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This report presents documentation of an emission factor basic computer code which calculates composite vehicle emission factors in terms of grams per vehicle mile, for carbon monoxide, oxides, of nitrogen, total hydrocarbons, and reactive hydrocarbons. The factors are computed as a function of average route speed, vehicle type distribution, high or low elevation, calendar year, and air basin.

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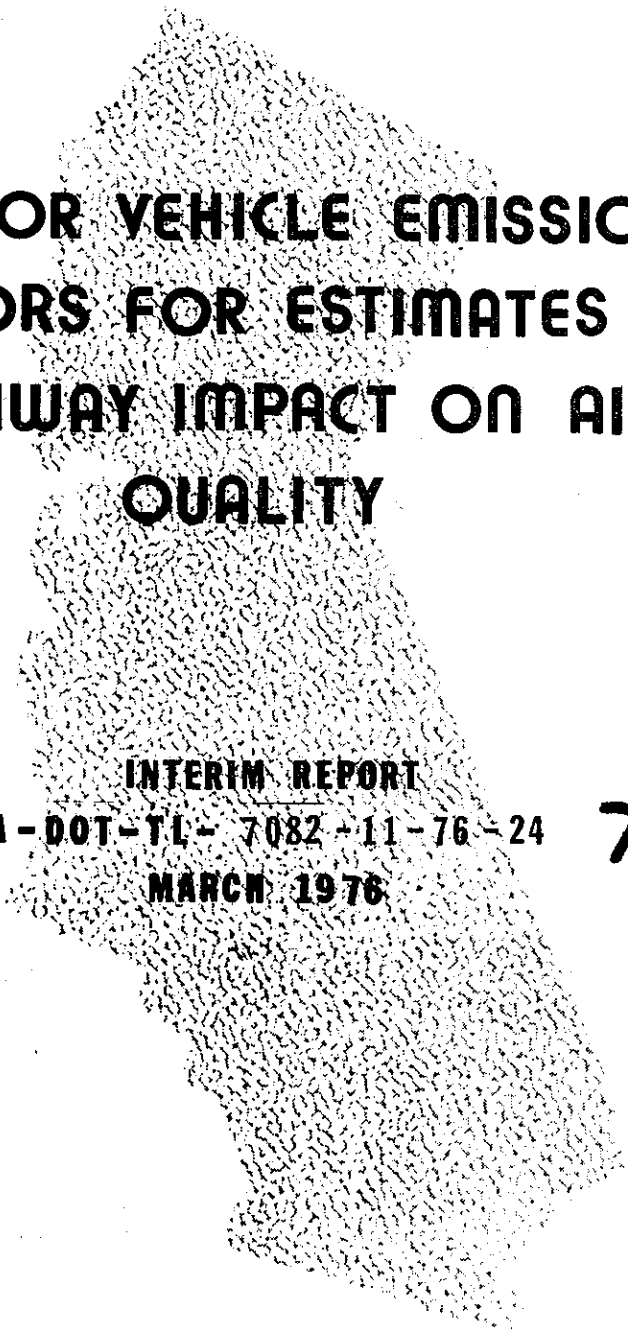
DIVISION OF STRUCTURES AND ENGINEERING SERVICES

TRANSPORTATION LABORATORY

RESEARCH REPORT

MOTOR VEHICLE EMISSION FACTORS FOR ESTIMATES OF HIGHWAY IMPACT ON AIR QUALITY



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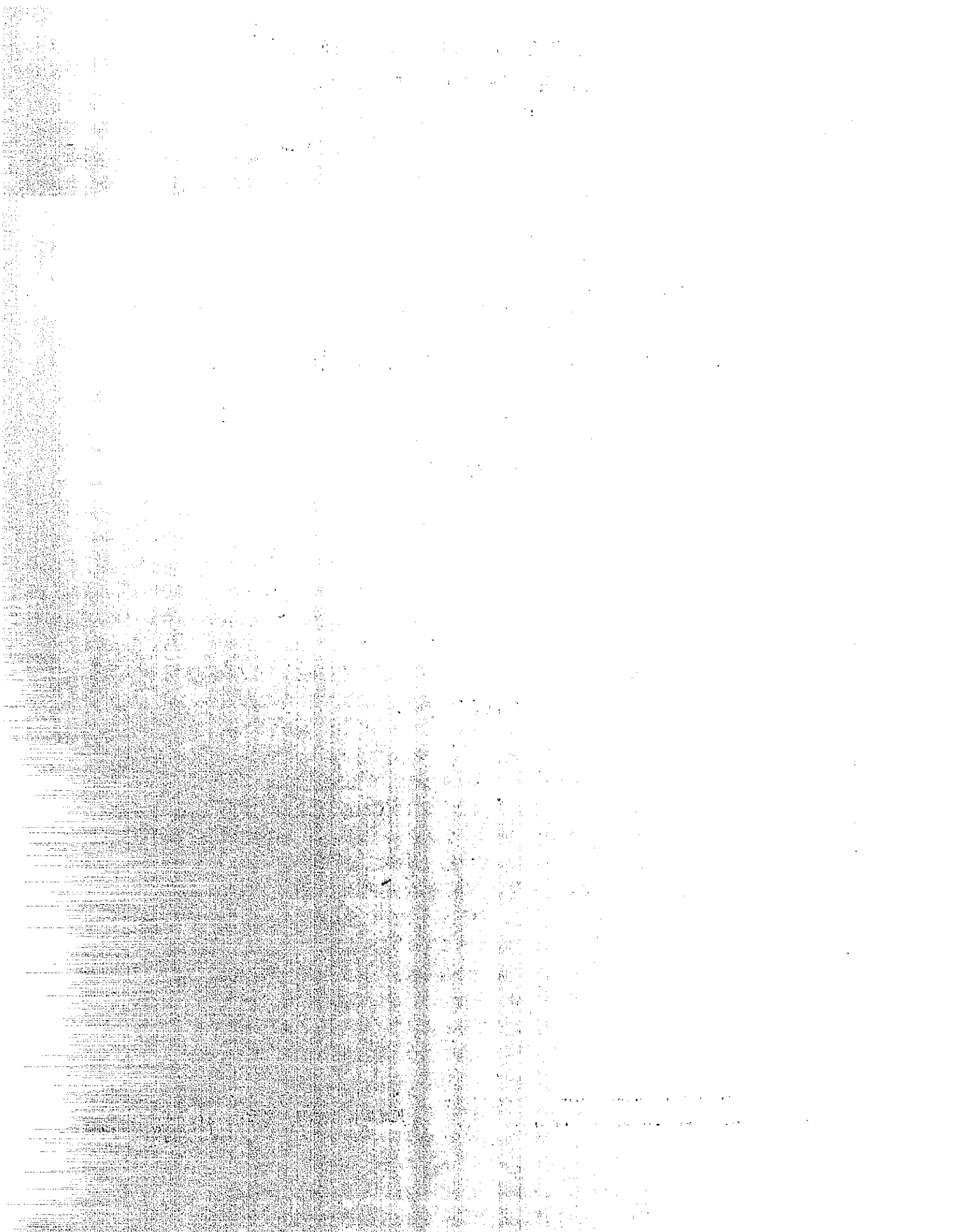

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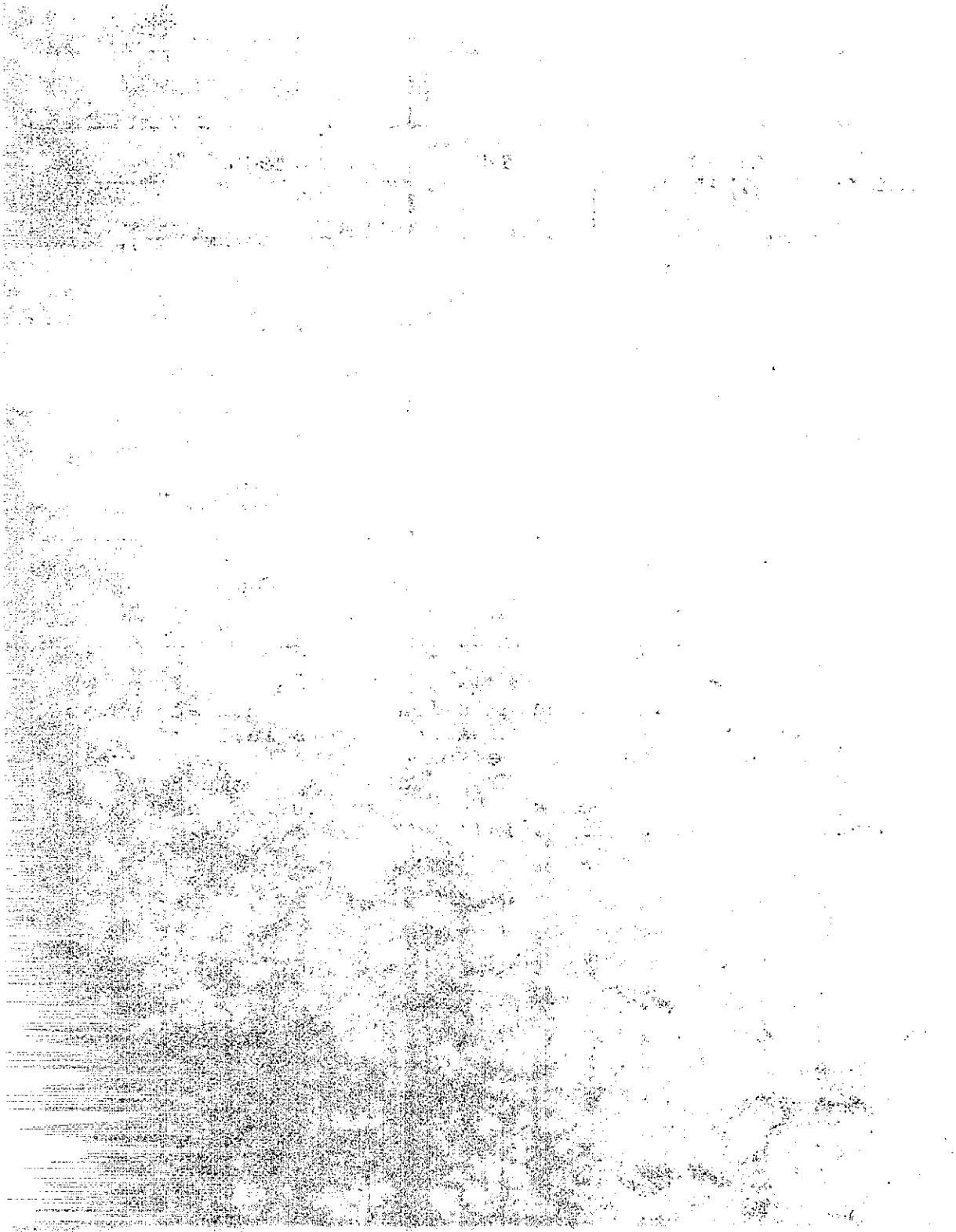

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STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF STRUCTURES & ENGINEERING SERVICES
OFFICE OF TRANSPORTATION LABORATORY

March 1976

TL No. 657082

Mr. C. E. Forbes
Chief Engineer

Dear Sir:

I have approved and now submit for your information this interim research project report titled:

MOTOR VEHICLE EMISSION FACTORS FOR ESTIMATES OF HIGHWAY IMPACT ON AIR QUALITY

Study made by . . . . . Enviro-Chemical Branch

Under the Supervision of . . . . . E. C. Shirley, P.E.

