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Air

**NATIONAL AIR POLLUTANT
EMISSION TRENDS,
PROCEDURES DOCUMENT
1900-1993**

$$E = A * EF * [1 - C/100]$$

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SECTION 1.0

INTRODUCTION

The Emission Inventory Branch (EIB) of the U.S. Environmental Protection Agency (EPA) is responsible for compiling and maintaining national emission data for the criteria pollutants. To that end, EIB produces estimates of the annual national air pollutant emissions for five major pollutants: carbon monoxide (CO), nitrogen oxides (NO_x), lead (Pb), particulate matter less than 10 microns (PM-10), sulfur dioxide (SO₂), and volatile organic compounds (VOC). In addition, total particulate matter (TSP) has been estimated in the past. These estimates are published annually in two EPA reports and are entitled for 1994, "National Air Pollutant Emission Trends, 1900-1993,"¹ and "National Air Quality and Emission Trends Report, 1993."² Collectively, these are known as the *Trends Reports*.

The 1994 *Trends Procedures Document* is an accompanying document designed to describe the methodology and procedures used to create the emission estimates presented in the 1994 *Trends Reports*. The emissions estimating methodologies fall into three major categories: 1900-1939 Methodology, 1940-1984 Methodology, and 1985-1993 Methodology. The methodology used to make specific estimates depends on the pollutant and the time period. Table 1-1 presents a detailed characterization of the emission estimates created using each of these three methodologies and the section of this report that describes the methodology.

In general, the SO₂, NO_x, and VOC emissions for the time period before 1940 were using the 1900-1939 methodology. The emissions of no other pollutants were estimated for these years.

The 1940-1984 methodology was originally developed specifically to make the emission estimates for all years and pollutants presented in the *Trends Reports*. For the 1994 *Trends report*, this methodology was generally used to estimate the emissions for the years from 1940 to 1984. In addition to SO₂, NO_x, and VOC emissions, the emissions of CO, Pb, PM-10, and TSP are estimated by this methodology. (Lead estimates have not been developed prior to the year 1970.)

The emissions for the years from 1985 to 1993 were estimated by the methodology underlying a new emission inventory, the Interim Inventory.³ This methodology was applied to the emission estimates for all pollutants, except Pb and TSP. The emissions of these pollutants are estimated using the 1940-1984 methodology. (TSP estimates were last developed for the 1992 emissions. Currently there is no plan to estimate TSP emissions in the future since the current National Air Quality Standards for particulate matter are for the size 10 microns or less.)

For each methodology, the procedures used to estimate the emissions are described by the source category divisions most appropriate for that methodology. For a given source category, the estimating procedure is described for all pollutants collectively, unless differences exist in the methods used for different pollutants. In this case, the methods used for each pollutant are described

separately. Because of the unique nature of the methodology used to estimate the lead emissions, this methodology is described in a separate section. This allows each section of the manual to be used independently.

Emission estimates presented in the 1994 *Trends* Reports are categorized using the Tier structure. Emissions derived by the 1900-1939 methodology are presented by the Tier 1 categories. All other emissions appear by the Tier 3 categories. Because the methodologies are not necessarily described by these Tier categories, a description of the correspondence between the source categories used to describe the estimating methodology and the Tier structure is included in each section of this document.

This document is best used as a reference for those personnel who already have some familiarity with the trends report production process or for a technical person inquiring about the origins of the estimates. Some details of procedures are vaguely or inadequately defined, since getting such details down on paper and keeping the document current, is a real challenge. A new person who takes over responsibility for this work will in general need help from an experienced person.

In the past, the emission estimates presented in the *Trends* reports would change from one year to the next based on the development of new information, data, or methodologies used to estimate the emissions. These changes were applied not only to the most recent year, but to all or some of the preceding years. As of 1994, no such changes will be made to the emissions for the years prior to 1985. Therefore, the methodologies and reference presented in this document for the determination of the emission for these years will not change. Updates may be made, however, to the emissions for the years 1985 to the current year of the report. Any changes in the data or methodologies used to estimate the emissions for this time period will be documented in yearly addenda to this procedures document.

1.1 REFERENCES

1. *National Air Pollutant Emission Trends, 1900-1993*. U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1994.
2. *National Air Quality Emissions Trends Report, 1993*. U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1994.
3. *Regional Interim Emission Inventories (1987-1991), Volume I: Development Methodologies*. EPA-454/R-93-021a. Source Receptor Analysis Branch, U.S. Environmental Protection Agency, Research Triangle Park, NC. May 1993.

Table 1-1. Estimating Methods Used in the 1994 Trends Report

Tier Category	Time Period	Pollutant(s)	Methodology	Section
Fuel Combustion - Electric Utilities	1900-1969, excluding 1940, 1950, and 1960	VOC, SO ₂ , and NO _x	1900-1939 Methodology	2
Fuel Combustion - Industrial		VOC, SO ₂ , NO _x , CO, and PM-10	1940-1984 Methodology	3
Fuel Combustion - Other	1940, 1950, and 1960 and 1970 through 1984	Pb	Lead Methodology	5
Chemical & Allied Product Mfg.		VOC, SO ₂ , NO _x , CO, and PM-10	1985-1993 Methodology	4
Metals Processing	1985 through 1993	Pb	Lead Methodology	5
Petroleum & Related Industries		VOC, SO ₂ , NO _x , CO, and PM-10	1985-1993 Methodology	4
Other Industrial Processes	1985 through 1993	Pb	Lead Methodology	5
Solvent Utilization		VOC, SO ₂ , NO _x , CO, and PM-10	1985-1993 Methodology	4
Storage & Transport	1985 through 1993	Pb	Lead Methodology	5
Waste Disposal & Recycling		VOC, SO ₂ , NO _x , CO, and PM-10	1985-1993 Methodology	4
Natural Sources	1985 through 1993	Pb	Lead Methodology	5
Miscellaneous		VOC, SO ₂ , NO _x , CO, and PM-10	1985-1993 Methodology	4
Highway Vehicles	1900-1939	VOC, SO ₂ , NO _x	1900-1939 Methodology	2
Off-Highway	1940 through 1969	VOC, SO ₂ , NO _x , CO, and PM-10	1940-1984 Methodology	3
		Pb	Lead Methodology	5
	1970 through 1993	VOC, SO ₂ , NO _x , CO, and PM-10	1985-1993 Methodology	4
		Pb	Lead Methodology	5

SECTION 2.0

1900 - 1939 METHODOLOGY

The SO₂, NO_x, and VOC emission estimates presented in the 1993 *Trends* report for the years 1900 through 1969, with the exception of the years 1940, 1950, and 1960,^a were taken from two reports on historic emissions. The first contained SO₂ and NO_x emissions for the years between 1900 and 1980.¹ The VOC emissions for the years between 1900 and 1985 were contained in the second.² A summary of the methodologies used to estimate these emissions is presented in this document. This summary includes the basic assumptions, categorization, and calculations used to estimate these emissions. The two reports^{1,2} provide a more detailed discussion of the methodologies used to estimate these emissions.

2.1 DESCRIPTION OF EMISSION ESTIMATION METHODOLOGIES FOR SO₂ AND NO_x

A methodology for estimating historic SO₂ and NO_x emissions was developed prior to the 1940 - 1984 methodology and served as the predecessor to that methodology. These historic emissions were prepared for the years 1900 to 1980. Of these historic estimates, the 1994 *Trends* report presented the emissions for the years 1900 through 1969, except for the years 1940, 1950, and 1960.^a The general methodologies for producing these emissions are described in this document along with specific information concerning the emissions for the years from 1900 through 1970.

The emissions were categorized based on the sources of the emissions. Each source category included specific processes which generate emissions such as the combustion of coal by locomotives. The general methodology for estimating emissions was based on two factors: (1) the activity indicator which represents the activity of each process (e.g. the quantity of coal consumed by railroad locomotives) and (2) the emission factor which represents the quantity of emissions produced by the process per unit of process activity (e.g. the pounds of SO₂ produced for every ton of coal burned by a locomotive). Table 2-1 lists the source categories, along with the activity indicators and a description of the processes included in each category.

2.1.1 State Level Estimates

The state level SO₂ and NO_x emissions were produced for every fifth year beginning in 1900 and ending in 1970. The methodologies used to estimate the state level emissions fall into three general groups. These groups are: (1) emissions from the combustion of fuels for heat and power, except by highway vehicles, (2) emissions from the combustion of fuel for transportation by highway vehicles, and (3) emissions from material processing, manufacturing, miscellaneous combustion, and miscellaneous burning. The three general methodologies used to estimate the emissions are described individually in the following sections.

^a The emissions for the years 1940, 1950, and 1960 were estimated using the 1940-1984 methodology. This methodology is describ

2.1.2 Emissions from Fuel Combustion, Excluding Highway Vehicles

The source categories representing emissions produced by burning a fuel to generate heat or power are: electric utilities, industrial boilers, commercial and residential fuel uses, all uses of anthracite coal (as a fuel), all uses of wood (as a fuel), railroads, vessels, and off-highway diesel engines. The emissions from each source category were further categorized by the fuel type (e.g., emissions from railroad were estimated for each of the two fuels burned by locomotives: coal and oil). The emissions from each source category and fuel type were determined using three pieces of information: (1) a fuel use indicator, (2) a fuel sulfur content (necessary to estimate SO₂ emissions only), and (3) an emission factor expressing the amount of SO₂ or NO_x produced by a given amount of fuel burned.

The primary fuel use indicator used was the state level fuel consumption for a specific source and fuel type. If such data were unavailable, then a state level fuel use indicator such as fuel demand, distribution, sales, or deliveries was used. Prior to 1940, state level data were often unavailable; in these cases, a national fuel use indicator was used, if available. The national indicator was apportioned to the states using the same state/national ratios established for the earliest year having available state level data. There were combinations of fuel types and source categories for which no fuel use indicators were available over specific time periods. For those cases listed in Table 2-2, emission estimates at the state level were not estimated.

The emission factor provided the ratio between the quantity of fuel consumed and the uncontrolled amount of SO₂ or NO_x emitted. The emission factors used to estimate the historic emissions were derived from those contained in AP-42, up to and including Supplement 14.³ Emission factors representing a given source category, fuel type, and pollutant were weighted averages of the AP-42 emission factors representing specific processes. The weighting factors were the quantities of the specific fuel type consumed by each of the processes. These national emission factors were applied to all state level fuel use data for all years.

In order to estimate SO₂ emissions, the sulfur content of the fuel burned was required. In 1970, the sulfur content was based on reports from individual plants. State average sulfur content was used for coal in 1965 and for other fuels in 1955. For the 1955 estimates, sulfur contents for coal were estimated for each state based on coal quality, quantity, and distribution. The emissions for all years prior to 1955 were estimated using the 1955 sulfur content data for all fuels.

The state level emissions for SO₂ and NO_x were calculated for every fifth year between 1900 and 1970 using the general equations given below. Equations 1 and 2 were used for all fuel combustion sources.

$$SO_2 \text{ emissions}_{i,j,k} = FC_{i,j,k} \times (EF_{j,SO_2} \times S_{i,j,k}) \quad (1)$$

$$NO_x \text{ emissions}_{i,j,k} = FC_{i,j,k} \times EF_{j,NO_x} \quad (2)$$

where: **FC** = fuel consumption **i** = year
EF = emission factor **j** = source category /fuel type
S = sulfur content **k** = state

2.1.3 Emissions from Fuel Combustion by Highway Vehicles

Emissions produced by highway vehicles were divided into two subcategories: emissions from gasoline-powered vehicles and emissions from diesel-powered vehicles. Emissions were made estimated based on three pieces of information: gasoline or diesel fuel consumption, fuel efficiency (for gasoline only), and emission factor. In 1970, vehicle miles traveled (VMT) data became available and was used in place of the state level fuel consumption and fuel efficiency. The fuel efficiency factor was needed to correlate the amount of gasoline consumed to the average number of miles traveled. A national average miles per gallon was estimated for every fifth year between 1965 and 1935. A constant fuel efficiency was used for all years prior to 1935.

The emission factors for estimating controlled emissions from gasoline-powered vehicles were expressed in terms of the amount of SO₂ or NO_x emitted for every mile traveled. State-specific emission factors were obtained from the MOBILE2 emission factor model⁴ for the years 1950 through 1970. The factors calculated for 1950 were used for all preceding years. The factors for NO_x emissions were derived to represent two distinct road types: urban and rural.

The emission factors for estimating controlled emissions from diesel-powered vehicles were expressed in term of the amount of SO₂ and NO_x emitted for every gallon of diesel fuel consumed. Unlike the emission factors for gasoline-powered vehicles, those used for diesel-powered vehicles were national and not year-specific. No fuel efficiency was required to estimate the emissions from this vehicle type.

The SO₂ and NO_x emission estimates from highway vehicles for the years prior to 1970 were produced using Equation 3. Equation 4 was used to produce the emission estimates for 1970.

$$\text{Highway Vehicle Emissions}_{i, j, k} = (FC_{i, k} \times FE_i) \times EF_{i, j, k} \quad (3)$$

$$\text{Highway Vehicle Emissions}_{1970, j, k} = VMT_{1970, j, k} \times EF_{1970, j, k} \quad (4)$$

where: **FC** = fuel consumption
FE = fuel efficiency (gasoline-powered vehicles only)
EF = emission factor
i = year

- j** = SO₂ or NO_x
- k** = state
- VMT** = vehicle miles traveled (1970 estimates only)

2.1.4 Emissions from Material Processing, Manufacturing, Miscellaneous Combustion, and Miscellaneous Burning

The source categories producing emissions as the result of material processing, manufacturing, miscellaneous combustion, and miscellaneous burning were: coke plants (combustion stacks), smelters, cement plants, wildfires, miscellaneous industrial processes, and miscellaneous other processes. With the exception of the two miscellaneous categories, the emissions were generally estimated from an activity indicator and an emission factor. The activity indicator specified the industrial output of the process or, in the case of the wildfire category, the area burned. The emission factors were derived from AP-42.³ The general equation used to calculate the emissions for both pollutants is given below.

$$E_{i, j, k, l} = A_{i, j, k, l} \times EF_{i, j, k, l} \tag{5}$$

- where:
- E** = emission estimate
 - A** = activity indicator
 - EF** = emission factor
 - i** = year
 - j** = SO₂ or NO_x
 - k** = state
 - l** = source category

Because of the diverse nature of this group, specific details of the methodologies used to calculate the emissions will be discussed for each category individually.

2.1.4.1 Coke Plants

The methodology used to estimate the uncontrolled emissions produced from the combustion stacks of coke plants was similar to that used for coal combustion. In place of the amount of coal burned, these estimates were based on the amount of coal charged into the coke ovens. The SO₂ and NO_x emissions were estimated using Equations 1 and 2, respectively, with the emission factors, the state level coal sulfur contents, and the state level quantities of coal charged. This methodology accounts for only about 67 percent of the total SO₂ emitted by coke plants. The remaining 33 percent of the emissions were passed to the coke oven gas and were emitted later in the steel manufacturing process and were categorized with miscellaneous industrial processes.

2.1.4.2 Smelters

The primary smelters category consisted of copper, lead, and zinc smelters. The copper smelters predominantly emitted SO₂ and only small amounts of NO_x, while the lead and zinc smelters

emitted only SO₂. The methodology used to estimate the emissions from smelters varied according to the availability of pertinent data.

For the years between 1950 and 1970, the emissions from copper smelters from all but the major producing states were estimated using the state level amounts of copper ore concentrate produced and a national emission factor. Emissions from the major copper smelter states were obtained from a visibility study.⁵ After 1960, SO₂ emissions from lead and zinc smelters were based on information obtained from a study of individual smelters.⁶

For copper smelters before 1955 and for lead and zinc smelters before 1965, a different methodology was employed. The state level quantity of ore smelted was estimated using the amount of recoverable metal produced by the mines in a given state. It was assumed that any ore mined in a given state was smelted in the same state. If the given state was known to have no smelters, then it was assumed that the ore was smelted in the nearest state having a smelter. A national SO₂ emission factor was used to convert the quantity of recoverable metal to the uncontrolled quantity of SO₂ produced. A national NO_x emission factor was used to calculate the NO_x produced by the copper smelters.

