA -- LOW ALTITUDE AREAS *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1972 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	62.44	62.44	136.14	136.14	136.14	42.75	67.70
HYDROCARBONS	5.87	5.87	16.61	16.61	16.61	7.50	6.66
NITROGEN OXIDES	4.40	4.40	9.32	9.32	9.32	61.11	5.10
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	2.32	2.32	3.00	3.00	3.00	0.0	2.36
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.53	0.53	2.12	2.12	2.12	0.0	0.64

TABLE B. 58

***** U.S. NATIONAL AVERAGE DATA -- LOW ALTITUDE AREAS *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1972 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	56.05	56.05	136.14	136.14	136.14	42.75	61.82
HYDROCARBONS	5.38	5.38	16.61	16.61	16.61	7.50	6.21
NITROGEN OXIDES	4.40	4.40	9.32	9.32	9.32	61.11	5.10
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	111.54	111.54	107.21	107.21	107.21	0.0	110.55
HYDROCARBONS	8.49	8.49	17.69	17.69	17.69	0.0	9.11
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	2.32	2.32	3.00	3.00	3.00	0.0	2.36
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.53	0.53	2.12	2.12	2.12	0.0	0.64

TABLE B. 59

***** U.S. NATIONAL AVERAGE DATA -- LOW ALTITUDE AREAS *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1973 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	55.88	55.88	135.02	135.02	135.02	40.89	61.57
HYDROCARBONS	5.26	5.26	16.50	16.50	16.50	6.82	6.09
NITROGEN OXIDES	4.25	4.25	9.30	9.30	9.30	63.89	4.98
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	1.95	1.95	3.00	3.00	3.00	0.0	2.01
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.38	0.38	1.67	1.67	1.67	0.0	0.47

TABLE B. 60

***** U.S. NATIONAL AVERAGE DATA -- LOW ALTITUDE AREAS *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1973 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	49.81	49.81	135.02	135.02	135.02	40.89	55.98
HYDROCARBONS	4.81	4.81	16.50	16.50	16.50	6.82	5.68
NITROGEN OXIDES	4.25	4.25	9.30	9.30	9.30	63.89	4.98
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	105.88	105.88	106.33	106.33	106.33	0.0	105.27
HYDROCARBONS	7.88	7.88	17.57	17.57	17.57	0.0	8.54
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	1.95	1.95	3.00	3.00	3.00	0.0	2.01
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.38	0.38	1.67	1.67	1.67	0.0	0.47

TABLE B. 61

***** U.S. NATIONAL AVERAGE DATA -- LOW ALTITUDE AREAS *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1974 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	49.84	49.84	134.07	134.07	134.07	39.29	55.92
HYDROCARBONS	4.75	4.75	16.09	16.09	16.09	6.25	5.58
NITROGEN OXIDES	4.02	4.02	9.28	9.28	9.28	66.27	4.77
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	1.63	1.63	3.00	3.00	3.00	0.0	1.72
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.28	0.28	1.34	1.34	1.34	0.0	0.35

TABLE B. 62

***** U.S. NATIONAL AVERAGE DATA -- LOW ALTITUDE AREAS *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1974 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	44.14	44.14	134.07	134.07	134.07	39.29	50.68
HYDROCARBONS	4.33	4.33	16.09	16.09	16.09	6.25	5.20
NITROGEN OXIDES	4.02	4.02	9.28	9.28	9.28	66.27	4.77
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	99.30	99.30	105.58	105.58	105.58	0.0	99.16
HYDROCARBONS	7.31	7.31	17.13	17.13	17.13	0.0	7.98
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	1.63	1.63	3.00	3.00	3.00	0.0	1.72
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.28	0.28	1.34	1.34	1.34	0.0	0.35

TABLE B. 63

***** U.S. NATIONAL AVERAGE DATA -- LOW ALTITUDE AREAS *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1975 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	43.88	43.88	133.21	133.21	133.21	37.85	50.36
HYDROCARBONS	4.15	4.15	15.52	15.52	15.52	5.72	4.99
NITROGEN OXIDES	3.79	3.79	9.26	9.26	9.26	68.42	4.58
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	1.31	1.31	3.00	3.00	3.00	0.0	1.43
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.11	0.11	1.07	1.07	1.07	0.0	0.18