Principal Investigator . . . . . A. J. Ranzieri, P.E.

Report Prepared by . . . . . M. D. Batham, P.E.
P. D. Allen, P.E.

Very truly yours,

George A. Hill

GEORGE A. HILL
Chief, Office of Transportation Laboratory

Attachment

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This manual has been authored by Michael D. Batham and Paul D. Allen under the supervision of Andrew J. Ranzieri and Earl C. Shirley.

Acknowledgement is given to Tony Xavier of the Air Resources Board staff for supplying retrofit factors by Air Basin, for use in the EMFAC program.

The computer program presented in the report was developed and written by Paul D. Allen.

The contents of this report reflect the views of the Transportation Laboratory, which is responsible for the facts and the accuracy of the information presented herein. The contents do not necessarily reflect the official views of the State of California. This report does not constitute a standard, specification, or regulation.

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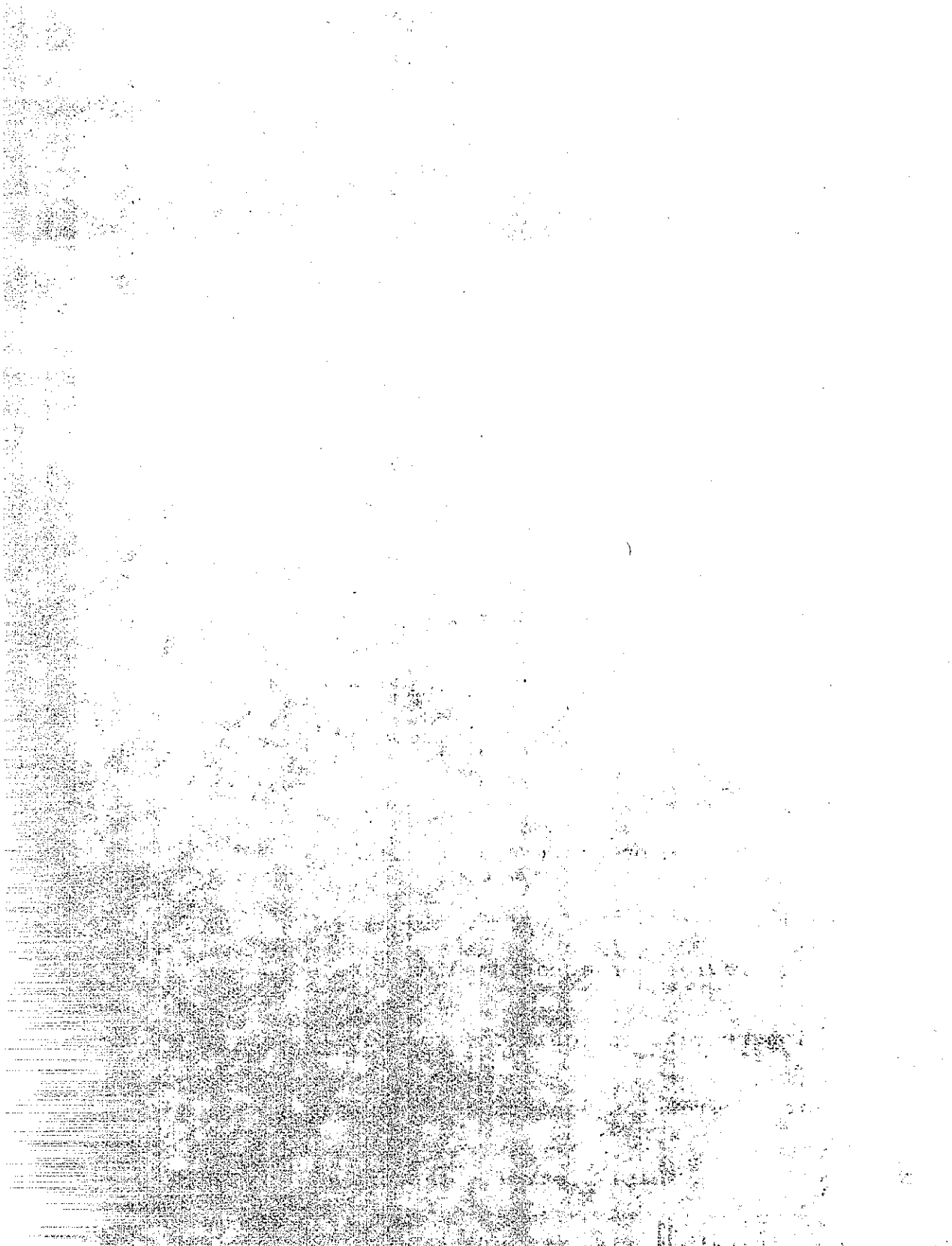

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INTRODUCTION

In order to determine the impact of transportation systems on the air environment, estimation of vehicular emission of carbon monoxide, hydrocarbons and oxides of nitrogen must be made. These emissions are then used as inputs to line source and regional air quality models to assess the impacts on air quality.

This report documents the Transportation Laboratory's computer program EMFAC, which calculates composite motor vehicle emission factors from the most recent data compiled by the California Air Resources Board. The bulk of this data has been published in a report by the Air Resources Board entitled "Interim Estimates of Emissions from Mobile Sources in California" (1).

The methodology used in the computations is consistent with methodology expressed in the April, 1973 edition of AP-42 (2). In all cases speed correction factors are applied as shown in Scott Research Laboratory's Report SRL 2148 07 0274 (3).

These sources incorporate the latest available information for California on speed correction equations, vehicle population distributions for all vehicle types (light duty autos, light duty trucks, heavy duty gas, and heavy duty diesel), interim California Emission Standards, modifications to the 1966-1970 vehicle retrofit program, and hydrocarbon reactivity factors. Modifications to the 1966-1970 retrofit program include 4 different sets of retrofit factors, one set for the Los Angeles Air Basin, one for the San Francisco Bay Area Air Basin, one for the San Diego Air Basin, and the last for the remainder of the State.

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At the present time, EMFAC is not designed to include motorcycles. When data become available for motorcycle mileages, motorcycle emission data will be included. Motorcycles can be considered as light duty vehicles at the present time.

CONCLUSIONS

The results of this study have provided transportation planners and engineers with a vehicular emissions model to give estimates of composite emission factors for carbon monoxide, total hydrocarbons, reactive hydrocarbons, and oxides of nitrogen. The computer program EMFAC can be used to estimate emission factors for any desired:

1) Vehicle type distribution
2) Average route speed
3) Year of inventory
4) Air basin
5) Low (<3500 feet) or high elevation (≥3500 feet)

The EMFAC vehicular emissions model can be easily interfaced with air quality models to give estimates of ambient concentrations due to pollutant emissions from roadways. Combined with stationary source and air craft emissions, EMFAC can be interfaced with regional air quality simulation models to more accurately estimate regional ambient concentrations.

RECOMMENDATIONS AND IMPLEMENTATION

The emission factors estimated by procedures illustrated in this report will replace the revised Air Quality Manual Modification, Numbers 3 and 4 (March 28, 1975) and Number 8 (August 19, 1975).

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This new emission factor program, which will be used on all future Air Quality Studies, is resident on the TENET time-share computer, and can be accessed by linking the program '5;LAB;EMFAC'.

This emission factor model will be interfaced in Headquarter's DOTP transportation simulation models to calculate vehicular emissions for links and grids in a given study region. These total emissions will then be inputs into regional air quality models to predict the temporal and spatial concentrations of air pollutants for a given transportation system. An assessment of various transportation alternatives and their impact on air quality can then be made.

This emission model will also be used in the CALINE2 line source dispersion model presently used by Caltrans. By incorporating the emission model in the CALINE2 model, predictions of air quality can be made within the immediate vicinity of a highway.

PROCEDURE

The EMFAC program computes composite emission factors for total and reactive hydrocarbons, oxides of nitrogen, and carbon monoxide, in units of grams per mile. For average route speeds from 10 to 65 mph, the following 3 equations are used to calculate emission factors for each of the 4 vehicle types (light duty passenger cars, light duty trucks, heavy duty gas trucks, and heavy duty diesels). The composite emission factors depend on the vehicle type distribution input by the user.

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The emission factor for CO and NO_x is calculated using equation (1) as follows:

$$E_{np} = \sum_{i = n-17}^{n+1} c_{ip}\, d_{ip}\, m_i\, s_{ip} \qquad (1)$$

where E_{np} = the exhaust emission factor in grams/vehicle mile for inventory year (n) and pollutant (p),

c_{ip} = the exhaust emission rate in grams/mile for model year (i), at low mileage,

d_{ip} = the controlled vehicle pollutant (p) emission deterioration factor for model year (i), at calendar year (n),

m_{ip} = the weighted percentage annual travel, of the i^{th} model year vehicle during calendar year (n),

s_{ip} = the weighted speed adjustment factor for the i^{th} model year vehicles.

To calculate the hydrocarbon emissions, evaporative and crankcase hydrocarbons must be added to the exhaust hydrocarbons. The following equations describe the calculation of evaporative and crankcase emissions respectively:

$$V_n = \sum_{i = n-17}^{n+1} v_i\, m_i \qquad (2)$$

where V_n = the evaporative hydrocarbon emission factor, for calendar year (n), and

v_i = the evaporative emission rate for the i^{th} model year vehicle.

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$$CC_n = \sum_{i = n-17}^{n+1} cc_i \, m_i \qquad (3)$$

where CC_n = the crankcase hydrocarbon emission factor for calendar year (n), and

cc_i = the crankcase emission rate for the i^{th} model year vehicle.

Each variable will be discussed in later sections of this report.

It is important to note here that several exceptions to the above equations exist in the calculation of a composite emission factor. These exceptions are noted here:

(1) All model year vehicles older than the calendar year (n) - 17 are included in the 17 year old vehicle category.

(2) The deterioration factors (d_{ip}) are not applied to heavy duty diesel powered vehicles or to heavy duty gasoline powered vehicles made earlier than 1975, because these vehicles are not controlled.

(3) Retrofit device factors are applied to light duty model year vehicles 1966-1970 for calendar years equal to or later than 1973. Since the retrofit device programs are at different stages in different areas, these factors are specific to air basins.

(4) Reactive hydrocarbons are calculated as a percentage of exhaust, evaporative, and crankcase total hydrocarbons.

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VEHICLE EMISSION RATES

Pollutant emission rates (c_{ip}) for light duty autos and trucks are taken directly from the ARB's interim report, reference (3). Table 1 and 2 present light duty exhaust emission rates for CO, NO_x, and THC, as well as crankcase and evaporative emission rates for THC. Rates shown for 1978 are also used for all model years greater than 1978 because all new vehicles are assumed to meet the clean air standards for emission controls.