The controlled SO₂ emissions were determined by subtracting the amount of SO₂ recovered during the production of sulfuric acid. Because only national by-product sulfuric acid production data was available, it was assumed that the amount of SO₂ recovered for each state was proportional to the smelter output for that state.

2.1.4.3 Cement Plants

SO₂ and NO_x emissions from cement plants were produced by both the minerals processed in the kiln and the combustion of fuels to heat the kiln. The industrial activity indicator used to estimate the emissions was the total annual production of portland cement by state. State level SO₂ emission factors were the sum of the emission factors for the mineral sources, the combustion of coal, and the combustion of oil. The NO_x emission factors were average national factors. The emission factors calculated for 1955 were used to determine the emission estimates for all preceding years.

2.1.4.4 Wildfires

Wildfire emissions were defined as emissions from the combustion of vegetation in any uncontrolled fire. The activity indicator for this category was the total area burned annually in each state. This information was available for most states by 1925 and for all states by 1940. Prior to 1925, the acreage burned was assumed to be equal to the acreage burned in 1925. State level emission factors reflected variations in vegetation (e.g. woodlands as compared to grasslands).

2.1.4.5 Miscellaneous Industrial Processes

A list of the industrial processes included in this category is given in Table 2-3. The SO₂ and NO_x emissions for this source category were determined by backcasting 1980 state-level emissions obtained from the National Emission Data System (NEDS)⁷ using national growth factors. The yearly national growth factors for the years after 1940 were defined as the ratio between the national emissions for the specific year and the 1980 national emissions. Growth factors for the earlier years were based on national population. The following equation was used to estimate the emissions for this category.

$$SE_i = SE_{1980} \times \frac{NE_i}{NE_{1980}} \quad (6)$$

where: SE = SO₂ or NO_x state emission estimate
 NE = SO₂ or NO_x national emission estimate
 i = year

2.1.4.6 Miscellaneous Other Processes

Table 2-3 contains a list of the processes included in this category. The methodology used to estimate the emissions for this category is similar to that used above for the industrial processes. For this category, national emissions were available from the 1980 NEDS⁷ and the emissions were apportioned to the states based on 1980 population data. State-level growth factors for a given year were applied to the 1980 state-level emissions to backcast the emissions for that given year. The growth factors for each state were calculated as the ratio between the estimated state population for that year and the 1980 state population. The equation used to calculate the SO₂ and NO_x emissions for this source category is given below.

$$SE_i = SE_{1980} \times \frac{S_i}{S_{1980}} \quad (7)$$

where: SE = SO₂ or NO_x state emissions
 S = state population
 i = year

State population data for every tenth year was obtained from population census data. For the intervening years, the state populations were estimated using the following equation:

$$S_{i\%j} = (S_{i\%10} \& S_i) \frac{N_{i\%j} \& N_i}{N_{i\%10} \& N_i} \% S_i \quad (8)$$

where: S = state population
 N = national population
 i = census year (1900, 1910, ..., 1970)
 j = integer 5 representing every fifth year

2.1.5 Yearly State-Level Emissions

The SO₂ and NO_x emissions were calculated every fifth year from 1900 to 1970 as described in the preceding section. For the source categories representing emissions produced by the combustion of fuels, the emissions for each intervening year were estimated by equating the changes in national fuel consumption to the changes in the state level emissions. Consumption data for the following fuels were used: bituminous coal, anthracite coal, distillate and residual oils (combined), natural gas, wood, and gasoline and diesel fuel (combined). The interpolated state level emissions for each pollutant were calculated using the equation below.

$$SE_{i\%j\%1} = (SE_{i\%5} \& SE_{i\%j}) \times \frac{NF_{i\%j\%1} \& NF_{i\%j}}{NF_{i\%5} \& NF_{i\%j}} \% SE_{i\%j} \quad (9)$$

where: SE = SO₂ or NO_x state emissions by source category and fuel type
 NF = national fuel consumption data corresponding to source category and fuel type
 i = study year (i.e., 1900, 1905, ..., 1970)
 j = integer representing the intervening year (0, 1, 2, or 3)

For the following fuel types and years, the national fuel consumption changed radically and, therefore, was not used to estimate the yearly emissions: bituminous coal for the years 1912 and 1913 and natural gas for the years 1931, 1932, and 1933. In these cases, the yearly SO₂ and NO_x emissions were determined by a linear interpolation according to the following equation:

$$SE_{i\%j} = SE_i \% ((SE_{i\%5} \& SE_i) \times j) 5 \quad (10)$$

where: SE = SO₂ or NO_x state emissions by source category
 i = study year (i.e., 1900, 1905, ..., 1970)
 j = integer representing the intervening year (1, 2, 3, or 4)

For the source categories in which the emissions were not based on fuel consumption (i.e. smelters, cement plants, wildfire, miscellaneous industrial processes, and miscellaneous other sources), the yearly emissions were also calculated by a linear interpolation as given in Equation 10.

2.1.6 Allocation of Emission Estimates to Tier 1 Categories

The emission estimates for the years 1900 through 1969 (excluding 1940, 1950, and 1960) were presented graphically in the 1994 *Trends* report by Tier 1 categories. These categories were not the same as those used in the original calculation of the emissions as described in the preceding sections. A correspondence was developed between the original historic emission categories and the Tier 1 categories.

The historic emissions were summed into five general categories as shown in Table 2-4. These categories were then mapped to the Tier 1 categories as shown in Table 2-5. There was a one-to-one correspondence between the major historic categories and the Tier 1 categories for three Tier 1 categories: (1) Fuel Combustion - Electric Utilities, (2) Fuel Combustion - Other, and (3) Highway Vehicles. The historic emissions were assumed to be zero for two Tier 1 categories: (1) Solvent Utilization and (2) Storage and Transport.

The emissions from the other two historic categories were allocated to the corresponding Tier 1 categories based on the distribution of emissions for a specific base year. The Industrial historic category was correlated to five Tier 1 categories: Fuel Combustion - Industrial (02), Chemical and Allied Products Manufacturing (04), Metals Processing (05), Petroleum and Related Industries (06), and Other Industrial Processes (07). To distribute the emissions from the Industrial historic category to a specific Tier 1 category, a ratio between the base year emissions for the specific Tier 1 category and the sum of the base year emissions for all five of the Tier 1 categories correlated to the Industrial historic category was used. The same procedure was used to distribute the emissions from the Other historic category which correlates to three Tier 1 categories: Waste Disposal and Recycling (10), Off-highway (12), and Miscellaneous (14). The base year was 1940, 1950, or 1960, depending on the year for which the emissions were being distributed. The emissions for these base years were developed using the 1940-1984 methodology (see section 3.0) and were distributed to the Tier 1 categories. The method for distributing emissions to Tier 1 categories is summarized in Equation 11.

$$E_{Tier 1, i} = E_{Historic, i} \times \left[\frac{E_{Tier 1}}{\sum_j (E_{Tier 1 \text{ categories corresponding to Historic category}})_B} \right] \quad (11)$$

where: E = SO₂ or NO_x emissions
i = historic emissions year (1900, 1905, ..., 1935, 1945, 1955, 1965)
B = base year: 1940 (for historic years 1900 to 1935 and 1945)

1950 (for historic year 1955)
 1960 (for historic year 1965)

Historic = Industrial historic category or Other historic category
 Tier 1 = categories 02, 04, 05, 06, or 07 or categories 10, 12, or 14
 Tier 1 categories corresponding to Historic category
 = 02 + 04 + 05 + 06 + 07 (for Industrial historic category)
 10 + 12 + 14 (for Other historic category)

For the intervening years, the distribution of the emissions to the Tier 1 categories was made from the historic emission estimates totaled over all categories. The average percentage distribution of the total emissions to a specific Tier 1 category was calculated for every six year period (e.g. 1900 to 1905, 1925 to 1930). The percentage distribution was applied to each intervening year within the six year period. Equation 12 illustrates this method.

$$E_{Tier1, i\%j} = E_{Total, i\%j} \times \left[\frac{E_{Tier1, i\%5}}{E_{Total, i\%5}} \right] \quad (12)$$

where: E = SO₂ or NO_x emissions
 i = every fifth year between 1900 and 1965
 j = integer representing the intervening year (1, 2, 3, or 4)
 Tier 1 = Tier 1 category
 Total = totaled over all historic categories

2.2 DESCRIPTION OF EMISSION ESTIMATION METHODOLOGY FOR VOC

The basic methodology for estimating the VOC emissions was a top-down method using national activity indicators and national emission factors. This was substantially different from the methodology used to produce the SO₂ and NO_x emission estimates where more detailed state level data was used wherever possible. The VOC emissions were divided into five broad source categories, each of which is subdivided into more refined subcategories. These categories and corresponding subcategories are presented in Table 2-6. For these emission estimates, the term national referred to the contiguous United States.

2.2.1 National VOC Emission Estimates (every five years between 1900 and 1970)

National emissions for the years 1940, 1950, 1960, 1965 and 1970 were obtained directly from the 1985 *Trends* report.⁸ These data, along with that for 1975, 1980, and 1985, were used to estimate the emissions for every fifth year between 1900 and 1935 and the years 1945 and 1955. The methodology described below pertains to these years.

The two data values required to estimate the national annual VOC emissions for each source subcategory were (1) national annual activity indicators, and (2) national annual emission factors. The national activity indicators for each source subcategory for the years 1955, 1945 and every fifth year between 1900 and 1935 were obtained from a variety of sources. In cases where the activity indicators contained data from Alaska, Hawaii, or the U.S. territories, the activity indicators for areas outside the contiguous United States were subtracted from the total activity indicators. This resulted in the national (i.e., contiguous United States) activity indicator.

The development of the national annual emission factors required two steps: (1) back-calculation of the emission factors for the years 1940, 1950, and every fifth year between 1960 and 1985 and (2) extrapolation of these national emission factors to the years under study. In order to back-calculate emission factors, activity indicators and emissions were required. National emissions were obtained for the years 1940, 1950, and every fifth year between 1960 and 1985 from the 1985 *Trends* report.⁸ These emissions were disaggregated into the source subcategories given in Table 2-6. The *Trends* report was also the source of the national activity indicators for all subcategories for the same years. For each year and source subcategory, a national emission factor was calculated using the following equation:

$$NEF_{i,j} = \frac{NE_{i,j}}{NA_{i,j}} \quad (13)$$

where: NEF = national emission factor i = year
 NE = national emissions j = source subcategory
 NA = national activity indicator

For some source subcategories, these national emission factors were unchanged over time. In those cases, the constant emission factor was used in calculating the emissions for all years. For source categories where the national emission factors changed between the years 1940 through 1985, the emission factors for the years before 1940 and for the years 1945 and 1955 were extrapolated from the back-calculated data.

The national VOC emissions for the years 1945 and 1955, and for every fifth year between 1900 and 1935, were calculated for each subcategory using the equation given below:

$$NE_{i,j} = NEF_{i,j} \times NA_{i,j} \quad (14)$$

where: NEF = national emission factor i = year
 NE = national emission estimate j = source subcategory

NA = national activity indicator

2.2.2 Yearly National Emissions

The national emissions for every fifth year between 1900 and 1970 were used to interpolate the national emissions for the intervening years. The activity indicators used to the interpolate the emissions for each subcategory or group of subcategories are presented in Table 2-6. The national activity data for each year were obtained from the report of historic SO₂ and NO_x emissions.¹ The national emissions for each of the intervening years were calculated by equating the yearly change in the national activity indicators to the yearly change in the national emissions. The national emissions were calculated according to Equation 15 when using fuel consumption indicators. For source categories where population was used as the activity indicators, the yearly emissions were calculated using a linear interpolation as shown in Equation 16.

$$NE_{i\%j} = (NE_{i\%5} \& NE_{i\%j\&1}) \times \frac{NA_{i\%j} \& NA_{i\%j\&1}}{NA_{i\%5} \& NA_{i\%j\&1}} \% NE_{i\%j\&1} \quad (15)$$

$$NE_{i\%j} = NE_i \% (NE_{i\%5} \& NE_i) \times j/5 \quad (16)$$

where: NE = national emissions by source subcategory
 NA = national activity by source category
 i = study year (1900, 1905, ..., 1970)
 j = integer representing intervening years (1, 2, 3, or 4)

2.2.3 Changes in Emissions

The emission factors for the source category External Fuel Combustion, subcategory Wood have been changed since the time the original report² was published. This adjustment of the erroneously high emission factors was based on more current information. The updated emission factors for the years 1900 through 1970 are presented in Table 2-7. No changes were made to the activity indicators for this subcategory. The emissions presented in the 1993 and the 1994 *Trends* reports for the years 1900 through 1969, excluding 1940, 1950 and 1960, were based on recalculated emissions for this subcategory using the adjusted emission factors. Therefore the values published in the original report differ from those presented in the most recent *Trends* reports.

2.2.4 Allocation of Emission Estimates to Tier 1 Categories

The emissions for the years 1900 through 1969 (excluding 1940, 1950, and 1960) were presented graphically in the 1994 *Trends* report by Tier 1 categories. These categories were not the same as

those used in the original calculation of the emissions as described in the preceding sections. A correspondence was developed between the original historic emission categories and the Tier 1 categories.

The historic emissions determined by source subcategories were summed to the five major source categories described previously in Table 2-6. These categories were then mapped to the Tier 1 categories as shown in Table 2-8. There was only one major historic source category (Solid Waste) which corresponds directly to a Tier 1 category (Waste Disposal and Recycling). For all other Tier 1 categories, the distribution of the historic major source categories to the Tier 1 categories was accomplished by the same method described in section 2.1.6 for the SO₂ and NO_x emissions and summarized in Equations 11 and 12.

2.3 REFERENCES

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Table 2-1. Historic NO_x and SO₂ Emission Source Categories, Fuel Types, and Descriptions*

Source Category	Activity Indicator Consumption or Production	Description
Electric Utilities	Bituminous Coal, Residual and Distillate Oil, Natural Gas, and Wood (after 1945)	Power plants using coal, oil or gas to provide electricity for public consumption
Industrial Boilers	Bituminous Coal, Residual and Distillate Oil, Natural Gas and Wood (after 1945)	Manufacturing and mining facilities using fuel for heat, power and chemical feedstocks, and natural gas lease and plant operations
Commercial/Residential	Bituminous Coal, Residual and Distillate Oil, Natural Gas, and Wood (after 1945)	Nonmanufacturing enterprises using fuel for heat or power and agricultural, forestry, and fisheries facilities using natural gas. Private dwellings using fuel for heating, cooking, and other household uses
Anthracite Coal - all uses	Anthracite Coal	All facilities using anthracite coal as a fuel
Wood - all uses (1900 through 1945)	Wood	All facilities using wood as a fuel
Pipelines	Natural Gas	Internal combustion engines and turbines used to compress gas
Highway Vehicles	Gasoline and Diesel fuel	Automobiles, trucks, buses, and motorcycles using gasoline or diesel fuel for transportation
Railroads	Bituminous Coal and Distillate Oil	Trains, operated railroad equipment and other related operations
Coke Plants	Bituminous Coal	Furnace and merchant plants which produce coke
Smelters	Ore	Primary copper, lead, and zinc smelting facilities
Vessels	Residual and Distillate Oil	Commercial and private boats, including ocean going vessels
Off-Highway Diesel	Diesel Fuel	Engines used in construction, logging, and road building
Cement Plants	Portland Cement	Portland cement manufacturing plants
Wildfire	Area	Projected and unprotected forest land burned
Miscellaneous	Other	Industrial processes not included above and other miscellaneous anthropogenic sources

* Taken from Reference 1, Table 1 and Table 2.

Table 2-2. Historic NO_x and SO₂ Emission Source Categories Not Estimated*

Source Categories	Range of Years
All Fuel Oil Burning	1900 to 1920
Natural Gas-fired Electric Utilities	1900 to 1915
Natural Gas-fired Industrial and Commercial/Residential Uses	1900 to 1920
Pipelines	1900 to 1945

* Taken from Reference 1, page 31.