TABLE B. 64

***** U.S. NATIONAL AVERAGE DATA -- LOW ALTITUDE AREAS *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1975 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	38.66	38.66	133.21	133.21	133.21	37.85	45.55
HYDROCARBONS	3.78	3.78	15.52	15.52	15.52	5.72	4.64
NITROGEN OXIDES	3.79	3.79	9.26	9.26	9.26	68.42	4.58
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	91.07	91.07	104.90	104.90	104.90	0.0	91.53
HYDROCARBONS	6.52	6.52	16.53	16.53	16.53	0.0	7.21
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	1.31	1.31	3.00	3.00	3.00	0.0	1.43
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.11	0.11	1.07	1.07	1.07	0.0	0.18

TABLE B. 65

***** U.S. NATIONAL AVERAGE DATA -- LOW ALTITUDE AREAS *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1976 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	36.69	36.69	132.58	132.58	132.58	36.81	43.69
HYDROCARBONS	3.45	3.45	15.10	15.10	15.10	5.34	4.32
NITROGEN OXIDES	3.49	3.49	9.25	9.25	9.25	69.97	4.31
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	1.02	1.02	3.00	3.00	3.00	0.0	1.16
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.08	0.08	0.88	0.88	0.88	0.0	0.13

TABLE B. 66

***** U.S. NATIONAL AVERAGE DATA -- LOW ALTITUDE AREAS *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1976 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	32.09	32.09	132.58	132.58	132.58	36.81	39.46
HYDROCARBONS	3.13	3.13	15.10	15.10	15.10	5.34	4.02
NITROGEN OXIDES	3.49	3.49	9.25	9.25	9.25	69.97	4.31
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	80.08	80.08	104.41	104.41	104.41	0.0	81.38
HYDROCARBONS	5.57	5.57	16.08	16.08	16.08	0.0	6.31
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	1.02	1.02	3.00	3.00	3.00	0.0	1.16
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.08	0.08	0.88	0.88	0.88	0.0	0.13

TABLE B. 67

***** U.S. NATIONAL AVERAGE DATA -- LOW ALTITUDE AREAS *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1977 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	29.96	29.96	132.05	132.05	132.05	35.93	37.45
HYDROCARBONS	2.84	2.84	14.71	14.71	14.71	5.02	3.72
NITROGEN OXIDES	3.06	3.06	9.24	9.24	9.24	71.29	3.92
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	0.79	0.79	3.00	3.00	3.00	0.0	0.95
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.05	0.05	0.73	0.73	0.73	0.0	0.10

TABLE B. 68

***** U.S. NATIONAL AVERAGE DATA -- LOW ALTITUDE AREAS *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1977 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	25.98	25.98	132.05	132.05	132.05	35.93	33.79
HYDROCARBONS	2.57	2.57	14.71	14.71	14.71	5.02	3.47
NITROGEN OXIDES	3.06	3.06	9.24	9.24	9.24	71.29	3.92
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	59.28	69.28	103.99	103.99	103.99	0.0	71.40
HYDROCARBONS	4.72	4.72	15.67	15.67	15.67	0.0	5.49
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	0.79	0.79	3.00	3.00	3.00	0.0	0.95
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.05	0.05	0.73	0.73	0.73	0.0	0.10

TABLE B. 69

***** U.S. NATIONAL AVERAGE DATA -- LOW ALTITUDE AREAS *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1978 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	24.07	24.07	131.68	131.68	131.68	35.31	32.00
HYDROCARBONS	2.33	2.33	14.39	14.39	14.39	4.80	3.23
NITROGEN OXIDES	2.54	2.54	9.23	9.23	9.23	72.21	3.45
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	0.61	0.61	3.00	3.00	3.00	0.0	0.78
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.04	0.04	0.64	0.64	0.64	0.0	0.08

TABLE B. 70

***** U.S. NATIONAL AVERAGE DATA -- LOW ALTITUDE AREAS *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1978 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	20.66	20.66	131.68	131.68	131.68	35.31	28.85
HYDROCARBONS	2.10	2.10	14.39	14.39	14.39	4.80	3.01
NITROGEN OXIDES	2.54	2.54	9.23	9.23	9.23	72.21	3.45
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	59.61	59.61	103.70	103.70	103.70	0.0	62.47
HYDROCARBONS	4.01	4.01	15.32	15.32	15.32	0.0	4.82
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	0.61	0.61	3.00	3.00	3.00	0.0	0.78
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.04	0.04	0.64	0.64	0.64	0.0	0.08

TABLE B. 71

***** U.S. NATIONAL AVERAGE DATA -- LOW ALTITUDE AREAS *****

MOTOR VEHICLE EMISSION FACTORS FOR 1979 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	19.28	19.28	131.41	131.41	131.41	34.85	27.56
HYDROCARBONS	1.90	1.90	14.10	14.10	14.10	4.63	2.81
NITROGEN OXIDES	2.11	2.11	9.23	9.23	9.23	72.90	3.05
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	0.48	0.48	3.00	3.00	3.00	0.0	0.66
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.03	0.03	0.56	0.56	0.56	0.0	0.07