Pollutant emission rates for heavy duty gas and diesel powered vehicles are also found in ARB's interim report (3). These rates are shown in Tables 3 and 4. Again, the 1978 rates are applied for all model years later than 1978.

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TABLE 1

EMISSION RATES FOR LIGHT DUTY VEHICLES
Below 3500 Feet in Elevation
(grams/mile)

	Passenger Cars					Light Duty Trucks				
Model Year	CO	NO_x	Exhaust THC	Crank. THC	Evap. THC	CO	NO_x	Exhaust THC	Crank. THC	Evap. THC
1960	87	3.6	8.8	4.1	3.0	87	3.6	8.8	4.1	3.0
1961	87	3.6	8.8	0.8	3.0	87	3.6	8.8	0.8	3.0
1962	87	3.6	8.8	0.8	3.0	87	3.6	8.8	0.8	3.0
1963	87	3.6	8.8	0.8	3.0	87	3.6	8.8	0.8	3.0
1964	87	3.6	8.8	0	3.0	87	3.6	8.8	0	3.0
1965	87	3.6	8.8	0	3.0	87	3.6	8.8	0	3.0
1966	59.9	8.0	6.0	0	3.0	59.9	8.0	6.0	0	3.0
1967	59.9	6.1	4.7	0	3.0	59.8	6.1	4.7	0	3.0
1968	44.8	6.7	5.1	0	3.0	44.8	6.7	5.1	0	3.0
1969	49.2	6.1	4.4	0	3.0	49.2	6.1	4.4	0	3.0
1970	49.5	4.6	4.6	0	0.5	49.5	4.6	4.6	0	0.5
1971	46.1	3.6	3.0	0	0.5	46.1	3.6	3.0	0	0.5
1972	37.4	3.7	3.0	0	0.2	37.4	3.7	3.0	0	0.2
1973	36.5	3.2	2.7	0	0.2	36.5	3.2	2.7	0	0.2
1974	30.5	2.2	2.6	0	0.2	30.5	2.2	2.6	0	0.2
1975	5.2	1.7	0.54	0	0.2	11.6	1.7	1.2	0	0.2
1976	5.2	1.7	0.54	0	0.2	9.8	1.7	0.54	0	0.2
1977	5.2	0.83	0.25	0	0.2	9.8	1.1	0.54	0	0.2
1978	2.0	0.22	0.25	0	0.2	9.8	1.1	0.54	0	0.2

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TABLE 2

EMISSION RATES FOR LIGHT DUTY VEHICLES
Above 3500 Feet in Elevation
(grams/mile)

	Passenger Cars					Light Duty Trucks				
Model Year	CO	NO_x	Exhaust THC	Crank. THC	Evap. THC	CO	NO_x	Exhaust THC	Crank. THC	Evap. THC
1960	130	1.9	10	4.1	3.0	130	1.9	10	4.1	3.0
1961	130	1.9	10	0.8	3.0	130	1.9	10	0.8	3.0
1962	130	1.9	10	0.8	3.0	130	1.9	10	0.8	3.0
1963	130	1.9	10	0.8	3.0	130	1.9	10	0.8	3.0
1964	130	1.9	10	0	3.0	130	1.9	10	0	3.0
1965	130	1.9	10	0	3.0	130	1.9	10	0	3.0
1966	89.3	4.2	6.8	0	3.0	89.3	4.2	6.8	0	3.0
1967	89.7	3.2	5.3	0	3.0	89.7	3.2	5.3	0	3.0
1968	72.1	3.4	6.8	0	3.0	72.1	3.4	6.8	0	3.0
1969	60.6	2.9	5.4	0	3.0	60.6	2.9	5.4	0	3.0
1970	99	2.5	7.8	0	0.5	99	2.5	7.8	0	0.5
1971	101.7	2.4	5.5	0	0.5	101.7	2.4	5.5	0	0.5
1972	82.7	2.4	5.4	0	0.2	82.7	2.4	5.4	0	0.2
1973	80.7	1.9	4.9	0	0.2	80.7	1.9	4.9	0	0.2
1974	67.4	1.3	4.7	0	0.2	67.4	1.3	4.7	0	0.2
1975	11.9	1.0	1.0	0	0.2	25.2	1.0	2.2	0	0.2
1976	11.9	1.0	1.0	0	0.2	21.8	1.0	1.0	0	0.2
1977	5.2	0.5	0.25	0	0.2	21.8	0.7	1.0	0	0.2
1978	2.0	0.22	0.25	0	0.2	21.8	0.7	1.0	0	0.2

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TABLE 3

EMISSION RATES FOR HEAVY DUTY VEHICLES
Below 3500 Feet in Elevation
(grams/mile)

	Gasoline Trucks					Diesel Trucks			
Model Year	CO	NO_x	Ex-haust THC	Crank. THC	Evap. THC	CO	NO_x	Ex-haust THC	Crank & Evap. THC
1960	140	9.4	17	5.2	3.0	20.4	34	3.4	0
1961	140	9.4	17	0.8	3.0	20.4	34	3.4	0
1962	140	9.4	17	0.8	3.0	20.4	34	3.4	0
1963	140	9.4	17	0.8	3.0	20.4	34	3.4	0
1964	140	9.4	17	0	3.0	20.4	34	3.4	0
1965	140	9.4	17	0	3.0	20.4	34	3.4	0
1966	140	9.4	17	0	3.0	20.4	34	3.4	0
1967	140	9.4	17	0	3.0	20.4	34	3.4	0
1968	140	9.4	17	0	3.0	20.4	34	3.4	0
1969	140	9.4	17	0	3.0	20.4	34	3.4	0
1970	130	9.2	16	0	3.0	20.4	34	3.4	0
1971	130	9.2	16	0	3.0	20.4	34	3.4	0
1972	130	9.2	13	0	3.0	20.4	34	3.4	0
1973	130	9.2	13	0	0.2	19	26	2.6	0
1974	130	9.2	13	0	0.2	19	26	2.6	0
1975	98	5.8	8.1	0	0.2	14	16	1.6	0
1976	98	5.8	8.1	0	0.2	14	16	1.6	0
1977	81	2.8	4.1	0	0.2	12	8	0.8	0
1978	81	2.8	4.1	0	0.2	12	8	0.8	0

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TABLE 4

EMISSION RATES FOR HEAVY DUTY VEHICLES
Above 3500 Feet in Elevation
(grams/mile)

	Gasoline Trucks					Diesel Trucks			
Model Year	CO	NO_x	Ex-haust THC	Crank. THC	Evap. THC	CO	NO_x	Ex-haust THC	Crank & Evap. THC
1960	210	5	19	5.2	3.0	31	18	3.8	0
1961	210	5	19	0.8	3.0	31	18	3.8	0
1962	210	5	19	0.8	3.0	31	18	3.8	0
1963	210	5	19	0.8	3.0	31	18	3.8	0
1964	210	5	19	0	3.0	31	18	3.8	0
1965	210	5	19	0	3.0	31	18	3.8	0
1966	210	5	19	0	3.0	31	18	3.8	0
1967	210	5	19	0	3.0	31	18	3.8	0
1968	210	5	19	0	3.0	31	18	3.8	0
1969	210	5	19	0	3.0	31	18	3.8	0
1970	190	4.9	18	0	3.0	31	18	3.8	0
1971	190	4.9	18	0	3.0	31	18	3.8	0
1972	190	4.9	15	0	3.0	31	18	3.8	0
1973	190	4.9	15	0	0.2	29	14	2.9	0
1974	190	4.9	15	0	0.2	29	14	2.9	0
1975	143	3.1	9	0	0.2	21	8	1.8	0
1976	143	3.1	9	0	0.2	21	8	1.8	0
1977	118	1.5	5	0	0.2	18	4	0.9	0
1978	118	1.5	5	0	0.2	18	4	0.9	0

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CONTROLLED VEHICLE DETERIORATION FACTORS

Deterioration factors used in EMFAC for light duty vehicles are found in the ARB's interim report (3), and presented here in Tables 5-7 for CO, NO_x, and THC. Deterioration factors for heavy duty gasoline powered vehicles are found in AP-42 (1). Pre-1975 heavy duty gas vehicles have no emission controls; therefore the deterioration factors are assumed equal to unity. Table 8 shows the deterioration factors for heavy duty gas vehicles.

Since heavy duty diesels are presently uncontrolled, deterioration factors are not applied to any model year.

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TABLE 5

CO DETERIORATION FACTORS FOR LIGHT DUTY VEHICLES[a]

Model Year	Age of Vehicle (Years)											
	0[b]	1	2	3	4	5	6	7	8	9	10	>10
Pre 1966 1/	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1966 2/	.98	1.11	1.17	1.21	1.23	1.25	1.26	1.28	1.28	1.29	1.30	1.30
1967	.98	1.08	1.14	1.17	1.18	1.20	1.21	1.27	1.22	1.23	1.23	1.24
1968	.97	1.16	1.27	1.32	1.36	1.39	1.41	1.43	1.45	1.45	1.46	1.47
1969	.96	1.20	1.34	1.41	1.47	1.50	1.53	1.55	1.58	1.59	1.60	1.61
1970	.96	1.21	1.35	1.43	1.48	1.52	1.55	1.58	1.60	1.62	1.63	1.63
1971	.98	1.09	1.15	1.18	1.20	1.22	1.23	1.24	1.25	1.25	1.26	1.26
1972	.96	1.20	1.34	1.42	1.47	1.51	1.54	1.56	1.58	1.60	1.61	1.62
1973	.97	1.17	1.28	1.34	1.38	1.41	1.44	1.46	1.47	1.49	1.49	1.50
1974	.94	1.31	1.54	1.67	1.76	1.83	1.89	1.93	1.97	2.00	2.02	2.03
1975 1/	.99	1.15	1.37	1.56	1.73	1.88	2.01	2.12	2.23	2.32	2.38	2.42
1976	.99	1.15	1.37	1.56	1.73	1.88	2.01	2.13	2.23	2.32	2.38	2.42
1977	.99	1.15	1.37	1.56	1.73	1.88	2.01	2.13	2.23	2.31	2.38	2.42
Post 1977	.99	1.15	1.37	1.56	1.73	1.88	2.01	2.13	2.23	2.31	2.38	2.42

a. Factors normalized to 4000 miles.
b. Represents new model year production beginning October 1 of inventory year.
1/ Pre 1966 and Post 1974 Deterioration Factors Derived From: "Supplement No. 2 for Compilation of Air Pollutant Emmission Factors", EPA Publication AP-42-Supplement 2, September, 1973, 3.1.2-7.
2/ 1966-1974: ARB Div. of Implementation and Enforcement analysis of ARB, Div. of Vehicle Emission Control, "Automobile Emission Regression Report" 3rd Quarter, 1974.