Table 2-3. Processes Included in the Miscellaneous Source Category*

Miscellaneous Subcategory	Processes	Subprocesses
Industrial Processes	Pulp and paper	
	Petroleum Refineries	
	Iron and Steel Manufacture	
	Primary Aluminum	
	Secondary Lead	
	Glass Manufacture	
	Chemical Manufacture	sulfuric acid carbon black petrochemicals ammonia nitric acid TNT
Other Sources	Aircraft	
	Vessels	gasoline-powered coal-powered
	Miscellaneous off-highway gasoline-powered vehicles	
	Fuel combustion	LPG coke-oven gas bagasse
	Solid Waste Disposal	
	Agricultural Burning	
	Coal Refuse Burning	
	Prescribed Burning	

* Taken from Reference 1, Tables 10 and 11, page 31.

Table 2-4. Major Source Categories for SO₂ and NO_x Historic Emissions

Major Source Categories	Source Categories (used in determination of emission estimates)
Electric Utilities	Electric Utilities: bituminous coal, residual oil, distillate oil, natural gas, and wood (after 1945)
Industrial	Industrial boilers: bituminous coal, residual oil, distillate oil, natural gas, and wood (after 1945) Pipelines Coke Plants Cement Plants
Commercial/Residential	Commercial/Residential: bituminous coal, residual oil, distillate oil, natural gas, and wood (after 1945)
Highway Vehicles	Highway Vehicles: gasoline and diesel
Other	Anthracite coal (all uses) Wood (all uses from 1900 to 1940) Railroads Smelters Vessels Wildfires Off-highway diesel Miscellaneous

Table 2-5. Correlation between Tier 1 Categories and Historic Major Source Categories for SO₂ and NO_x Emission Estimates

Tier 1 Categories		Historic Major Source Categories
Code	Name	
01	Fuel Combustion - Electric Utilities	Electric Utilities
02	Fuel Combustion - Industrial	Industrial
03	Fuel Combustion - Other	Commercial/Residential
04	Chemical and Allied Product Manufacturing	Industrial
05	Metals Processing	Industrial
06	Petroleum and Related Industries	Industrial
07	Other Industrial Processes	Industrial
08	Solvent Utilization	assumed zero
09	Storage and Transport	assumed zero
10	Waste disposal and Recycling	Other
11	Highway Vehicles	Highway Vehicles
12	Off-highway	Other
13	Miscellaneous	Other

Table 2-6. Source Categories and Activity Indicators for Historic VOC Emission Estimates*

Source Category	Estimates for Every Fifth Year from 1900 to 1970		Estimates for Intervening Years	
	Source Subcategory	Activity Indicators	Source Subcategories	Activity Indicators
TRANSPORTATION				
	Highway Vehicles	Highway Vehicle Gasoline plus Diesel Consumption	Highway Vehicles	Gasoline and Diesel Consumption
	Aircraft	Population	All Other Subcategories	Population
	Railroads			
	oil-fired	Railroad Oil Consumption		
	coal-fired	Railroad Oil Consumption		
	Vessels			
	oil-fired	Vessel Oil Consumption		
	coal-fired	Vessel Coal Consumption		
	Other Off-highway Use	Off-highway Fuel Use		
EXTERNAL FUEL COMBUSTION				
	Anthracite Coal	Anthracite Consumption	Anthracite Coal	Anthracite Consumption
	Bituminous Coal	Bituminous Consumption	Bituminous Coal	Bituminous Consumption
	Residual Oil	Residual Oil Consumption	Residual and Distillate Oil	Fuel Oil Consumption
	Distillate Oil	Distillate Oil Consumption		
	Natural Gas	Natural Gas Consumption	Natural Gas	Natural Gas Consumption
	Wood	Wood Consumption	Wood	Wood Consumption
	Coke and Other Fuels	Coke Production	Coke and Other Fuels	Population
INDUSTRIAL PROCESSES				
	Petrochemical Manufacture	Population	Petrochemical Manufacture	Population
	Petroleum Marketing		Petroleum Marketing	Gasoline and Diesel Consumption
	gasoline	Highway Vehicle Gasoline Consumption		
	other	Diesel plus Distillate Oil Consumption		

Table 2-6. (continued)

Source Category	Estimates for Every Fifth Year from 1900 to 1970		Estimates for Intervening Years	
	Source Subcategory	Activity Indicators	Source Subcategories	Activity Indicators
INDUSTRIAL PROCESSES (continued)				
	Surface Coating Operations	Population and Cement Production	Surface Coating Operations	Population
	Petroleum Refinery Process Operations	Crude Oil Run	All Other Subcategories	Crude Oil Consumption
	Petroleum Production			
	crude oil	Crude Oil Run		
	natural gas liquids	Crude Oil Run		
	Miscellaneous Industrial Processes	Population		
	Carbon Black Mfg.	VMT		
SOLID WASTE DISPOSAL				
	Incineration	Population	All Subcategories	Population
	Open Burning	Population		
MISCELLANEOUS OTHER SOURCES				
	Wildfire	Area Burned	All Subcategories	Population
	Prescribed Fires	State Land Area minus Wildfire Area		
	Other Burning	State Land Area minus Wildfire Area		
	Other Solvent Evaporation	Population		

* Taken from Reference 2, Tables 1 and 2, pages 5 and 9, respectively.

Table 2-7. Adjusted VOC Emission Factors for External Fuel Combustion, Wood

Year	Emission Factors (tons/1000 tons)
1900	15
1905	15
1910	14
1915	13
1920	13
1925	12
1930	11
1935	11
1940	10
1945	10
1950	9
1955	8
1960	7
1965	5
1970	4
1975	4
1980	5
1985	5
1990	5

Table 2-8. Correlation between Tier 1 Categories and Historic Major Source Categories for VOC Emission Estimates

Tier 1 Categories		Historic Major Source Categories
Code	Name	
01	Fuel Combustion - Electric Utilities	External Combustion
02	Fuel Combustion - Industrial	External Combustion
03	Fuel Combustion - Other	External Combustion
04	Chemical and Allied Product Manufacturing	Industrial Processes
05	Metals Processing	Industrial Processes
06	Petroleum and Related Industries	Industrial Processes
07	Other Industrial Processes	Industrial Processes
08	Solvent Utilization	Miscellaneous
09	Storage and Transport	Industrial Processes
10	Waste Disposal and Recycling	Solid waste
11	Highway Vehicles	Transportation
12	Off-highway	Transportation
13	Miscellaneous	Miscellaneous

SECTION 3.0

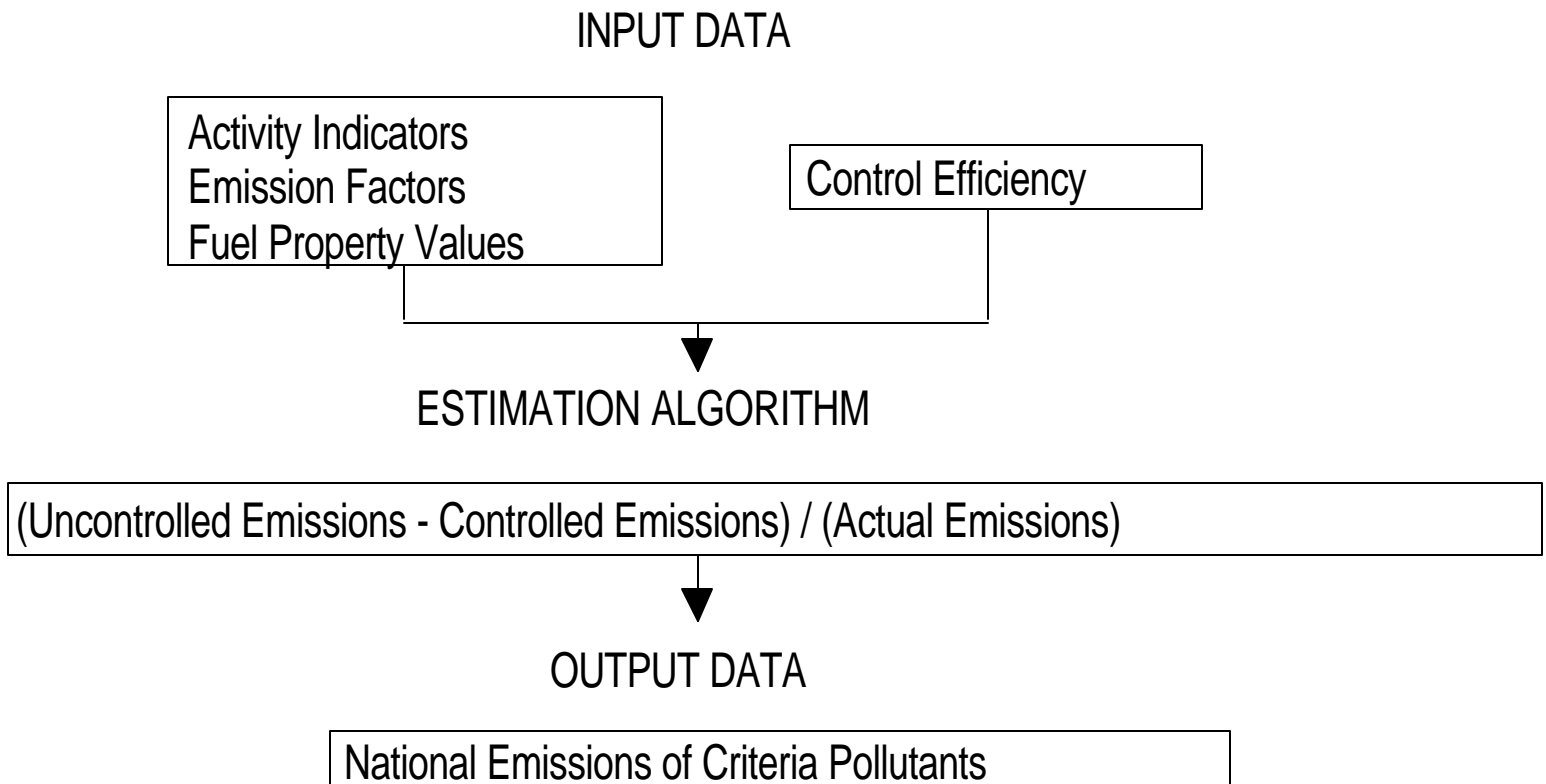
1940 - 1984 METHODOLOGY

This methodology was used to estimate emissions for the majority of pollutants presented in the *Trends* report for the years 1940, 1950, 1960, and 1970 to 1984. For all source categories, excluding highway vehicles and off-highway, this methodology was used to estimate the CO, NO_x, PM-10, SO₂, and VOC for these years. The TSP emissions for the years 1940, 1950, 1960, and 1970 to 1992 were estimated using this methodology. The lead emissions are explained in section 5.0. The emissions originating from highway vehicles and off-highway sources were estimated for the years 1940, 1950 and 1960 using this methodology. This section describes, in detail, the procedures used to estimate these emissions.

3.1 INTRODUCTION

The 1940-1984 Methodology was based on a "top-down" approach where national information was used to create a national emission estimate. Emissions were estimated based on the source of the emissions and, in the case of combustion sources, the fuel type. National activity of a process producing emissions of interest was measured by the consumption of fuel, the throughput of raw materials, or some other production indicator. The emission factor was used to determine the amount of an individual pollutant emitted based on the activity of the process. In the case of PM-10, TSP, and SO₂ emissions, average fuel property values of ash and sulfur content were incorporated into the estimating procedure as part of the emission factor. The final element used to estimate emissions was the control efficiency which quantifies the amount of a pollutant not emitted due to the presence of control devices.

The overall procedure is outlined below:



The emissions were presented in the 1994 *Trends* report by Tier categories, but in the 1940-1984 methodology, the emissions were estimated by a different set of source categories. In most cases, these source categories or subcategories were regrouped into the Tier categories. For several categories or subcategories, the emissions were apportioned to more than one Tier 2 category. The estimation procedures are presented in this section by the Tier 2 categories. Correspondence between these Tier 2 categories and the 1940-1984 Methodology source categories are presented in Table 3.1-1. This correspondence between the categories is reiterated within the description of the procedures for each Tier 2 category.

3.1.1 General Procedure

Since it is impossible to measure the emissions of every historic source individually, a top-down estimating procedure must be used. The emissions are calculated either for individual sources or for many sources combined, using indicators of emissions. Depending on the source category, these indicators may include fuel consumption or deliveries, VMT, tons of refuse burned, or raw material processed. When indicators are used, emission factors which relate quantity of emissions to the activity indicator must also be used.

Emission factors are not necessarily precise indicators of emissions. They are quantitative estimates of the average rate of emissions from many source combined. These factors are most valid when applied to a large number of sources. If their limitations are recognized, emission factors can be extremely useful tools for estimating national emissions. The calculations of the emissions were made according to the following general equation:

$$Emissions_{i,j,k} = A_{i,j} \times EF_{i,j,k} \times [1 - CE_{i,j,k}]$$

where: A = activity
EF = emission factor
CE = control efficiency (fraction)
i = year
j = source category
k = pollutant

The SO₂ emission factor for sources where the emissions were based on fuel combustion included the sulfur content of the fuel. Emission factors for TSP and PM-10 included the ash content of the fuel for combustion sources. The VOC emission factors included a factor representing the reactive portion for a variety of source categories.

As an aid in the calculation of the emissions by the 1940-1984 Methodology, two Excel spreadsheets, collectively referred to as the *Trends* spreadsheets, were created for each year. An example is provided in Table 3.1-2. These spreadsheets were entitled TRENDSxx.XLS and MGTMPxx.XLS, where xx represents the year. The required data was entered into the TRENDSxx.XLS spreadsheet, after which the MGTMPxx.XLS spreadsheet was opened and the necessary calculations (those shown above) were made to estimate the national emissions. This procedure was designed to simplify the process of estimating emissions for a new year. By using the TRENDSxx.XLS spreadsheet from the previous year as a template, the spreadsheet for the new year was created by editing only the data requiring updating. These spreadsheets now serve as a record of the calculations used to estimate the national emissions for CO, NO_x, PM-10, SO₂, TSP, and VOC for the years 1940, 1950, 1960 and the years 1970 through 1984.

The calculations employed within the TRENDSxx.XLS spreadsheets required the use of specific units for the activity indicators and the emission factors. These required units are specified in the descriptions of the

procedures for each of the Tier 2 categories. In general, the units for activity indicators were short tons for solids, gallons for liquids, and cubic feet for gases. Emission factors were expressed in units of metric pounds of pollutant per unit consumption or throughput. Control efficiency was expressed as a dimensionless decimal fraction. By using these units, emissions calculated within the spreadsheets are expressed in metric tons. The units of the raw data used as the basis for the activity indicator or the emission factors often required conversion to the units specified above. The following conversion factors were employed in many cases.

1 ton (metric)	=	1.1023 tons (short)
1 ton (long)	=	1.12 tons (short)
1 ton (short)	=	0.9072 tons (metric)
1 lb (metric)	=	1.1023 lb
1 bbl	=	42 gal

Emission factors were based on the most recent information available as of 1992. For many categories, this most recent emission factor was used to estimate emissions for all years. For some categories, the emission factor was the weighted average of emission factors for more specific subprocesses, equipment types, or other subcategories. Weighting factors used to calculate an average emission factor were often based on the relative activity of contributing subprocesses. In cases where the activities of the subprocesses changed from one year to the next, the emission factors also varied over time. Sulfur content or ash content of some fuels varied over time producing yearly variations in the SO₂, TSP, or PM-10 emission factors.

The PM-10 emission factors for some emission sources are not provided in the published documents referenced within this section. In these cases, the emission factors may be found in the supplemental list presented in Table 3.1-3. Therefore, the references given throughout this section are the possible sources of PM-10 emission factors, including published documents and Table 3.1-3.

Control efficiencies were calculated from information provided in the latest AIRS/AFS extraction utilizing the standard report number AFP650. This standard report contains emissions, annual throughput (when available), and number of facilities by Source Classification Codes (SCC). If a AIRS/AFS snapshot is not available for the current year, the current year's control efficiency was estimated by projecting the previous years' results. Also one should use a projection of previous years' results if the calculated control efficiency is nonsense. This could easily result if the operating rates (a confidential field in AIRS/AFS) of several SCCs are not extracted and the calculated control efficiency would be very low compare to previous year.

Calculation of the control efficiency involves three steps.