TABLE B. 72

***** U.S. NATIONAL AVERAGE DATA -- LOW ALTITUDE AREAS *****

MOTOR VEHICLE EMISSION FACTORS FOR 1979 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	16.31	16.31	131.41	131.41	131.41	34.85	24.82
HYDROCARBONS	1.71	1.71	14.10	14.10	14.10	4.63	2.63
NITROGEN OXIDES	2.11	2.11	9.23	9.23	9.23	72.90	3.05
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	51.83	51.83	103.48	103.48	103.48	0.0	55.29
HYDROCARBONS	3.42	3.42	15.02	15.02	15.02	0.0	4.25
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	0.48	0.48	3.00	3.00	3.00	0.0	0.66
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.03	0.03	0.56	0.56	0.56	0.0	0.07

TABLE B. 73

***** U.S. NATIONAL AVERAGE DATA -- LOW ALTITUDE AREAS *****
 MOTOR VEHICLE EMISSION FACTORS FOR 1980 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	14.83	14.83	131.23	131.23	131.23	34.55	23.45
HYDROCARBONS	1.46	1.46	13.90	13.90	13.90	4.53	2.38
NITROGEN OXIDES	1.80	1.80	9.22	9.22	9.22	73.34	2.77
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	0.40	0.40	3.00	3.00	3.00	0.0	0.58
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE B. 74

***** U.S. NATIONAL AVERAGE DATA -- LOW ALTITUDE AREAS *****
 MOTOR VEHICLE EMISSION FACTORS FOR 1980 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	12.18	12.18	131.23	131.23	131.23	34.55	21.00
HYDROCARBONS	1.29	1.29	13.90	13.90	13.90	4.53	2.23
NITROGEN OXIDES	1.80	1.80	9.22	9.22	9.22	73.34	2.77
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	46.27	46.27	103.34	103.34	103.34	0.0	50.16
HYDROCARBONS	2.90	2.90	14.80	14.80	14.80	0.0	3.75
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	0.40	0.40	3.00	3.00	3.00	0.0	0.58
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE B. 75

***** U.S. NATIONAL AVERAGE DATA -- LOW ALTITUDE AREAS *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1985 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	4.38	4.38	130.00	130.00	130.00	32.50	13.72
HYDROCARBONS	0.52	0.52	13.32	13.32	13.32	3.78	1.47
NITROGEN OXIDES	0.69	0.69	9.20	9.20	9.20	76.40	1.76
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	0.20	0.20	3.00	3.00	3.00	0.0	0.40
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE B. 76

***** U.S. NATIONAL AVERAGE DATA -- LOW ALTITUDE AREAS *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1985 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	2.62	2.62	130.00	130.00	130.00	32.50	12.10
HYDROCARBONS	0.42	0.42	13.32	13.32	13.32	3.78	1.38
NITROGEN OXIDES	0.69	0.69	9.20	9.20	9.20	76.40	1.76
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	30.66	30.66	102.38	102.38	102.38	0.0	35.71
HYDROCARBONS	1.64	1.64	14.19	14.19	14.19	0.0	2.55
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	0.20	0.20	3.00	3.00	3.00	0.0	0.40
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE B. 77

***** U.S. NATIONAL AVERAGE DATA -- LOW ALTITUDE AREAS *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1990 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	2.83	2.83	130.00	130.00	130.00	32.50	12.29
HYDROCARBONS	0.35	0.35	13.00	13.00	13.00	3.78	1.29
NITROGEN OXIDES	0.50	0.50	9.20	9.20	9.20	76.40	1.59
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	0.20	0.20	3.00	3.00	3.00	0.0	0.40
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE B. 78

***** U.S. NATIONAL AVERAGE DATA -- LOW ALTITUDE AREAS *****							
MOTOR VEHICLE EMISSION FACTORS FOR 1990 MID-YEAR AT A SPEED OF 19.60 MPH							
CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	1.16	1.16	130.00	130.00	130.00	32.50	10.76
HYDROCARBONS	0.26	0.26	13.00	13.00	13.00	3.78	1.21
NITROGEN OXIDES	0.50	0.50	9.20	9.20	9.20	76.40	1.59
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	29.02	29.02	102.38	102.38	102.38	0.0	34.20
HYDROCARBONS	1.44	1.44	13.85	13.85	13.85	0.0	2.34
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RUNNING (GMS/MI)	0.20	0.20	3.00	3.00	3.00	0.0	0.40
HOT SOAK (GRAMS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Set 4 TREFACT
Input Data Deck