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TABLE 6

NO_x DETERIORATION FACTORS FOR LIGHT DUTY VEHICLES[a]

Model Year	Age of Vehicles (Years)											
	0[b]	1	2	3	4	5	6	7	8	9	10	>10
Pre 1966 1/	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1966 2/	1.08	.69	.56	.50	.46	.44	.42	.41	.40	.39	.39	.38
1967	1.05	.79	.69	.64	.61	.59	.58	.57	.56	.55	.55	.54
1968	1.04	.82	.73	.69	.66	.65	.63	.62	.61	.61	.60	.60
1969	1.02	.90	.85	.82	.81	.79	.78	.78	.77	.77	.77	.76
1970	1.00	.99	.98	.98	.97	.97	.97	.97	.97	.97	.97	.97
1971	.99	1.03	1.05	1.06	1.07	1.07	1.07	1.08	1.08	1.08	1.08	1.08
1972	.99	1.03	1.05	1.05	1.06	1.07	1.07	1.07	1.07	1.08	1.08	1.08
1973	.99	1.06	1.10	1.12	1.13	1.14	1.14	1.15	1.15	1.16	1.16	1.16
1974	.96	1.21	1.36	1.44	1.49	1.53	1.56	1.59	1.61	1.63	1.64	1.65
1975 2/	1.00	1.03	1.08	1.12	1.15	1.18	1.21	1.24	1.26	1.28	1.29	1.30
1976	1.00	1.03	1.07	1.12	1.15	1.18	1.21	1.24	1.26	1.28	1.29	1.30
1977	.98	1.16	1.40	1.60	1.78	1.94	2.08	2.22	2.33	2.42	2.48	2.53
Post 1977	.98	1.16	1.40	1.60	1.78	1.94	2.09	2.22	2.33	2.42	2.48	2.53

a. Factors normalized to 4,000 miles.
b. Represents new model year production beginning October 1st of inventory year.
1/ Pre 1966 & Post 1974 derived from: "Supplement No. 2 for Compilation of Air Pollutant Emission Factors", EPA Publication AP-42-Supplement-2, September 1973, p. 3.1.2-7.
2/ Pre 1966 & Post 1974 deterioration factor derived from: "Supplement No. 2 for "Compilation of Air Pollutant Emission Factors", EPA Publication AP-42-Supplement-2, September 1973, p. 3.12-7.

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TABLE 7

EXHAUST THC DETERIORATION FACTORS FOR LIGHT DUTY VEHICLES[a]

Model Year	Age of Vehicle (Years)											
	0[b]	1	2	3	4	5	6	7	8	9	10	>10
Pre 1966 1/	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1966 2/	.98	1.10	1.17	1.20	1.22	1.24	1.25	1.27	1.27	1.28	1.29	1.29
1967	.99	1.06	1.10	1.12	1.13	1.14	1.15	1.16	1.16	1.17	1.17	1.17
1968	.98	1.09	1.14	1.17	1.19	1.20	1.22	1.22	1.23	1.24	1.24	1.24
1969	.98	1.09	1.14	1.17	1.19	1.20	1.22	1.22	1.23	1.24	1.24	1.24
1970	.97	1.15	1.24	1.29	1.33	1.35	1.37	1.39	1.40	1.41	1.42	1.42
1971	.97	1.13	1.21	1.26	1.29	1.31	1.33	1.34	1.35	1.36	1.37	1.37
1972	.97	1.17	1.29	1.35	1.39	1.42	1.45	1.47	1.49	1.50	1.51	1.51
1973	.98	1.12	1.19	1.23	1.25	1.27	1.29	1.30	1.31	1.32	1.32	1.33
1974	.97	1.18	1.31	1.37	1.42	1.45	1.48	1.50	1.52	1.53	1.54	1.55
1975 1/	.99	1.13	1.33	1.49	1.63	1.76	1.88	1.99	2.08	2.15	2.20	2.24
1976	.99	1.13	1.33	1.49	1.63	1.76	1.88	1.99	2.08	2.15	2.20	2.24
1977	.99	1.13	1.33	1.49	1.63	1.76	1.88	1.99	2.08	2.15	2.20	2.24
Post 1977	.99	1.13	1.33	1.49	1.63	1.76	1.88	1.99	2.08	2.15	2.20	2.24

a. Factors normalized to 4,000 miles
b. Represents new model year production beginning October 1st of inventory year.
1/ Pre 1966 & Post 1974 deterioration factor derived from: "Supplement No. 2 for Compilation of Air Pollutant Emission Factors", EPA Publication AP-42-Supplement-2, September 1973, p. 3.1.2-7.
2/ 1966-74: ARB Div. of Implementation & Enforcement analysis of ARB Div. of Vehicle Emission Control "Automobile Emission Regression Report" 3rd Quarter, 1974.

TABLE 8

DETERIORATION FACTORS FOR GASOLINE POWERED HEAVY DUTY VEHICLES

Model Year	Vehicle Age, Years 0	1	2	3	4	5	6	7	8	≥9
CO Deterioration Factor										
1974 & earlier	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1975 & later	1.00	1.24	1.35	1.43	1.50	1.57	1.63	1.69	1.73	1.77
NO_x Deterioration Factor										
1974 & earlier	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1975 & later	1.00	1.11	1.18	1.20	1.22	1.23	1.24	1.25	1.27	1.28
Exhaust THC Deterioration Factor										
1974 & earlier	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1975 & later	1.00	1.12	1.18	1.22	1.25	1.28	1.30	1.33	1.36	1.38

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WEIGHTED ANNUAL TRAVEL DISTRIBUTIONS BY VEHICLE TYPE

The weighted annual travel distributions used in EMFAC were provided by the ARB's Emission Inventory Unit, and supersede the distributions presented in reference (3). Tables 9-12 show the distributions used in EMFAC for each vehicle type. Each distribution reflects a smooth curve drawn through 1973 distributions calculated by the ARB. The distribution shown in Tables 9-12 are used for all inventory years.

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Table 9

WEIGHTED ANNUAL TRAVEL FOR LIGHT-DUTY PASSENGER VEHICLES

Nominal Age (Years)	Average Age At End Of Inventory Year (Years)	Fraction[1] of Total Vehicles In Use (1)	Average[2] Annual Mileage (2)	(1) X (2) (3)	(3) ÷ 8367 Fraction of Vehicle Miles Travelled
0	.125	.0035	24,208	84.7	0.0101
1	.75	.0794	17,564	1395.0	0.1667
2	1.75	.1047	14,022	1468.0	0.1755
3	2.75	.1003	11,774	1181.0	0.1411
4	3.75	.0958	10,334	990.0	0.1183
5	4.75	.0889	9,341	830.0	0.0992
6	5.75	.0838	8,492	712.0	0.0851
7	6.75	.0764	7,561	578.0	0.0690
8	7.75	.0679	6,418	436.0	0.0521
9	8.75	.0595	5,025	299.0	0.0357
10	9.75	.0520	3,464	180.0	0.0215
11	10.75	.0439	1,140	50.0	0.0060
12	11.75	.0355	1,140	40.5	0.0048
13	12.75	.0287	1,140	32.7	0.0039
14	13.75	.0221	1,140	25.2	0.0030
15	14.75	.0146	1,140	16.6	0.0020
16	15.75	.0069	1,140	7.87	0.0009
≥17	≥16.75	.0360	1,140	41.0	0.0049
	Total	1.0000		8367.0	1.0000

1/ Internal ARB report "Total Number of Motor Vehicles in Use and Distribution According to Model Year", Division of Implementation and Enforcement, January 1975.

2/ Based on ARB study of "Periodic Vehicle Inspection, Semi-Annual Report 5" California Highway Patrol, December 5, 1972 and April 12, 1973

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Table 10

WEIGHTED ANNUAL TRAVEL FOR LIGHT-DUTY TRUCKS

Nominal Age (Years)	Average Age At End Of Inventory Year (Years)	Fraction[1] of Total Vehicles In Use (1)	Average[2] Annual Mileage (2)	(1) X (2) (3)	(3) ÷ 8016 Fraction of Vehicle Miles Travelled
0	.125	.0035	24,208	84.7	0.0106
1	.75	.0871	17,564	1530.0	0.1908
2	1.75	.1064	14,022	1492.0	0.1861
3	2.75	.0965	11,774	1136.0	0.1417
4	3.75	.0876	10,334	905.0	0.1129
5	4.75	.0785	9,341	733.0	0.0915
6	5.75	.0746	8,492	634.0	0.0790
7	6.75	.0619	7,561	468.0	0.0584
8	7.75	.0547	6,418	351.0	0.0438
9	8.75	.0485	5,025	244.0	0.0304
10	9.75	.0413	3,464	143.0	0.0178
11	10.75	.0353	1,140	40.2	0.0050
12	11.75	.0309	1,140	35.2	0.0044
13	12.75	.0260	1,140	29.6	0.0037
14	13.75	.0223	1,140	25.4	0.0032
15	14.75	.0186	1,140	21.2	0.0026
16	15.75	.0148	1,140	16.9	0.0021
≥ 17	≥ 16.75	.1116	1,140	127.0	0.0159
	Total	1.0000		8016.0	1.0000

1/ Internal ARB report, "Total Number of Motor Vehicles In Use and Distribution According to Model Year", Division of Implementation and Enforcement, January 1975.

2/ Based on ARB study of data, "Periodic Vehicle Inspection, Semi-Annual Report 5", California Highway Patrol, December 5, 1972 and April 12, 197

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TABLE 11

WEIGHTED ANNAUL TRAVEL FOR HEAVY-DUTY GASOLINE POWERED VEHICLES

Nominal Age	Average Age At end of Inventory Year (Years)	Fraction[1] of Total Vehicles In Use (1)	Average[2] Annual Mileage (2)	(1) X (2) (3)	(3) ÷ 11820 Fraction of Vehicle Miles Traveled
0	0	.0000	0	0	0
1	.5	.0331	19,700	652	.0552
2	1.5	.0661	19,700	1,302	.1102
3	2.5	.0661	18,000	1,190	.1007
4	3.5	.0661	18,000	1,190	.1007
5	4.5	.0651	15,100	983	.0832
6	5.5	.0640	15,100	966	.0818
7	6.5	.0630	11,500	725	.0613
8	7.5	.0620	11,500	713	.0603
9	8.5	.0599	10,000	599	.0507
10	9.5	.0568	10,000	568	.0481
11	10.5	.0527	7,370	388	.0329
12	11.5	.0486	7,370	358	.0303
13	12.5	.0413	7,370	304	.0258
14	13.5	.0351	7,370	259	.0219
15	14.5	.0289	7,370	213	.0180
16	15.5	.0238	7,370	175	.0148
≥ 17	≥ 16.5	.1674	7,370	1,234	.1044
TOTAL		1.0000		11,820	1.0000

1/ Internal ARB report "Total Number of Motor Vehicles in Use and Distribution According to Model Year". Division of Implementation and Enforcement, January 15, 1975.

2/ Based on study of "1972 Census of Transportation, Truck Inventory and Use Survey", U.S. Bureau of the Census, May 1973.