1. Calculate uncontrolled emissions for the SCC or SCCs that incorporate a source category. This is done by multiplying the operating rate by the latest emissions factor and converting to appropriate units.
2. Add all uncontrolled and then all controlled emissions separately.

3. Calculate a percentage control efficiency as follows:

$$\% \text{ Control efficiency} = \frac{\left(\text{Uncontrolled emissions} \ \& \ \text{Actual emissions} \right)}{\left(\text{Uncontrolled emissions} \right)} \times 100$$

The following information used in the next two equations, can be obtained from the AFP650 Report or AP-42.

SCC	1-01-005-04	1-01-005-01
Operating rate (1000 gallons)	419478	72889
PM-10 Emission Factor (lbs per 1000 gallons)	5.19	1.0
PM-10 Actual Emissions (tons)	723	11

The following information was calculated.

PM-10 Uncontrolled Emissions (tons)	1089	36
-------------------------------------	------	----

For SCC = 1-01-005-04

$$\text{Uncontrolled emissions} = 419478 \left[\frac{1000}{\text{gallons}} \right] \times 5.19 \left[\frac{\text{lbs}}{1000} \right] \times \frac{1[\text{ton}]}{2000 [\text{lbs}]}$$

For SCC = 1-01-005-01

$$\text{Uncontrolled emissions} = 72889 \left[\frac{1000}{\text{gallons}} \right] \times 1.0 \left[\frac{\text{lbs}}{1000} \right] \times \frac{1[\text{ton}]}{2000 [\text{lbs}]}$$

The control efficiency for this source category was calculated as follows:

$$\% \text{ Control efficiency} = \frac{\left(\frac{1089}{1089} \ \% \ 36 \right) \ \& \ \left(\frac{723}{723} \ \% \ 11 \right) [\text{tons}]}{\left(\frac{1089}{1089} \ \% \ 36 \right) [\text{tons}]} \times 100 = 35 \%$$

NOTE: Since the estimates are based on input data which may be updated or revised from time to time, the estimating procedure may change. For example, the emission factors published in AP-42 may be revised. If this occurs, it is necessary to revise all previous estimates where the original emission factor was used. Similarly, fuel consumption data may change from one year to the next as the statistics produced by various trade associations and government agencies are revised. Therefore, it is necessary to revise previous annual estimates when revised data are available. During the estimation procedure, it will become known which previous estimates require updating. In addition, all information for the last calendar year may not be available. Therefore, the best available information is used with the intent to amend the estimates as necessary in the following year.

3.1.2 Organization of Procedures

The 1940-1984 Methodology used to estimate emissions is described by Tier 2 category. For each category the procedure is divided into four sections: (1) technical approach, (2) activity indicator, (3) emission factor, and (4) control efficiency. The procedures for obtaining the activity indicators, emission factors or control efficiencies are arranged in a variety of different ways, depending on the specific requirements of the category (e.g., by pollutant, process, or fuel type).

References are provided at the end of the description of procedures for each Tier 2 category. Many of these references are published annually as part of a series. In some cases, several references are provided for the same information reflecting a change or discontinuation of one source and its replacement by another. The specific source used would depend on the specific year for which information was needed. All tables and supporting data immediately follow the description of the procedures for each Tier 2 category.

Table 3.1-1. Correspondence Between Tier 2 Categories and 1940-1984 Methodology Emission Source Categories

Tier 1 Category	Tier 2 Category	Tier 1/Tier 2 Code	1940-1984 Methodology Emission Source Categories	1940-1984 Methodology Emission Source Subcategories
Fuel Combustion - Electric Utilities	Coal	01-01	Bituminous Coal and Lignite	Electric Utilities
			Anthracite Coal	Electric Utilities
	Oil	01-02	Residual Oil	Electric Utilities
Distillate Oil			Electric Utilities	
	Gas	01-03	Natural Gas	Electric Utilities
Fuel Combustion - Industrial	Coal	02-01	Bituminous Coal and Lignite	Industrial
			Anthracite Coal	Industrial
	Oil	02-02	Residual Oil	Industrial
Distillate Oil			Industrial	
Industrial Processes - CO Emissions			Process Heaters (oil)	
Industrial Processes - NO _x Emissions			Petroleum Refineries (process heaters - oil)	
Industrial Processes - PM-10 Emissions			Miscellaneous Process Sources (process heaters - oil)	
Industrial Processes - SO ₂ Emissions			Other Industrial Processes (petroleum refineries - process heaters (oil))	
Industrial Processes - VOC Emissions			Petroleum Refinery Process Operation (process heaters - oil)	

Table 3.1-1. Correspondence Between Tier 2 Categories and 1940-1984 Methodology Emission Source Categories

Tier 1 Category	Tier 2 Category	Tier 1/Tier 2 Code	1940-1984 Methodology Emission Source Categories	1940-1984 Methodology Emission Source Subcategories
Fuel Combustion - Industrial, con't.	Gas	02-03	Natural Gas Miscellaneous Fuels Industrial Processes - CO Emissions Industrial Processes - NO _x Emissions Industrial Processes - PM-10 Emissions Industrial Processes - SO ₂ Emissions Industrial Processes - VOC Emissions	Industrial (boilers and gas pipelines and plants) Industrial (coke-oven gas) Process Heaters (gas) Petroleum Refineries (process heaters - gas) Miscellaneous Process Sources (process heaters - gas) Other Industrial Processes (petroleum refineries - process heaters (gas)) Petroleum Refinery Process Operation (process heaters - gas)
	Other	03-04	Miscellaneous Fuels	Industrial (coke, bagasse, kerosene, LPG, and wood)

Table 3.1-1. Correspondence Between Tier 2 Categories and 1940-1984 Methodology Emission Source Categories

Tier 1 Category	Tier 2 Category	Tier 1/Tier 2 Code	1940-1984 Methodology Emission Source Categories	1940-1984 Methodology Emission Source Subcategories
Fuel Combustion - Other	Commercial and Institutional Coal	03-01	Bituminous Coal and Lignite	Commercial and Institutional
			Anthracite Coal	Commercial and Institutional
	Commercial and Institutional Oil	03-02	Residual Oil	Commercial and Institutional
			Distillate Oil	Commercial and Institutional
	Commercial and Institutional Gas	03-03	Natural Gas	Commercial and Institutional
	Residential Wood	03-05	Miscellaneous Fuels	Residential (wood)
	Residential Other	03-06	Bituminous Coal and Lignite	Residential
			Anthracite Coal	Residential
			Residual Oil	Residential
			Distillate Oil	Residential
Natural Gas			Residential	
		Miscellaneous Fuels	Residential (kerosene and LPG)	

Table 3.1-1. Correspondence Between Tier 2 Categories and 1940-1984 Methodology Emission Source Categories

Tier 1 Category	Tier 2 Category	Tier 1/Tier 2 Code	1940-1984 Methodology Emission Source Categories	1940-1984 Methodology Emission Source Subcategories
Chemical and Allied Product Manufacture	Organic Chemical Manufacturing	04-01	Industrial Processes - CO Emissions Industrial Processes - NO _x Emissions Industrial Processes - PM-10 Emissions Industrial Processes - VOC Emissions	Charcoal Petrochemicals Petrochemicals Charcoal Chemical Industry (petrochemicals) Manufacture of Petrochemicals (all subcategories, excluding storage and handling and waste disposal) Miscellaneous Industrial Processes [miscellaneous chemical products (charcoal)]
	Inorganic Chemical Manufacturing	04-02	Industrial Processes - CO Emissions Industrial Processes - NO _x Emissions Industrial Processes - PM-10 Emissions Industrial Processes - SO ₂ Emissions Industrial Processes - VOC Emissions	Ammonia Titanium Dioxide - chloride process Ammonia Nitric Acid Chemical Industry (sulfuric acid and calcium carbide) Other Industrial Processes (sulfuric acid) Miscellaneous Industrial Processes [miscellaneous chemical products (ammonia)]

Table 3.1-1. Correspondence Between Tier 2 Categories and 1940-1984 Methodology Emission Source Categories

Tier 1 Category	Tier 2 Category	Tier 1/Tier 2 Code	1940-1984 Methodology Emission Source Categories	1940-1984 Methodology Emission Source Subcategories
Chemical and Allied Product Manufacture, cont.	Polymer and Resin Manufacturing	04-03	Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [plastics manufacture (all subcategories, excluding fabrication) and miscellaneous chemical products (synthetic fibers and synthetic rubber)]
	Agricultural Chemical Manufacturing	04-04	Industrial Processes - PM-10 Emissions	Chemical Industry [fertilizers (ammonium nitrate, diammonium phosphate, and urea)]
	Pain, Varnish, Lacquer, and Enamel Manufacturing	04-05	Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [miscellaneous chemical products (paint)]
	Pharmaceutical Manufacturing	04-06	Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [miscellaneous chemical products (pharmaceuticals)]
	Other Chemical Manufacturing	04-07	Industrial Processes - CO Emissions Industrial Processes - PM-10 Emissions Industrial Processes - SO ₂ Emissions Industrial Processes - VOC Emissions	Carbon Black Production (oil process, gas process, and channel process) Chemical Industry [carbon black production (oil process, gas process, and channel process), charcoal, and soap and detergent] Other Industrial Processes (carbon black) Miscellaneous Industrial Processes [miscellaneous chemical products (carbon black - oil process and gas process)]

Table 3.1-1. Correspondence Between Tier 2 Categories and 1940-1984 Methodology Emission Source Categories

Tier 1 Category	Tier 2 Category	Tier 1/Tier 2 Code	1940-1984 Methodology Emission Source Categories	1940-1984 Methodology Emission Source Subcategories
Metals Processing	Nonferrous	05-01	Industrial Processes - CO Emissions Industrial Processes - PM-10 Emissions Industrial Processes - SO ₂ Emissions	Primary Aluminum Primary Metals Industry (aluminum, copper, zinc, and lead) Secondary Metal Industry (aluminum, copper, and lead) Nonferrous Smelters Other Industrial Processes (primary aluminum and secondary lead)
	Ferrous	05-02	Industrial Processes - CO Emissions Industrial Processes - NO _x Emissions Industrial Processes - PM-10 Emissions Industrial Processes - SO ₂ Emissions Industrial Processes - VOC Emissions	Iron Foundries Steel Manufacturing Iron and Steel Iron and Steel Industry Primary Metals Industry (ferroalloys) Secondary Metals Industry (grey iron foundries and steel foundries) Other Industrial Processes (iron and steel) Miscellaneous Industrial Processes [other processes (by-product coke and sintering)]
	Not Elsewhere Classified	05-03	Industrial Processes - PM-10 Emissions	Mining Operations
Petroleum and Related Industries	Oil and Gas Production	06-01	Industrial Processes - SO ₂ Emissions Industrial Processes - VOC Emissions	Other Industrial Processes [sulfur recovery plants (natural gas fields)] Petroleum Marketing and Production (crude oil production and natural gas liquids)

Table 3.1-1. Correspondence Between Tier 2 Categories and 1940-1984 Methodology Emission Source Categories

Tier 1 Category	Tier 2 Category	Tier 1/Tier 2 Code	1940-1984 Methodology Emission Source Categories	1940-1984 Methodology Emission Source Subcategories
	Petroleum Refineries and Related Industries	06-02	Industrial Processes - CO Emissions Industrial Processes - NO _x Emissions Industrial Processes - PM-10 Emissions Industrial Processes - SO ₂ Emissions Industrial Processes - VOC Emissions	Petroleum Refineries Petroleum Refineries (FCC, TCC, and flares) Miscellaneous Process Sources (petroleum refining) Other Industrial Processes [sulfur recovery plants (refineries) and petroleum refineries (FCC, TCC, and flares)] Petroleum Refinery Process Operation (refinery operations, compressors, blow down systems, process drains, vacuum jets, cooling towers, and miscellaneous)
	Asphalt Manufacturing	06-03	Industrial Processes - PM-10 Emissions Industrial Processes - VOC Emissions	Mineral Products Industry (asphalt batching and asphalt roofing) Petroleum Refinery Process Operation (asphalt blowing)

Table 3.1-1. Correspondence Between Tier 2 Categories and 1940-1984 Methodology Emission Source Categories

Tier 1 Category	Tier 2 Category	Tier 1/Tier 2 Code	1940-1984 Methodology Emission Source Categories	1940-1984 Methodology Emission Source Subcategories
Other Industrial Processes	Agriculture, Food, and Kindred Products	07-01	Industrial Processes - PM-10 Emissions Industrial Processes - VOC Emissions	Agricultural Industries Miscellaneous Industrial Processes [other processes (bakeries, fermentation, and vegetable oil)]
	Wood, Pulp and Paper, and Publishing Products	07-03	Industrial Processes - CO Emissions Industrial Processes - NO _x Emissions Industrial Processes - PM-10 Emissions Industrial Processes - SO ₂ Emissions	Kraft Pulp and Paper Kraft Pulp Miscellaneous Process Sources (pulp and paper, semi-chemical, plywood, and lumber) Other Industrial Processes (kraft pulp production and sulfite)
	Rubber and Miscellaneous Plastic Products	07-04	Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [other processes (tires)]

Table 3.1-1. Correspondence Between Tier 2 Categories and 1940-1984 Methodology Emission Source Categories

Tier 1 Category	Tier 2 Category	Tier 1/Tier 2 Code	1940-1984 Methodology Emission Source Categories	1940-1984 Methodology Emission Source Subcategories
Other Industrial Processes, con't.	Mineral Products	07-05	Industrial Processes - CO Emissions Industrial Processes - NO _x Emissions Industrial Processes - PM-10 Emissions Industrial Processes - SO ₂ Emissions Industrial Processes - VOC Emissions	Asphalt Roofing Lime Cement Manufacturing Glass Manufacturing Lime Mineral Products Industry (cement manufacturing, bricks, clay sintering, concrete batching, fiber glass, glass, gypsum manufacturing, and lime manufacturing) Mining Operations (coal mining, sand and gravel, stone and rock crushing, phosphate rock, clays, and potash) Chemical Industry [fertilizers (rock pulverization)] Other Industrial Processes (cement manufacturing, glass manufacturing, and lime processing) Miscellaneous Industrial Processes [other processes (glass manufacturing)]

Table 3.1-1. Correspondence Between Tier 2 Categories and 1940-1984 Methodology Emission Source Categories

Tier 1 Category	Tier 2 Category	Tier 1/Tier 2 Code	1940-1984 Methodology Emission Source Categories	1940-1984 Methodology Emission Source Subcategories
Solvent Utilization	Degreasing	08-01	Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [other processes (degreasing)]
	Graphic Arts	08-02	Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [other processes (graphic arts)]
	Dry Cleaning	08-03	Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [other processes (dry cleaning)]
	Surface Coating	08-04	Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [other processes (adhesives)] Surface Coating Operations Miscellaneous Organic Solvent Evaporation (architectural coating, auto refinishing, and other solvent use)
	Other Industrial	08-05	Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [plastics manufacture (fabrication) and other processes (waste solvent recovery, organic solvent, and solvent extraction)]
	Nonindustrial	08-06	Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [other processes (fabric scouring)] Miscellaneous Organic Solvent Evaporation (cutback asphalt paving, pesticides, and other solvent use)
Storage and Transport	Bulk Terminals and Plants	09-01	Industrial Processes - VOC Emissions	Petroleum Marketing and Production (bulk gasoline terminals and gasoline bulk plants)
	Petroleum and Petroleum Product Storage	09-02	Industrial Processes - VOC Emissions	Petroleum Marketing and Production (gasoline storage at refineries, crude oil storage, and other products)

Table 3.1-1. Correspondence Between Tier 2 Categories and 1940-1984 Methodology Emission Source Categories