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//GO.SYSIN DD *
***U.S. NATIONAL AVERAGE DATA--LOW ALTITUDE AREAS--HDV BY GVW. EVAP BY SOURCE**
1 1 1 2 1 1 1 2 1 1 1
1970 0 0 0 19.6
1970 0 0 1 19.6
1971 0 0 0 19.6
1971 0 0 1 19.6
1972 0 0 0 19.6
1972 0 0 1 19.6
1973 0 0 0 19.6
1973 0 0 1 19.6
1974 0 0 0 19.6
1974 0 0 1 19.6
1975 0 0 0 19.6
1975 0 0 1 19.6
1976 0 0 0 19.6
1976 0 0 1 19.6
1977 0 0 0 19.6
1977 0 0 1 19.6
1978 0 0 0 19.6
1978 0 0 1 19.6
1979 0 0 0 19.6
1979 0 0 1 19.6
1980 0 0 0 19.6
1980 0 0 1 19.6
1985 0 0 0 19.6
1985 0 0 1 19.6
1990 0 0 0 19.6
1990 0 0 1 19.6
/*
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TABLE B. 79

U.S. NATIONAL AVERAGE DATA--LOW ALTITUDE AREAS--HDV BY GVW, EVAP BY SOURCE
 MOTOR VEHICLE EMISSION FACTORS FOR 1970 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	73.45	73.45	107.68	145.08	269.23	47.42	78.08
HYDROCARBONS	7.18	7.18	13.01	20.07	28.82	9.19	7.90
NITROGEN OXIDES	4.14	4.14	9.38	9.58	9.28	54.16	4.83
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	26.00	26.00	26.00	26.00	26.00	0.0	25.84
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	14.70	14.70	14.70	14.70	14.70	0.0	14.61
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.95	0.95	3.19	3.19	3.19	0.0	1.11

TABLE B. 80

U.S. NATIONAL AVERAGE DATA--LOW ALTITUDE AREAS--HDV BY GVW, EVAP BY SOURCE
 MOTOR VEHICLE EMISSION FACTORS FOR 1970 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	66.74	66.74	107.68	145.08	269.23	47.42	71.90
HYDROCARBONS	6.62	6.62	13.01	20.07	28.82	9.19	7.38
NITROGEN OXIDES	4.14	4.14	9.38	9.58	9.28	54.16	4.83
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	117.07	117.07	192.21	82.70	66.63	0.0	118.62
HYDROCARBONS	9.86	9.86	16.69	20.93	28.31	0.0	10.49
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	26.00	26.00	26.00	26.00	26.00	0.0	25.84
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	14.70	14.70	14.70	14.70	14.70	0.0	14.61
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.95	0.95	3.19	3.19	3.19	0.0	1.11

TABLE B. 81

U.S. NATIONAL AVERAGE DATA--LOW ALTITUDE AREAS--HDV BY GVW, EVAP BY SOURCE
 MOTOR VEHICLE EMISSION FACTORS FOR 1971 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	68.51	68.51	106.45	143.41	266.14	44.76	73.40
HYDROCARBONS	6.55	6.55	12.89	19.88	28.55	8.23	7.30
NITROGEN OXIDES	4.29	4.29	9.35	9.55	9.25	58.12	4.98
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	24.96	24.96	26.00	26.00	26.00	0.0	24.89
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	14.29	14.29	14.70	14.70	14.70	0.0	14.24
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.71	0.71	2.61	2.61	2.61	0.0	0.84

TABLE B. 82

U.S. NATIONAL AVERAGE DATA--LOW ALTITUDE AREAS--HDV BY GVW, EVAP BY SOURCE
 MOTOR VEHICLE EMISSION FACTORS FOR 1971 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	51.87	61.87	106.45	143.41	266.14	44.76	67.29
HYDROCARBONS	6.02	6.02	12.89	19.88	28.55	8.23	6.81
NITROGEN OXIDES	4.29	4.29	9.35	9.55	9.25	58.12	4.98
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	115.78	115.78	190.02	81.74	65.37	0.0	117.32
HYDROCARBONS	9.22	9.22	16.53	20.73	28.05	0.0	9.89
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	24.96	24.96	26.00	26.00	26.00	0.0	24.89
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	14.29	14.29	14.70	14.70	14.70	0.0	14.24
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.71	0.71	2.61	2.61	2.61	0.0	0.84

