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Research Triangle Park NC 27711

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Air



# Methodologies to Conduct Regulatory Impact Analysis of Ambient Air Quality Standards for Carbon Monoxide

EPA-450/5-80-006



# Methodologies to Conduct Regulatory Impact Analysis of Ambient Air Quality Standards for Carbon Monoxide

by

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## FOREWORD

As its second task under Contract No. 68-02-2835, Work Assignment Number 19, SRI International was to develop a computer program to conduct various impact analyses of ambient air quality standards for carbon monoxide. The initial general specifications of the desired program were contained in Attachment A of the work assignment. Various modifications and additions were implemented in the program as the specific requirements became more clear during the course of the project.

This report summarizes the functional details of the final version of the program as it existed in the month of September 1979. Technical details and a user's manual for the program have been documented separately.*

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*A. Dermant, R. Patterson, and W. Siddiqee, "Program to Conduct Regulatory Impact Analysis of Ambient Air Quality Standards for Carbon Monoxide," Contract No. 68-02-2835, SRI Project 6780, SRI International, Menlo Park, California (September 1979).

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## TABLES

# 1. INTRODUCTION

This report presents a summary of the functional details of a computer program developed by SRI International in accordance with the specifications provided by EPA. The program has been designed to analyze the carbon monoxide-related data for counties in the United States that could be potentially in violation of current and proposed carbon monoxide (CO) standards. A list of the 272 counties and a discussion of the criteria for selecting these counties is included in Appendix A. A list and a discussion of the alternative forms and levels of the CO standard is given in Appendix B.

The following major activities were performed to accomplish the development of the program:

1. Collecting, processing and coding the basic data related to each of the 272 counties mentioned above.
2. Generating necessary effectiveness factors related to Federal Motor Vehicle Control Program (FMVCP) and Inspection and Maintenance (I/M) programs using the MOBILE 1 mobile source emission factors program.
3. Developing unit costs related to I/M programs and program Transportation Control Measures (TCM) in consultation with EPA project officers.
4. Developing the logic of the desired computer program and coding it in COBOL language.
5. Testing and debugging the program and producing a set of results

urgently needed by EPA.

6. Transferring the program and associated utility programs to North Carolina.

7. Preparing the present report.

8. Preparing a programmers manual for the program.

Various sections of this report include sufficiently detailed discussion of each of the above-noted activities.

## 2. SUMMARY OF THE BASIC METHODOLOGY

The overall logic of the program can conveniently be explained by considering a single county and noting that certain basic data about each county is stored in a county file as shown in Table 2.1. Tables of CO emission reduction factors due to Federal Motor Vehicle Control Program (FMVCP) and reduction factors due to Inspection and Maintenance (I/M) programs are also separately stored.

With the above-noted background information, the basic logic of the program can be stated as follows. Details of each of the following steps are presented in Section 4.

1. The existing design value of CO concentration corresponding to the standard being considered is compared with the value of the standard. If the design value is less than the value of the standard, the county is not in violation of the standard and is not analyzed any further for that standard. If the design value is greater than the value of the standard, the needed percentage reduction (also called rollback) is calculated as follows:

$$\%R = \frac{D - S}{D - B} \times 100$$

where

%R = Percentage rollback
D = Design value in $mg/m^3$
S = Value of the standard $mg/m^3$
B = Background level of concentration $mg/m^3$

Table 2.1

BASIC COUNTY-RELATED DATA STORED
IN THE COUNTY FILE

| | | |
|---|---|---|
| 1. | County Code | (e.g., 01073) |
| 2. | County name | (e.g., Jefferson) |
| 3. | State code | (e.g., AL) |
| 4. | Area emissions 1979 | (tons/year) |
| 5. | Point emissions 1979 | (tons/year) |
| 6. | Mobile emissions 1976* | (tons/year) |
| 7. | Emission density | (tons/sq. mile/year) |
| 8. | Population 1970 | (SMSA or urban area population to which the county belongs) |
| 9. | Population 1980 | |
| 10. | Population 1985 | |
| 11. | Population 1990 | |
| 12. | Population adjustment factor 1980 | (based on BEA data) |
| 13. | Population adjustment factor 1985 | |
| 14. | Population adjustment factor 1990 | |
| 15. | VMT growth factor | (annual %) |
| 16. | County passenger car count 1977 | |
| 17. | 14 design values | ($mg/m^3$) |
| 18. | Temperature | (degrees F) |
| 19. | Location code | (low altitude, high altitude, California) |
| 20. | Background concentration level | ($mg/m^3$) |
| 21. | Code indicating I/M program in county | |
| 22. | Code indicating I/M program in state | |
| 23. | Urbanized area code | |

*The 1979 line emissions were not readily available. However 1976 estimated values were available based on 75° temperature. These are used as a base value and the projected values for 1979, 1982, etc. are calculated by the program using suitable factors as will be explained later in this report.

For example, suppose the current 8-hour second high design value of a county is 14 $mg/m^3$ and the background level is zero. Comparing it with the 8-hour second high standard of 10 $mg/m^3$, it is seen that the needed percentage reduction is: $\frac{14-10}{14-0} \times 100 = 28.6\%$. (1)

For those counties not having design value data, emission densities are used as design value surrogates to calculate the percentage rollback. Specifically:

$$\%R = \frac{(d - QD) \times 100}{(QD - b)}$$

where

d = Emisson density of the county in tons/sq. mile/year

Q = A factor to convert the value of standard from $mg/m^3$ to tons/sq. mile/year

D = Value of standard in $mg/m^3$

b = Background density in tons/sq. mile/year.

The value of conversion factor Q has been calculated to be 107.43 as explained in Appendix C.

2. The above-noted reduction factor is used to calculate the total allowable emissions for the county as follows:

$$E_a = (1 - \frac{\%R}{100})(E_e) \text{ tons}$$

where

$E_a$ = Allowable emissions in tons/year

$E_e$ = Total emissions in 1979.

For example, suppose the total 1979 emissions of the above-noted county are 333,870 tons/year. The allowable emissions then are:

$$(1 - .286) \times 333870 = 238478 \text{ tons} \qquad (2)$$

3. Projected emissions for the years 1982*, 1984*, and 1987* are calculated for area, point, and line source emissions. Area source emissions are assumed to be directly proportional to population, point source emissions are projected using projections for national total manufacturing income (from OBERS and BEA reports) and line source emissions are projected based on the FMVCP-related factors and VMT growth factors based on <u>National Functional System Mileage Travel Summary</u>, U.S. Department of Transportation, 1977. An average VMT growth factor for all counties can also be specified as an option.

4. The total projected emissions for each of the three years 1982, 1984 and 1987 are compared with the allowable emissions. If the projected emissions in 1982, 1984, and 1987 are all less than the allowable emissions, the county data is not analyzed any further. In case the projected emissions in any of the years 1982, 1984, and 1987 are greater than the allowable emissions, the needed reductions for the respective years are calculated as:

   Needed reduction in 1982 (1984, 1987) = Projected emissions in 1982 (1984, 1987) - Allowable emissions.

   The needed reduction is then converted to a percentage of needed reduction using the projected emissions of the corresponding year as the base value. If the projected emissions are less

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*The rationale for considering these three specific years is as follows: The Clean Air Act requires compliance with current levels of CO standards by 1982 and with new stricter standards (if introduced) by 1984. An extension to 1987 is granted, if necessary, provided that suitable inspection and maintenance programs and other control strategies are shown to be included in the state implementation plans.

than the allowable emissions, the needed reductions are assumed to be zero. Considering the above example, suppose the projected total emissions are calculated to be:

| | |
|---|---|
| 1982 | 267,720 tons/year |
| 1984 | 221,010 tons/year |
| 1987 | 168,728 tons/year |

Therefore, the needed reductions are:

1982: 267,720-238,478 = 29,242 tons

The projected emissions in 1984 and 1987 are both less than the allowable emissions, therefore the needed reductions for 1984 and 1987 are assumed to be zero. The needed reduction of 29,242 tons in 1982 is expressed as a percentage of 1982 emissions, i.e.,

$$\text{percentage reduction needed in 1982} = \frac{29,242}{267,720} \times 100 = 11\%$$

5. An I/M program with an appropriate stringency[#] is then selected. Three stringency levels are included in the program, namely 20%, 30% and 40%.[*] Associated with each stringency level is an estimated percentage reduction in CO emissions of the total car population. For example, an I/M program with a 20% stringency, initiated in 1984 in a low altitude area with an ambient temperature of 50°F, is estimated to reduce to CO emissions of the total car population by 13.8%. Factors similar to this are stored in a table for various temperatures,

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[#] Stringency of an I/M program indicates the strictness of the test standards. The stricter the standards the more the percentage of tested cars that will fail the test. Thus, an I/M program characterized by a stringency of 20% means that the test standards are so selective that 20% of the tested cars will fail.

[*] See also the discussions of I/M factors in Section 2.2.

locations and I/M program initiation years. If possible, the smallest of the three stringency factors (i.e., 20%, 30%, and 40%) that produces an overall reduction at least as high as the needed reduction is selected. However, if even the highest of the three stringency factors does not produce the needed reduction, then the highest stringency is selected and a need for additional transportation control measures (TCM) is established.

6. Assuming that a certain stringency factor has been selected, the I/M investment costs, inspection costs and repair costs are calculated for the year 1987, using the projected car population of the country in 1987 and using average unit costs. For example, suppose the projected 1987 car population of a county is 386,956 and the selected stringency factor is 20%. The I/M related costs are then calculated using the following relationships:

   - I/M investment cost = (386,956)(average investment cost per car--$13.21/car)
   - I/M inspection cost = (386,956)(average inspection cost per car--$7/car)
   - I/M repair cost = (386,956)(20/100)(average repair cost per car--$22/car)

7. The expected fuel saving in 1987 due to the implementation of I/M program is also calculated using essentially the following relationship:

   Fuel saving due to I/M = (car population)(stringency factor) (estimated fuel savings per repaired car)

Details of various factors used in the above calculation are presented later in this report. The cost of the fuel saved is also calculated assuming an average price per gallon.

8. If the needed reductions in the future years are less than 5%, this is assumed to be realizable by TCM programs unless an I/M program already exists or is already planned for the county. Also, if an I/M program with the maximum allowable stringency is unable to accomplish the needed reduction, it is assumed that up to 5% additional reduction can be realized through TCM programs. Costs of the TCM program in 1987 are calculated using a relationship of the form:

   TCM costs = (tons reduced by TCM)(cost per ton reduced by TCM)

   Fuel saved by TCM is also calculated using a relationship of the form:

   Fuel saved by TCM = (tons reduced by TCM)(fuel saved per ton of CO reduction by TCM)

   Specific details of the above-noted relationships and the various factors used initially are presented in Section 4 and in Appendix F.

## 3. SOURCES OF INPUT DATA

A brief explanation related to the sources of various input data is presented in this section. Referring first to Table 2.1, the sources of various county related data are as follows.

### 3.1 County-Related Data

- County codes, county names, and state codes--Counties were coded by FIPS codes and appropriate state codes were selected using judgement.
- 1979 area emissions, 1979 point emissions, and 1976 line emissions--were supplied to SRI by EPA based on NEDS emission summary report (NE204, 1979). Line sources include all highway vehicles, i.e., passenger vehicles and trucks of all kinds. Area sources include space heating units, aircrafts, and vessels. Point sources essentially consist of industrial plants and solid waste processes. The 1979 line emissions are calculated by the program using appropriate VMT and FMVCP factors as will be explained later.
- Emission density data--was supplied by EPA in the form of a computer printout. This data contained CO emission density data for almost all the counties in the U.S.A with reference to FIPS codes of the counties. Density data for the counties to be analyzed were taken from this list and stored in the county file. As explained in Section 2, the density data is

used as a design value surrogate to calculate the percentage rollback for those counties that do not have design value data. Appendix C includes technical details of the calculation of surrogate values.

- 1970/1980/1985/1990 populations of appropriate SMSAS/urban areas--were taken essentially from OBERS Projections - Regional Economic Activity in the U.S., 1972, U.S. Water Resources Council, WDC.*
- 1980/1985/1990 population adjustment factors--were derived from Population, Personal Incomes, and Earnings by State - Projections to 2000, October 1977, BEA, U.S. DOC.*
- VMT growth factors--were supplied by EPA, based on National Functional System Mileage Travel Summary, U.S. Department of Transportation, 1977. A copy of the original table is included in Appendix D for convenience. Where a VMT growth factor was unavailable, a 3% growth rate was assumed.
- 1977 passenger car count--was obtained for each county, based on passenger-car registrations, from the 1979 Commercial Atlas and Marketing Guide published by Rand McNally and Company.
- Design values--An initial set of design values corresponding to existing standards was supplied by EPA, based on a validated SAROAD data base. The design values as they exist now in county files are based essentially on the initial set of values, supplemented and modified to some extent during the course of the project as more reliable data became available to EPA. There are still several

*Note: Refer also to the memo, "Uniform Growth Projections for NAAQS Economic Impact Assessments," dated January 9, 1979, from Jack McGinnity to Joseph Padget, Director, Strategies and Air Standards Division.

design values unavailable for many counties. However, the county file has provision for entering the missing design values when they become available. The program is designed to use the emission density data in place of missing design values to calculate the needed reductions (rollbacks) as explained in Section 2 and Appendix C.