Tier 1 Category	Tier 2 Category	Tier 1/Tier 2 Code	1940-1984 Methodology Emission Source Categories	1940-1984 Methodology Emission Source Subcategories
Storage and Transport, cont.	Petroleum and Petroleum Product Transport	09-03	Industrial Processes - VOC Emissions	Petroleum Marketing and Production (refinery product loading and crude oil loading)
	Service Stations: Stage I	09-04	Industrial Processes - VOC Emissions	Petroleum Marketing and Production [gasoline service stations (loading or stage 1)]
	Service Stations: Stage II	09-05	Industrial Processes - VOC Emissions	Petroleum Marketing and Production [gasoline service stations (unloading or stage 2)]
	Organic Chemical Storage	09-07	Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [other processes (waste solvent recovery)] Manufacture of Petrochemicals (storage and handling)
Waste Disposal and Recycling	Incineration	10-01	Solid Waste Disposal	Incineration
	Open Burning	10-02	Solid Waste Disposal	Open Burning
	Other	10-07	Industrial Processes - VOC Emissions	Manufacture of Petrochemicals (waste disposal)
Highway Vehicles	(All Categories) Light-Duty Gas Vehicles and Motorcycles, Light-Duty Gas Trucks, and Heavy-Duty Gas Vehicles	11	Highway Vehicles	Gasoline (leaded and unleaded)

Table 3.1-1. Correspondence Between Tier 2 Categories and 1940-1984 Methodology Emission Source Categories

Tier 1 Category	Tier 2 Category	Tier 1/Tier 2 Code	1940-1984 Methodology Emission Source Categories	1940-1984 Methodology Emission Source Subcategories
Off-Highway Vehicles	Nonroad Gasoline	12-01	Other Off-Highway Vessels	Gasoline Gasoline
	Nonroad Diesel	12-02	Other Off-Highway	Diesel
	Aircraft	12-03	Aircraft	all subcategories
	Marine Vessels	12-04	Vessels	Residual Fuel Oil Diesel Oil Coal
	Railroads	12-05	Railroads	all subcategories
Miscellaneous	Other Combustion (forest fires)	14-02	Forest fires and Prescribed Burning	all subcategories
			Other Miscellaneous Sources	all subcategories

Table 3.1-2. Example Spreadsheet - Distillate Oil Combustion and Emission Factors for Year 19xx

Source Category	Consumption 10 ⁶ gal	TSP Factors MLB/10 ³ gal	SO ₂ Factors MLB/10 ³ gal	NO _x Factors MLB/10 ³ gal	VOC Factors MLB/10 ³ gal	CO Factors MLB/10 ³ gal	Pb Factors MLB/10 ⁶ gal	PM-10 Factors MLB/10 ³ gal
Electric Utilities	733.6	4.7	36.0	61.8	3.5	13.2	0.38	4.1
Industrial	3378.1	2.6	35.6	29.5	1.0	7.0	0.38	1.73
Commercial- Institutional	3555.2	1.8	39.9	18.1	0.3	4.5	0.38	0.98
Residential	6152.5	2.3	31.6	16.3	0.6	4.5	0.38	2.23
Total	13819.4							
PM-10 Control efficiencies for Distillate Oil								
Electric Utility	0.565							
Industrial	0.096							
Commercial- Institutional	0.123							
Residential	0							
Nationwide Emissions from Distillate Oil Combustion								
Source Category	TSP Emissions 1000 MT	SO ₂ Emissions 1000 MT	NO _x Emissions 1000 MT	VOC Emissions 1000 MT	CO Emissions 1000 MT	Pb Emissions Megagrams	PM-10 Emissions 1000 MT	
Electric Utilities	1.7	8.7	2.8	0.0	4.8	0.1	0.7	
Industrial	4.4	60.2	49.8	1.7	11.8	0.6	2.6	
Commercial- Institutional	3.2	70.9	32.2	0.5	8.0	0.7	1.5	
Residential	7.1	97.3	50.1	1.8	13.8	1.2	6.9	
Total	16.4	237.0	135.0	4.1	38.5	2.6	11.7	

NOTES: gal=gallon; MLB=metric pound [1 lb/1.1016]; and MT=metric ton

Table 3.1-3. Supplemental PM-10 Emission Factors

1940 - 1984 Methodology Emission Sources	TSP lb/unit	PM-10 lb/unit	PM-10 Mlb/unit	Units
External Combustion, Boilers				
Industrial				
coke, petroleum	1.5	1.2	1.09	tons burned
Residential				
Distillate oil	2.5	2.46	2.23	10 ³ gallons
Kerosene	2.5	2.46	2.23	10 ³ gallons
Wood				
Stoves	40.2	40.2	36.5	tons burned
Fireplaces	28.0	28.0	25.4	tons burned
Chemical Industry				
Plastics Production				
Polyethylene	1.0	0.66	.599	tons product
Primary Metals				
Copper				
Fugitives	26.5	17.5	14.42	tons of ore concentrate
Ferroalloys				
Other Ferroalloys	300.0	234.0	212.29	tons produced
Ferroalloy Handling	28.0	18.5	16.78	tons processed
Lead				
Fugitives	25.8	22.0	19.95	tons of ore concentrate
Zinc				
Fugitives	7.5	6.4	5.81	tons of ore concentrate
Mining Operations				
Copper Ore				
Crushing	8.6	3.9	3.54	tons of ore processed
Open pit overburden removal	0.0008	0.0003	0.00027	tons of ore processed
Drill/blasting	0.001	0.0008	0.00073	tons of ore processed
Loading	0.05	0.022	0.019958	tons of ore processed
Truck dumping	0.04	0.032	0.0290	tons of ore processed
Transfer/conveying	0.15	0.08	0.0726	tons of ore processed
Ore crushing	6.4	2.9	2.631	tons of ore processed
Storage	2.0	0.7	0.635	tons of ore processed
Iron Ore Mining	0.44	0.18	0.16	tons of ore processed
Lead Ore Crushing	6.0	5.1	4.63	tons of ore processed
Zinc Ore Crushing	6.0	2.3	2.09	tons of ore processed
Coal				
Surface Mining	0.5	0.2	1.81	tons of coal mined
Coal Handling	0.5	0.17	0.15	tons of coal shipped
Pneumatic Dryer	3.0	1.5	1.36	tons of coal dried
Sand and Gravel	0.1	0.029	.026	tons of product
Secondary Metals				
Aluminum				
Fugitives	3.7	3.4	3.08	tons of metal produced
Copper				
Fugitives	10.7	6.4	5.81	tons of charge
Grey Iron				
Fugitives	8.6	5.2	4.72	tons of metal charged
Steel Foundry				
Fugitives	13.0	7.8	7.08	tons of metal charged
Lead				

Table 3.1-3. (continued)

1940 - 1984 Methodology Emission Sources	TSP lb/unit	PM-10 lb/unit	PM-10 Mlb/unit	Units
Fugitives	14.3	12.0	10.89	tons of metal charged

Table 3.1-3. (continued)

1940 - 1984 Methodology Emission Sources	TSP lb/unit	PM-10 lb/unit	PM-10 Mlb/unit	Units
Mineral Products				
Asphalt concrete				
Fugitives	0.3	0.15	0.14	tons of concrete produced
Brick Manufacture				
Material Handling	4.5	1.4	1.27	tons of raw material
Cement Manufacture				
Fugitives	18.0	10.4	9.44	tons of cement produced
Lime Manufacture				
Fugitives	4.7	1.75	1.59	tons of lime produced
Miscellaneous Process Sources				
Pulp and Paper				
Sulfite	14.0	12.6	11.4	ton air dry unbleached pulp
Semichemical, recovery furnace	24.0	22.3	20.2	ton air dry unbleached pulp
Wood Products				
Plywood	2.5	1.3	1.2	tons of plywood produced
Lumber	3.6	1.4	1.0	tons of lumber produced
Solid Waste Disposal				
Incinerators				
Residential Single Chamber				
w/o Primary Burner	35.0	13.0	11.8	tons of waste
w/ Primary Burner	7.0	4.7	4.3	tons of waste
Forest Fires and Prescribed Burning				
Forest Wild Fires	17.0	13.3	12.1	tons of vegetation burned
Prescribed Burning	20.0	15.6	14.2	tons of vegetation burned
Other Miscellaneous Sources				
Agricultural Burning	14.1	13.5	12.3	tons of vegetation burned
Structural Fires	16.0	6.0	5.4	tons of vegetation burned
Coal Refuse Fires	17.0	17.0	15.4	tons of vegetation burned
Off-highway Vehicles				
Aircraft				
Commercial Aviation	1.0	1.0	0.9072	LTO
Air Taxi	.5	0.45	0.408	LTO
General Aviation	.2	0.18	0.163	LTO
Military	16.2	16.2	14.70	LTO
Railroads				
Diesel	25.0	25.0	22.68	10 ³ Gallons
Residual	25.0	23.0	20.87	10 ³ Gallons
Coal	60.0	31.0	28.12	Tons burned
Vessels				
Residual	19.3	17.8	16.15	10 ³ Gallons
Diesel	24.0	24.0	21.77	10 ³ Gallons
Gasoline	0.0	---	---	---

3.2 FUEL COMBUSTION ELECTRIC UTILITIES - COAL: 01-01

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source categories.

Category:	Subcategory:
Bituminous Coal and Lignite	Electric Utilities
Anthracite Coal	Electric Utilities

3.2.1 Technical Approach

The CO, NO_x, PM-10, TSP, SO₂, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, the activity indicator for bituminous coal was expressed in million short tons and the emission factors were expressed in metric pounds/short ton. The activity indicator for anthracite coal was expressed in thousand short tons and the emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

The NO_x emissions produced by the combustion of bituminous coal by electric utilities were calculated with an applied 80 percent EPA-specified rule effectiveness for post-1977 years. The following equation summarizes this calculation:

$$Emissions_{NO_x, bit. coal} = AI_{bit. coal} \times EF_{NO_x, bit. coal} \times [1 - RE] \times \left[\frac{CE_{NO_x, bit. coal}}{100} \right]$$

where: AI = activity indicator
 EF = emission factor
 RE = rule effectiveness of 0.80
 CE = control efficiency (expressed as a percentage)

3.2.2 Activity Indicator

The activity indicator for the combustion of anthracite coal by electric utilities was the anthracite coal receipts at electric utilities obtained from Reference 1a.

The activity indicator for bituminous coal and lignite combustion was calculated as the difference between the total national consumption of coal by electric utilities and the anthracite coal consumption at electric utilities as determined above. The total national consumption of coal was obtained from Reference 2 or Reference 3.

3.2.3 Emission Factor

For the combustion of anthracite coal (SCC 1-01-001-xx), the emission factors for all pollutants except PM-10 were obtained from Reference 4a. The PM-10 emission factor was obtained from Reference 13. Emission factors for TSP and PM-10 were multiplied by an ash content value of 11 percent. The SO₂ emission factor was multiplied by the national average sulfur content value obtained from Reference 1.

For the combustion of bituminous coal and lignite (SCC 1-01-002-xx), the emission factors were the weighted averages of the emission factors for different firing configurations. The CO, NO_x, TSP, and VOC emission factors for each firing configuration were obtained from References 4b and 4c. The PM-10 emissions factors were obtained from Reference 13. The CO and VOC emission factors were weighted by the 1980 quantity of bituminous coal and lignite burned by industry in each firing configuration as reported in Reference 3. For the years 1977 through 1984, the NO_x, PM-10, and TSP emission factors were weighted by the national capacity of each boiler types determined annually. Boiler capacity data was based on 1976 data obtained from Reference 9. To update the capacity data after 1976, additional capacities of all coal-fired plants that came on line during each year between 1976 and the year under study were obtained from Reference 5. All new boilers added since 1977 were assumed to be pulverized dry bottom tangentially-fired boilers and were subject to New Source Performance Standards. These weighting factors were used to determine the bituminous coal and the lignite emission factors for NO_x, PM-10, and TSP. The weighted averages of these two emission factors for each of the three pollutants were calculated using the total fuel receipts obtained from Reference 1a as

weighting factors. Ash contents of 13 percent for bituminous coal and 11 percent for lignite were applied to the PM-10 and TSP emission factors.

No specific information concerning the procedures for determining the NO_x and TSP emission factors for the years prior to 1977 or the PM-10 emission factor for 1975 through 1977 is currently available. Emission factors were not used in the estimations of PM-10 emissions prior to 1975.

The uncontrolled SO₂ emission factor was the weighted average of the bituminous, subbituminous and lignite SO₂ emission factors obtained from Reference 4. Weighting factors were the quantity of fuel receipts at electric utilities for steam plants with a capacity greater than 50 MW as reported in Reference 1. Each emission factor was multiplied by the sulfur content value obtained from Reference 1. The calculation is summarized in the equation below:

$$EF_{uncontrolled} = \frac{(Q_B \times EF_B \times S_B)\% + (Q_{SB} \times EF_{SB} \times S_{SB})\% + (Q_L \times EF_L \times S_L)\%}{Q_B\% + Q_{SB}\% + Q_L}$$

- where:
- EF = uncontrolled emission factor
 - Q = quantity of fuel receipts
 - S = sulfur content value
 - B = bituminous coal
 - SB = subbituminous coal
 - L = lignite

This uncontrolled emission factor was adjusted for emission controls using the control efficiency, resulting in a controlled emission factor. The procedure for determining the control efficiency is presented in the next section.

3.2.4 Control Efficiency

3.2.4.1 Anthracite Coal

The TSP control efficiency was obtained from Reference 7. When this source was unavailable, a control efficiency of 99 percent was used.

The PM-10 control efficiencies for the years 1975 through 1984 were based on the 1988 PM-10 control efficiency obtained from Reference 3. During these years, any changes in the TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

No control efficiencies were applied to the activity data to estimate the CO, NO_x, SO₂, or VOC emissions from this source.

3.2.4.2 Bituminous Coal and Lignite

The TSP control efficiencies were derived from the uncontrolled and controlled emissions. Uncontrolled TSP emissions were calculated for all point sources with SCCs 101002xx and 101003xx by multiplying the operating rates as obtained from NEDS or AIRS (References 9 and 10) by the appropriate emission factors (see preceding section). These products were summed to obtain the total uncontrolled TSP emissions. The controlled TSP emissions for all point sources with SCCs 101002xx and 101003xx were obtained from Reference 9 or Reference 10 and summed to obtain the total controlled TSP emissions. These values were used in the equation below to calculate the TSP control efficiencies.

$$CE = \frac{(UE + AE)}{UE}$$

where: CE = control efficiency
UE = uncontrolled emissions
AE = controlled emissions

The PM-10 control efficiencies for the years 1975 through 1984 were based on the 1988 PM-10 control efficiency obtained from Reference 8. During these years, any changes in the TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate the PM-10 emissions.

No control efficiencies were applied to the activity data to estimate the CO, NO_x, or VOC emissions from bituminous coal and lignite combustion.

The SO₂ control efficiency was based on plant level information on the amount of SO₂ removed by the control devices. The control efficiency was then applied to the uncontrolled emission factor to obtain the controlled SO₂ emission factor.

The following information was obtained from Reference 11: (1) plant and unit name and number, (2) percentage of SO₂ removed, and (3) commercial start-up date. The amount of SO₂ removed at each plant was calculated using this information along with the amount of coal consumed by the plant obtained from Reference 1b or Reference 12, the unit and plant capacity obtained from Reference 6, the percent sulfur content obtained from Reference 1, and the uncontrolled SO₂ emission factor for the combustion of bituminous coal at electric utilities (see preceding section). The amount of SO₂ removed at each plant was calculated according to the following equation:

$$SO_{2, removed} = C \times \left[\frac{UC}{PC} \right] \times EF_{uncontrolled} \times RF \times SC \times OP$$

where: C = coal consumed at plant
UC = unit capacity at plant
PC = total plant capacity

- EF = SO₂ emission factor
- RF = fraction of SO₂ removed at plant
- SC = sulfur content
- OP = fraction of year plant in operation (assumed that the month after start-up date was first full month of operation)

The SO₂ removed at each unit was summed to obtain the national total SO₂ removed. The SO₂ control efficiency was calculated according to the equation below and was then applied to the uncontrolled emission factor to obtain the controlled emission factor.

$$CE_{SO_2} = \frac{SO_{2, \text{ removed}}}{EF_{\text{ uncontrolled}} \times AI_{\text{ Bituminous Coal}}}$$

- where:
- CE = control efficiency
 - EF = emission factor
 - AI = activity indicator

3.2.5 References

1. *Cost and Quality of Fuels for Electric Utility Plants*. DOE/EIA-0191(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
 - (a) Table entitled "Receipts of Coal by Rank Census Division, and State, [YEAR]"
 - (b) Appendix A
2. *Electric Power Annual*. DOE/EIA-0348(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
3. *Quarterly Coal Report: January - March*. DOE/EIA-0121(xx/1Q). Energy Information Administration, U.S. Department of Energy, Washington, DC. Quarterly.
4. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency. Research Triangle Park, NC. September 1991.
 - (a) Volume I, Table 1.2-1, Supplement B, September 1988.
 - (b) Volume I, Table 1.1-1
 - (c) Volume I, Table 1.7-1
5. Energy Data System, FPC 67 form run to print boiler capacity sorted by boiler type. 1976.
6. *Inventory of Power Plants in the United States 19xx*. DOE/EIA-0095(xx). U.S. Department of Energy, Energy Information Administration. Washington, DC. Annual.