TABLE B. 83

U.S. NATIONAL AVERAGE DATA--LOW ALTITUDE AREAS--HDV BY GVW, EVAP BY SOURCE
 MOTOR VEHICLE EMISSION FACTORS FOR 1972 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	62.44	62.44	105.53	142.15	263.81	42.75	67.71
HYDROCARBONS	5.87	5.87	12.79	19.74	28.34	7.50	6.66
NITROGEN OXIDES	4.40	4.40	9.32	9.52	9.22	61.11	5.10
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	22.45	22.45	26.00	26.00	26.00	0.0	22.57
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	13.02	13.02	14.70	14.70	14.70	0.0	13.07
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.53	0.53	2.12	2.12	2.12	0.0	0.64

TABLE B. 84

U.S. NATIONAL AVERAGE DATA--LOW ALTITUDE AREAS--HDV BY GVW, EVAP BY SOURCE
 MOTOR VEHICLE EMISSION FACTORS FOR 1972 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	56.05	56.05	105.53	142.15	263.81	42.75	61.82
HYDROCARBONS	5.38	5.38	12.79	19.74	28.34	7.50	6.22
NITROGEN OXIDES	4.40	4.40	9.32	9.52	9.22	61.11	5.10
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	111.54	111.54	188.37	81.02	65.29	0.0	113.31
HYDROCARBONS	8.49	8.49	16.40	20.58	27.85	0.0	9.21
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	22.45	22.45	26.00	26.00	26.00	0.0	22.57
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	13.02	13.02	14.70	14.70	14.70	0.0	13.07
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.53	0.53	2.12	2.12	2.12	0.0	0.64

TABLE B. 85

U.S. NATIONAL AVERAGE DATA--LOW ALTITUDE AREAS--HDV BY GVW, EVAP BY SOURCE
 MOTOR VEHICLE EMISSION FACTORS FOR 1973 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	55.88	55.88	104.67	140.97	261.64	40.89	61.58
HYDROCARBONS	5.26	5.26	12.70	19.60	28.15	6.82	6.09
NITROGEN OXIDES	4.25	4.25	9.30	9.50	9.20	63.89	4.98
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	19.68	19.68	26.00	26.00	26.00	0.0	20.02
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	11.54	11.54	14.70	14.70	14.70	0.0	11.70
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.38	0.38	1.67	1.67	1.67	0.0	0.47

TABLE B. 86

U.S. NATIONAL AVERAGE DATA--LOW ALTITUDE AREAS--HDV BY GVW, EVAP BY SOURCE
 MOTOR VEHICLE EMISSION FACTORS FOR 1973 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	49.81	49.81	104.67	140.97	261.64	40.89	55.99
HYDROCARBONS	4.81	4.81	12.70	19.60	28.15	6.82	5.68
NITROGEN OXIDES	4.25	4.25	9.30	9.50	9.20	63.89	4.98
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	105.88	105.88	186.83	80.35	64.76	0.0	108.01
HYDROCARBONS	7.88	7.88	16.29	20.44	27.66	0.0	8.64
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	19.68	19.68	26.00	26.00	26.00	0.0	20.02
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	11.54	11.54	14.70	14.70	14.70	0.0	11.70
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.38	0.38	1.67	1.67	1.67	0.0	0.47

TABLE P. 87

U.S. NATIONAL AVERAGE DATA--LOW ALTITUDE AREAS--HDV BY GVW, EVAP BY SOURCE
MOTOR VEHICLE EMISSION FACTORS FOR 1974 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	49.84	49.84	103.93	139.97	259.79	39.29	55.93
HYDROCARBONS	4.75	4.75	12.38	19.10	27.46	6.25	5.58
NITROGEN OXIDES	4.02	4.02	9.28	9.48	9.18	66.27	4.78
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	17.30	17.30	26.00	26.00	26.00	0.0	17.83
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	10.25	10.25	14.70	14.70	14.70	0.0	10.51
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.28	0.28	1.34	1.34	1.34	0.0	0.35

TABLE B. 88

U.S. NATIONAL AVERAGE DATA--LOW ALTITUDE AREAS--HDV BY GVW, EVAP BY SOURCE
MOTOR VEHICLE EMISSION FACTORS FOR 1974 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	44.14	44.14	103.93	139.97	259.79	39.29	50.69
HYDROCARBONS	4.33	4.33	12.38	19.10	27.46	6.25	5.20
NITROGEN OXIDES	4.02	4.02	9.28	9.48	9.18	66.27	4.78
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	99.30	99.30	185.52	79.78	64.30	0.0	101.88
HYDROCARBONS	7.31	7.31	15.88	19.92	26.98	0.0	8.08
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	17.30	17.30	26.00	26.00	26.00	0.0	17.83
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	10.25	10.25	14.70	14.70	14.70	0.0	10.51
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.28	0.28	1.34	1.34	1.34	0.0	0.35