- Temperature--Temperatures associated with each county were selected by SRI in consultation with EPA. The value used is the mean monthly average temperature for January rounded to the nearest ten degrees.
- Location code--The location codes, i.e., low altitude, high altitude and California, were assigned to the counties in consultation with EPA. Actual codes used in the county file are 1 for low altitude, 2 for high and 3 for California.
- Background concentration level--The background levels for all counties have been assumed to be zero for initial analysis. However, there is provision to change them to suitable nonzero values.
- Codes indicating the status of I/M programs in county and states--were inferred from a list received from EPA on the status of I/M as of May 1979 ("Inspection/Maintenance Status Sheets," EPA, Ann Arbor, Michigan, May 29, 1979.) This list indicated the counties belonging to various urban areas, updated design values related to 8-hour second high standard, and gave the status of I/M programs in various counties and states. A consolidated version of this list including information related to the status of I/M programs is included in Appendix A. This appendix also contains information about urban areas

based on a report by Bureau of the Census.*

- Urbanized area code--As mentioned above, a list of the urbanized area names and counties belonging to each of the urban areas is included in Appendix A. The program is designed to calculate the needed CO reductions and the I/M cost not only on a county basis but also to estimate the CO reduction and I/M costs for various urban areas. This is needed since I/M programs will generally be implemented on an urban basis rather than on a county basis.

## 3.2 Input Data Applicable to All Counties

- FMVCP factors--The FMVCP factors as stored in the program are compounded annual percentage reductions in CO emission due to FMVCP, considering all modes. These FMVCP factors were developed by SRI using the MOBILE 1 program for temperatures through 80° in 10-degree increments for three locations, i.e., low altitude, high altitude and California. (Note: A temperature of 75° is also considered in the interval 70° and 80°.) Other assumptions related to MOBILE 1 are:

Mode Mix: Light-Duty Vehicles (LDV) - 80.3%

Light-Duty Trucks (LDT1) (<6000 lbs) - 5.8%

Light-Duty Trucks (LDT2) (6001-8500 lbs) - 5.8%

Heavy-Duty Gas Trucks (HDG) - 4.5%

Heavy-Duty Diesel Trucks (HDD) - 3.1%

Motorcycles (MC) - 0.5%

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*Bureau of the Census, Population and Land Area of Urbanized Areas for the United States: 1970 and 1960, Washington, U.S. Department of Commerce, 1979.

Average Speed: 19.6 mph.

Cold Start: 20.6%

Hot Start: 27.3%

CO Emissions Standard in 1981 and later LDV: 3.4 gms/mile

The above assumptions are in line with the set of assumptions in Appendix F of the EPA report, "Mobile Source Emissions Factors; Final Document," (EPA-400/9-78-005), March 1978. FMVCP annual reduction factors were developed for the four periods: 1976-1979, 1979-1982, 1982-1984, and 1984-1987. Although the validity of MOBILE 1- generated factors for 1979 and later years is not yet established, these were used as a best estimate. This aspect and a discussion of the CO emissions versus ambient temperature relationship is presented in Appendix E.

The following example is presented to explain the specific method to develop the annual reduction factors from the output of MOBILE 1 program. According to the output of MOBILE 1 program, the average fleetwide CO emissions per mile, considering all modes, for a temperature of 0°F and a low altitude region is:

119.67 gms/mile in 1976

111.94 gms/mile in 1979

84.98 gms/mile in 1982

66.49 gms/mile in 1984

46.16 gms/mile in 1987.

To develop the compounded annual reduction factor for the period 1976-1979, first calculate the ratio:

$$\frac{\text{Emissions/mile in 1979}}{\text{Emissions/mile in 1976}} = \frac{111.94}{119.67} = 0.93532$$

The period 1976-1979 spans 3 years, therefore calculate:

$$(0.93532)^{1/3} = 0.978$$

Then the compounded annual reduction factor for the period 1976-1979 (for temperature $0^o$ F, region low altitude) is calculated as:

$$1 - 0.978 = 0.022$$

The value 0.022 is the value that is stored in a table of of FMVCP factors included in the program. Factors for other temperatures, regions and time period were calculated in a similar manner and were stored in a table. Considering the fact that there are 10 values of temperatures (including 75°), 3 regions and 4 periods of time, there are 10x3x4 = 120 reduction factors stored in the FMVCP factor table. The FMVCP reduction factors are used in combination with VMT growth factors to estimate the projected line emissions for future years. For example, the 1979 line emissions for a county with 0° F temperature in low altitude with, say, an annual VMT growth factor of 2.8% is calculated as:

$$\text{1979 Line Emissions} = (\text{1976 line emissions}) \times (1+.028-.022)^3$$

It is to be noted that 1976 line emissions and VMT growth factors are available from the county file. Line emission calculations for other years are made in a similar manner.

• I/M Effectiveness Factors--The following example will be useful in explaining the meaning of I/M effectiveness factors as stored in the program:

Suppose the average CO emissions/mile in 1987 as given by MOBILE 1, considering only the FMVCP program, is 46.16 gms/mile (see example above). Suppose also that the average CO emissions/mile in 1987 as given by MOBILE 1, considering an I/M program with a stringency factor of 20% initiated in 1982, in addition to FMVCP, is 36.18. Then the ratio 36.18/46.18 = 0.784 is defined as the I/M effectiveness factor for a program with 20% stringency factor and initiated in 1982. Factors calculated in the above manner are stored in the I/M effectiveness table.

The I/M factors were developed by SRI using the MOBILE 1 program assuming no mechanics training and with other assumptions similar to those for MOBILE 1 runs for FMVCP factors. Also, the I/M programs were assumed to be applicable to light-duty vehicles only. Three locations, i.e., low altitude, high altitude and California, were considered. The temperature increments were in 10° as for FMVCP calculations (including 75°F). Three stringency levels, i.e., 20%, 30%, and 40%, and 5 time periods were considered, namely:

| I/M started in | Consider the effect in |
|---|---|
| 1982 | 1984 |
| 1982 | 1987 |
| 1983 | 1984 |
| 1983 | 1987 |
| 1984 | 1987. |

Thus, a total of: 3x10x3x5 = 450 I/M factors are stored in the program. Presently, only the factors associated with consideration of effects in 1987 are being used.

- Correction Factors for 1976 Line Emissions

The 1976 line emission values provided by EPA were based on a constant ambient temperature of 75°F. In order to make these values more realistic in terms of the effect of temperature, it was necessary to adjust these emissions corresponding to the county temperatures used for each county. Therefore, a table of correction factors was developed by SRI using the results of MOBILE 1 program. The following example explains how the correction factor was developed and used. Consider, a low altitude region. The 1976 CO emissions for various temperatures as given by MOBILE 1 are:

| Temperature, °F | Emissions, gms/mile |
|---|---|
| 0 | 119.67 |
| 10 | 109.30 |
| : | : |
| : | : |
| 50 | 83.11 |
| 75 | 74.32 |
| 80 | 72.98 |

The correction factor for a county with 0° F temperature will be $\frac{119.67}{74.32} = 1.610$, i.e., the 1976 line emissions of this county, as originally provided by EPA, must be multiplied by 1.610 to get more realistic line emissions in 1976. Corrections factors for other temperatures and regions were calculated similarly and are stored in a table. With 3 regions and 10 levels of temperature, there are a total of 3x10=30 correction factors included in this correction table.

## 3.3 Input Data Related to Costs and Fuel Savings

- I/M-related costs and fuel savings--The following initial unit costs and fuel-saving factors were developed jointly by SRI and EPA, in consultation with the Inspection and Maintenance Staff, Emission Control Technology Division, EPA, Ann Arbor, Michigan. An explanation of the background and methodology to develop these cost factors is included in Appendix F.

| | |
|---|---|
| - Investment costs (capital costs) | = $13.21/car |
| - Inspection costs | = $ 7.00/car |
| - Repair costs | = $22.00/car |
| - Fuel Savings: (two cases) | = a) no fuel savings<br>b) no fuel savings in pre-1981 cars;<br>7.5% saving/repaired car at 20% stringency (1981 and post-1981 cars);<br>6% saving/repaired car at 30% stringency (1981 and post-1981 cars);<br>4.5% saving/repaired car at 40% stringency (1981 and post-1981 cars) |

- Percent of 1981 and post 1981 cars in the year 1987 = 78.1%

- Average yearly gas consumption = 430 gallons/car in 1987

The above-noted cost and gasoline-related factors can be changed without much difficulty if more accurate data becomes available.

- <u>TCM-Related Costs and Fuel-Savings</u>--As was the case with I/M costs and fuel savings, the following TCM-related initial costs and fuel-saving factors were developed jointly by SRI and EPA. An explanation of the background and methodology to develop these cost factors is included in Appendix F.

  - Maximum realizable reduction due to TCM = 5%.
  - The first 3% or less achievable, using localized TCM measures such as signal-timing optimatization, at an average cost of $170/ton of CO reduction.
  - Another 1% or less achievable, using areawide TCM measures such as ride-sharing, at an average cost of $400/ton reduction.
  - The last 1% or less achievable, using areawide TCM measures such as public transit improvements, at an average cost of $9200/ton reduction.
  - Fuel savings due to TCM is assumed to be 1088 gallons per ton of CO reduction.

  The above-noted percentages and cost factors can be changed easily if more reliable data becomes available.

- <u>Gasoline Cost</u>--has been assumed to be $1.00 per gallon using 1979 as the reference year. Again, this value can be easily changed if so desired.

# 4. SPECIFIC ASSUMPTIONS AND CALCULATION PROCEDURES

Specific assumptions and methods of calculations are explained in this section with references to a sample output for a county and a summary report.

## 4.1 County-Related Analysis

First consider a sample output for Los Angeles County shown in Figure 4.1. This output presents the analysis of Los Angeles County with reference to 8-hour daily maximum standard of 10 $mg/m^3$ (9ppm). Assumptions and procedures to produce various numerical results and statements are explained below:

- FIPS Code "06037", county name "Los Angeles", state code "CA"--are reproduced from the county file.
- Region "California", temperature "50$^{o}$degrees, design value "27.9"--are reproduced from the county file.
- Rollback=64 --is calculated by the program using the relationship:

$$\text{Rollback} = \frac{\text{Design Value - Value of Standard}}{\text{Design Value - Background level}} \times 100$$

$$= \frac{27.9 - 10}{27.9 - 0} \times 100 = 64$$

In this particular run, the background value of the county in the county file was zero and the user did not specify any general background value either. As such, the program assumed the background level to be zero.

```
06037          LOS ANGELES    , CA                                                              09/06/79  PAGE    9
                                                                     MAX STRINGENCY : 30%
ANALYSIS FOR 8-HOUR DAILY MAXIMUM OF 10 MG/M3 (9 PPM).               VMT ANNUAL GROWTH RATE :  1.20 %
                                                                     ANNUAL AREA EMISSION GROWTH RATE BASED ON POPULATION
CALIFORNIA     50 DEGREES                                            EFFECTIVENESS :  20% AREA,   0% POINT, 100% LINE
                                                                     MOBIL 1 THRESHHOLD TEMP :     DEGREES, FACTOR :  1.0
STANDARD =     10     DESIGN VALUE =      27.9     ROLLBACK =  64

MOBILE SOURCE PROBLEM IN           1982
MOBILE SOURCE PROBLEM IN           1984
MOBILE SOURCE PROBLEM IN           1987

EMISSIONS <--------------------- ACTUAL --------------->     <------------------ EFFECTIVE -------------->
             AREA      POINT       LINE       TOTAL % REDUCTION        AREA      POINT    LINE        TOTAL % REDUCTION
   1979    239,281   20,891   2,832,566   3,092,738                 47,856        0   2,832,566   2,880,422
   1982    245,926   22,932   2,220,101   2,498,959      20         49,185        0   2,220,101   2,260,286      21
   1984    249,697   24,239   1,858,724   2,132,661      31         49,939        0   1,853,724   1,908,664      34
   1987    255,454   26,145   1,519,322   1,800,922      42         51,090        0   1,510,322   1,570,413      45

TOTAL ALLOWABLE EMISSIONS :  1,032,499

NEEDED
REDUCTIONS        TOTAL                                       LINE %
1982          1,236,877                                        55.7
1984            876,254                                        47.1
1987            538,003                                        35.4

I/M          AUTOMOBILES         STRINGENCY  TONS REDUCED      TONS %  I/M PROGRAM START
1987          6,012,535             30          309,941         20.3      1982

ESTIMATED INITIAL I/M INVESTMENT COST = $39,712,795

I/M COSTS     INSPECTION        REPAIR        TOTAL                      FUEL SAVED     $ VALUE     NET I/M COST
1987          21,043,873     19,841,366    40,885,239                    18,172,707   18,172,707    22,712,532

LOCAL TCM      TONS REDUCED   % REDUCED     ANNUAL COSTS  AREA TCM      TONS REDUCED  % REDUCED      ANNUAL COSTS
1987               45,579         3.0        7,748,543    1987              30,386         2.0     148,893,580

TCM FUEL SAVINGS              FUEL SAVED      $ VALUE    NET TCM COST   TOTAL TONS  NET TOTAL COST          REMAINING NEEDED REDUCTION
             1987             82,651,130    82,651,130    73,990,993      385,907    96,703,526                 10%       152,095 TONS
```

FIGURE 4.1 SAMPLE OF ANALYSIS RESULTS FOR LOS ANGELES COUNTY

- Maximum stringency: 30%, VMT annual growth rate: 1.20% MOBILE 1 threshold temperature: degrees, factor: 1.0--are general input parameters (not county-specific) specified by the user for this particular run and are reprinted for convenient reference. The specific calculations where these input parameters are used are discussed below.
- Mobile Source Problem in 1982, 1984, and 1987--These statements are established after certain analyses are completed as discussed below.
- Actual Emissions 1979--The actual 1979 area and point emissions are reproduced from the county file. However, the 1979 line emissions are calculated by the program using the 1976 line emissions that are available in the county file as follows:

  1979 Line Emissions = (1976 Line Emissions) x (temperature correction factor) x (1 + VMT growth factor - FMVCP reduction Factor)$^3$.