7. *Computer Retrieval, NE257 report, by Source Classification Code (SCC) from the National Emission Data System (NEDS)*. Unpublished computer report. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. February 9, 1980.
8. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends," Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.
9. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
10. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
11. Flue Gas Desulfurization Information System, FGDIS.
12. U.S. Department of Energy. Electric Generating Plant List (GURF) Report. Washington, DC.
13. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listing for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

3.3 FUEL COMBUSTION ELECTRIC UTILITIES - OIL: 01-02

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source categories.

Category:	Subcategory:
Residual Oil	Electric Utilities
Distillate Oil	Electric Utilities

3.3.1 Technical Approach

The CO, NO_x, PM-10, TSP, SO₂, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million gallons and emission factors were expressed in metric pounds/thousand gallons. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.3.2 Activity Indicators

The activity indicators for the combustion of residual oil and distillate oil were the consumption of these fuel types by electric utilities. Distillate oil consumption was assumed to be equal to the "adjusted" distillate fuel oil sales to electric utilities obtained from Reference 1 or Reference 2. Residual fuel oil consumption was obtained from Reference 1 or, when this reference was unavailable, the residual oil consumption was calculated

as the difference between the total oil consumption and the distillate oil consumption. The total annual oil consumption was obtained from Reference 3.

3.3.3 Emission Factors

The emission factors for residual oil were calculated from the emission factors for the following four SCCs: 1-01-004-01, 1-01004-04, 1-01-004-05, and 1-01-004-05. For each pollutant, except PM-10, these emission factors were obtained from Reference 4a. The PM-10 emission factors were obtained from Reference 5. The SO₂ emission factors for these four SCCs were each the sum of the emission factors for SO₂ and SO₃. Each SO₃ emission factor was converted to an emission factor by weight of SO₂ prior to the summing by using the ratio of the molecular weights of SO₂ and SO₃ (i.e., 64/80). The SO₂, TSP, and PM-10 emission factors for these four SCCs were multiplied by the fuel sulfur content from Reference 6.

For each pollutant, the overall emission factor for the combustion of residual oil was the arithmetic average of the emission factors for the four SCCs, with the exception for the NO_x emission factor. The NO_x emission factors for the four SCCs were weighted by the residual oil capacity of each boiler type. Any additional capacity added since 1981 was assumed to be subject to the New Source Performance Standards. An emission factor of 45 lb/thousand gallons was assumed for these boilers and was weighted by the additional capacity. The yearly boiler capacities were obtained from Reference 7.

The emission factors for the combustion of distillate oil were calculated from the emission factors for the SCCs listed in Table 3.3-1. The emission factors for all pollutants except PM-10 were obtained from References 4a, 4b, and 4c. The PM-10 emission factors were obtained from Reference 5. Weighted averages of the boiler emission factors for each pollutant, except SO₂, were calculated using the weighting factors given in Table 3.3-1. Weighted average nonboiler emission factors for each pollutant, except SO₂, were calculated in the same manner.

The SO₂ emission factors for the four SCCs were multiplied by the fuel sulfur content for #2 and #4 heating oils obtained yearly from Reference 8. The #2 heating oil sulfur content was applied to the emission factors for the SCCs 1-01-005-01 and 2-01-001-01. The #4 heating oil sulfur content was applied to the SCC 1-01-005-04. No sulfur content was applied to the emission factor for reciprocating engines. Emission factors for the two boiler SCCs were weighted according to the distribution of #2 and #4 heating oils to electric utilities as reported in Reference 6. Emission factors for the nonboiler SCCs were weighted in the same manner as described for the other pollutants.

The overall emission factors for the combustion of distillate oil were the weighted average of the boiler and nonboiler emission factors for each pollutant. Weighting factors were dependent on the year for which the emission factors were being determined. For the years 1970 through 1980, the boiler emission factors were weighted 40 percent and the nonboiler emission factors were weighted 60 percent. After 1980, weighting factors were 50 percent for both boiler and nonboiler emission factors. The weighting factors used prior to 1970 are currently unavailable.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier 2 category.

3.3.4 Control Efficiency

The PM-10 control efficiencies for the combustion of residual and distillate oil for the years 1975 through 1984 were equal to the 1988 PM-10 control efficiencies obtained from Reference 9. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

No control efficiencies were applied to the activity data to estimate CO, NO_x, SO₂, TSP, or VOC emissions from the combustion of residual and distillate oil.

3.3.5 References

1. *Fuel Oil and Kerosene Sales 19xx*. DOE/EIA-0535(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
2. *Petroleum Marketing Annual*. DOE/EIA-0389(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
3. *Electric Power Annual*. DOE/EIA-0348(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
4. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - (a) Volume I, Table 1.3-1
 - (b) Volume I, Table 3.1-2
 - (c) Volume I, Table 3.3-1
5. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listings for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.
6. *Cost and Quality of Fuels for Electric Utility Plants*. DOE/EIA-0191(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
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9. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends," Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.

Table 3.3-1. Emission Factor SCCs for Distillate Oil
Combustion by Electric Utilities

SCC	Description	Weighting Factors
1-01-005-01	Boiler - #2 oil	0.9
1-01-005-04	Boiler - #4 oil	0.1
2-01-001-01	Nonboiler - gas turbine	0.9
2-01-001-02	Nonboiler - reciprocating	0.1

3.4 FUEL COMBUSTION ELECTRIC UTILITIES - GAS: 01-03

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source category.

Category:

Natural Gas

Subcategory:

Electric Utilities

3.4.1 Technical Approach

The CO, NO_x, PM-10, TSP, SO₂, and VOC emissions included in this Tier category were the sum of the emissions from the source category listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, the activity indicator was expressed in billion cubic feet and the emission factors were expressed in metric pounds/million cubic feet. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating PM-10 emissions based on activity indicators, emission factors, and control efficiencies.

3.4.2 Activity Indicator

The total annual natural gas consumption obtained from Reference 1 was the activity indicator for this category.

3.4.3 Emission Factor

The emission factors for all pollutants, except NO_x, were based on the emission factors for the five boiler and nonboiler types listed by SCC in Table 3.4-1. These emission factors for all pollutants except PM-10 were obtained from Reference 2a, 2b, and 2c. The PM-10 emission factors were obtained from Reference 8. Weighted average of the boiler emission factors were calculated using weighting factors obtained from Reference 3 or Reference 4. Weighted averages of the nonboiler emission factors were calculated using the weighting factors presented in Table 3.4-1. The overall weighted emission factors were calculated by weighting the boiler emission factors 94 percent and the nonboiler emission factors 6 percent.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the source included in this Tier 2 category.

The NO_x emission factors were based on the emission factors for the two nonboiler types listed in 3.4-1 and the following three boiler types listed in 3.4-2. The nonboiler emission factors were obtained from Reference 2b and 2c and were weighted in the same manner as for the other pollutants. The emission factors for the three boiler types are presented in 3.4-2. These emission factors were weighted by the boiler capacity data which was based on 1976 data obtained from Reference 5. In order to update the capacity data to a year after 1976, the additional capacities of plants that came on line each year between 1976 and the year under study were obtained from Reference 6. The procedure for determining the boiler capacities for the years prior to 1976 is currently unavailable. All new boilers added since 1983 were assumed to be subject to New Source Performance Standards and, therefore the new boiler capacity was added to this category. The resulting boiler capacities were used as weighting factors in the calculation of average NO_x emission factors for boilers. The overall weighted emission factors were calculated in the same manner as for the other pollutants.

3.4.4 Control Efficiency

The PM-10 control efficiencies for the combustion of natural gas for the years 1975 through 1984 were equal to the 1988 PM-10 control efficiency obtained from Reference 7. For the years 1940 through 1974, no control efficiencies were used to estimate the PM-10 emissions.

No control efficiencies were applied to the activity data to estimate the CO, NO_x, SO₂, TSP, or VOC emissions from the combustion of natural gas.

3.4.5 References

1. *Natural Gas Annual*. DOE/EIA-0131(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
2. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - (a) Volume I, Table 1.4-1, Supplement A, October 1986.
 - (b) Volume I, Table 3.1-2, September 1985.
 - (c) Volume I, Table 3.2-1, September 1985.

3. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem.* Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
4. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS).* Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
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6. Energy Data System, FPC 67 form run to print boiler capacity sorted by boiler type. 1976.
7. Barnard, William R. and Patricia M. Carlson. "PM-10 emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.
8. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listings for Criteria Air Pollutants.* EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

Table 3.4-1. Emission Factor SCCs for the Combustion of Natural Gas by Electric Utilities

SCC	Description	Weighting Factors
1-01-006-01	Utility/Large Industrial Boiler	
1-01-006-02	Small Industrial Boiler	
1-01-006-04	Tangentially-Fired Boiler	
2-01-002-01	Nonboiler - gas turbine	0.9
2-01-002-02	Nonboiler - reciprocating engine	0.1

Table 3.4-2. NO_x Emission Factors by Boiler Types for the Combustion of Natural Gas by Electric Utilities

Boiler Type	Emission Factor (lb/10 ⁶ cu. ft.)
Normal	550
Tangential	275
New Source Performance Standard	200

3.5 FUEL COMBUSTION INDUSTRIAL - COAL: 02-01

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source categories.

Category:	Subcategory:
Anthracite Coal	Industrial
Bituminous Coal and Lignite	Industrial

3.5.1 Technical Approach

The CO, NO_x, PM-10, TSP, SO₂, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, the activity indicator for bituminous coal and lignite was expressed in million short tons and the emission factors were expressed in metric pounds/short ton. The activity indicator for anthracite coal was expressed in thousand short tons and the emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.5.2 Activity Indicator

The activity indicator for the combustion of anthracite coal was the distribution of anthracite coal from Pennsylvania (i.e. District 24) obtained from Reference 1a under the category "Other Industrial".

The activity indicator for bituminous coal and lignite was based on total national coal consumption obtained from Reference 2 under the category "Other Industrial." This value included the coal consumption from coke plants which were not appropriate for this activity indicator. Therefore, the coal consumption of cement plants and lime plants were subtracted from the total coal consumption. Coal consumption by cement plants was obtained from Reference 3. Coal consumption by lime plants was estimated by multiplying the lime production value obtained from Reference 4 by the conversion factor: 0.1 tons coal/ton lime produced.

3.5.3 Emission Factors

The emission factors for the combustion of anthracite coal were the weighted averages of the emission factors for three different firing configurations. For all pollutants except PM-10, the emission factors for each firing configuration were obtained from Reference 5a; the PM-10 emission factors were obtained from Reference 12. These emission factors were weighted by the 1980 quantity of anthracite coal burned by industry in each firing configuration as reported in Reference 6. An ash content of 11 percent was applied to selected TSP and PM-10 emission factors. The SO₂ emission factors were multiplied by a sulfur content value of 0.7 percent.

The emission factors for the combustion of bituminous coal and lignite were the weighted average of the emission factors for the different firing configurations obtained from Reference 5b and 5c, respectively. These emission factors were weighted by the 1980 quantity of bituminous coal and lignite burned by industry in each firing configuration as reported in Reference 6. The ash content was assumed to be 13 percent for bituminous coal and 11 percent for lignite.

The SO₂ emission factor was multiplied by the average sulfur content for all coal shipped to industrial plants. The average sulfur content of coal was determined from the sulfur content by coal producing districts obtained for the category "Other industrial uses and retail dealers" in Reference 7a. This reference provided the sulfur content values reported in 1977 and it was assumed that these values remained constant during the years 1940 through 1984. In order to obtain the average sulfur content for a specific year, the sulfur content by district was weighted by the distribution of coal by district of origin for the category "Other Industrial" obtained from Reference 1a or Reference 8.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the source included in this Tier 2 category.

3.5.4 Control Efficiency

The TSP control efficiency for the combustion of anthracite coal was derived from Reference 9 or Reference 10 using the equation below. When these values were unavailable, a control efficiency of 0.95 was used.

$$CE = \frac{(UE - AE)}{UE}$$

where: CE = control efficiency
 UE = emissions before control
 AE = emissions after control

The TSP control efficiency for the combustion of bituminous coal and lignite was calculated based on the uncontrolled and controlled emissions. In order to calculate the uncontrolled TSP emissions, the operating rates for each type of boiler using bituminous and subbituminous coal and lignite (i.e. SCCs within the group 1-02-002-xx) were obtained from Reference 9 or Reference 10. These rates were multiplied by the corresponding emission factors obtained from Reference 5 and an ash content of 13 percent. The emissions were summed over all boiler types and converted to tons to obtain the total uncontrolled TSP emissions. The actual emissions reported in Reference 9 or Reference 10 were summed over the same boiler types to obtain the total actual TSP emissions. The TSP control efficiency was calculated from these values according to the equation given above.

The PM-10 control efficiencies for anthracite coal and bituminous coal and lignite combustion for the years 1975 through 1984 were based on the 1988 PM-10 control efficiency obtained from Reference 11. During these years, any changes in the TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions from the combustion of these fuels.

No control efficiencies were applied to the activity data to estimate CO, NO_x, SO₂, or VOC emissions from the combustion of anthracite coal and of bituminous coal and lignite.

3.5.5 References:

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 - (a) Table entitled "Domestic Distribution of U.S. Coal by Origin, Destination, and Consumer: January-December 19xx".
2. *Quarterly Coal Report: January - March*. DOE/EIA-0121(xx/1Q). Energy Information Administration, U.S. Department of Energy, Washington, DC. Quarterly.
3. *Minerals Industry Surveys, Cement*. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Monthly.
4. *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.

5. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42.* U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - a. Volume I, Table 1.2-1, Supplement B, September 1988.
 - b. Volume I, Table 1.1-1
 - c. Volume I, Table 1.7-1
6. *Computer Retrieval, NE257 report, by Source Classification Code (SCC) from the National Emission Data System (NEDS).* Unpublished computer report. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. February 9, 1980.
7. *Coal Production.* DOE/EIA-0118(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
 - (a) Table entitled "Shipments of Bituminous Coal and Lignite by District, Consumer, Use, Average Sulfur Content - 1977."
8. *Minerals Yearbook, Coal.* Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.
9. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem.* Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
10. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS).* Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
11. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.
12. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listing for Criteria Air Pollutants.* EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

3.6 FUEL COMBUSTION INDUSTRIAL - OIL: 02-02

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source categories.

Category:	Subcategory:
Residual Oil	Industrial
Distillate Oil	Industrial
Industrial Processes - CO Emissions	Process Heaters (oil)
Industrial Processes - NO _x Emissions	Petroleum Refineries [Process Heaters (oil)]
Industrial Processes - Particulates and PM-10 Emissions	Miscellaneous Process Sources [Process Heaters (oil)]
Industrial Processes - SO ₂ Emissions	Other Industrial Processes [Petroleum Refineries (process heaters - oil)]
Industrial Processes - VOC Emissions	Petroleum Refinery Process Operations [Process Heaters (oil)]

3.6.1 Technical Approach

The CO, NO_x, PM-10, TSP, SO₂, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators for residual oil and distillate oil were expressed in million gallons and emission factors were expressed in metric pounds/thousand gallons. For CO, NO_x, PM-10, TSP, and SO₂ emissions, activity indicators for oil-fired process heaters were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton. For VOC emissions, the activity indicator for process heaters was expressed in million barrels and the emission factors was expressed in metric pounds/thousand barrels. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.6.2 Activity Indicator

The activity indicator for residual oil combustion was based on the adjusted quantity of residual oil sales for industrial and oil company use obtained from Reference 1 or 2. The total of three statistics were subtracted from this value to obtain the activity indicator. The first statistic was two-thirds of the quantity of oil consumed by cement plants reported in Reference 3 converted to gallons. The second statistic was the quantity of residual oil consumed by petroleum refineries reported in Reference 4a, converted to gallons. The third statistic was the quantity of residual oil consumed by steel mills. This value was calculated by multiplying the quantity of raw steel production obtained from Reference 5, by 0.00738×10^6 gal/ 10^3 ton steel. The conversion factor between the gallons of oil and the tons of steel was updated in 1982 based on Reference 6.