TABLE B. 89

U.S. NATIONAL AVERAGE DATA--LOW ALTITUDE AREAS--HDV BY GVW, EVAP BY SOURCE
 MOTOR VEHICLE EMISSION FACTORS FOR 1975 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	43.88	43.88	103.27	139.07	258.12	37.85	50.37
HYDROCARBONS	4.15	4.15	11.94	18.43	26.52	5.72	4.99
NITROGEN OXIDES	3.79	3.79	9.26	9.46	9.16	68.42	4.58
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	15.12	15.12	26.00	26.00	26.00	0.0	15.83
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	9.10	9.10	14.70	14.70	14.70	0.0	9.46
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.11	0.11	1.07	1.07	1.07	0.0	0.18

TABLE B. 90

U.S. NATIONAL AVERAGE DATA--LOW ALTITUDE AREAS--HDV BY GVW, EVAP BY SOURCE
 MOTOR VEHICLE EMISSION FACTORS FOR 1975 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	38.66	38.66	103.27	139.07	258.12	37.85	45.56
HYDROCARBONS	3.78	3.78	11.94	18.43	26.52	5.72	4.65
NITROGEN OXIDES	3.79	3.79	9.26	9.46	9.16	68.42	4.58
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	91.07	91.07	184.33	79.27	63.88	0.0	94.24
HYDROCARBONS	6.52	6.52	15.32	19.21	26.05	0.0	7.30
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	15.12	15.12	26.00	26.00	26.00	0.0	15.83
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	9.10	9.10	14.70	14.70	14.70	0.0	9.46
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.11	0.11	1.07	1.07	1.07	0.0	0.18

TABLE B. 91

U.S. NATIONAL AVERAGE DATA--LOW ALTITUDE AREAS--HDV BY GVW, EVAP BY SOURCE
 MOTOR VEHICLE EMISSION FACTORS FOR 1976 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	36.69	36.69	102.79	138.41	256.91	36.81	43.69
HYDROCARBONS	3.45	3.45	11.62	17.92	25.81	5.34	4.32
NITROGEN OXIDES	3.49	3.49	9.25	9.45	9.15	69.97	4.31
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	13.02	13.02	26.00	26.00	26.00	0.0	13.89
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	7.98	7.98	14.70	14.70	14.70	0.0	8.42
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.08	0.08	0.88	0.88	0.88	0.0	0.13

TABLE B. 92

U.S. NATIONAL AVERAGE DATA--LOW ALTITUDE AREAS--HDV BY GVW, EVAP BY SOURCE
 MOTOR VEHICLE EMISSION FACTORS FOR 1976 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	32.09	32.09	102.79	138.41	256.91	36.81	39.47
HYDROCARBONS	3.13	3.13	11.62	17.92	25.81	5.34	4.02
NITROGEN OXIDES	3.49	3.49	9.25	9.45	9.15	69.97	4.31
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	80.08	80.08	183.48	78.89	63.58	0.0	84.07
HYDROCARBONS	5.57	5.57	14.90	18.68	25.36	0.0	6.39
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	13.02	13.02	26.00	26.00	26.00	0.0	13.89
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	7.98	7.98	14.70	14.70	14.70	0.0	8.42
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.08	0.08	0.88	0.88	0.88	0.0	0.13

TABLE B. 93

U.S. NATIONAL AVERAGE DATA--LOW ALTITUDE AREAS--HDV BY GVW, EVAP BY SOURCE
 MOTOR VEHICLE EMISSION FACTORS FOR 1977 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	29.96	29.96	102.38	137.86	255.88	35.93	37.45
HYDROCARBONS	2.84	2.84	11.32	17.45	25.16	5.02	3.72
NITROGEN OXIDES	3.06	3.06	9.24	9.44	9.14	71.29	3.92
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	11.25	11.25	26.00	26.00	26.00	0.0	12.26
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	7.01	7.01	14.70	14.70	14.70	0.0	7.53
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.05	0.05	0.73	0.73	0.73	0.0	0.10

TABLE B. 94

U.S. NATIONAL AVERAGE DATA--LOW ALTITUDE AREAS--HDV BY GVW, EVAP BY SOURCE
 MOTOR VEHICLE EMISSION FACTORS FOR 1977 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	25.98	25.98	102.38	137.86	255.88	35.93	33.79
HYDROCARBONS	2.57	2.57	11.32	17.45	25.16	5.02	3.47
NITROGEN OXIDES	3.06	3.06	9.24	9.44	9.14	71.29	3.92
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	69.28	69.28	182.75	78.58	63.33	0.0	74.08
HYDROCARBONS	4.72	4.72	14.52	18.20	24.72	0.0	5.58
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	11.25	11.25	26.00	26.00	26.00	0.0	12.26
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	7.01	7.01	14.70	14.70	14.70	0.0	7.53
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.05	0.05	0.73	0.73	0.73	0.0	0.10