  The VMT growth factor in this particular run was externally specified by the user to be 1.2%. Therefore the VMT growth factor in the county file is disregarded and the value specified by the user is used. The FMVCP factor is selected from the FMVCP factor table corresponding to 50°, California region, and 1976/1979 time period. The temperature correction factor is also suitably selected from the correction factor table. For this particular run:

  1976 Line Emission for Los Angeles = 3,126,330 tons (from county file)

Temperature Correction Factor = 1.112 (from correction factor table)

VMT Growth Factor = .012 (specified by user)

FMVCP Reduction Factor = 0.078 (from FMVCP factor table)

∴ 1979 Line Emissions = 3126330 x 1.112 x $(1 + .012 - .078)^3$= 2,832,566 tons.

- Actual Emissions 1982, 1984 and 1987

- Area Emissions. If the user specifies a general (not county-specific) yearly area emission growth rate, say x%, then the area emissions for 1982, 1984 and 1987 are calculated as follows:

$$1982 \text{ Area Emissions} = (1979 \text{ Area Emissions}) \times [(100 + x)/100]^3$$

$$1984 \text{ Area Emissions} = (1982 \text{ Area Emissions}) \times [(100 + x)/100]^2$$

$$1987 \text{ Area Emissions} = (1984 \text{ Area Emissions}) \times [(100 + x)/100]^3$$

However, if the user does not specify any growth rate, the program uses a default formula based on population as follows:

$$1982 \text{ Area Emissions} = (1979 \text{ Area Emissions}) \left(\frac{1982 \text{ population}}{1979 \text{ population}}\right)$$

Similarly, calculations are performed for 1984 and 1987 emissions. The 1979, 1982, 1984 and 1987 population is calculated internally by referring to the population of 1970, 1980, 1985, and 1990, which is available in the county file. For example:

$$1979 \text{ population} = (1970 \text{ population}) \times \left(\frac{1980 \text{ population}}{1970 \text{ population}}\right)^{9/10}$$

$$1982 \text{ population} = (1980 \text{ population}) \times \left(\frac{1985 \text{ population}}{1980 \text{ population}}\right)^{2/5}$$

and so on.

In the sample output the future area source emissions are population proportional as indicated on the upper right corner.

-<u>Point Emissions</u>. If the user has not specified any point emission growth factor, then the future year point emissions are calculated as follows:

1982 point emissions = 1979 point emissions x 1.0977

1984 point emissions = 1979 point emissions x 1.1603

1987 point emissions = 1979 point emissions x 1.2515

The factors 1.0977, 1.1603 and 1.2515 were developed by SRI based on projected national total manufacturing income. The user may specify other suitable values.

-<u>Line Emissions</u>. The line emissions for 1982, 1984, and 1987 are calculated in a manner similar to that explained above with reference to 1979 emissions. However, the temperature correction factor is not used for 1982, 1984, or 1987 calculations because the base emissions used for calculations for 1982 and other future years is that of 1979, which is already a corrected value for temperatures. For example:

$$1982 \text{ Line Emissions} = (1979 \text{ line emissions}) \times (1 + \text{VMT growth factor} - \text{reduction factor})^3$$

and so on.

- <u>Actual Percent Reductions</u>--These are calculated by subtracting the total 1982, 1984 and 1987 emissions from the total 1979 emissions and expressing it as a percentage of 1979 emissions.

- Effective Emissions--The various emission sources differ in effectiveness in producing the CO concentrations recorded at monitoring locations. For example, only 20% of the total area source emissions might be the real contributor to the CO concentration levels in the urban areas since area emission sources are scattered over a large area. Similarly, point source emissions are usually located away from urban areas and their emissions are contained in a small area. Thus, for urban CO concentration levels the contribution from point source emissions may be negligible. On the other hand, the line emissions contribute directly to urban CO concentrations. The program is designed to provide the flexibility to the user in choosing different effectiveness factors for different emission sources. In the example printout the user had specified a 20% effectiveness factor for area source emissions, a 0% effectiveness factor for point emissions and a 100% effectiveness for line emissions. (See the statements on upper right corner of Figure 4.1.) Thus, the effective area source emissions are obtained by multiplying the actual emissions by a factor 0.2. The effective point emissions are all zero since effectiveness is 0. The line emissions are the same as actual because the effectiveness factor is 100%. The effective total emissions are the summation of effective area, point, and line emissions.

- Effective Percent Reductions--These are calculated in the same manner as actual percent reductions except that emission values are effective values.

- Total Allowable Emissions--These are calculated using the effective emissions of 1979 and the needed rollback as follows:

  (Total Effectiveness Emissions in 1979) x (1 - rollback expressed as a fraction)

  In the sample output: Allowable Emissions = 2,880,422 x

  $$\left[1 - \frac{(27.9) - 10}{27.9}\right] = 1{,}032{,}409 \text{ tons.}$$

- Needed Reductions--These are calculated as follows:

  Needed Reductions 1982 = (Effective Total Emissions in 1982) - (Total Allowable Emissions)

  In the sample output: Needed 1982 reduction = 2,269,286 - 1,032,409= 1,236,877. Similar calculations are made for 1984 and 1987.

- Percent Line Reductions--It is assumed that the burden of reduction will be borne by line sources (i.e., automobiles). Thus, the needed percent reductions are calculated as a percent of effective line emissions in respective years. For example, in the sample output the 1982 line emissions are 2,220,101 and the needed reduction in 1982 is 1,236,877. Therefore, the percent line reduction needed is

  $$\frac{1{,}236{,}877}{2{,}220{,}101} \times 100 = 55.7\%.$$

  Similar calculations are made for other years.

- I/M 1987 Automobiles--The county car count of 1977 is available in the county file. It is assumed that the car count is linearly proportional to population. Thus, 1987 car count is calculated as:

$$\text{1987 car count} = \text{(1977 car count)} \times \frac{\text{(1987 population)}}{\text{(1977 population)}}$$

- 1987 Stringency, Tons Reduced, Tons Percentage, I/M Program Start--If an area cannot attain standards by 1982 (or 1984)*, the Clean Air Act (CAA) requires implementation of an I/M program to get an extension to 1987. This is the case even if the FMVCP alone is sufficient in 1987, though this affects the stringency of the I/M program. With the above-noted background, the logic of the program associated with these results is as follows:

  Case 1. The needed percent reductions in 1982/1984* are less than or equal to 5%.

  If the needed reductions in 1982/1984* are less than or equal to 5% and if the county already has an I/M program (see the discussion on I/M status code in Section 2), then the starting year of the I/M program is selected as 1982 and the stringency selected is 20%. The percent reduced (which is actually the percent reduction obtained by an I/M program) is obtained from the 1982-1987 I/M effectiveness factor table. The tons reduced by the I/M program are calculated by applying the above-noted percent to the line emissions of 1987. If there is no existing I/M program, the needed reductions are assumed to be accomplished through TCM.

*1982 for 1-hour 40 mg/m$^3$, 8-hour 10 mg/m$^3$, and 8-hour 14 mg/m$^3$ standards; 1984 for other standards.

Case 2. The needed percent reductions in 1982/1984 are greater than 5%.

If the needed percent reductions in 1982/1984 are greater than 5% and the county already has an I/M program, then the starting year of the I/M program is selected as before to be 1982. However, the selection of stringency is made on the basis of the percent reduction needed in 1987. If the needed percent reduction in 1987 is more than can be accomplished by an I/M program initiated in 1982 with maximum-allowable stringency, then the maximum-allowable stringency value is selected, and the still-remaining needed reduction is passed over to TCM. However, if the needed percent reduction can be accomplished with allowable levels of stringencies, then the smallest stringency that produces at least as much reduction as is needed is selected. If the county does not currently have an I/M program planned, but the state has one, then the I/M initiation year is selected to be 1983. If no plans for an I/M program currently exist, then the initiation year is assumed to be 1984. Other logic and procedures are the same as discussed above.

In the sample output, the needed reduction in 1982 is 55.7%, which is greater than 5%, i.e., Case 2 holds. The Los Angeles County has plans for an I/M program (see Appendix A). Therefore, I/M initiation year is 1982. The reduction needed in 1987 is 35.4%. The maximum-allowable stringency for this run is 30% (see the remarks in the upper right of Figure 4.1). The percent reduction accomplished by 30% stringency is 20.3% (obtained from I/M effectiveness table) which is not sufficient. Therefore, the program selected the maximum-allowable stringency level of 30% since that is the highest allowable. Tons reduced are then calculated as:

= (1-I/M effectiveness factor) (Line Emissions in 1987)

= (1-0.796) (1,519,322) = 0.2204 x 1,519,322 = 309,941

The factor 0.796 is obtained from the I/M effectiveness factor table corresponding to 50°, California region, and 1982-1987 period. The tons % value of 20.3 is the ratio: $\frac{\text{Tons Reduced}}{\text{1987 line emissions}}$ x 100 which theoretically should be the same as: (1-0.796) x 100 = 20.4 (or 20.3 due to rounding).

- Estimated Initial I/M Investment Costs--These costs are calculated by multiplying the number of 1987 cars by the average value of I/M investment cost per car. I/M programs are planned for initiation in 1982 for both CO and $O_3$ as shown in Appendix A. As such, only one-half of the I/M costs are generally assigned to CO, and the rest are assumed to be for other pollutants. For I/M programs required to be initiated in 1983 or 1984, it is not yet certain whether these will be combined with other pollutants or not. As such, full I/M costs are assigned to CO for these programs. In the sample output for Los Angeles, the average investment cost per car is assumed to be $13.21 and the I/M program is assumed to start in 1982. Therefore, the I/M investment cost assigned to CO is:

6,012,535 x 13.21 x 1/2 = $39,712,795

- I/M Inspection and Repair costs--The inspection costs are calculated by multiplying the 1987 car count by the average value of I/M inspection cost per car. The repair cost is calculated by multiplying the number of repaired cars by the average repair cost/car. As was the case with investment costs, full inspection and repair costs are assigned to CO if the I/M program is initated in 1983 or 1984 and only half of the total inspection and repair cost are assigned to CO if the I/M program starts in 1982. In the sample output, the average inspection and repair costs were assumed to be $7 and $22 per car respectively, Therefore:

  Inspection cost = 6,012,535 x 7 x 1/2 = $21,043,873

  Repair cost = 6,012,535 x 0.3 x 22 x 1/2 = $19,841,366

  The number under the term "total" is the sum of inspection and repair costs.

- I/M Fuel Saved, $ Value and Net I/M Cost--

  I/M fuel savings are calculated assuming that 1) no fuel saving benefits occur in pre-1981 cars, 2) in 1981 and post-1981 cars the fuel savings is assumed to be 7.5% per repaired vehicle for 20% stringency factor, 6% per repaired vehicle for 30% stringency factor, and 4.5% for repaired vehicle for 40% stringency factor. The fraction of 1981 and post-1981 cars in the year 1987 was calculated to be 0.781. Thus:

  Fuel saving = (0.781) (1987 car count) x (average yearly gasoline consumption per car) x (stringency) x (fuel savings/repaired vehicle)

Average yearly gasoline consumption in 1987 is assumed to be 430 gallons/car and the average cost of gasoline is assumed to be $1.00/gallon as discussed in Appendix F. For I/M programs started in 1982, only one-half of the fuel savings and costs are assigned to CO. In the sample output, the stringency factor is 30% and the I/M program starts in 1982. Therefore:

Fuel saved = (0.781) x (6,012,535) x (430) x (.06 x 0.3) x 1/2 = 18,172,707 gallons

$Value = $18,172,707

The net I/M costs = (total inspection and repair costs) - (cost of fuel saved due to I/M)

= 40,885,239 - 18,172,707 = $22,712,532

- TCM Costs, Fuel Savings and Fuel Costs--When percent reductions needed in 1982* (or 1984)* are either less than or equal to 5%, and when the county or the state does not have an existing I/M program, or when an I/M program cannot fully accomplish needed reductions, then a maximum of 5% emission reduction from TCM is assumed to be available. If the county has an existing I/M program, then even this 5% or less reduction is accomplished with the I/M program initiated in 1982 with a stringency factor of 20%. Up to 3% reduction is assumed to be available through local TCM strategies at a cost of $170/ton of CO reduction. Another 1% at $400/ton of CO reduction and finally the last 1% at $9,400/ton is assumed available due to areawide TCMs. These percentages and unit costs can, however

*1982 for 1-hour 40 $mg/m^3$, 8-hour 10 $mg/m^3$ and 8-hour 14 $mg/m^3$ standards; 1984 for other standards.

be easily changed since these are used as parameters.