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TABLE 12

WEIGHTED ANNUAL TRAVEL FOR HEAVY-DUTY DIESEL-POWERED TRUCKS

Nominal Age	Average Age At End Of Inventory Year (Years)	Fraction[1] Of Total Vehicles In Use (1)	Average[2] Annual Mileage (2)	(1) X (2) (3)	(3) ÷ 53,685 Fraction of Vehicle Miles Travelled
0	0	.0000	0	0	0
1	.5	.0521	78,600	4,095	.0763
2	1.5	.1021	78,600	8,025	.1495
3	2.5	.0978	72,000	7,042	.1312
4	3.5	.0926	72,000	6,667	.1242
5	4.5	.0863	60,200	5,195	.0968
6	5.5	.0800	60,200	4,816	.0897
7	6.5	.0736	45,700	3,364	.0627
8	7.5	.0663	45,700	3,030	.0564
9	8.5	.0600	39,900	2,394	.0446
10	9.5	.0526	39,900	2,099	.0391
11	10.5	.0452	29,400	1,329	.0248
12	11.5	.0379	29,400	1,114	.0208
13	12.5	.0316	29,400	929	.0173
14	13.5	.0242	29,400	711	.0133
15	14.5	.0168	29,400	494	.0092
16	15.5	.0084	29,400	247	.0046
≥17	≥16.5	.0726	29,400	2,134	.0398
TOTAL		1.0000		53,685	1.000

1/ Internal ARB report "Total Number of Motor Vehicles in Use and Distribution According to Model Year". Division of Implementation and Enforcement, January 15, 1975.

2/ Based on study of "1972 Census of Transportation, Truck Inventory and Use Survey", U.S. Bureau of the Census, May 1973.

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SPEED CORRECTION FACTORS

The exhaust emission rates in Tables 1-4 are based on an average speed of 19.6 mph. To calculate composite emission factors for any other speed involves the use of speed correction regression equations developed by the Scott Research Laboratory (2) for the U.S. EPA. Speed correction equations for 1955-1971 light duty vehicles are developed in reference (2) for CO, NO_x, and THC. In addition, the speeds used to develop the equations ranged from 15 to 45 mph.

To the authors' knowledge, there are no correction equations for heavy duty vehicles. Therefore, EMFAC assumes the light duty vehicle correction equations are representative for heavy duty vehicle exhaust emissions. Speed corrections are not applied to crankcase or evaporative emissions.

The equations used to calculated the THC and CO speed correction factors are parabolic. To calculate speed correction factors outside the 15 to 45 mph range for these pollutants, the following extrapolation scheme is used:

(1) If the slope of the speed function remains negative up to 65 mph, then the speed correction factor is calculated from the parabolic function.

(2) If the slope of the function becomes zero (minimum value) before 65 mph, then the speed correction factor is assumed to remain constant at the minimum value up to 65 mph.

(3) The lower range of speed correction factors are extrapolated using the parabolic function from 15 to 10 mph.

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The total range of the speed adjustment factor is, therefore, from 10 to 65 mph.

The speed adjustment factors for NO_x are assumed to follow a linear function as shown in reference (2). This also applies to the extrapolated ranges of 15 down to 10 mph and 45 up to 65 mph.

Tables 13 - 15 show the speed correction regression equations from reference (2), which are used in EMFAC.

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Table 13

Speed Correction Regression Equations
For Carbon Monoxide

$$LnCO = A + B(S) + C(S^2)$$

where LnCO = natural log of CO,
CO = the CO emission factor in grams/mile,
A, B, and C are regression coefficients, and
S = average route speed in mph.

Model Year Vehicle	A	B($\times 10^{-2}$)	C($\times 10^{-4}$)
$\leq$1955 - 1965	5.33475	-6.06584	5.78421
1966 - 1967	4.88181	-6.21854	6.18978
1968	5.22263	-6.51947	6.00899
1969	5.20578	-7.71552	6.59770
1970	5.01179	-7.71946	6.40350
$\geq$1971	5.01669	-7.52438	6.08591

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Table 14

Speed Correction Regression Equations
For Total Hydrocarbons

$$\text{Ln THC} = A + B(S) + C(S^2)$$

where Ln THC = natural log of THC,
THC = the THC emission factor in grams/mile,
A, B, and C are regression coefficients, and
S = average route speed in mph.

Model Year Vehicle	A	B(x10^{-2})	C(x10^{-4})
≤ 1955 - 1965	2.98338	-5.99767	5.80943
1966 - 1967	2.66145	-5.98232	5.63255
1968	2.70316	-6.63011	5.98211
1969	2.54636	-6.26878	5.79923
1970	2.16247	-5.69535	5.58732
≥ 1971	2.04527	-5.92347	5.67343

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Table 15

Speed Correction Regression Equations
For Oxides of Nitrogen

$$NO_x = A + B(S)$$

where NO_x = the NO_x emission factor in grams/mile,
A and B are regression coefficients, and
S = average route speed in mph.

Model Year Vehicle	A	B(x10^{-2})
≤ 1955 - 1965	3.17413	3.85334
1966 - 1967	3.15629	2.98311
1968	4.24644	2.71939
1969	5.83611	2.75849
1970	4.93157	4.66796
≥ 1971	4.49361	4.28722

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1966-1970 MODEL YEAR VEHICLE RETROFIT PROGRAMS

The ARB's emission inventory unit has provided retrofit factors to apply to 1966-1970 model light duty passenger cars and light duty trucks. This applies for inventory years later than 1972. Also, the Emission Inventory Unit has determined that varying percentages of vehicles have been fitted with retrofit devices in various air basins. Therefore, the South Coast, San Francisco Bay Area, and San Diego Air Basins each have retrofit factors applicable to them only. Another set of factors apply to the remainder of the State. Retrofit factors are developed for THC, CO, and NO_x.

The abandoned mandatory retrofit device program is not considered in any of the retrofit factors.

Tables 16 - 19 present the retrofit factor for light duty vehicle emissions as used in EMFAC.

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Table 16

1966 - 1970 Model Year Vehicle Retrofit Factors
South Coast Basin

Inventory Year	Factor Applied to Emissions from 1966-1970 Model Year Vehicles		
	CO	NO_x	THC
1973	.994	.985	.988
1974	.976	.942	.954
1975	.957	.894	.917
1976	.941	.855	.887
1977	.928	.823	.862
1978	.917	.797	.841
1979	.909	.775	.825
1980	.902	.758	.811
1981	.896	.743	.799
1982	.891	.732	.791
1983	.887	.723	.783
1984	.883	.715	.777
1985	.881	.708	.772
1986	.879	.703	.768
1987	.878	.699	.765

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Table 17

1966 - 1970 Model Year Vehicle Retrofit Factors
San Francisco Bay Area Basin

	Factor Applied to Emissions from 1966 - 1970 Model Year Vehicles		
Inventory Year	CO	NO_x	THC
1973	.998	.996	.997
1974	.982	.995	.965
1975	.961	.905	.926
1976	.945	.864	.894
1977	.931	.830	.867
1978	.920	.803	.846
1979	.911	.780	.828
1980	.903	.762	.814
1981	.897	.747	.802
1982	.892	.736	.793
1983	.888	.725	.785
1984	.885	.717	.779
1985	.882	.710	.773
1986	.880	.704	.769
1987	.878	.700	.766

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Table 18

1966 - 1970 Model Year Vehicle Retrofit Factors
San Diego Basin

Inventory Year	Factor Applied to Emissions from 1966 - 1970 Model Year Vehicles		
	CO	NO_x	THC
1973	1.000	.999	.999
1974	.984	.960	.969
1975	.963	.909	.929
1976	.946	.867	.896
1977	.932	.833	.869
1978	.921	.805	.848
1979	.911	.782	.830
1980	.904	.763	.815
1981	.898	.748	.803
1982	.889	.727	.787
1983	.886	.718	.780
1984	.883	.711	.775
1985	.880	.706	.770
1986	.878	.701	.766
1987	.877	.697	.763

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Table 19

1966 - 1970 Model Year Vehicle Retrofit Factors
All California Basins Except
South Coast, San Francisco Bay Area, San Diego

Inventory Year	Factor Applied to Emissions from 1966 - 1970 Model Year Vehicles		
	CO	NO_x	THC
1973	1.000	1.000	1.000
1974	.994	.984	.988
1975	.973	.933	.948
1976	.954	.887	.911
1977	.939	.849	.882
1978	.929	.818	.858
1979	.916	.793	.838
1980	.907	.772	.822
1981	.901	.755	.809
1982	.895	.742	.798
1983	.890	.730	.789
1984	.887	.721	.782
1985	.884	.714	.776
1986	.881	.708	.772
1987	.879	.702	.768

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HYDROCARBON REACTIVITY FACTORS

As mentioned previously, reactive hydrocarbon emission factors are based on ratios of the various sources of total hydrocarbon emissions. Reactivity factors, obtained from reference (3) are applied separately to exhaust, evaporative, and crankcase total hydrocarbons, for light duty vehicles, heavy duty gas, and heavy duty diesels. These factors are shown in Tables 20 - 22.

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Table 20

REACTIVITY FACTORS FOR LIGHT-DUTY GASOLINE-POWERED VEHICLES 1/

Emission Source	Reactivity Factor (Weight fraction of total organic gases that are reactive)
Exhaust from gasoline-powered vehicles (not equipped with catalytic converters)	0.80
Exhaust from gasoline-powered vehicles (equipped with catalytic converters)	0.64 2/
Gasoline evaporation	0.95
Crankcase	0.88

1/ "Technical Assumptions for Revising Method of Estimating Emissions from Motor Vehicles - Preliminary Draft", California Air Resources Board, August 28, 1974.

2/ Federal Register-November 12, 1973.

Based on assumption that all organic gases emitted from mobile sources are reactive except for methane, ethane, propane, acetylene, benzene, and organic acids. (except for where indicated otherwise by foot-note 2).

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Table 21

REACTIVITY FACTORS FOR HEAVY-DUTY GASOLINE-POWERED VEHICLES

Emission Source	Reactivity Factor (weight fraction of reactive organic gases)
Exhaust from gasoline-powered vehicles	0.80
Gasoline Evaporation	0.95
Crankcase	0.88

Technical Support Document, California ARB, April 1975.

Based on assumption that all organic gases emitted from mobile sources are reactive except for methane, ethane, propane, acetylene, benzene.

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TABLE 22

REACTIVITY FACTORS FOR HEAVY-DUTY DIESEL-POWERED VEHICLES

Emission Source	Reactivity Factor
Exhaust from diesel-powered vehicles	0.99
Diesel evaporation	(negligible)
Crankcase	(negligible)

"Technical Support Document, California Air Resources Board," April 1975.

Based on assumption that all organic gases emitted from mobile sources are reactive except for methane, ethane, propane, acetylene, benzene.

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EMFAC USER'S INSTRUCTIONS

EMFAC is resident on the Caltrans TENET timeshare system. It is accessed in the basic mode, by the command LINK "5;LAB; EMFAC". The user inputs to the program are accomplished by answering a series of questions appearing at the timeshare terminal. Each question is discussed below:

(1) JOB TITLE:

Any title can be typed in for the run. It will appear at the top of each page of output.