TABLE B. 95
 U.S. NATIONAL AVERAGE DATA--LOW ALTITUDE AREAS--HDV BY GVW, EVAP BY SOURCE
 MOTOR VEHICLE EMISSION FACTORS FOR 1978 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	24.07	24.07	102.10	137.47	255.17	35.31	32.01
HYDROCARBONS	2.33	2.33	11.07	17.07	24.62	4.80	3.23
NITROGEN OXIDES	2.54	2.54	9.23	9.43	9.13	72.21	3.45
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	9.86	9.86	26.00	26.00	26.00	0.0	10.98
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	6.26	6.26	14.70	14.70	14.70	0.0	6.84
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.04	0.04	0.64	0.64	0.64	0.0	0.08

TABLE B. 96
 U.S. NATIONAL AVERAGE DATA--LOW ALTITUDE AREAS--HDV BY GVW, EVAP BY SOURCE
 MOTOR VEHICLE EMISSION FACTORS FOR 1978 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	20.66	20.66	102.10	137.47	255.17	35.31	28.86
HYDROCARBONS	2.10	2.10	11.07	17.07	24.62	4.80	3.02
NITROGEN OXIDES	2.54	2.54	9.23	9.43	9.13	72.21	3.45
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	59.61	59.61	182.24	78.36	63.15	0.0	65.14
HYDROCARBONS	4.01	4.01	14.20	17.79	24.19	0.0	4.90
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	9.86	9.86	26.00	26.00	26.00	0.0	10.98
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	6.26	6.26	14.70	14.70	14.70	0.0	6.84
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.04	0.04	0.64	0.64	0.64	0.0	0.08

TABLE B. 97

U.S. NATIONAL AVERAGE DATA--LOW ALTITUDE AREAS--HDV BY GVW, EVAP BY SOURCE
 MOTOR VEHICLE EMISSION FACTORS FOR 1979 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	19.28	19.28	101.88	137.18	254.63	34.85	27.57
HYDROCARBONS	1.90	1.90	10.85	16.72	24.14	4.63	2.81
NITROGEN OXIDES	2.11	2.11	9.23	9.43	9.13	72.90	3.06
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	8.79	8.79	26.00	26.00	26.00	0.0	9.99
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	5.67	5.67	14.70	14.70	14.70	0.0	6.30
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.03	0.03	0.56	0.56	0.56	0.0	0.07

TABLE B. 98

U.S. NATIONAL AVERAGE DATA--LOW ALTITUDE AREAS--HDV BY GVW, EVAP BY SOURCE
 MOTOR VEHICLE EMISSION FACTORS FOR 1979 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	16.31	16.31	101.88	137.18	254.63	34.85	24.83
HYDROCARBONS	1.71	1.71	10.85	16.72	24.14	4.63	2.63
NITROGEN OXIDES	2.11	2.11	9.23	9.43	9.13	72.90	3.06
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	51.83	51.83	181.86	78.19	63.02	0.0	57.95
HYDROCARBONS	3.42	3.42	13.91	17.43	23.72	0.0	4.33
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	8.79	8.79	26.00	26.00	26.00	0.0	9.99
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	5.67	5.67	14.70	14.70	14.70	0.0	6.30
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.03	0.03	0.56	0.56	0.56	0.0	0.07

TABLE B. 99

U.S. NATIONAL AVERAGE DATA--LOW ALTITUDE AREAS--HDV BY GVW, EVAP BY SOURCE
 MOTOR VEHICLE EMISSION FACTORS FOR 1980 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	14.83	14.83	101.75	136.99	254.29	34.55	23.46
HYDROCARBONS	1.46	1.46	10.69	16.48	23.80	4.53	2.38
NITROGEN OXIDES	1.80	1.80	9.22	9.42	9.12	73.34	2.77
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	8.08	8.08	26.00	26.00	26.00	0.0	9.34
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	5.27	5.27	14.70	14.70	14.70	0.0	5.92
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE B.100