Fuel savings due to TCM are calculated at a rate of 1088 gallons/ton of CO reduction. Also, refer to Appendix F for further explanation. Cost of fuel saved is calculated using an average value of $1.00/gallon though this unit cost can be easily changed.

In the example printout, the needed percent reduction of CO in 1987 is 35.4%. An I/M program using the maximum allowable stringency of 30% can accomplish a reduction of 20.3% only. Therefore, an additional reduction of 5% by local and areawide TCM was selected. Specifically:

Tons Reduced by Local TCM = .03 x 1,51',322 = 45,579 tons

Annual cost of Local TCM = 45,579 x $170 = $7,748,543

Tons Reduced by areawide TCM = (.01 x 1,519,322) + (.01 x 1,519,322)

= 15,193 + 15,193 = 30,386 tons.

Annual Cost of areawide TCM = (15,193 x 400) + (15,193 x $9,400))

= $148,893,580

TCM Fuel Savings = (45,579 + 30,386) x (1,088) = 82,651,130 gallons.

$ Value of fuel savings @ $1.00/gallon = $82,651,130

Net TCM Cost = TCM Costs - Cost of fuel saved due to TCM

= $7,748,543 + $148,893,580 - $82,651,130

= $73,990,993

- Total Tons and Net Total Costs

Total tons indicate the sum of CO reductions from both I/M and TCM programs. Net total costs indicate the sum of net I/M costs and net TCM costs. In the example output results were:

Total tons = (309,941) + (45,579 + 30,386) = 385,907 tons

Net total = $22,712,532 + $73,990,993 = $96,703,526

- Remaining Needed Reductions

These are calculated as:

Remaining percent = (Needed percent reduction in 1987) - (Total percent reductions due to I/M plus TCM)

In the sample printout,

Remaining percent = 35.4 - 20.3 - 5 = 10%

The remaining reduction in tons = (Needed reduction in 1987 in tons) - (Total reduction in tons due to I/M and TCM)

= 538,003 - 385,907 = 153,095 tons

- Miscellaneous

1. The statements "Mobil source problem in 1982, 1984, etc." are printed on the basis of percent reduction accomplished considering only the FMVCP effects in combination with VMT growth factors. Referring to the sample output, it is seen that the effective percent reductions in 1982, 1984 and 1987 are 21%, 34% and 45% respectively. These are all less than the needed rollback percentage of 64%. Therefore, it is stated that in all these 3 years, there is a mobile source problem meaning that FMVCP is not sufficient to reduce CO emissions to the degree needed. In case the effective percent reductions are more than or equal to needed rollback percentage, a statement such as "FMVCP sufficient in 1984" is printed. However, even if FMVCP is sufficient in 1984 or 1987, an I/M program is still initiated because of CAA requirements

to obtain an extension from 1982 to 1987.

2. Threshold Temperature and Factor--As discussed in some detail in Appendix E, it is believed that I/M programs imposed in cold areas (defined as average temperature below 50°F) will be less effective in reducing total emissions than presently modeled by MOBILE 1. As temperature decreases, the emission during warm-up of the vehicle increases. As a result, the overall emissions in cold areas may not be reducible due to I/M to the extent assumed in MOBILE 1. Keeping the above-noted facts in view and in order to provide some flexibility in adjusting the I/M effectiveness factors based on test results and engineering judgement, two parameters have been provided in the program, namely a "threshold temperature value" and a "fraction". If, for example, the user specifies a threshold temperature of 50° and a factor of 0.5, then for all counties whose temperatures are less than 50° (i.e., 40°, 30° ...), the I/M effectiveness will be assumed to be 0.5 times that given by MOBILE 1. For temperatures greater than or equal to 50°, the I/M factors will not be changed.

In the example printout, the user has not specified any threshold temperature. In such a case, the program uses the I/M effectiveness factors, as given by MOBILE 1 without any adjustments.

## 4.2 Urban Area-Related Analysis and Summary Reports

Some additional analyses related to prespecified urban areas and analyses related to some useful summary tables are performed by an additional program that uses the results of the county analyses program. An explanation of the procedures and assumptions related to this additional program is presented below with reference to typical sample output results.

### 4.2.1 Urban Area-Related Analyses

A list of specified urbanized areas and the names of counties belonging to each of the urban areas is shown in Appendix A. The general logic of urban area analyses is as follows.

If any county of an urbanized area needs an I/M program, the I/M program is assumed to be implemented in the entire urban area. The I/M costs are calculated using the sum of the vehicle population of all the counties included in the urban area. The stringency factor used is that of the county in the urbanized area with the highest stringency factor. If more than one county has the same highest stringency factor, then the first in the list is used as reference.

Referring to Figure 4.2, which show a typical output for an urban area analysis, the various numerical results are calculated as follows:

- Automobiles-- The projected 1987 car count of all counties included in the area is summed and printed in this column.
- Stringency--If more than one county of the urban area is in violation then the county using an I/M with the highest stringency factor is selected as the reference county. If only one county is in violation then the I/M stringency of this one county is used for the entire urban area. In this particular case only the San Francisco county was in violation of the standard and

*** STANDARD : 1-HOUR STATISTICAL STANDARD OF 17 MG/M3 (15 PPM). RUN # 2 09/17/79 PAGE 7

| | URBANIZED AREA* | AUTOMOBILES | STRIN-GENCY (%) | INSPECTION ($) | REPAIR ($) | TOTAL ($) | URBAN REDUCTION (TONS) | I/M FUEL SAVED (GALLONS) | VALUE ($) | NET COST ($) |
|---|---|---|---|---|---|---|---|---|---|---|
| 01 | | 2,882,900 | 30 | 10,090,150 | 9,513,570 | 19,603,720 | 112,166 | 8,713,478 | 8,713,478 | 10,890,241 |
| 02 | | 7,573,470 | 30 | 26,507,145 | 24,992,451 | 51,499,596 | 331,245 | 22,890,585 | 22,890,585 | 28,609,010 |
| 05 | | 1,111,985 | 20 | 3,891,947 | 2,446,367 | 6,338,314 | 115,377 | 2,800,784 | 2,800,784 | 3,537,530 |
| 07 | | 1,062,765 | 20 | 7,439,355 | 4,676,166 | 12,115,521 | 18,181 | 5,353,625 | 5,353,625 | 6,761,895 |
| 08 | | 990,946 | 20 | 3,468,311 | 2,180,081 | 5,648,392 | 88,411 | 2,495,920 | 2,495,920 | 3,152,471 |
| 09 | | 3,409,320 | 20 | 11,932,620 | 7,500,504 | 19,433,124 | 336,543 | 8,587,139 | 8,587,139 | 10,845,984 |
| 15 | | 518,910 | 20 | 1,815,835 | 1,141,382 | 2,957,217 | 37,438 | 1,306,739 | 1,306,739 | 1,650,477 |
| 17 | | 1,783,484 | 30 | 6,242,194 | 5,885,497 | 12,127,691 | 202,579 | 5,390,526 | 5,390,526 | 6,737,164 |
| 21 | | 1,098,743 | 20 | 7,688,401 | 4,832,709 | 12,521,110 | 95,466 | 5,532,847 | 5,532,847 | 6,988,262 |
| 25 | | 721,598 | 20 | 2,525,593 | 1,587,515 | 4,113,108 | 185,704 | 1,817,506 | 1,817,506 | 2,295,601 |
| 26 | | 339,402 | 20 | 2,375,814 | 1,493,368 | 3,869,182 | 27,316 | 1,709,720 | 1,709,720 | 2,159,462 |
| 27 | | 7,103,774 | 30 | 24,863,209 | 23,442,454 | 48,305,663 | 619,964 | 21,470,943 | 21,470,943 | 26,834,719 |
| 30 | | 1,139,718 | 20 | 3,989,013 | 2,507,379 | 6,496,392 | 63,119 | 2,870,636 | 2,870,636 | 3,625,756 |
| 33 | | 79,834 | 30 | 558,838 | 526,904 | 1,085,742 | 5,489 | 482,591 | 482,591 | 603,150 |
| 35 | | 645,960 | 20 | 4,521,720 | 2,842,224 | 7,363,944 | 32,223 | 3,253,991 | 3,253,991 | 4,109,952 |
| 36 | | 430,916 | 20 | 3,016,412 | 1,896,030 | 4,912,442 | 25,968 | 2,170,717 | 2,170,717 | 2,741,724 |
| 37 | | 587,276 | 20 | 4,110,932 | 2,584,014 | 6,694,946 | 25,175 | 2,958,373 | 2,958,373 | 3,736,572 |
| 38 | | 934,711 | 20 | 3,271,488 | 2,056,364 | 5,327,852 | 69,368 | 2,354,279 | 2,354,279 | 2,973,572 |
| 39 | | 1,728,101 | 20 | 6,048,353 | 3,801,822 | 9,850,175 | 135,270 | 4,352,611 | 4,352,611 | 5,497,564 |
| 41 | | 1,015,903 | 20 | 3,555,660 | 2,234,986 | 5,790,647 | 103,171 | 2,558,780 | 2,558,780 | 3,231,866 |
| 42 | | 332,416 | 20 | 1,163,456 | 731,315 | 1,894,771 | 22,244 | 837,264 | 837,264 | 1,057,506 |
| 46 | | 412,801 | 20 | 1,444,803 | 908,162 | 2,352,965 | 48,349 | 1,039,732 | 1,039,732 | 1,313,233 |
| 49 | | 346,800 | 20 | 1,213,800 | 762,960 | 1,976,760 | 32,048 | 873,493 | 873,493 | 1,103,266 |
| 50 | | 1,156,712 | 20 | 4,046,742 | 2,543,666 | 6,590,408 | 93,551 | 2,912,180 | 2,912,180 | 3,678,228 |
| URBAN SUBTOTALS | | 37,407,445 | | 145,781,791 | 113,087,890 | 258,869,681 | 2,866,665 | 114,734,459 | 114,734,459 | 144,135,205 |

FIGURE 4.2 SAMPLE OF URBAN AREA I/M ANALYSIS TABLE

*Names of actual urban areas have been intentionally blocked out because this table is to be treated purely as an example output.

an I/M with 30% stringency was selected for the county. Therefore, the stringency used for the entire urban area is 30%.

- I/M Inspection & Repair Costs; Fuel Savings & Fuel Costs
The I/M inspection and repair costs as well as fuel savings and fuel costs for the urban areas are calculated using the same relationships as are used for counties, except that the car count used is that for an urban area instead of a county car count. Also, for areas with current plans for I/M programs, only half of the inspection and repair costs and fuel savings are assigned to CO. However, full costs and full fuel savings are assigned to CO for any urban area which does not have current plans for I/M programs.

- Urban Reduction (tons)--The urban CO reductions should theoretically be the summation of the CO reductions in the counties constituting the urban area. However, out of the 272 counties included in the county file, only 220 counties have design values and 1979 CO emission data. The data associated with the remaining 52 counties consists only of the car count in 1977 and the populations of the SMSAs or urban areas associated with these counties for the years 1970, 1980, 1985, and 1990. As such, the CO emissions and reductions in future years for these 52 counties is not calculable by the program. However, a reasonable estimate can be made by assuming that CO emissions of a county are roughly proportional to the car count of that county. This is the basic assumption that has been used to calculate the urban reductions. Specifically, the following formula has been used:

$$\text{Urban Reduction} = \frac{\text{(Urban Car Count)}}{\text{(Car count of the county with highest stringency)}} \times \text{(Tons of CO reduced due to I/M in the county with highest stringency)}$$

For example, the output for San Francisco county, for a 1-hour 17 mg/m$^3$ statistical standard, shows a CO reduction of 17,327 tons in 1987 with an I/M using 30% stringency. The car count of San Francisco county in 1987 is 445,367, and the car count of San Francisco urban area is 2,882,900. Therefore:

$$\text{Urban Reduction for San Francisco Area} = \frac{2{,}882{,}900}{445{,}367} \times 17{,}327 = 112{,}166 \text{ tons}$$

Similar calculations are done for other urban areas.

- Urban Subtotals--These are the summations under each column of the urban analysis table.

### 4.2.2 Summary Tables

The program is designed to generate several useful summary tables for the user as explained below.