(2) PERCENT OF HDV THAT ARE DIESEL POWERED? IF NOT KNOWN, ENTER 10 FOR STATE AVERAGE.

Unless the user has a specific percentage breakdown between heavy duty diesels and heavy duty gas-powered trucks, 10 should be typed as the answer to this question.

(3) PERCENT OF LDV THAT ARE LIGHT DUTY TRUCKS? ENTER 14 FOR STATE AVERAGE.

Again, unless the user has a specific percentage breakdown between light duty autos and trucks, 14 should be typed as the answer to this question.

(4) ELEVATION LESS THEN 3500 FEET (YES OR NO)?

If the emission factors are to be applied to vehicles below 3500 feet in elevation, type YES, otherwise type NO. The program will use different sets of pollutant emission rates for high and low elevations.

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(5) ENTER 2 FOR SOUTH COAST BASIN,
3 FOR SAN FRANCISCO BAY AREA BASIN,
4 FOR SAN DIEGO BASIN, OR
5 FOR ANY OTHER BASIN?

The answer to this question causes selection of the proper 1966-1970 vehicle retrofit program factors to be used by the program. Enter the number for the basin where the emission factors are to be applied.

(6) ENTER NO. OF YEARS, PREDICTION YEARS?

The first entry is the number of years the user wants emission factors for. After this entry, place a comma, then list each year separating each one with a comma.

(7) NUMBER OF CALCULATIONS FOR EACH YEAR?

The user should input the number of combinations of %HDV and speed that an emission factor is needed.

(8) ENTER %HDV, SPEED FOR:
CALC. 1?
The percent of HDV (heavy duty gas + heavy duty diesels) per the total traffic is entered, then a comma, and the related average route speed. Entries for the same number of calculations entered as an answer to question 7 will be requested by the program.

A sample program execution follows, to familiarize the user with the format of the inputs and outputs.

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>LINK "5;LAB;EMFAC"


**** *** EMFAC      DECEMBER 1975 VERSION*********

JOB TITLE?TEST RUN

PERCENT OF HDV THAT ARE DIESEL POWERED.
IF NOT KNOWN, ENTER 10 FOR STATE AVERAGE?10

PERCENT OF LDV THAT ARE LIGHT DUTY TRUCKS.
ENTER 14 FOR STATE AVERAGE?14

ELEVATION LESS THAN 3500 FEET (YES OR NO)?YES

ENTER 2 FOR SOUTH COAST BASIN,
      3 FOR SAN FRANCISCO BAY AREA BASIN,
      4 FOR SAN DIEGO BASIN, OR
      5 FOR ANY OTHER BASIN?3

ENTER NO. YEARS, PREDICTION YEARS?3,1975,1980,1985

NUMBER OF CALCULATIONS FOR EACH YEAR?10

ENTER %HDV, SPEED FOR:
   CALC. 1  ?5,20
   CALC. 2  ?5,30
   CALC. 3  ?5,40
   CALC. 4  ?5,50
   CALC. 5  ?5,60
   CALC. 6  ?10,20
   CALC. 7  ?10,30
   CALC. 8  ?10,40
   CALC. 9  ?10,50
   CALC. 10 ?10,60
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TEST RUN
DATE: 12/09/75

ALTITUDE LESS THAN 3500 FEET

SAN FRANCISCO BAY AREA AIR BASIN

PREDICTED VEHICLE EMISSION FACTORS FOR YEAR 1975

VEHICLE DISTRIBUTION - %				AVG. SPEED	POLLUTANT GRAMS/MILE			
AUTO	LD TRK	HD GAS	HD DSL	M.P.H.	CO	THC	RHC	NOX
81.7	13.3	4.5	.5	20	51.8	5.2	4.3	3.7
81.7	13.3	4.5	.5	30	34.1	4.0	3.3	4.0
81.7	13.3	4.5	.5	40	25.4	3.5	2.9	4.2
81.7	13.3	4.5	.5	50	21.5	3.3	2.7	4.5
81.7	13.3	4.5	.5	60	20.3	3.3	2.7	4.8
77.4	12.6	9.0	1.0	20	55.4	5.8	4.7	4.1
77.4	12.6	9.0	1.0	30	36.6	4.5	3.7	4.4
77.4	12.6	9.0	1.0	40	27.3	3.9	3.2	4.7
77.4	12.6	9.0	1.0	50	23.2	3.6	3.0	5.0
77.4	12.6	9.0	1.0	60	22.0	3.6	3.0	5.3

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TEST RUN
DATE: 12/09/75

ALTITUDE LESS THAN 3500 FEET

SAN FRANCISCO BAY AREA AIR BASIN

PREDICTED VEHICLE EMISSION FACTORS FOR YEAR 1980

VEHICLE DISTRIBUTION - %				AVG. SPEED	POLLUTANT GRAMS/MILE			
AUTO	LD TRK	HD GAS	HD DSL	M.P.H.	CO	THC	RHC	NOX
81.7	13.3	4.5	.5	20	22.0	2.0	1.6	1.8
81.7	13.3	4.5	.5	30	14.3	1.5	1.2	2.0
81.7	13.3	4.5	.5	40	10.5	1.3	1.1	2.1
81.7	13.3	4.5	.5	50	8.7	1.2	1.0	2.3
81.7	13.3	4.5	.5	60	8.1	1.2	1.0	2.4
77.4	12.6	9.0	1.0	20	27.0	2.5	2.0	2.2
77.4	12.6	9.0	1.0	30	17.5	1.9	1.5	2.3
77.4	12.6	9.0	1.0	40	12.9	1.6	1.3	2.5
77.4	12.6	9.0	1.0	50	10.7	1.5	1.2	2.7
77.4	12.6	9.0	1.0	60	10.0	1.5	1.2	2.8

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TEST RUN
DATE: 12/09/75

ALTITUDE LESS THAN 3500 FEET

SAN FRANCISCO BAY AREA AIR BASIN

PREDICTED VEHICLE EMISSION FACTORS FOR YEAR 1985

VEHICLE DISTRIBUTION - %				AVG. SPEED	POLLUTANT GRAMS/MILE			
AUTO	LD TRK	HD GAS	HD DSL	M.P.H.	CO	THC	RHC	NOX
81.7	13.3	4.5	.5	20	12.1	1.1	.9	1.0
81.7	13.3	4.5	.5	30	7.7	.9	.7	1.1
81.7	13.3	4.5	.5	40	5.6	.8	.6	1.1
81.7	13.3	4.5	.5	50	4.5	.7	.6	1.2
81.7	13.3	4.5	.5	60	4.2	.7	.6	1.3
77.4	12.6	9.0	1.0	20	17.5	1.5	1.1	1.2
77.4	12.6	9.0	1.0	30	11.2	1.1	.9	1.3
77.4	12.6	9.0	1.0	40	8.1	1.0	.8	1.4
77.4	12.6	9.0	1.0	50	6.6	.9	.7	1.5
77.4	12.6	9.0	1.0	60	6.1	.9	.7	1.6

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EMFAC and DATA FILE

LISTINGS

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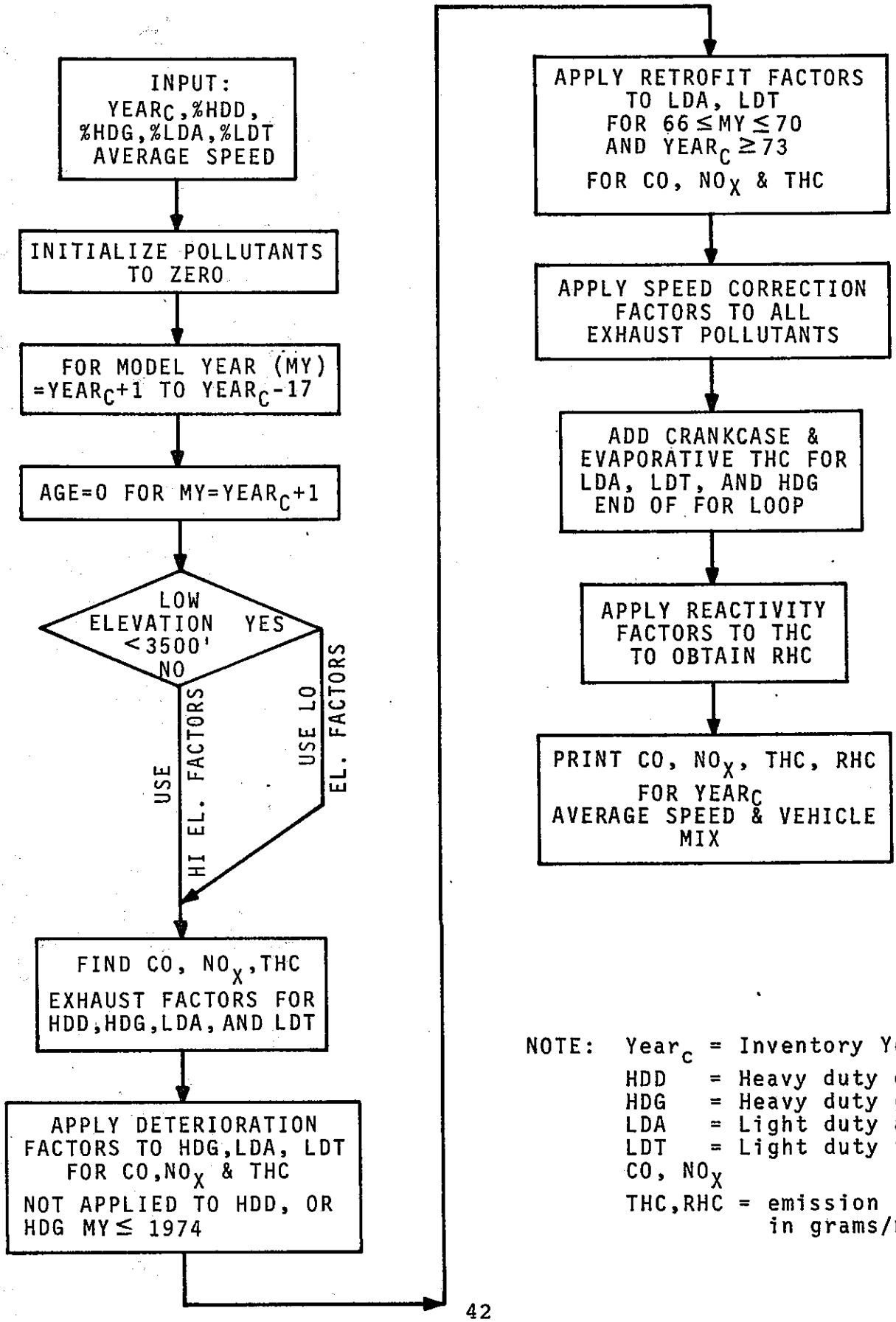
GENERALIZED EMFAC FLOWCHART