U.S. NATIONAL AVERAGE DATA--LOW ALTITUDE AREAS--HDV BY GVW, EVAP BY SOURCE
 MOTOR VEHICLE EMISSION FACTORS FOR 1980 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	12.18	12.18	101.75	136.99	254.29	34.55	21.01
HYDROCARBONS	1.29	1.29	10.69	16.48	23.80	4.53	2.23
NITROGEN OXIDES	1.80	1.80	9.22	9.42	9.12	73.34	2.77
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	46.27	46.27	181.62	78.09	62.94	0.0	52.82
HYDROCARBONS	2.90	2.90	13.71	17.18	23.38	0.0	3.83
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	8.08	8.08	26.00	26.00	26.00	0.0	9.34
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	5.27	5.27	14.70	14.70	14.70	0.0	5.92
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE B.101

U.S. NATIONAL AVERAGE DATA--LOW ALTITUDE AREAS--HDV BY GVW, EVAP BY SOURCE
 MOTOR VEHICLE EMISSION FACTORS FOR 1985 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	4.38	4.38	100.80	135.70	251.90	32.50	13.72
HYDROCARBONS	0.52	0.52	10.25	15.79	22.84	3.78	1.47
NITROGEN OXIDES	0.69	0.69	9.20	9.40	9.10	76.40	1.77
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	6.50	6.50	26.00	26.00	26.00	0.0	7.88
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	4.40	4.40	14.70	14.70	14.70	0.0	5.13
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE B.102

U.S. NATIONAL AVERAGE DATA--LOW ALTITUDE AREAS--HDV BY GVW, EVAP BY SOURCE
 MOTOR VEHICLE EMISSION FACTORS FOR 1985 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	2.62	2.62	100.80	135.70	251.90	32.50	12.11
HYDROCARBONS	0.42	0.42	10.25	15.79	22.84	3.78	1.38
NITROGEN OXIDES	0.69	0.69	9.20	9.40	9.10	76.40	1.77
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	30.66	30.66	179.93	77.35	62.35	0.0	38.35
HYDROCARBONS	1.64	1.64	13.14	16.46	22.44	0.0	2.63
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	6.50	6.50	26.00	26.00	26.00	0.0	7.88
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	4.40	4.40	14.70	14.70	14.70	0.0	5.13
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE B.103

U.S. NATIONAL AVERAGE DATA--LOW ALTITUDE AREAS--HDV BY GVW, EVAP BY SOURCE
 MOTOR VEHICLE EMISSION FACTORS FOR 1990 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE							
CARBON MONOXIDE	2.83	2.83	100.80	135.70	251.90	32.50	12.30
HYDROCARBONS	0.35	0.35	10.00	15.40	22.30	3.78	1.29
NITROGEN OXIDES	0.50	0.50	9.20	9.40	9.10	76.40	1.59
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	6.50	6.50	26.00	26.00	26.00	0.0	7.88
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	4.40	4.40	14.70	14.70	14.70	0.0	5.13
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE B.104

U.S. NATIONAL AVERAGE DATA--LOW ALTITUDE AREAS--HDV BY GVW, EVAP BY SOURCE
 MOTOR VEHICLE EMISSION FACTORS FOR 1990 MID-YEAR AT A SPEED OF 19.60 MPH

CLASS	1	2	3	4	5	6	WEIGHTED
EXHAUST EMISSIONS -- GRAMS/VEHICLE-MILE -- HOT OPERATING ONLY							
CARBON MONOXIDE	1.16	1.16	100.80	135.70	251.90	32.50	10.76
HYDROCARBONS	0.26	0.26	10.00	15.40	22.30	3.78	1.22
NITROGEN OXIDES	0.50	0.50	9.20	9.40	9.10	76.40	1.59
COLD START EMISSIONS -- GRAMS							
CARBON MONOXIDE	29.02	29.02	179.93	77.35	62.35	0.0	36.84
HYDROCARBONS	1.44	1.44	12.83	16.05	21.91	0.0	2.41
EVAPORATIVE HYDROCARBON EMISSIONS							
DIURNAL (GRAMS)	6.50	6.50	26.00	26.00	26.00	0.0	7.88
RUNNING (GMS/MI)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HOT SOAK (GRAMS)	4.40	4.40	14.70	14.70	14.70	0.0	5.13
CRANKCASE HYDROCARBON EMISSIONS -- GRAMS/VEHICLE-MILE							
	0.0	0.0	0.0	0.0	0.0	0.0	0.0

ACKNOWLEDGMENTS

The information contained in this report was compiled with the help of a number of people from various government and private organizations. A special note of thanks is due to David S. Kircher and Donald P. Armstrong of the U.S. Environmental Protection Agency for their assistance. Also making significant contributions to this work were:

Jay E. Norco, Environmental Technology Assessment, Inc.

Stuart W. Martens, General Motors Corp.

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