- I/M-Related Summary Data

  Referring to Figure 4.3, a listing of all the individual counties (including those that are also single county urban areas) is printed along with I/M-related summaries of costs, fuel savings, and CO reductions. "County Subtotals" are the summation of numbers in respective columns. "Urban-County subtotals" are the summation of respective urban and county subtotals. The urban

| INDIVIDUAL COUNTIES* | AUTOMOBILES | STRINGENCY (%) | INSPECTION ($) | REPAIR ($) | TOTAL ($) | REDUCTION (TONS) | I/M FUEL SAVED (GALLONS) | VALUE ($) | NET COST ($) |
|---|---|---|---|---|---|---|---|---|---|
| | 29,900 | 30 | 209,304 | 197,344 | 406,648 | 2,837 | 180,747 | 180,747 | 225,901 |
| | 911,722 | 20 | 3,191,030 | 2,005,790 | 5,196,820 | 22,949 | 2,296,379 | 2,296,379 | 2,900,441 |
| | 284,125 | 20 | 994,438 | 625,075 | 1,619,513 | 9,185 | 715,633 | 715,633 | 903,880 |
| | 335,922 | 20 | 1,175,729 | 739,029 | 1,914,758 | 13,087 | 846,096 | 846,096 | 1,068,662 |
| | 1,202,490 | 20 | 4,208,715 | 2,645,478 | 6,854,193 | 42,683 | 3,028,741 | 3,028,741 | 3,825,452 |
| | 148,415 | 20 | 1,038,907 | 653,027 | 1,691,934 | 9,514 | 747,635 | 747,635 | 944,299 |
| | 89,777 | 20 | 628,440 | 395,019 | 1,023,459 | 7,598 | 452,248 | 452,248 | 571,211 |
| | 142,170 | 30 | 995,194 | 938,326 | 1,933,520 | 5,951 | 859,413 | 859,413 | 1,074,107 |
| | 222,352 | 20 | 1,556,466 | 978,350 | 2,534,816 | 17,002 | 1,120,088 | 1,120,088 | 1,414,728 |
| | 43,691 | 20 | 305,839 | 192,241 | 498,080 | 2,990 | 220,092 | 220,092 | 277,988 |
| | 338,651 | 20 | 1,185,278 | 745,032 | 1,930,310 | 30,433 | 852,968 | 852,968 | 1,077,342 |
| | 300,257 | 20 | 1,050,901 | 660,566 | 1,711,467 | 29,728 | 756,266 | 756,266 | 955,201 |
| | 128,536 | 20 | 899,755 | 565,560 | 1,465,315 | 11,928 | 647,496 | 647,496 | 817,319 |
| | 53,353 | 20 | 373,476 | 234,756 | 608,232 | 4,282 | 268,767 | 268,767 | 339,465 |
| | 46,909 | 20 | 328,367 | 206,402 | 534,769 | 2,098 | 236,304 | 236,304 | 298,465 |
| | 109,188 | 20 | 764,317 | 480,427 | 1,244,744 | 9,435 | 550,029 | 550,029 | 694,715 |
| | 12,859 | 20 | 90,015 | 56,581 | 146,596 | 844 | 64,778 | 64,778 | 81,818 |
| | 255,863 | 20 | 895,521 | 562,899 | 1,458,420 | 21,344 | 644,449 | 644,449 | 813,971 |
| | 27,487 | 20 | 192,413 | 120,945 | 313,358 | 2,496 | 138,467 | 138,467 | 174,891 |
| | 37,461 | 20 | 262,227 | 164,828 | 427,055 | 3,931 | 188,708 | 188,708 | 238,347 |
| | 295,467 | 20 | 1,034,137 | 650,029 | 1,684,166 | 21,311 | 744,202 | 744,202 | 939,964 |
| | 84,970 | 20 | 594,794 | 373,870 | 968,664 | 9,691 | 428,035 | 428,035 | 540,629 |
| | 192,832 | 20 | 674,912 | 424,230 | 1,099,142 | 18,597 | 485,691 | 485,691 | 613,451 |
| COUNTY SUBTOTALS | 5,294,397 | | 22,650,175 | 14,615,804 | 37,265,979 | 300,414 | 16,473,232 | 16,473,232 | 20,792,747 |
| URBAN-COUNTY SUBTOTALS | 42,701,842 | | 168,431,966 | 127,703,694 | 296,135,660 | 3,167,079 | 131,207,691 | 131,207,691 | 164,927,952 |

FIGURE 4.3 SAMPLE OF INDIVIDUAL COUNTIES I/M SUMMARY TABLE

*Names of actual counties and FIPS codes have been intentionally blocked out because this table is to be treated purely as an example output.

table shown in Figure 4.2, and the individual county I/M-related table shown in Figure 4.3 together constitute the complete summary of I/M-related analysis data for a particular study, i.e., for a 1-hour statistical standard of 17 $mg/m^3$.

- TCM-Related Summary Data--All those counties that used TCM either in addition to an I/M program or TCM alone are listed in Figure 4.4. The CO reductions, fuel savings, and net TCM costs are printed for each respective county. "TCM Subtotals" indicate the summation of numbers in various columns. "Grand Totals" indicate the sum of I/M urban, I/M individual counties, and TCM subtotals.

  The value indicated for "Net cost excluding I/M fuel savings" is: (Grand total - total costs of fuel saved due to I/M for both urban areas and individual counties).

- Summary Lists of Counties in Violation of Standards

  The following summary lists are produced.

  - Counties in violation in 1982 with FMVCP as the only control measure (for 1-hour standards of 40 $mg/m^3$, 8-hour standards of 10 $mg/m^3$ and 8-hour standards of 14 $mg/m^3$). These are all counties whose effective total percent reduction in 1982 is less than required rollback percent reduction.
  - Counties in violation with only FMVCP in 1984 (for all standards). These are all those counties whose effective percent

*** STANDARD* : 1-HOUR STATISTICAL STANDARD OF 17 MG/M3 (15 PPM). RUN # 2 09/17/79 PAGE 9

| COUNTIES NEEDING TCM | REDUCTION (TONS) | FUEL SAVED (GALLONS) | NET COST ($) |
|---|---|---|---|
| | 735 | 799,797 | 715,995 |
| | 74,183 | 80,711,624 | 72,254,708 |
| | 2,145 | 2,334,233 | -1,969,509 |
| | 1,671 | 1,818,738 | 1,628,172 |
| | 3,836 | 4,174,320 | -3,469,833 |
| | 2,342 | 2,548,660 | -2,128,687 |
| | 9,084 | 9,884,088 | 8,848,439 |
| | 3,799 | 4,134,171 | 3,700,995 |
| | 436 | 475,451 | -401,162 |
| | 2,013 | 2,190,928 | 1,961,364 |
| TCM SUBTOTALS | 100,244 | 109,072,010 | 81,140,482 |
| GRAND TOTALS | 3,267,323 | 240,279,701 | 246,068,434 |

NET COST EXCLUDING I/M FUEL SAVINGS = $ 377,276,142

FIGURE 4.4 SAMPLE OF SUMMARY TABLE OF COUNTIES NEEDING TCM

*See comments for Figure 4.3.

reduction in 1984 is less than required rollback percent reduction.

- Counties in violation with only FMVCP in 1987 (for all standards). These are all those counties whose effective total percent reduction in 1987 is less than the required rollback percent reduction.
- Counties in violation with FMVCP + I/M + TCM (for all standards). These are all those counties whose CO reductions in 1987 are less than the percent rollback needed even with FMVCP, I/M and TCM programs combined together. The remaining needed percent and tons are also printed along with the name of the counties.

# APPENDICES

# APPENDIX A

## LIST OF 272 COUNTIES AND URBAN AREAS WITH STATUS OF I/M PROGRAMS

## Appendix A

## LIST OF 272 COUNTIES AND URBAN AREAS WITH STATUS OF I/M PROGRAMS

The following list of 272 counties potentially in violation of the existing and other proposed standards was selected as follows:

1. Started with the list of nonattainment areas as given in the Federal Register of March 3, 1978.
2. Added to this list those counties that showed design values that are equal to or greater than 80% of the current standard values. The design values were obtained from the Storage and Retrieval of Aerometric Data (SAROAD) reporting system.
3. Checked the emission densities of those counties for which no ambient concentration data exist and whose emission densities were greater than a cutoff value of 100 tons/sq. mile/year. Added the names of the counties whose emission densities were greater than the cutoff values to the list above.
4. Included all those counties that are part of the same urban area as those counties mentioned above.

The counties were then grouped into three categories, namely: 1) counties that are a part of multicounty urban areas which may cross state boundaries; 2) counties that are a part of a single county urban areas; and 3) counties not included in any urban area. The listing of urban areas and associated counties was derived from the report: Bureau of the Census, Population and Land Area of Urbanized Areas for the United States, 1970 and 1960, Washington, D.C., U.S. Department of Commerce, 1979. The status of I/M programs for various counties was taken from the "Inspection/Maintenance Status Sheets", EPA, Ann Arbor, Michigan, May 29, 1979.

Referring to the list under the column headed, "Current Plans for I/M

Programs to be Initiated in 1982", the + mark(s) indicate that an I/M program is planned for initiation by July 1982 as required by EPA regulations for hydrocarbon control for the ozone National Ambient Air Quality Standards. If there is no + mark against a county, but there is a + mark(s) for a county in the same state, it is assumed that the state has the legal authority for implementing an I/M program and the county can initiate an I/M program in 1983. If no county in the state has a + mark, then it is assumed that legal authority does not exist, and the earliest an I/M program can be initiated is in 1984.

LIST OF THE 272 COUNTIES AND URBAN AREAS WITH
STATUS OF I/M PROGRAMS

## 1. Counties Included in Multicounty Urban Areas

| No. | State | Urban Area | Associated Counties | Current Plans for I/M Programs to be Initiated in 1982 CO | $O_3$ |
|---|---|---|---|---|---|
| 1 | California | San Francisco | Alameda | + | + |
| 2 | | | Contra Costa | + | + |
| 3 | | | Marin | + | + |
| 4 | | | San Francisco | + | + |
| 5 | | | San Mateo | + | + |
| 6 | | | Solano | + | + |
| 7 | | | Napa | | |
| 8 | | Los Angeles | Los Angeles | + | + |
| 9 | | | Orange | + | + |
| 10 | | Sacramento | Placer | + | + |
| 11 | | | Sacramento | + | + |
| 12 | | | Yolo | + | + |
| 13 | | San Bernardino | Riverside | + | + |
| 14 | | | San Bernardino | + | + |
| 15 | Colorado | Denver | Adams | + | + |
| 16 | | | Arapahoe | + | + |
| 17 | | | Denver | + | + |
| 18 | | | Jefferson | + | + |
| 19 | Delaware | Wilmington | New Castle | | + |
| 20 | | | Salem, N.J. | | + |
| 21 | Florida | Jacksonville | Clay | | |
| 22 | | | Duval | | |
| 23 | Georgia | Atlanta | Clayton | + | + |
| 24 | | | Cobb | + | + |
| 25 | | | DeKalb | + | + |
| 26 | | | Fulton | + | + |

| No. | State | Urban Area | Associated Counties | Current Plans for I/M Programs to be Initiated in 1982 CO | $O_3$ |
|---|---|---|---|---|---|
| 27 | Illinois | Chicago | Cook | + | + |
| 28 | | | Lake, Ill. | + | + |
| 29 | | | Lake, Ind. | + | + |
| 30 | | | Porter, Ind. | + | + |
| 31 | | | Tazewell | | |
| 32 | Indiana | Indianapolis | Marion | | |
| 33 | | | Hamilton | | |
| 34 | Iowa | Davenport-Rock | Scott | | |
| 35 | | | Rock Island | | |
| 36 | Kentucky | Louisville | Jefferson | + | + |
| 37 | | | Clark, Ind. | + | + |
| 38 | | | Floyd, Ind. | + | + |
| 39 | Maryland | Baltimore | Baltimore City | + | + |
| 40 | | | Baltimore | + | + |
| 41 | | | Anne Arundel | + | + |
| 42 | District of Columbia | Washington, D.C. | Alexandria City, Va. | | + |
| 43 | | | Arlington, Va. | | + |
| 44 | | | Fairfax, Va. | | + |
| 45 | | | Montgomery | | + |
| 46 | | | Prince Georges | | + |
| 47 | | | Washington D.C. | | |
| 48 | Michigan | Detroit | Macomb | + | + |
| 49 | | | Oakland | + | + |
| 50 | | | Wayne | + | + |
| 51 | Minnesota | Minneapolis-St. Paul | Dakota | | |
| 52 | | | Hennepin | | |
| 53 | | | Ramsey | | |
| 54 | | | Washington | | |
| 55 | | | Carver | | |
| 56 | | | Scott | | |
| 57 | | | Anoka | | |

| No. | State | Urban Area | Associated Counties | Current Plans for I/M Programs to be Initiated in 1982 CO | $O_3$ |
|---|---|---|---|---|---|
| 58 | Minnesota | St. Cloud | Benton | | |
| 59 | | | Stearns | | |
| 60 | | | Sherbourne | | |
| 61 | | Duluth-Superior | St. Louis | | |
| 62 | | | Douglas, Wisc. | | |
| 63 | Missouri | St. Louis | St. Louis City | + | + |
| 64 | | | St. Louis | + | + |
| 65 | | | St. Charles | + | + |
| 66 | | | Madison, Il. | + | + |
| 67 | | | St. Clair, Il. | + | + |
| 68 | Nebraska | Omaha | Douglas | | |
| 69 | | | Sarpy | | |
| 70 | | | Pottawattamie, Io. | | |
| 71 | New York | New York City | Bronx | + | + |
| 72 | | | Kings | + | + |
| 73 | | | Nassau | + | + |
| 74 | | | New York | + | + |
| 75 | | | Queens | + | + |
| 76 | | | Richmond | + | + |
| 77 | | | Rockland | + | + |
| 78 | | | Suffolk | + | + |
| 79 | | | Westchester | + | + |
| 80 | | | Bergen, N.J. | | + |
| 81 | | | Essex, N.J. | | + |
| 82 | | | Hudson, N.J. | | + |
| 83 | | | Middlesex, N.J. | | + |
| 84 | | | Monmouth N.J. | | + |
| 85 | | | Morris, N.J. | | + |
| 86 | | | Ocean, N.J. | | + |
| 87 | | | Passaic, N.J. | | + |
| 88 | | | Somerset, N.J. | | + |
| 89 | | | Union, N.J. | | + |
| 90 | | Albany-Schenectady | Albany | | |
| 91 | | | Rensselaer | | |
| 92 | | | Schenectady | | |
| 93 | | Buffalo | Erie | | |
| 94 | | | Niagra | | |