NOTE: Year$_C$ = Inventory Year
HDD = Heavy duty diesel
HDG = Heavy duty gas
LDA = Light duty autos
LDT = Light duty trucks
CO, NO$_X$
THC,RHC = emission factors in grams/mile

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```
LIST
1000 REM        ***** PROGRAM EMFAC ** DECEMBER 1975 VERSION****
1010 REM  PROGRAMMED BY P. ALLEN, DECEMBER 1975 FOR
                ENVIRONMENTAL IMPROVEMENT SECTION
                    TRANSPORTATION LABORATORY
              CALIFORNIA DEPARTMENT OF TRANSPORTATION

1020 PRINT
1030 PRINT;'********* EMFAC      DECEMBER 1975 VERSION*********'
1050 PRINT
1060 REM          **MATRIX TABLES ***

          M = % VEHICLE DISTRIBUTION
        RET = 1966-1970 VEHICLE RETROFIT FACTORS
1061 REM  L = DETERIORATION FACTORS - LDV
          H = DETERIORATION FACTORS - HDV
1062 REM  S = SPEED CORRECTION FACTORS
          F = VEHICLE EMISSION FACTORS
1080 LEMY=65          ! EARLIEST MODEL YEAR LIMIT - MAT L
1090 SEMY=65          ! EARLIEST MODEL YEAR LIMIT - MAT S
1100 FEMY=60          ! EARLIEST MODEL YEAR LIMIT - MAT F
1110 LLMY=77          ! LATEST   MODEL YEAR LIMIT - MAT L
1120 SLMY=71          ! LATEST   MODEL YEAR LIMIT - MAT S
1130 FLMY=78          ! LATEST   MODEL YEAR LIMIT - MAT F
1140 MAGE=17          ! AGE LIMIT FOR % DISTRIBUTION
1150 LAGE=11          ! AGE LIMIT FOR DETERIORIATION - LDV
1160 HAGE=9           ! AGE LIMIT FOR DETERIORIATION - HDV
1170 C=4,T=5, T3=3    ! SEE BELOW

1180 REM              C1 = AUTOMOBILES
                      C2 = LT DUTY TRUCKS
                      C3 = GAS POWERED HD TRUCKS
                      C4 = DSL POWERED HD TRUCKS

1190 REM              T1 = CARBON MONOXIDE
                      T2 = NITROGEN OXIDES
                      T3 = HYDORCARBONS - EXHAUST
                      T4 = HYDROCARBONS - EVAPORATIVE
                      T5 = HYDROCARBONS - CRANKCASE
1200 DIM M(0:MAGE,C),RET(73:87,3),L(T3,LEMY:LLMY,0:LAGE),H(T3,0:HAGE),
       S(SEMY:SLMY,3,4),F(FEMY:FLMY,C,T)
1210 OPEN '452:STAR:NEWFILE',1,INPUT,OLD,BINARY,RANDOM
1220 MAT INPUT FROM 1 AT 1:M!
          ***** INPUT PROBLEM PARAMETERS *****

1230 PRINT;'JOB TITLE':
1240 INPUT TIT$
1250 PRINT

1260 PRINT;'PERCENT OF HDV THAT ARE DIESEL POWERED.'
1270 PRINT;'IF NOT KNOWN, ENTER 10 FOR STATE AVERAGE':
1280 INPUT HDVD
1290 IF HDVD<=100 THEN 1310 ELSE PRINT;
      'PLEASE INPUT VALUE LESS THAN OR EQUAL TO 100':
1300 GOTO 1280
1310 HDVD=.01*HDVD
1320 PRINT

1321 PRINT;'PERCENT OF LDV THAT ARE LIGHT DUTY TRUCKS.'
1322 PRINT;'ENTER 14 FOR STATE AVERAGE':
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1323 INPUT LDT
1324 IF LDT<=100 THEN 1326 ELSE PRINT;
       'PLEASE INPUT VALUE LESS THAN OR EQUAL TO 100':
1325 GOTO 1323
1326 LDT=.01*LDT
1329 PRINT
1330 PRINT;'ELEVATION LESS THAN 3500 FEET (YES OR NO)':
1340 INPUT AN$
1350 IF AN$='YES' OR AN$='NO' THEN 1370 ELSE PRINT;
       'PLEASE ANSWER YES OR NO':
1360 GOTO 1340
1370 IF AN$='YES' THEN T$='LESS', K=7
                  ELSE T$='GREATER', K=8
1371 PRINT
1375 PRINT;'ENTER 2 FOR SOUTH COAST BASIN,'
1376 PRINT;'       3 FOR SAN FRANCISCO BAY AREA BASIN,'
1377 PRINT;'       4 FOR SAN DIEGO BASIN, OR'
1378 PRINT;'       5 FOR ANY OTHER BASIN':
1379 INPUT BAS
1380 MAT INPUT FROM 1 AT BAS:RET
1381 MAT INPUT FROM 1 AT 6:L,H,S
1382 MAT INPUT FROM 1 AT K:F
1390 CLOSE 1
1400 PRINT

1470 PRINT;'ENTER NO. YEARS, PREDICTION YEARS':
1480 MAT INPUT NY(1),YR(NY(1))
1490 PRINT

1500 PRINT;'NUMBER OF CALCULATIONS FOR EACH YEAR':
1510 INPUT NC
1520 PRINT

1530 DIM PCT(NC),SPD(NC)
1540 PRINT;'ENTER %HDV, SPEED FOR:'
1550    FOR I=1 TO NC
1560    PRINT;;'CALC. ':I:TAB(15):
1570    INPUT PCT(I),SPD(I)
1580    IF PCT(I)<=100 THEN 1600 ELSE PRINT;
         'INVALID INPUT - TRY AGAIN'
1590    GOTO 1560
1600    PCT(I)=.01*PCT(I)
1610    SPD(I)=MIN(SPD(I),65)
1615    IF SPD(I)<10 THEN SPD(I)=10
1620    NEXT I !
          ***** BEGIN OUTPUT *****
    PAGE FOR EACH PREDICTION YEAR YR(I)

1630    FOR I=1 TO NY(1)
1640    IF YR(I)>99 THEN YR(I)=YR(I)-1900
1650    PRINT CHAR(12)
1660    PRINT
1670    PRINT;TIT$
1675 PRINT;'DATE: ':TDATE
1680    PRINT
1690    PRINT;'ALTITUDE ':T$:' THAN 3500 FEET'
1691   PRINT
1695 IF BAS = 2 THEN PRINT;'SOUTH COAST AIR BASIN'
1696 IF BAS = 3 THEN PRINT;'SAN FRANCISCO BAY AREA AIR BASIN'
1697 IF BAS = 4 THEN PRINT;'SAN DIEGO AIR BASIN'
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1698 IF BAS = 5 THEN PRINT IN FORM " 3B
      'ALL CALIFORNIA AIR BASINS EXCEPT SOUTH COAST, SAN FRANCISCO BAY AREA,'
       / 3B 'OR SAN DIEGO' /":
1699 IF BAS <2 OR BAS >5 THEN 1375
1700    PRINT IN FORM"/3B'PREDICTED VEHICLE EMISSION FACTORS'
         ' FOR YEAR'5%///4B'VEHICLE DISTRIBUTION - %    AVG. SPEED'
        4B'POLLUTANT  GRAMS/MILE'/":1900+YR(I)
1710    PRINT IN FORM"3B'AUTO LD TRK  HD GAS HD DSL     M.P.H.'
         5B'CO' 6B 'THC' 5B 'RHC' 4B 'NOX'//":
1720 REM
          ***** START AN INDIVIDUAL CALCULATION *****
            CALCULATE % DISTRIBUTION BY VEHICLE TYPE

1730        FOR J=1 TO NC
1740        IF J=1 THEN 1760
1750 IF PCT(J) = PCT(J-1) THEN PRINT ELSE 1770
1760        P4=HDVD*PCT(J), P3=PCT(J)-P4,
             K= 1-PCT(J), P1= (1-LDT)*K, P2= LDT*K
1770        CO,HC1,HC2,HC3,HC4,HC5,TH,THA,THD,NOX=0 ! INITIALIZE POLLUTANTS
1780           FOR K=0 TO MAGE
1781           TC,TN,TH,THA=0   !    INITIALIZE POLLUTANTS
1790           MY=YR(I)-K+1,
               LMY=MAX(LEMY,MIN(MY,LLMY)),
               FMY=MAX(FEMY,MIN(MY,FLMY)),
               SMY=MAX(SEMY,MIN(MY,SLMY))
1800           C1=P1*M(K,1), C2=P2*M(K,2),
               C3=P3*M(K,3), C4=P4*M(K,4) !
               ***** LIGHT DUTY VEHICLES *****

1810           AGE=MIN(K,LAGE)
1820           TC=L(1,LMY,AGE)*(C1*F(FMY,1,1)+C2*F(FMY,2,1))
1830           TN=L(2,LMY,AGE)*(C1*F(FMY,1,2)+C2*F(FMY,2,2))
1832 IF MY >= 75 THEN 1834 ELSE 1840
1833 REM    THA = THC FROM LDV EXHAUST FOR MY >= 1975
            TH  = THC FROM LDV EXHAUST FOR MY < 1975
1834 THA = L(3,LMY,AGE)*(C1*F(FMY,1,3)+C2*F(FMY,2,3))
1835 GOTO 1841
1840           TH=L(3,LMY,AGE)*(C1*F(FMY,1,3)+C2*F(FMY,2,3)) !
               AFTER 1974, CORRECT FOR RETROFIT KITS ON
                   1966 TO 1970 MODEL YEAR VEHICLES

1841            IF YR(I)<73 OR YR(I) >87 THEN 1870
1842            IF MY<66 THEN 1870
1843            IF MY>70 THEN 1870
1844 REM        !
             **STATEWIDE 66-70 RETROFIT**

1845 TC = RET(YR(I),2)*TC
1847 TN = RET(YR(I),3)*TN
1849 TH = RET(YR(I),1)*TH
1851 THA = RET(YR(I),1)*THA
1857 REM

                  ** HEAVY DUTY VEHICLES ***
          DETIORATION FACTORS NOT APPLIED TO DIESELS
1858 REM
1870           IF MY>74 THEN AGE=MIN(K,HAGE) ELSE AGE=0
1880           TC=TC+H(1,AGE)*(C3*F(FMY,3,1)) + C4*F(FMY,4,1)
1890           TN=TN+H(2,AGE)*(C3*F(FMY,3,2)) + C4*F(FMY,4,2)
1900           TH=TH+H(3,AGE)*(C3*F(FMY,3,3))
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1905              THD=C4*F(FMY,4,3)    !
1910              RC=MIN(SPD(J),S(SMY,1,2)/(2*S(SMY,1,3))),
                  RH=MIN(SPD(J),S(SMY,3,2)/(2*S(SMY,3,3)))
1920              CO=(EXP(S(SMY,1,1)-S(SMY,1,2)*RC+S(SMY,1,3)*RC*RC))*
                  TC/S(SMY,1,4)+CO
1930              NOX=(S(SMY,2,1)+S(SMY,2,2)*SPD(J))*TN/S(SMY,2,4)+NOX
1940              HC1=(EXP(S(SMY,3,1)-S(SMY,3,2)*RH+S(SMY,3,3)*RH*RH))*
          (TH)/S(SMY,3,4)+HC1 !