The activity indicator for distillate oil combustion was based on the adjusted quantity of distillate oil sales to industrial and oil companies obtained from Reference 1 or 2. The total of two statistics were subtracted from this value to obtain the activity indicator for distillate oil. The first statistic was one-thirds of the quantity of oil consumed by cement plants, expressed in gallons, reported in Reference 3. The second statistic was the quantity of distillate oil consumed by petroleum refineries, expressed in gallons, reported in Reference 4a.

The activity indicator for oil-fired process heaters was the total quantity of oil consumed at petroleum refineries. This value was the sum of the distillate, residual and crude oil consumptions at petroleum refineries as reported in Reference 4a.

3.6.3 Emission Factor

The emission factors for each pollutant for the combustion of residual oil (SCC 1-02-004-01) were obtained from Reference 7 under the classification industrial boilers - residual oil for all pollutants except PM-10. The PM-10 emission factors were obtained from Reference 10. The SO₂, TSP and PM-10 emission factors were multiplied by the sulfur content obtained for No. 6 fuel oil from Reference 8.

The emission factors for each pollutant for the combustion of distillate oil were the weighted average of the emission factors for two SCCs (1-02-005-01 and 1-02-005-04). These emission factors were obtained from Reference 7 for all pollutants except PM-10. The PM-10 emission factors were obtained from Reference 10. Weighting factors were obtained from Reference 9.

The SO₂ emission factors were multiplied by a weighted average sulfur content. Sulfur content values for No. 1, No. 2, and No. 4 oils were obtained from Reference 8. These values were weighted by the corresponding distribution of fuel oil sales to the industrial sector as reported in Reference 1 or 2.

For oil-fired process heaters, the emission factors for all pollutants, except PM-10, were obtained from Reference 7 under the classification for industrial boiler - residual oil. The PM-10 emission factor was obtained from Reference 10.

The TSP emission factor, as specified in Reference 7, was a function of sulfur content (10(S) + 3 lb/1,000 gal). The sulfur content was obtained for SCC 30600103 from Reference 9. The SO₂ and PM-10 emission factors were multiplied by the sulfur content. The VOC emission factor was converted to a reactive basis using the VOC species profile SDM 101004 from Reference 11.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier 2 category.

3.6.4 Control Efficiency

The PM-10 control efficiencies for all emission sources included in this Tier 2 category for the years 1975 through 1984 were equal to the 1988 PM-10 control efficiencies obtained from Reference 12. For the years 1940 through 1974, no control efficiencies were used to estimate the PM-10 emissions.

No control efficiencies were applied to the activity data to estimate CO, NO_x, SO₂, TSP, or VOC emissions from the source included in this Tier 2 category.

3.6.5 References

1. *Petroleum Marketing Monthly*. DOE/EIA-0380(xx/01). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
2. *Fuel Oil and Kerosene Sales 19xx*. DOE/EIA-0535(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
3. *Minerals Industry Surveys, Cement*. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Monthly.
4. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
 - a. Table entitled "Fuel Consumed at Refineries by PAD District."
5. *Survey of Current Business*. Bureau of Economic Analysis, U.S. Department of Commerce, Washington, DC.
 - a. Table containing information on Metals and Manufacturers

6. *Census of Manufactures (Fuels and Electric Energy Consumed)*. Bureau of the Census, U.S. Department of Commerce, Washington, DC. 1982.
7. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991. Volume I, Table 1.3-1
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10. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listing for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.
11. *Volatile Organic Compound (VOC) Species Data Manual*. EPA-450/4-80-015. U.S. Environmental Protection Agency, Research Triangle Park, NC. July 1980.
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3.7 FUEL COMBUSTION INDUSTRIAL - GAS: 02-03

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source categories.

Category:	Subcategory:
Natural Gas	Industrial (boilers and gas pipelines and plants)
Miscellaneous Fuels	Industrial (coke-oven gas)
Industrial Processes - CO Emissions	Process Heaters (gas)
Industrial Processes - NO _x Emissions	Petroleum Refineries [process heaters (gas)]
Industrial Processes - Particulates and PM-10 Emissions	Miscellaneous Process Sources (process heaters (gas))
Industrial Processes - SO ₂ Emissions	Other Industrial Processes [petroleum refineries (process heaters - gas)]
Industrial Processes - VOC Emissions	Petroleum Refinery Process Operations [process heaters (gas)]

3.7.1 Technical Approach

The CO, NO_x, PM-10, TSP, SO₂, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators for natural gas and coke-oven gas were expressed in billion cubic feet and emission factors were expressed in metric pounds/million cubic feet. For CO, NO_x, PM-10, TSP, and SO₂ emissions, the activity indicator for gas-fired process heaters was expressed in thousand short tons and the emission factors were expressed in metric pounds/short ton. For VOC emissions, the activity indicator for gas-fired process heaters was expressed in million barrels and the emission factor was expressed in metric pounds/thousand barrels. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.7.2 Activity Indicator

The activity indicator for the combustion of natural gas in industrial boilers was based on the total industrial consumption of natural gas obtained from Reference 1. From this value was subtracted the sum of the total natural gas consumption by cement plants, petroleum refineries, iron and steel industries, and glass manufacturers. Total natural gas consumption by cement plants obtained from Reference 2. Total natural gas consumption by petroleum refineries was obtained from Reference 3. The total natural gas consumption by iron and steel industries was calculated by multiplying the raw steel production obtained from Reference 4 by 4.25×10^6 cu. ft. natural gas/1000 tons steel. The conversion factor relating steel production to natural gas consumption was updated in 1982 based on data from Reference 5. Total natural gas consumption by glass manufacturers was determined from the total glass production. This total was calculated by summing the total production of flat glass from Reference 6 and the net packed weight of glass containers from Reference 7 and multiplying the resulting sum by 1.1 to account for miscellaneous glass products. The total glass production was multiplied by 10.8×10^6 cu. ft. natural gas/1000 tons glass produced to obtain the total natural gas consumption. The conversion factor relating glass production to natural gas consumption was updated in 1982 based on data from Reference 5.

The activity indicator for the combustion of natural gas by gas pipelines and plants was the total natural gas consumption for lease and plant fuel plus pipeline fuel obtained from Reference 1.

The activity indicator for coke-oven gas combustion represented the amount of coke-oven gas consumed outside of the iron and steel industry which was assumed to be 18.8 percent of the total coke-oven gas produced. The total coke-oven gas production, in cubic feet, as reported in Reference 8, was multiplied by 0.188 to obtain the activity indicator for this subcategory.

The activity indicator for gas-fired process heaters was the total of natural gas and still (process) gas consumed at petroleum refineries obtained from Reference 3.

3.7.3 Emission Factor

The emission factors for all pollutants except PM-10 for the combustion of natural gas in industrial boilers (SCC 1-02-006-02) were obtained from Reference 9a. The PM-10 emission factor was obtained from Reference 11.

The emission factors for the combustion of natural gas by gas pipeline and plants were the weighted averages of the emission factors for SCCs 2-02-002-01 and 2-02-002-02. Reference 9b was the source of the emission factors for all pollutants except PM-10; Reference 11 was the source for the PM-10 emission factors. The weighting factors were based on data from Reference 10.

The emission factors for all pollutants for the combustion of coke-oven gas were obtained from Reference 11. The SO₂ emission factor was multiplied by the constant sulfur content value of 1.605 percent.

The CO and NO_x emission factors for all types of gas-fired process heaters were obtained from Reference 9c. The PM-10 emission factor was obtained from Reference 11, the TSP and PM-10 emission factors were obtained from Reference 9a and the VOC emission factor from Reference 9d. In each case, the emission factors were listed as the uncontrolled emission factors for small industrial boilers. The VOC emission factor was converted to a reactive basis using the VOC species profile SDM 101007 from Reference 12.

The SO₂ emission factor was the weighted average of the emission factors for natural gas obtained from Reference 5c and for refinery gas given as 356.25 lb/10⁶ cu.ft.). The weighting factors were the natural gas and refinery gas consumption obtained from Reference 3.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier 2 category.

3.7.4 Control Efficiency

The PM-10 control efficiencies for all emission sources included in this Tier 2 category for the years 1975 through 1984 were equal to the 1988 PM-10 control efficiencies obtained from Reference 13. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

No control efficiencies were applied to the activity data to estimate CO, NO_x, SO₂, TSP, or VOC emissions from these sources.

3.7.5 References

1. *Natural Gas Annual*. DOE/EIA-0131(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
2. *Minerals Industry Surveys, Cement*. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Monthly.
3. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
4. *Minerals Industry Surveys, Iron Ore*. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Monthly.

5. *Census of Manufactures (Fuels and Electric Energy Consumed)*. Bureau of the Census, U.S. Department of Commerce, Washington, DC. 1982.
6. *Current Industrial Reports, Glass Containers*. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Annual.
7. *Current Industrial Reports, Flat Glass*. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Annual.
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 - (b) Volume I, Table 3.2-1
 - (c) Volume I, Table 1.4-2
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10. *Computer Retrieval, NE257 report, by Source Classification Code (SCC) from the National Emission Data System (NEDS)*. Unpublished computer report. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. February 9, 1980.
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3.8 FUEL COMBUSTION INDUSTRIAL - OTHER: 02-04

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source category.

Category:

Miscellaneous Fuels

Subcategory:

Industrial (coke, bagasse, kerosene, LPG, and wood)

3.8.1 Technical Approach

The CO, NO_x, PM-10, TSP, SO₂, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators for coke, bagasse, and wood were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton. For kerosene and LPG, activity indicators were expressed in million barrels and emission factors was expressed in metric pounds/thousand barrels. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.8.2 Activity Indicator

The activity indicator for the combustion of coke was the consumption of coke outside the iron and steel industry. This quantity was calculated by summing the total coke production from coal and the total petroleum

coke receipts. The total quantity of petroleum coke consumed or received by power plants was obtained from Reference 1 or Reference 2.

In order to obtain the total coke produced from coal, the following data were obtained from Reference 3: (1) total breeze production at coke plants and (2) coke sales to "other industrial plants". Because it was assumed that 24 percent of the total breeze production was sold for use as boiler fuel, the total breeze production at coke plants was multiplied 0.24 to obtain the total breeze consumed as fuel. If data for foundries and other industrial plants were combined, it was assumed that 49 percent of the total was for other industrial plants. Total coke production from coal was the sum of the total breeze production used for fuel and the total coke sales to other industrial plants. Alternatively, if data from Reference 3 were not available, it was assumed that 5.75 percent of total coke production obtained from Reference 3 represented the coke consumption outside the iron and steel industry.

The activity indicator for the combustion of bagasse was the consumption of bagasse obtained from Reference 4.

The activity indicator for the combustion of kerosene was the quantity of kerosene sales. This value was obtained by summing the sales figures reported for the industrial and the all other end use categories as reported in Reference 5 or Reference 6.

The activity indicator for the combustion of liquid petroleum gas was the LPG supplied for industrial use. This quantity was derived from the 1982 consumption figures ($5,397 \times 10^6$ gal) using the ratio between the quantity of products supplied in 1982 ($1,499 \times 10^3$ bbl/day) and in the year under study. The quantity of products supplied for a given year and for 1982 was obtained from Reference 7. The following equation summarizes the calculation of the LPG supplied for industrial use:

$$LPG_{Industrial, i} = LPG_{Industrial, 1982} \times \frac{Products_{Supplied, i}}{Products_{Supplied, 1982}}$$

where: i = year under study

The activity indicator for the industrial combustion of wood was based on the consumption of wood for industrial combustion obtained from Reference 8. It was assume that 15 percent of the heating value was lost to moisture on a typical basis. Therefore, the reported consumption figure was multiplied by 0.85 to obtain the activity indicator.

3.8.3 Emission Factor

The emission factors for industrial coke combustion were the weighted averages of the emission factors for petroleum coke and coal coke. These emission factors for which the references are currently unavailable are presented in Table 3.8-1. Weighting factors were the total petroleum coke receipts and the total coke

produced from coal as determined for the activity indicator for the coke category. A sulfur content value of 3.25 percent was used for the petroleum coke SO₂ emission factor.

The emission factors for bagasse combustion (SCC 1-02-001-01) were obtained from Reference 9a for all pollutants except PM-10. The PM-10 emission factor was obtained from Reference 10. The TSP control efficiency was applied directly to the TSP emission factor, resulting in the controlled emission factor. The TSP control efficiency was obtained from Reference 10.

The emission factors used for kerosene combustion (SCC 1-02-005-01) were those for the combustion of distillate oil in industrial boilers obtained from Reference 9b for all pollutants except PM-10. The PM-10 emission factor was obtained from Reference 10. The SO₂ emission factors was multiplied by a sulfur content value of 0.075 percent.

The emission factors for all pollutants for LPG combustion (SCC 1-02-010-01) were obtained from Reference 9c. The PM-10 emission factor was obtained from Reference 10. The SO₂ emission factor was multiplied by a sulfur content value of 0.0013 percent.

For industrial wood combustion the emission factors were the weighted averages of the emission factors for three SCCs (1-02-009-01, 1-02-009-02, and 1-02-009-03). These emission factors were obtained from Reference 9d for all pollutants except PM-10 which was obtained from Reference 10. For the years 1975 through 1984, the weighting factors were derived from throughput data obtained from Reference 10. Prior to 1975, the procedure for determining the weighting factors is currently unavailable.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier 2 category.

3.8.4 Control Efficiency

The PM-10 control efficiencies for all emission sources included in this Tier 2 category for the years 1975 through 1984 were equal to the 1988 PM-10 control efficiencies obtained from Reference 12. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

No control efficiencies were applied to the activity data to estimate CO, NO_x, SO₂, TSP, or VOC emissions from the source included in this Tier 2 category.

3.8.5 References

1. *Cost and Quality of Fuels for Electric Utility Plants*. DOE/EIA-0191(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
2. *Electric Power Annual*. DOE/EIA-0348(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.

3. *Quarterly Coal Report: January - March*. DOE/EIA-0121(xx/1Q). Energy Information Administration, U.S. Department of Energy, Washington, DC. Quarterly.
4. *Standard Computer Retrievals, NE213 report (dual use summary), from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
5. *Fuel Oil and Kerosene Sales 19xx*. DOE/EIA-0535(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
6. *Petroleum Marketing Monthly*. DOE/EIA-0380(xx/01). Energy Information Administration, U.S. Department of Energy, Washington, DC. January issue.
7. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
8. *Estimates of U.S. Biofuels Consumption*. SR/CNEAF/91-02. U.S. Department of Energy, Washington, DC. Annual.
9. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - (a) Volume I, Table 1.8-1
 - (b) Volume I, Table 1.3-1
 - (c) Volume I, Table 1.5-1
 - (d) Volume I, Table 1.6-1, Supplement A, October 1986
10. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listing for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.
11. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
12. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.

Table 3.8-1. Emission Factors for Miscellaneous Fuels - Industrial (coke)

Coke Type	Emission Factors (lb/ton)					
	TSP	SO ₂	NO _x	VOC	CO	PM-10
Petroleum Coke	1.5	38.8*	20.9	.64	.54	1.2
Coal Coke	4.6	30.3	14.0	.64	.54	3.6

* Multiply by sulfur content

3.9 FUEL COMBUSTION OTHER - COMMERCIAL / INSTITUTIONAL COAL: 03-01

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source categories.

Category:	Subcategory:
Anthracite Coal	Commercial / Institutional
Bituminous Coal and Lignite	Commercial / Institutional

3.9.1 Technical Approach

The CO, NO_x, PM-10, TSP, SO₂, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, the activity indicator for bituminous coal was expressed in million short tons and the emission factors were expressed in metric pounds/short ton. The activity indicator for anthracite coal was expressed in thousand short tons and the emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.9.2 Activity Indicator

The activity indicators for the combustion of these two fuels were the consumption of the specific coal type by commercial and institutional users. Determination of these activity indicators required the activity indicators

for both anthracite and bituminous residential coal combustion. The latter activity indicators are described both here and in section 3.13.2.