| No. | State | Urban Area | Associated Counties | Current Plans for I/M Programs to be Initiated in 1982 CO | $O_3$ |
|---|---|---|---|---|---|
| 95 | Ohio | Cleveland | Cuyahoga | | + |
| 96 | | | Lake | | |
| 97 | | Cincinnati | Clermont | | + |
| 98 | | | Hamilton | | + |
| 99 | | | Boone, Ky. | | |
| 100 | | | Campbell, Ky. | | |
| 101 | | | Kenton, Ky. | | |
| 102 | | Youngstown | Mahoning | | + |
| 103 | | | Trumbell | | + |
| 104 | | Steubenville | Jefferson | | |
| 105 | | | Brook, W.Va. | | |
| 106 | | | Hancock, W.Va. | | |
| 107 | | Toledo | Lucas | | |
| 108 | | | Wood | | |
| 109 | | Dayton | Butler | | |
| 110 | | | Greene | | |
| 111 | | | Montgomery | | |
| 112 | | Akron | Portage | | |
| 113 | | | Summit | | |
| 114 | Oklahoma | Oklahoma City | Cleveland | | |
| 115 | | | Oklahoma | | |
| 116 | Oregon | Portland | Clackamas | + | + |
| 117 | | | Multnomah | + | + |
| 118 | | | Washington | + | + |
| 119 | | | Clark, Wa. | + | + |
| 120 | Pennsylvania | Philadelphia | Philadelphia | + | + |
| 121 | | | Bucks | + | + |
| 122 | | | Delaware | + | + |
| 123 | | | Burlington, N.J. | | + |
| 124 | | | Camden, N.J. | | + |
| 125 | | | Goucester, N.J. | | + |
| 126 | | Scranton-Wilkes | Lackawana | | + |
| 127 | | | Luzerne | | + |
| 128 | | Pittsburg | Allegheny | + | + |
| 129 | | | Beaver | + | + |
| 130 | | | Westmoreland | + | + |

| No. | State | Urban Area | Associated Counties | Current Plans for I/M Programs to be Initiated in 1982 CO | $O_3$ |
|---|---|---|---|---|---|
| 131 | Pennsylvania | Allentown-Bethlehem | Lehigh | | + |
| 132 | | | Northampton | | + |
| 133 | | | Warren, N.J. | | + |
| 134 | Rhode Island | Providence | Bristol | + | + |
| 135 | | | Kent | + | + |
| 136 | | | Providence | + | + |
| 137 | | | Washington | + | + |
| 138 | South Carolina | Columbia | Lexington | | |
| 139 | | | Richland | | |
| 140 | Tennessee | Chattanooga | Hamilton | | |
| 141 | | | Catoosa, Ga. | | |
| 142 | | | Walker, Ga. | | |
| 143 | Utah | Salt Lake City | Davis | + | + |
| 144 | | | Salt Lake | + | + |
| 145 | Virginia | Richmond | Richmond City | | |
| 146 | | | Chesterfield | | |
| 147 | | | Henrico | | |
| 148 | | Norfolk | Chesapeake City | | |
| 149 | | | Norfolk City | | |
| 150 | | | Portsmouth City | | |
| 151 | | | Virginia Beach City | | |
| 152 | Washington | Seattle-Tacoma | King | + | |
| 153 | | | Pierce | + | |
| 154 | | | Snohomish | + | |
| 155 | Wisconsin | Milwaukee | Milwaukee | | + |
| 156 | | | Ozaukee | | + |
| 157 | | | Waukesha | | + |

## 2. Counties Included in Single County Urban Areas

| No. | State | Urban Area | Associated Counties | Current Plans for I/M Programs Initiated in 1982 CO | $O_3$ |
|---|---|---|---|---|---|
| 158 | Alabama | Birmingham | Jefferson | | |
| 159 | Arizona | Phoenix | Maricopa | + | |
| 160 | | Tucson | Pima | + | |
| 161 | California | Fresno | Fresno | + | + |
| 162 | | Bakersfield | Kern | + | + |
| 163 | | San Diego | San Diego | + | + |
| 164 | | Stockton | San Joaquin | | |
| 165 | | Santa Barbara | Santa Barbara | + | |
| 166 | | San Jose | Santa Clara | + | + |
| 167 | | Modesto | Stanislaus | | |
| 168 | | Santa Rosa | Sonoma | | |
| 169 | | Ventura | Ventura | | + |
| 170 | Colorado | Boulder | Boulder | | |
| 171 | | Colorado Springs | El Paso | + | |
| 172 | Connecticut | Bridgeport | Fairfield | | + |
| 173 | | Hartford | Hartford | | + |
| 174 | | New Haven | New Haven | | + |
| 175 | | Waterbury | Litchfield | | |
| 176 | | Meriden | Middlesex | | |
| 177 | Florida | Ft. Lauderdale | Broward | | |
| 178 | Idaho | Boise | Ada | | |
| 179 | Iowa | Cedar Rapids | Linn | | |
| 180 | | Des Moines | Polk | | |
| 181 | Kansas | Wichita | Sedgwick | | |
| 182 | Kentucky | Owensboro | Daviess | | |
| 183 | Maine | Lewiston-Auburn | Androscoggin | | |
| 184 | Michigan | Saginaw | Saginaw | | |

| No. | State | Urban Area | Associated Counties | Current Plans for I/M Programs Initiated in 1982 CO | $O_3$ |
|---|---|---|---|---|---|
| 185 | Minnesota | Rochester | Olmstead | | |
| 186 | Missouri | Springfield | Greene | | |
| 187 | Montana | Great Falls | Cascade | | |
| 188 | | Billings | Yellowstone | | |
| 189 | Nebraska | Lincoln | Lancaster | | |
| 190 | Nevada | Las Vegas | Clark | + | |
| 191 | | Reno | Washoe | + | |
| 192 | New Hampshire | Manchester | Hillsborough | | |
| 193 | New Jersey | Atlantic City | Atlantic | | + |
| 194 | | Trenton | Mercer | | + |
| 195 | New Mexico | Albuquerque | Bernalillo | + | |
| 196 | New York | Syracuse | Onondaga | | |
| 197 | | Rochester | Monroe | | |
| 198 | North Carolina | Charlotte | Mecklenburg | + | |
| 199 | Ohio | Columbus | Franklin | | |
| 200 | Oklahoma | Tulsa | Tulsa | | |
| 201 | Oregon | Eugene | Lane | | |
| 202 | | Salem | Marion | | |
| 203 | Tennessee | Memphis | Shelby | + | |
| 204 | | Nashville | Davidson | + | |
| 205 | | Knoxville | Knox | | |
| 206 | Texas | Houston | Harris | | + |
| 207 | | El Paso | El Paso | | |

| No. | State | Urban Area | Associated Counties | Current Plans for I/M Programs Initiated in 1982 CO | $O_3$ |
|---|---|---|---|---|---|
| 208 | Utah | Ogden | Weber | + | + |
| 209 | | Provo | Utah | | |
| 210 | Virginia | Newport News | Hampton | | |
| 211 | Washington | Spokane | Spokane | + | |
| 212 | | Yakima | Yakima | | |

### 3. Counties That Are Not in Urbanized Areas

| No. | State | Urban Area | Associated Counties | CO | $O_3$ |
|---|---|---|---|---|---|
| 213 | Alabama | | Mobile | | |
| 214 | Alaska | | Anchorage | | |
| 215 | | | Fairbanks | | |
| 216 | California | | Butte | | |
| 217 | | | Merced | | |
| 218 | | | Santa Cruz | | |
| 219 | | | Sutter | | |
| 220 | | | Tulare | | |
| 221 | Colorado | | Larimer | | |
| 222 | | | Douglas | | |
| 223 | | | Weld | | |
| 224 | Connecticut | | New London | | |
| 225 | | | Tolland | | |
| 226 | Florida | | Dade | | |
| 227 | | | Hillsborough | | |
| 228 | | | Orange | | |
| 229 | | | Palm Beach | | |
| 230 | | | Pinellas | | |
| 231 | | | Volusia | | |
| 232 | Illinois | | Peoria | | |
| 233 | | | Will | | |
| 234 | Kansas | | Douglas | | |
| 235 | | | Shawnee | | |
| 236 | | | Wyandotte | | |

| No. | State | Urban Area | Associated Counties | Current Plans for I/M Programs Initiated in 1982 | |
|---|---|---|---|---|---|
| | | | | CO | $O_3$ |
| 237 | Kentucky | | McCracken | | |
| 238 | Louisiana | | E. Baton Rouge | | |
| 239 | Maine | | Penobscot | | |
| 240 | Maryland | | Alleghany | | |
| 241 | | | Washington | | |
| 243 | Massachusetts | | Central | | |
| 244 | | | Pioneer | | |
| 245 | | | Boston Met | | |
| 246 | Michigan | | Kent | | |
| 247 | Montana | | Missoula | | |
| 248 | Nevada | | Carson City | | |
| 249 | | | Douglas | | |
| 250 | | | Storey | | |
| 251 | New Hampshire | | Coos | | |
| 252 | | | Merrimack | | |
| 253 | | | Rockingham | | |
| 254 | New Jersey | | Cape May | | + |
| 255 | New Mexico | | Chaves | | |
| 256 | | | Dona Ana | | |
| 257 | | | San Juan | | |
| 258 | | | Santa Fe | | |
| 259 | North Carolina | | Durham | | |
| 260 | Ohio | | Clark | | |
| 261 | | | Stark | | |
| 262 | Oregon | | Jackson | | |

| No. | State | Urban Area | Associated Counties | Current Plans for I/M Programs Initiated in 1982 CO | $O_3$ |
|---|---|---|---|---|---|
| 263 | South Carolina | | York | | |
| 264 | Texas | | Bexar | | |
| 265 | | | Dallas | | |
| 266 | | | Nueces | | |
| 267 | | | Tarrant | | |
| 268 | | | Travis | | |
| 269 | Utah | | Utah | | |
| 270 | Vermont | | Chittenden | | |
| 271 | Virginia | | Roanoke | | |
| 272 | Wisconsin | | Kenosha | | |

# APPENDIX B

## THE ALTERNATIVE CO STANDARDS INCLUDED IN THE PROGRAM AND THE BASIS FOR CALCULATING DESIGN VALUES

## Appendix B

## THE ALTERNATIVE CO STANDARDS INCLUDED IN THE PROGRAM AND THE BASIS FOR CALCULATING DESIGN VALUES

### General

The current CO standards specify that the hourly average CO concentration must not exceed 40 $mg/m^3$ (approximately 35 ppm) more than once per year and that the 8-hour average CO concentration must not exceed 10 $mg/m^3$ (approximately 9 ppm) more than once per year. In addition to assessing alternative standard levels in the standard-setting regulatory analyses, EPA is also considering alternative procedures for calculating exceedances of the standard. These procedures affect the form of the standard.

In its current form, the standard is based on the second highest monitored value in an area during a year. However, this deterministic (once-per-year) approach has limitations in that it does not account for the probabilistic nature of maximum CO concentrations. For example, to maintain such a standard year after year necessitates a zero probability that the second high value will ever again exceed the standard. On a practical basis, permitting only a single absolute exceedance in a year means that there is some possibility of occasionally having two or more exceedances in a particular year.

The form of the standard not only influences the determination of the number of exceedances of the standard, but also affects the calculation of an area's design value. The design value represents the estimated ambient concentration from which emission reductions are calculated in the strategy planning process.

The program is designed to evaluate the current 1-hour and 8-hour standard as well as six additional 1-hour and six additional 8-hour standards based on various levels and forms as shown in Table B-1. Brief discussions related to the statistical forms of the standards and calculation of corresponding design values are presented below.

Statistical Forms of the Standard

To remedy the logical conflict and to adjust for the effect of missing data, EPA is considering defining the standard on a statistical basis whereby the expected number of exceedances per calendar year is determined. Statistical forms of the standard vary, depending on whether all possible values are used or daily values alone, and how running averages are handled for the 8-hour standard.

For purposes of the analysis contained in this document, two interpretations of the statistical standard are used. For the 1-hour standard, the hourly interpretation bases the design value on the ambient hourly concentration which on the average will be exceeded once per year in each area. The daily interpretation on the other hand, bases the standard on the number of days with maximum hourly CO averages above the level of the standard. This means that a day with two or more hourly values over the standard level counts as one exceedance of the standard level rather than two or more.

Statistical forms of the 8-hour standard follow the same basic approach, but the interpretation is complicated by running averages, as discussed by EPA in "Guidelines for the Interpretation of Air Quality Data with Respect to the National Ambient Air Quality Standards," Guideline Series

Table B-1

THE 14 ALTERNATIVE CO STANDARDS INCLUDED IN THE PROGRAM

| One-Hour Standards | | | Eight-Hour Standards | | |
|---|---|---|---|---|---|
| Konometric (PPM) | SI Equivalent (mg/m3) | | Konometric (PPM) | SI Equivalent (mg/m3) | |
| 35 | 40 | Annual Second High Existing | 9 | 10 | Annual Second High Existing |
| 35 | 40 | Statistical, on an annual maximum basis * | 7 | 8 | Statistical, on an annual maximum basis * |
| 25 | 29 | | 9 | 10 | |
| 15 | 17 | | 12 | 14 | |
| 35 | 40 | Statistical, on a daily maximum basis # | 7 | 8 | Statistical, on a daily maximum basis # |
| 25 | 29 | | 9 | 10 | |
| 15 | 17 | | 12 | 14 | |

*Where the expected number of annual maximum exceedances is ≤ 1 per year.