1941              HC5=(EXP(S(SMY,3,1)-S(SMY,3,2)*RH+S(SMY,3,3)*RH*RH))*
          (THA)/S(SMY,3,4)+HC5
1942              HC4=(EXP(S(SMY,3,1)-S(SMY,3,2)*RH+S(SMY,3,3)*RH*RH))*
          (THD)/S(SMY,3,4)+HC4
1949 REM
                 ADD CRANKCASE $ EVAPORATIVE HYDROCARBONS

1950              HC2=HC2+C1*F(FMY,1,4)+C2*F(FMY,2,4)
                         +C3*F(FMY,3,4)+C4*F(FMY,4,4)
1952              HC3=HC3+C1*F(FMY,1,5)+C2*F(FMY,2,5)+C3*F(FMY,3,5)
1960              NEXT K !
                  PRINT POLLUTANT CONCENTRATION

1965 REM     HC1 =  THC FROM PRE 1975 LDV EXHAUST + HDV GAS EXHAUST
             HC2 = THC FROM EVAPORATIVE EMISSION LDV & HDV
             HC3 = THC FROM CRANKCASE  LDV & HDV
             HC4 = THC FORM HDV DIESEL EXHAUST

1966 REM     HC5 = THC FROM LDV MY >= 1975
1970 HCR = .80*HC1 + .64*HC5 + .99*HC4 + .95*HC2 + .88*HC3
1971 THC = HC1+HC5+HC4+HC2+HC3
1980          PRINT IN FORM'5%,% 4%,% 6%,% 5%,% 9% 8%,% 3(6%,%)/':
       100*P1,100*P2,100*P3,100*P4,SPD(J),CO,THC,HCR,NOX
1990       NEXT J,I

2000 PRINT CHAR(12)
>
```


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```
COPY NEWFILET TO TEL
001 .0103 .0106 .0000 .0000
002 .1667 .1908 .0552 .0763
003 .1755 .1861 .1102 .1495
004 .1411 .1417 .1007 .1312
005 .1183 .1129 .1007 .1242
006 .0992 .0915 .0832 .0968
007 .0851 .0790 .0818 .0897
008 .0690 .0584 .0613 .0627
009 .0521 .0438 .0603 .0564
010 .0357 .0304 .0507 .0446
011 .0215 .0178 .0481 .0391
012 .0160 .0050 .0329 .0248
013 .0048 .0044 .0303 .0208
014 .0039 .0037 .0258 .0173
015 .0030 .0032 .0219 .0133
016 .0020 .0026 .0180 .0092
017 .0009 .0021 .0148 .0046
018 .0049 .0159 .1044 .0398
021 .988 .994 .985
022 .954 .976 .942
023 .917 .957 .894
024 .887 .941 .855
025 .862 .928 .823
026 .841 .917 .797
027 .825 .909 .775
028 .811 .902 .758
029 .799 .896 .743
030 .791 .891 .732
031 .783 .887 .723
032 .777 .883 .715
033 .772 .881 .708
034 .768 .879 .703
035 .765 .878 .699
040 .997 .998 .996
041 .965 .982 .955
042 .926 .961 .905
043 .894 .945 .864
044 .867 .931 .830
045 .846 .920 .803
046 .828 .911 .780
047 .814 .903 .762
048 .802 .897 .747
049 .793 .892 .736
050 .785 .889 .725
051 .779 .885 .717
052 .773 .882 .710
053 .769 .880 .704
054 .766 .878 .700
060 .999 1.00 .999
061 .969 .984 .960
062 .929 .963 .909
063 .896 .946 .867
064 .869 .932 .833
065 .848 .921 .805
066 .830 .911 .782
067 .815 .904 .763
068 .803 .898 .748
069 .787 .889 .727
070 .780 .886 .718
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071 .775 .843 .711
072 .770 .860 .706
073 .766 .878 .701
074 .763 .877 .697
079 1.00 1.00 1.00
080 .988 .994 .984
081 .948 .973 .933
082 .911 .954 .887
083 .882 .939 .849
084 .858 .926 .818
085 .838 .916 .793
086 .822 .907 .772
087 .809 .901 .755
088 .798 .895 .742
089 .789 .890 .730
090 .782 .887 .721
091 .776 .884 .714
092 .772 .881 .708
093 .768 .879 .702
165 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
166 .98 1.11 1.17 1.21 1.23 1.25 1.26 1.28 1.28 1.29 1.30 1.30
167 .98 1.08 1.14 1.17 1.18 1.20 1.21 1.27 1.22 1.23 1.23 1.24
168 .97 1.16 1.27 1.32 1.36 1.39 1.41 1.43 1.45 1.45 1.46 1.47
169 .96 1.20 1.34 1.41 1.47 1.50 1.53 1.55 1.58 1.59 1.60 1.61
170 .96 1.21 1.35 1.43 1.48 1.52 1.55 1.58 1.60 1.62 1.63 1.63
171 .98 1.09 1.15 1.18 1.20 1.22 1.23 1.24 1.25 1.25 1.26 1.26
172 .96 1.20 1.34 1.42 1.47 1.51 1.54 1.56 1.58 1.60 1.61 1.62
173 .97 1.17 1.28 1.34 1.38 1.41 1.44 1.46 1.47 1.49 1.49 1.50
174 .94 1.31 1.54 1.67 1.76 1.83 1.89 1.93 1.97 2.00 2.02 2.03
175 .99 1.15 1.37 1.56 1.73 1.88 2.01 2.12 2.23 2.32 2.38 2.42
176 .99 1.15 1.37 1.56 1.73 1.88 2.01 2.13 2.23 2.32 2.38 2.42
177 .99 1.15 1.37 1.56 1.73 1.88 2.01 2.13 2.23 2.31 2.38 2.42
265 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00 1.00
266 1.08 .69 .56 .50 .46 .44 .42 .41 .40 .39 .39 .38
267 1.05 .79 .69 .64 .61 .59 .58 .57 .56 .55 .55 .54
268 1.04 .82 .73 .69 .66 .65 .63 .62 .61 .61 .60 .60
269 1.02 .90 .85 .82 .81 .79 .78 .78 .77 .77 .77 .76
270 1.00 .99 .98 .98 .97 .97 .97 .97 .97 .97 .97 .97
271 .99 1.03 1.05 1.06 1.07 1.07 1.07 1.08 1.08 1.08 1.08 1.08
272 .99 1.03 1.05 1.05 1.06 1.07 1.07 1.07 1.07 1.08 1.08 1.08
273 .99 1.06 1.10 1.12 1.13 1.14 1.14 1.15 1.15 1.16 1.16 1.16
274 .96 1.21 1.36 1.44 1.49 1.53 1.56 1.59 1.61 1.63 1.64 1.65
275 1.00 1.03 1.08 1.12 1.15 1.18 1.21 1.24 1.26 1.28 1.29 1.30
276 1.00 1.03 1.07 1.12 1.15 1.18 1.21 1.24 1.26 1.28 1.29 1.30
277 .98 1.16 1.40 1.60 1.78 1.94 2.08 2.22 2.33 2.42 2.48 2.53
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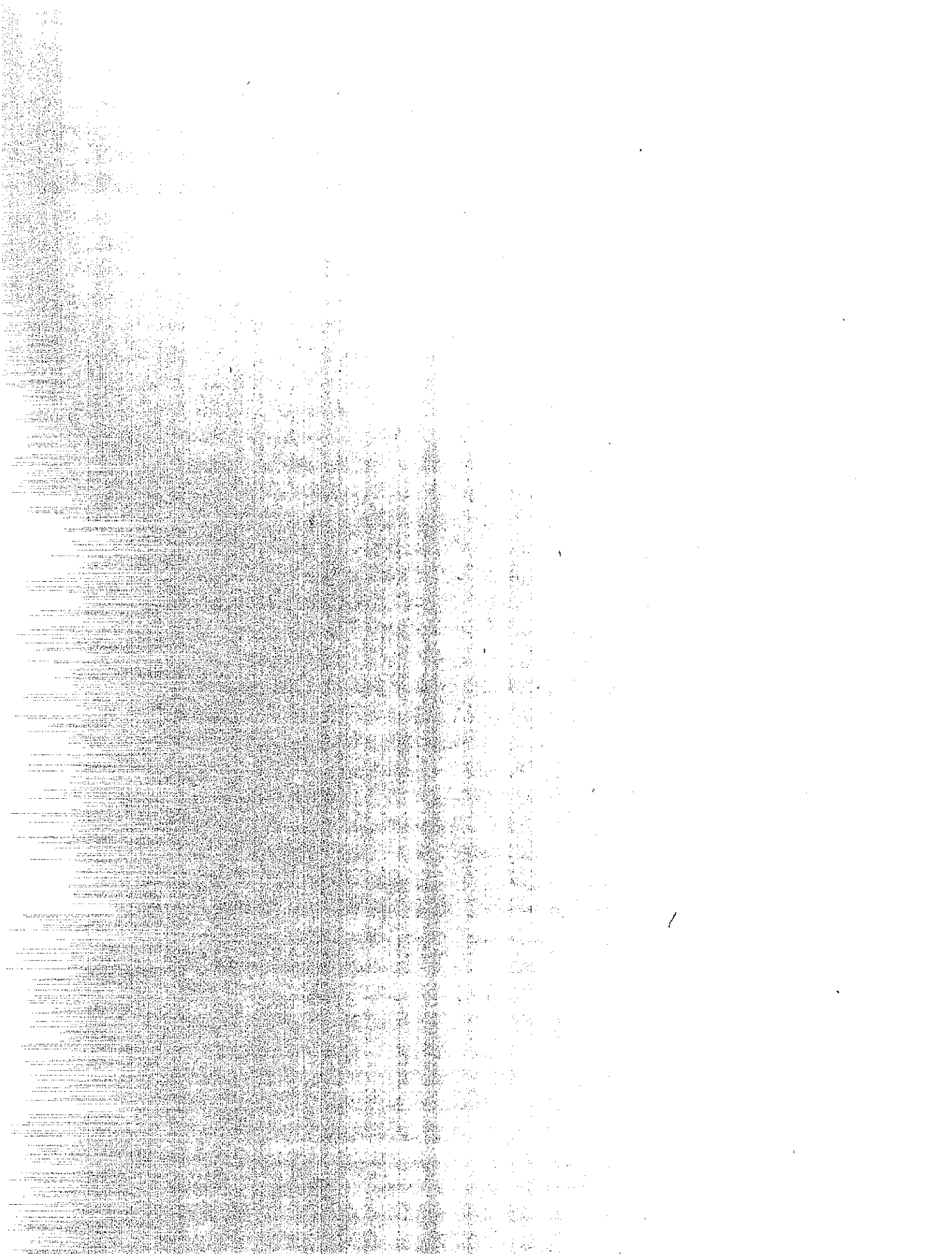

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