#Where the expected number of daily maximum exceedances are ≤ 1 per year.

OAQPS 1.2-008, revised February 1977. The current CO standard is chosen so that the second exceedance does not come from an 8-hour period which contains at least 1-hour in common with the first exceedance.

In calculating design values for use in this analysis, the daily interpretation uses overlapping 8-hour averages in computing the expected number of exceedances. For each day, the highest of the 24 possible 8-hour averages is the daily maximum 8-hour average. With this method, the possibility arises that two daily exceedances could have common hourly values. The other statistical approach (the hourly interpretation) employed in this analysis uses all possible 8-hour averages for the year so that more than one exceedance per day could be counted. This is more stringent than the current form of the standard because exceedances may overlap.

Calculation of Design Values

Design values for use in this analysis were obtained from a review of 1976-1978 CO ambient air quality data in EPA's SAROAD data base. For the current form of the standard, the second highest maximum value was used. Using the three years of data, design values based on the respective statistical forms of the standard are expected to fall between the third and fourth highest maximum value, whether it be an hourly or daily value. In selecting design values, the fourth highest value over the three year period was used. If only two years of data were available, the third highest value was chosen. These design values are approximate and suitable only for analytical purposes in this assessment. In State Implementation Plan (SIP) revisions submitted to EPA, States will calculate the actual design values used for attainment determinations and for planning purposes. The values will be calculated based on guidance provided by EPA.

# APPENDIX C

## CONVERSION OF EMISSION DENSITY VALUES TO SURROGATE DESIGN VALUES

## Appendix C

## CONVERSION OF EMISSION DENSITY VALUES TO SURROGATE DESIGN VALUES

As indicated in Section 2 of this report, emission densities were used as design value surrogates for those counties not having design value data. As compatible surrogates for the various standards, equivalent emission densitites were calculated that would lead to a concentration equal to the standards under a certain set of conservative conditions. These were calculated as described below.

The Holzworth model* was used with a correction from Calder.# The basic model applies to a ground-level pollutant released from a rectangular urban area source distribution of uniform strength Q(g/$m^2$-sec). The width of the rectangle, 2B, is perpendicular to the wind direction and the downwind length is S. A rectangular coordinate system is used with x along the wind direction and the origin at the center of the upwind edge of the rectangle. The concentration $\chi(x,o,o)$ at ground level and downwind distance x along the center line of the area is then given by

---

*Holtzworth, G.C., Mixing Heights, Wind Speeds, and Potential for Urban Air Pollution Throughout the Contiguous United States, EPA Report No. AP-101.

#Calder, K.L., "A Correction to the Holzworth Model of Meteorlogical Potential for Urban Air Pollution," Atmospheric Environment, Vol. 11, pp. 761-764, 1977.

$$\chi(x,o,o) = \int_{o}^{x}\int_{-B}^{B} \frac{Q}{\pi\sigma(x-x_o)\sigma_z(x-x_o)U} \tag{1}$$

$$\exp\left(\frac{-Y_o^{\ 2}}{2\sigma_y^{\ 2}\ (x-x_o)}\right) dx_o dy_x$$

where U is the average wind speed and is assumed constant throughout the region. If the half-width of this hypothetical point source plume is less than the crosswind half-width, B, of the source area, then (1) may be closely approximated by setting B = ∞. Then (1) reduces to

$$\chi(x,o,o)=(\tfrac{2}{\pi})^{\frac{1}{2}} \quad \frac{Q}{U}\int_{o}^{x} \frac{dx_o}{\sigma_z(x-x_o)} \tag{2}$$

This relationship is valid provided that vertical dispersion is not restricted. For a mixing height, H, there is a critical distance, X, that occurs when $\sigma_z(X)=0.8H$. Complete vertical mixing is assumed to occur beyond this distance and the concentration maintains a constant value in the vertical direction. Expressing the vertical dispersion coefficient as a power law relation

$$\sigma_z(x) = ax^b$$

the concentration at a point x beyond the critical distance may be expressed as

$$\chi(x,o,o) = \frac{QX}{UH(1-b)} + \frac{Q(x-X)}{UH} \quad \text{for } x > X \tag{3}$$

A number of conservative assumptions were used to calculate "standard-equivalent" emission densities from this relationship. These included:

| | | |
|---|---|---|
| region size, S | = | 100 km |
| mixing height, H | = | 125 m |
| wind speed, U | = | 1 m/sec |
| stability class | = | E |
| downwind distance, x | = | S = 100 km |

Values for a and b were chosen from the power law formulation of the vertical dispersion coefficient in APRAC-1A for E stability:

$$a = 1.35$$

$$b = 0.51$$

Using these assumptions,

$$\sigma_z(X) = 1.35X^{0.51} = (0.8)\ 125,$$

and $X = 4635$ m.

Then

$$\frac{\chi U}{Q} = \frac{4635}{125(1-0.51)} + \frac{10^5-4635}{125}$$

$$= 838.6$$

Since U is assumed to be 1 m/sec,

$$\frac{\chi}{Q} = 838.6 \text{ sec/m},$$

or

$$Q = \chi/838.6 \text{ sec/m}.$$

With $\chi$ expressed in mg/m$^3$, Q may be expressed in tons/mi$^2$-yr by

$$Q = \left(\frac{\chi}{838.6}\right) \frac{1}{1.11 \times 10^{-5}} \quad \frac{\text{tons/mi}^2\text{-yr}}{\text{mg/m}^2\text{-sec}} \qquad (4)$$

and $Q = 107.43\chi$ tons/mi$^2$-yr. The "standard-equivalent" emission densities were calculated using equation (4).

The table below lists the different standards and the associated emission densities.

| Standard (mg/m$^3$) | Emission Density (tons/mi$^2$-yr) |
|---|---|
| 40 | 4296 |
| 29 | 3115 |
| 17 | 1826 |
| 14 | 1504 |
| 10 | 1074 |
| 8 | 859 |

These emission densities were used for both the second high and the statistical forms of the standards because the assumed conditions were taken to occur frequently enough to apply to the different forms.

# APPENDIX D

# ORIGINAL COUNTY AREAWIDE VMT GROWTH FACTORS

## Appendix D

## ORIGINAL COUNTY AREAWIDE VMT GROWTH FACTORS*

| State | Urbanized Area | Compound Annual Percentage Change |
|---|---|---|
| Alabama | Birmingham | 5.20 |
| | Mobile | 3.12 |
| Arizona | Phoenix | 2.89 |
| | Tucson | 2.49 |
| Arkansas | Little Rock | 3.97 |
| California | Fresno | 4.18 |
| | Los Angeles | 3.16 |
| | Oxnard | 5.10 |
| | Sacramento | 4.12 |
| | San Bernadino | 4.25 |
| | San Diego | 4.78 |
| | San Francisco | 3.80 |
| | San Jose | 4.24 |
| Colorado | Colorado Springs | 2.99 |
| | Denver | 3.67 |
| Connecticut | Bridgeport | 1.85 |
| | Hartford | 1.89 |
| | New Haven | 1.79 |
| Delaware | Wilmington | 3.73 |
| District of Columbia | Washington, D.C. | 1.98 |
| Florida | Fort Lauderdale | 2.71 |
| | Jacksonville | 2.54 |
| | Miami | 2.48 |

*Source: Program Management Division, FHWA, National Functional System Mileage Travel Summary, U.S. Department of Transportation, Washington, D.C., 1977.

| State | Urbanized Area | Compound Annual Percentage Change |
|---|---|---|
| Florida | Orlando | 3.24 |
| | St. Petersburg | 1.92 |
| | Tampa | 3.16 |
| | W. Palm Beach | 3.73 |
| Georgia | Atlanta | 4.52 |
| | Columbus | 3.80 |
| Hawaii | Honolulu | 2.18 |
| Illinois | Chicago | 1.20 |
| | Peoria | 2.54 |
| | Rockford | 1.85 |
| Indiana | Fort Wayne | 2.85 |
| | Indianapolis | 3.15 |
| | South Bend | 3.29 |
| Iowa | Davenport | 2.57 |
| | Des Moines | 2.84 |
| Kansas | Wichita | 1.93 |
| Kentucky | Louisville | 3.01 |
| Louisiana | Baton Rouge | 3.42 |
| | New Orleans | 3.14 |
| | Shreveport | 3.39 |
| Maryland | Baltimore | 2.98 |
| Massachusetts | Boston | 2.44 |
| | Lawrence | 2.36 |
| | Springfield | 2.47 |
| | Worcester | 2.46 |
| Michigan | Detroit | 3.86 |
| | Flint | 4.24 |
| | Grand Rapids | 1.93 |
| | Lansing | 3.30 |
| Minnesota | Minneapolis | 2.80 |
| Missouri | Kansas City | 1.67 |
| | St. Louis | 1.71 |
| Nebraska | Omaha | 2.69 |

| State | Urbanized Area | Compound Annual Percentage Change |
|---|---|---|
| Nevada | Las Vegas | 1.80 |
| New Jersey | Trenton | 2.61 |
| New Mexico | Albuquerque | 2.64 |
| New York | Albany | 2.20 |
| | Buffalo | 2.20 |
| | New York | 2.39 |
| | Rochester | 2.88 |
| | Syracuse | 2.20 |
| North Carolina | Charlotte | 3.15 |
| Ohio | Akron | 1.75 |
| | Canton | 2.31 |
| | Cincinnati | 2.20 |
| | Cleveland | 2.24 |
| | Columbus | 2.29 |
| | Dayton | 2.34 |
| | Toledo | 2.04 |
| | Youngstown | 2.09 |
| Oklahoma | Oklahoma City | 3.34 |
| | Tulsa | 2.75 |
| Oregon | Portland | 3.08 |
| Pennsylvania | Allentown | 1.80 |
| | Harrisburg | 1.88 |
| | Philadelphia | 1.94 |
| | Pittsburg | 2.00 |
| | Scranton | 1.38 |
| Rhode Island | Providence | 0.76 |
| South Carolina | Charleston | 4.22 |
| | Columbia | 4.37 |
| Tennessee | Chattanooga | 5.26 |
| | Memphis | 3.64 |
| | Nashville | 4.21 |
| Texas | Austin | 3.53 |
| | Corpus Christi | 3.04 |
| | Dallas | 4.35 |
| | El Paso | 3.70 |

| State | Urbanized Area | Compound Annual Percentage Change |
|---|---|---|
| Texas | Houston | 3.85 |
| | San Antonio | 3.34 |
| Utah | Salt Lake City | 3.88 |
| Virginia | Newport News | 4.79 |
| | Norfolk | 2.80 |
| | Richmond | 4.12 |
| Washington | Seattle | 3.05 |
| | Spokane | 2.73 |
| Wisconsin | Madison | 1.76 |
| | Milwaukee | 1.46 |

# APPENDIX E

# MOBILE SOURCE CO EMISSIONS VERSUS AMBIENT TEMPERATURE

Appendix E

# MOBILE SOURCE CO EMISSIONS VERSUS AMBIENT TEMPERATURE

## General

During vehicle operation at cold ambient temperatures, emissions of carbon monoxide (CO) increase over the levels emitted at the moderate ambient temperature range (68°F to 86°F, nominally 75°F) of the official Federal Test Procedure (FTP). The increased CO emissions are primarily emitted during the cold-start portion of vehicle operation. The cold-start portion is the portion of vehicle operation before emission-important vehicle and control system temperatures have reached nominal values. CO emissions are high during the cold-start portion of vehicle operation because the engines typically operate with rich air/fuel mixtures, which increase the CO produced by the engine. Secondly, after-treatment systems, such as catalysts, are operating at a lower temperature than is required for efficient conversion of the CO emissions from the engine. Thirdly, engine and drivetrain friction is higher during the cold-start portion of vehicle operation and to overcome this extra friction the mass throughput of the engine must be higher, which also increases the mass emissions.

MOBILE 1, the computer program used in this study, accounts for the increase in CO emissions as ambient temperature decreases. There are four different classes of vehicles which were used to model the emissions versus temperature relationship given in MOBILE 1: (1) pre-1968 model year and earlier vehicles, (2) 1968-1974 model-year vehicles, (3) 1975 model-year non-California vehicles, and (4) 1975 model-year California vehicles. Each class of vehicles has its own CO versus temperature adjustment factor curve.

Special attention must be drawn to the CO versus temperature adjustment curves for the 1975 and later model-year category. The data that were used to generate the relationship used in MOBILE 1 came primarily from 1975 model-year vehicles. Since technology for the 1975-1979 model year vehicles did not change substantially, the relationship of the 1975 model year federal vehicles is assumed applicable through 1979. For 1980 and later models, the relationship of the 1975 model-year California vehicles was used. However, the emission control technology that will be used on future model-year vehicles (especially those for model-year 1981 and later) is expected to be substantially different from that used on the 1975 model-year California vehicles. Therefore, it is also possible that the CO versus temperature behavior of the future vehicles could also be substantially different.

Because of the sophisticated nature of the future systems, the possibility exists that the CO versus temperature relationship could be relatively worse <u>or</u> relatively better than is estimated by MOBILE 1. This introduces some uncertainty into this analysis. EPA is conducting studies to improve the estimates of the CO versus temperature effect for future vehicles, but these studies are not complete at this time. In order to perform this analysis, the MOBILE 1 projections were used as a best-estimate. It must be pointed out that the use of the MOBILE 1 estimates is tantamount to making the assumption that the automobile industry will consider lower temperature CO emissions in the design of future vehicles, at least to the extent needed to maintain the same relative relationship in CO versus temperature that existed with the 1975-1979 vehicles, even though the FTP CO emissions of the future vehicles will be much lower than those of the 1975-1979 models.

I/M- Related Issues

In the analysis of inspection and maintenance (I/M) as a control strategy for CO, the MOBILE 1 computer model of mobile source emissions was used as the basic tool for calculating I/M's effectiveness. Although the I/M effectiveness estimates provided in MOBILE 1 are EPA's best estimates, they represent standard FTP conditions. Included in the standard FTP conditions is an average ambient temperature of 68° to 86°F, nominally 75°F.

On the basis of monitoring data, it appears that most violations of the current ambient CO standard occur in a temperature range of 30° to 50°, which is somewhat lower than the 68° to 86°F range of the FTP. There are very few data on I/M's effectiveness in cold temperatures. However, colder temperatures imply that a vehicle will experience more cold operation than would occur at 75°, and, therefore, higher CO emissions. This is the case no matter what the vehicles's state of tune. Limited data from EPA's FY77 Emission Factor Program suggest that CO cold-start emissions from "as-received" vehicles are incrementally higher, not proportionately higher, than those from the tuned-up vehicles.

MOBILE 1 models emission reduction from I/M to be a constant percent no matter what the temperature and no matter what the percent of cold operation. In view of the information presented above, it was decided to use a range of I/M effectiveness for cases of CO violations that are modeled to occur below 50°F. This selection of 50°F is based on engineering judgment and is intended to divide the temperature range into two parts: one in which primarily FTP temperature conditions occur, and one which represents colder temperature conditions.

For modeling cases with ambient temperatures lower than 50°F, two calculations of I/M effectiveness were performed:

1. 100% of the effectiveness modeled in MOBILE 1.

2. 50% of the effectiveness modeled in MOBILE 1.

It is felt that 50% of the effectiveness modeled in MOBILE 1 represents a lower limit estimate of I/M's effectiveness for temperatures down to 20°F. The 50% estimate is based on data from EPA's Portland study, where cold operation CO percent reductions on failed cars were about 50% of the CO-percent reductions over the entire FTP.

# APPENDIX F

## ASSUMPTIONS AND PROCEDURES RELATED TO COST AND FUEL SAVING FACTORS IN I/M & TCM PROGRAMS

Appendix F

ASSUMPTIONS AND PROCEDURES RELATED TO
COST AND FUEL SAVING FACTORS IN I/M & TCM PROGRAMS

## I/M Programs

### Estimation of Capital Costs

Estimation of capital costs of an I/M program for a given county or area has been calculated as the product of the following two variables:

1. $N_{1987}$ = The estimated population of vehicles $N_{1987}$, to be inspected yearly in the year 1987.

2. $P_c$ = Average capital cost of an I/M program per vehicle.

$N_{1987}$: Starting with the number of vehicles in the year $N_{1977}$, and the population $P_{1977}$ in the year 1977, the number of vehicles is 1987 is assumed to increase with the same rate as population.

Thus,

$$N_{1987} = \frac{N_{1977}}{P_{1977}} \times P_{1987} \qquad (1)$$

$P_c$ : $P_c$ is composed of three factors, namely:

$P_1$ = portion of capital for land
$P_2$ = portion of capital for construction
$P_3$ = portion of capital for other investment and administration startup costs.

Unfortunately, the values of $P_c$ or $P_1$, $P_2$, $P_3$ are not available directly in the literature. However in the document "Questions and Answers Concerning the Technical Details of Inspection and Maintenance," dated April 1979, issued by The Inspection and Maintenance Staff, Emission Control Technology Division, Office of Mobile Source Air Pollution Control, Office of Air, Noise and Radiation, U.S. EPA, Ann Arbor, Michigan, the following annualized costs of capital and depreciation periods are given in Table A, page 24 (for a typical contractor-operated I/M program using idle emissions inspection).

| Part | Annualized Cost/ per Vehicle | Depreciation Period |
|---|---|---|
| Land | 0.30 | No Depreciation |
| Construction | 0.61 | 20 Years |
| Other Investment | 0.62 | 5 Years |
| Administrative Startup | 0.31 | 5 Years |

It is also stated that the assumed net return income is 8% (page 22). Using the above noted information, the initial capital cost for each of the parts was calculated by the formula

$$R = P\left[\frac{i(1+i)^n}{(1+i)^n-1}\right] \qquad (2)$$

where R = Equivalent annual cost of capital
P = Initial capital cost
n = Service life (depreciation period)
i = Net rate of return

Note that for very large n (no depreciation), R = Pi; thus:

The initial capital cost for land $= \frac{0.3}{0.08}$ = \$3.75 per vehicle.

Now:

The initial capital cost for construction $= 0.61\left(\frac{(1.08)^{20}-1}{.08\ (1.08)^{20}}\right) =$

= \$5.98 per vehicle

The initial capital cost for other investment plus administrative startup $= (0.62 + .31)\left[\frac{(1.08)^5-1}{.08\ (1.08)^5}\right]$

= \$3.48

Thus, the total initial capital cost $P_c$ = 3.75 + 5.98 + 3.48 = \$13.21

This is the cost factor that has been used initially in the program. However, it can easily be changed since it is treated as an input parameter.

Inspection Costs

Currently, the inspection costs range from \$2.50 to \$14.00 per car. However, many I/M programs are coupled with safety inspection or have other features. Referring to Table A, page 24, of the above-noted question-answer document issued by EPA, Ann Arbor, values of inspection fees to cover the annualized investment and annual operating costs have been estimated to be \$6.87 for state-operated I/M programs, \$7.36 for contractor-operated programs, and \$8.54 for decentralized programs. Based on these estimates, an average inspection cost of \$7 per car has been used initially in the program. This value can be changed easily since it is treated as an input parameter.

I/M Repair Cost

Again, the above-noted document has been used as a reference. Page 2 of this document gives average maintenance (repair) cost for various stringency factors. However, the range of costs is not too large. As such an average repair cost of $22/car has been assumed irrespective of stringency factors. Again this cost factor has been treated as a parameter that can easily be changed.

Potential Fuel Economy From I/M

Data from the Portland study indicated repaired vehicles with current emission control technology are not exhibiting fuel economy improvements. Thus, as a worst case, the assumption is made that no repaired cars will experience a fuel economy benefit. However, based on a theoretical assessment of future emission control technology, EPA believes that future vehicles will most likely experience a fuel economy benefit as a result of I/M repairs. Hence, an alternative case is analyzed whereby the fuel savings per repaired vehicle is assumed to be 7.5% with 20% stringency, 6% with 30% stringency, and 4.5% with 40% stringency for 1981 and post-1981 cars. The percentage of 1981 and post-1981 cars in the years 1987 is estimated to be 78.1% based on historical trends.

The average yearly gasoline consumption in 1987 was estimated to be 430 gallons. This is SRI's estimate based on the Energy Act of 1975 as well as an estimated population mix of vehicles in various years. The Energy Act mandates an average of 20 mpg by 1980 and 26-27.5 mpg by 1985. It was estimated that due to various mixes of car ages, the average mpg in 1982 will be 17, in 1984 it will be 19, and in 1987 it will be 22. Assuming an average yearly mileage of 9,400 miles/car, the yearly gasoline consumption in 1987 is calculated to be

$$\frac{9400}{22} \simeq 430 \text{ gallons.}$$

TCM Programs

General

Based on the study of readily available literature* as well as based on

*Refer to SRI International's report, "Assessment of Mobile Source Control Strategy Cost Effectiveness," dated June 1979, prepared under EPA contract No. 68-02-2835, available from EPA through Ambient Standards Branch (MD-12). This report presents a summary of cost information available in recent literature as well as several references.

on consultations with EPA, it is assumed that TCM programs can accomplish a maximum of up to 5% reduction in CO emissions--3% by local TCM strategies and 2% by areawide TCM strategies. However, it is to be noted that almost all of the TCM programs are primarily implemented to improve the transit operations and conserve energy. The reductions in CO and other pollutants are usually cited as additional advantages. As such, it is misleading to allocate the total costs of implementing a TCM program to either traffic improvement or energy savings or to pollution reduction, although a major portion should be allocated to transit operation improvements and energy savings. However, since no clearly stated rules of allocating the costs to various consequences are presently available, the cost per VMT reduction of various programs have been converted to cost per ton of CO reductions assuming suitable values of CO emissions per VMT and are reported as if the costs were allocated to CO reductions. Estimated energy savings are also reported separately.

An average CO emisson value of 41 gms ($41 \times 10^{-6}$ tons) per mile was assumed for 75° temperature areas and a value of 51 gms ($51 \times 10^{-6}$ tons) per mile was assumed for 20° temperature areas. These values are based on the Tables F-1 and F-3 of EPA document "Mobile Source Emission Factors." The average value was calculated using the values for the years 1982, 1984 and 1987.

Cost and Effectiveness of Local TCM Programs

The costs of local control programs are available in literature and are generally expressed in $ per Vehicle Hour of Travel (VHT). It was assumed that 1 VHT is equivalent to 25 VMT so that costs could be expressed in $ per VMT. The following four strategies were selected for estimating average costs of local TCM programs. These are the strategies for which general data were readily available.

| | Assumed Cost/VMT $ | Estimated Cost/Ton 20° temp $ | Estimated Cost/Ton 75° temp $ | Average of 20° & 75° values $ | Assumed Effectiveness in CO Reduction |
|---|---|---|---|---|---|
| a. Signal Timing optimization | .001 | 19.60 | 24.40 | 22 | 2% |
| b. Computerized Control of streets flow | 0.01 | 196 | 244 | 220 | 0.5% |
| c. Freeway surveillance and control | 0.04 | 784 | 976 | 880 | 0.3% |
| d. Truck restrictions on certain streets | 0.02 | 396 | 488 | 440 | 0.2% |
| | | | | Total | 3% |

Costs and Effectiveness of Areawide TCM Programs

Four strategies have been selected for the purposes of estimating average costs of areawide TCM programs. These are the strategies for which general data were readily available.

| Strategy | Assumed Cost/VMT $ | Estimated Cost/Ton 20° temp $ | Estimated Cost/Ton 75° temp $ | Average of 20 & 75° valued $ | Assumed Effectiveness in CO Reduction |
|---|---|---|---|---|---|
| a. Ridesharing | 0.02 | 390 | 480 | 435 | .8% |
| b. Transit improvement with express bus service | 0.43 | 8,430 | 10,500 | 9,465 | 0.5% |
| c. Local bus service improvement | 0.40 | 7,840 | 9,750 | 8,795 | 0.5% |
| d. Work rescheduling | 0.01 | 195 | 240 | 218 | 0.2% |
| | | | | Total | 2% |

Approach Used in the Computer Program to Calculate TCM Costs

Based on the study of the cost effectiveness of various strategies and keeping in mind that various areas may need various strategies, it was assumed that typically:

1. Up to 3% reduction in CO emissions can be accomplished at an average cost of \$170/ton of CO reduction. This is the weighted average cost (rounded-up value) of the local TCM programs, i.e.,

$$170 \simeq [(22 \times .02) + (220 \times .005) + 880 \times .003) + (440 \times .002)]/.03$$

2. Another 1% reduction can be accomplished at a average cost of \$400/ton. This is a rounded-up value of the weighted average cost of ridesharing and work rescheduling programs, i.e.,

$$400 \simeq [(435 \times .008) + (218 \times .002)]/.01$$

3. A further 1% reduction results if public transit improvments are implemented and the average cost per ton is \$9200/ton. This is the rounded-up value of express bus and local bus improvement programs, i.e.,

$$9200 \simeq [(9465 \times .005) + (8795 \times .005)]/.01$$

Potential Fuel Economy Due to TCM

The amount of gasoline saved per ton of CO reduction due to TCM strategies has been estimated assuming an average value of 46* gms ($46 \times 10^{-6}$ tons) CO emissions per mile and a gasoline consumption of 1 gallon per 20 miles.

Thus, gasoline saved per ton of CO reduction due to TCM

$$= \frac{10^6}{46 \times 20} \simeq 1088 \text{ gallons/ton of CO reduction}$$

Above are the initial values selected. However, these have been treated as parameters in the program so that, if necessary, improved values can easily be used.

*$46 = \frac{51 + 41}{2}$; 51 gms/mile for 20° temperature and 41 gms/mile for 75° temperature used in earlier calculations.

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16. ABSTRACT

The report is a summary of a methodology developed to analyze mobile source emission reductions needed to attain alternative proposed national ambient air quality standards for carbon monoxide. A costing routine is part of the procedure. The methodology was used in the carbon monoxide regulatory impact analysis for alternative national air standards.

17. KEY WORDS AND DOCUMENT ANALYSIS

| a. DESCRIPTORS | b. IDENTIFIERS/OPEN ENDED TERMS | c. COSATI Field/Group |
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