The commercial/institutional consumption of anthracite coal was obtained by subtracting residential anthracite consumption from residential and commercial/institutional anthracite consumption. Residential and commercial/institutional consumption of anthracite coal was obtained from Reference 1a for District 24 only.

$$\text{Anthracite Coal}_{C/I} = \text{Anthracite Coal}_{R \text{ and } C/I} - \text{Anthracite Coal}_R$$

where: C/I = commercial/institutional consumption
 R = residential consumption

Residential consumption of anthracite coal was determined by extrapolating the consumption of the previous year based on the change in the number of dwelling units in the Northeastern United States having coal as the main fuel for space heating. Data concerning the number of dwelling units was obtained from Reference 2. The calculation of the residential anthracite coal consumption is summarized in the equation below.

$$\text{Anthracite Coal}_{R, i} = \text{Anthracite Coal}_{R, i\&1} \times \frac{\text{Dwelling Units}_i}{\text{Dwelling Units}_{i\&1}}$$

where: R = residential consumption
 i = year under study

Commercial/institutional consumption of bituminous coal was obtained by subtracting residential bituminous consumption from residential and commercial/institutional bituminous consumption. Residential and commercial/institutional consumption of bituminous coal was calculated by subtracting the residential and commercial/institutional consumption of anthracite coal from residential and commercial/institutional consumption of all types of coal. These two consumption values were obtained from Reference 1a and excluded coal from District 24 which represents anthracite coal consumption. This calculation is summarized in the equation below.

$$\text{Bituminous Coal}_{C/I} = (\text{All Coal}_{R \text{ and } C/I} - \text{Anthracite Coal}_{R \text{ and } C/I}) - \text{Bituminous Coal}_R$$

where: C/I = commercial/institutional consumption
 R = residential consumption

Residential consumption of bituminous coal was determined by estimating the quantity of all coal consumed by all dwelling units using coal as the main fuel and subtracting from this value the residential consumption of anthracite coal calculated above. The quantity of all coal consumed was calculated using the number of dwelling units using coal as the main fuel for space heating obtained from Reference 2 and a factor

Bituminous Coal_R' (Dwelling Units × 6.73 tons burned /dwelling /year) & Anthracite Coal_R

estimating the average annual consumption of coal per dwelling unit. This calculation is summarized in the equation below.

3.9.3 Emission Factors

The emission factors for anthracite coal combustion were the weighted average of the emission factors for three different firing configurations. The emission factors for each firing configuration were obtained from Reference 3a for all pollutants except PM-10. The PM-10 emission factors were obtained from Reference 10. These CO, SO₂, and VOC emission factors were weighted by the 1980 quantity of anthracite coal burned by industry in each firing configuration as reported in Reference 6. The procedure for determining the weighting factors for the NO_x, PM-10 and TSP emission factors is currently unavailable, although it is known that the same factors were applied for the years 1940 through 1984. An ash content of 11 percent was applied to selected TSP and PM-10 emission factors. The SO₂ emission factors were multiplied by a sulfur content value of 0.7 percent.

The emission factors for the combustion of bituminous coal and lignite were the weighted average of the emission factors for different firing configurations. For all pollutants except PM-10, these emission factors were obtained from Reference 3b and 3c. The PM-10 emission factors were obtained from Reference 10. These emission factors were weighted by the 1980 quantity of bituminous coal and lignite burned by industry in each firing configuration as reported in Reference 6. The ash content was assumed to be 13 percent for bituminous coal and 11 percent for lignite.

The SO₂ emission factor was multiplied by the average sulfur content for all coal shipped to industrial plants. The average sulfur content of coal was determined from the sulfur content by coal producing districts obtained for the category "All other uses" in Reference 7a. This reference provided the sulfur content values reported in 1977 and it was assumed that these values remained constant during the years 1940 through 1984. In order to obtain the average sulfur content for a specific year, the sulfur content by district was weighted by the distribution of coal by district of origin for the category "Residential and Commercial" obtained from Reference 1a or Reference 8.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier 2 category.

3.9.4 Control Efficiency

The TSP control efficiency for the combustion of anthracite coal was obtained from Reference 4 or Reference 5. When this value was unavailable, a control efficiency of 33 percent was used.

For bituminous coal and lignite, the TSP control efficiency was calculated based on the uncontrolled and controlled emissions. In order to calculate the uncontrolled TSP emissions, the operating rates for each type of

boiler using bituminous and subbituminous coal and lignite (i.e. SCCs within the group 1-02-002-xx) were obtained from Reference 4 or Reference 5. These rates were multiplied by the corresponding emission factors obtained from Reference 3a and an ash content of 13 percent. The emissions were summed over all boiler types and converted to tons to obtain the total uncontrolled TSP emissions. The actual emissions reported in Reference 4 or Reference 5 were summed over the same boiler types to obtain the total actual TSP emissions. The TSP control efficiency was calculated from these values according to the equation below.

$$CE = \frac{(UE \& AE)}{UE}$$

where: CE = control efficiency
 UE = uncontrolled emissions
 AE = controlled emissions

The PM-10 control efficiencies for anthracite and bituminous coal combustion for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 9. During these years, any changes in the TSP control efficiencies from the 1985 TSP control efficiency values were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

No control efficiencies were applied to the activity data to estimate CO, NO_x, SO₂, or VOC emissions from the combustion of anthracite coal and bituminous coal and lignite.

3.9.5 References

1. *Coal Distribution January-December 19xx*. DOE/EIA-0125(xx/4Q). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
 - (a) table entitled "Domestic Distribution of U.S. Coal to the Residential and Commercial Sector by Origin."
2. *American Housing Survey, Current Housing Reports, Series H-150-83*. Bureau of the Census, U.S. Department of Commerce, Washington DC. Biennial.
3. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - (a) Volume I, Table 1.2-1, Supplement B, September 1988.
 - (b) Volume I, Table 1.1-2
 - (c) Volume I, Table 1.7-1
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5. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
6. *Computer Retrieval, NE257 report, by Source Classification Code (SCC) from the National Emission Data System (NEDS)*. Unpublished computer report. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. February 9, 1980.
7. *Coal Production*. DOE/EIA-0118(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
 - (a) table entitled "Shipments of bituminous coal and lignite by district, consumer, use, and average sulfur content - 1977."
8. *Minerals Yearbook, Coal*. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.
9. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.
10. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listings for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

3.10 FUEL COMBUSTION OTHER - COMMERCIAL/INSTITUTIONAL OIL: 03-02

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source categories.

Category:	Subcategory:
Residual Oil	Commercial / Institutional
Distillate Oil	Commercial / Institutional

3.10.1 Technical Approach

The CO, NO_x, PM-10, TSP, SO₂, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million gallons and emission factors were expressed in metric pounds/thousand gallons. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.10.2 Activity Indicator

The activity indicator for residual oil combustion was the "adjusted" total quantity of residual oil sales for commercial and military use obtained from Reference 1 or Reference 2.

The activity indicator for distillate oil combustion was the "adjusted" total quantity of distillate oil sales for commercial and military use (not including military diesel fuel) obtained from Reference 1 or Reference 2.

3.10.3 Emission Factor

The emission factors for the combustion of residual oil were the weighted average of the emission factors for the combustion of Grade 6 and Grade 5 fuel oils (SCCs 1-03-004-01 and 1-03-004-04). For all pollutants except PM-10, these emission factors were obtained from Reference 3a. The PM-10 emission factors were obtained from Reference 8. The TSP, SO₂, and PM-10 emission factors for Grade 6 fuel oil and the SO₂ emission factor for Grade 5 fuel oil were multiplied by the average sulfur content. The weighted average emission factors were determined using the relative consumption of Grade 5 and Grade 6 fuel oils obtained from Reference 5 or Reference 6.

The average sulfur content for residual oil was calculated from sulfur content values obtained from Reference 4 for No. 5 light, No. 5 heavy and No. 6 oils. The sulfur content values for the two No. 5 oils were averaged. Weighting factors for the averaged No. 5 oils and the No. 6 oil were 0.13 and 0.87 respectively. The following equation summarizes this calculation.

$$S_{Residual\ Oil} = \left[\frac{S_{No.\ 5\ light} + S_{No.\ 5\ heavy}}{2} \times 0.13 \right] + (S_{No.\ 6} \times 0.87)$$

where: S = sulfur content

The emission factors for distillate oil combustion were the weighted averages of the emission factors for the SCCs 1-03-005-01 and 1-03-005-04. The emission factors were obtained from Reference 3b for all pollutants except PM-10. The PM-10 emission factors were obtained from Reference 8. The SO₂ emission factors for both SCCs were multiplied by a weighted average sulfur content. Sulfur content values for No. 1, No. 2, and No. 4 oils were obtained from Reference 4. These values were weighted by the corresponding commercial deliveries of each oil type reported in Reference 1 or Reference 2 to obtain the weighted average sulfur content. To determine the weighted average emission factors, throughput values for the corresponding SCCs obtained from Reference 5 or Reference 6 were used as weighting factors.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier 2 category.

3.10.4 Control Efficiency

The PM-10 control efficiencies for all emission sources included in this Tier 2 category for the years 1975 through 1984 were equal to the 1988 PM-10 control efficiencies obtained from Reference 7. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

No control efficiencies were applied to the activity data to estimate CO, NO_x, SO₂, TSP, or VOC emissions from the source included in this Tier 2 category.

3.10.5 References

1. *Petroleum Marketing Monthly*. DOE/EIA-0380(xx/01). Energy Information Administration, U.S. Department of Energy, Washington, DC. January issue.
2. *Fuel Oil and Kerosene Sales 19xx*. DOE/EIA-0535(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
3. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - a. Volume I, Table 1.3-1
 - b. Volume I, Table 1.3-1
4. *Heating Oils*. U.S. Department of Energy. Obtainable from the National Institute for Petroleum and Energy Research, ITT Research Institute, P.O. Box 2128, Bartlesville, OK. Annual.
5. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
6. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
7. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.
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3.11 FUEL COMBUSTION OTHER - COMMERCIAL/INSTITUTIONAL GAS: 03-03

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source category.

Category:

Natural Gas

Subcategory:

Commercial / Institutional

3.11.1 Technical Approach

The CO, NO_x, PM-10, TSP, SO₂, and VOC emissions included in this Tier category were the emissions from the source category listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, the activity indicator was expressed in billion cubic feet and the emission factors were expressed in metric pounds/million cubic feet. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.11.2 Activity Indicator

The activity indicator for natural gas combustion was the total natural gas consumption for commercial uses as reported in Reference 1.

3.11.3 Emission Factor

The emission factors for all pollutants except PM-10 for the combustion of natural gas (SCC 1-03-006-03) were obtained from Reference 2a. The PM-10 emission factor was obtained from Reference 4.

3.11.4 Control Efficiency

The PM-10 control efficiencies for the years 1975 through 1984 were equal to the 1988 PM-10 control efficiency obtained from Reference 3. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions from natural gas combustion.

No control efficiencies were applied to the activity data to estimate CO, NO_x, SO₂, TSP, or VOC emissions from this source.

3.11.5 References

1. *Natural Gas Annual*. DOE/EIA-0131(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
2. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - a. Volume I, Table 1.4-1
3. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.
4. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listings for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

3.12 FUEL COMBUSTION OTHER - RESIDENTIAL WOOD: 03-05

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source category.

Category:

Miscellaneous Fuels

Subcategory:

Residential (wood)

3.12.1 Technical Approach

The CO, NO_x, PM-10, TSP, SO₂, and VOC emissions included in this Tier category were the emissions from the source category listed above. Emissions were estimated from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, the activity indicator was expressed in thousand short tons and the emission factors were expressed in metric pounds/short ton.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating the emissions based on activity indicators and emission factors.

3.12.2 Activity Indicator

The activity indicator for the residential combustion of wood was based on the consumption of wood for residential combustion as reported in Reference 1. It was assumed that 15 percent of the heating value is lost to moisture on a typical basis. Therefore, the reported consumption figure was multiplied by 0.85 to obtain the activity indicator. Alternatively, the procedure used to determine the emission factors for this category was used to estimate residential wood consumption as described below in section 3.12.3. The wood consumption calculated by this method was normalized to the total wood consumption reported by the Department of Energy (no reference for this value is currently available).

3.12.3 Emission Factor

The emission factors for the residential burning of wood were the weighted average of the emission factors for wood burned in wood stoves and in fireplaces. These emission factors for all pollutants except PM-10 and TSP obtained from References 2a and 2b for wood stoves and fireplaces, respectively. The PM-10 and TSP emission factors were obtained from Table 3.1-3. Weighting factors were based on the relative quantity of wood burned in wood stoves and in fireplaces. Weighting factors of 0.755 for wood stoves and 0.245 for fireplaces were used when the factors were not determined as described below.

The quantity of wood consumed in fireplaces was determined from the number of fireplaces obtained from Reference 3a and the assumption that on average one-half cord of wood is burned in each fireplace per year. The calculation, including the necessary conversion factors is given below.

$$\text{Wood Consumption}_{\text{fireplaces}} = N_{\text{fireplaces}} \times \frac{0.5 \text{ cord}}{\text{yr}} \times \frac{4 \text{ m}^3}{\text{cord}} \times \frac{0.028317 \text{ ft}^3}{\text{m}^3} \times \frac{35 \text{ lb}}{\text{ft}^3} \times \frac{1 \text{ ton}}{2,000 \text{ lb}}$$

The quantity of wood burned in wood stoves was determined from the number of wood stoves and the stove heat input rates. The number of wood stoves being used in a given year was calculated as the number of stoves being used in the previous year, the number of new shipments of stoves, and the number of obsolete stoves as summarized in the equation below.

$$N_{\text{Wood Stoves}, i} = N_{\text{Wood Stoves}, i-1} + \% N_{\text{New Wood Stoves}, i} - N_{\text{New Wood Stoves}, i-6}$$

where i = year under study

The total shipments and imports of stoves was obtained from Reference 4. It was assumed that for the years 1981 through 1984, the number of shipments remained constant at the 1981 value. The number of obsolete stoves was assumed to be the number of stove shipments from the sixth previous year.

The total number of wood stoves in use was divided into two categories: primary and secondary. The number of primary stoves was extrapolated from the previous year's number based on the relative change in the number of dwelling units using wood as the primary house heating fuel obtained from Reference 3. The number of secondary stoves was calculated as the difference between the total number of wood stoves and the number of primary stoves.

The stove heat input rate for each stove type was used to calculate the total energy consumed by each stove type. The 1984 stove heat input rates for primary and secondary stoves were $112,453 \times 10^6$ Btu and 42.37×10^6 Btu, respectively. No reference is currently available for this value and it is not known at this time if year-specific heat input rates were used for the year prior to 1984. The total energy consumed by the primary and secondary wood stoves were summed and converted to the quantity of wood consumed using the factor 17.2×10^6 Btu/ton.

The total quantity of wood consumed by residential combustion was calculated as the sum of the quantity of wood consumed in fireplaces and in wood stoves. The relative quantities of wood consumed by fireplaces and wood stoves were calculated and used as the weighting factors for determining the emission factors for this source category.

3.12.4 Control Efficiency

No control efficiencies were applied to the activity data to estimate the emissions from the residential combustion of wood.

3.12.5 References

1. *Estimates of U.S. Biofuels Consumption*. SR/CNEAF/91-02. Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
2. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - (a) Volume I, Table 1.10-1, Supplement D, September 1991, Supplement C, September 1990, or Supplement B, September 1988.
 - (b) Volume I, Table 1.9-1, Supplement D, September 1991
3. *American Housing Survey, Current Housing Reports, Series H-150-83*. Bureau of the Census, U.S. Department of Commerce, Washington DC. Biennial.
 - (a) Table 2-4, Selected Equipment and Plumbing - Occupied Units
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3.13 FUEL COMBUSTION OTHER - RESIDENTIAL OTHER: 03-06

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source categories.

Category:	Subcategory:
Anthracite Coal	Residential
Bituminous Coal and Lignite	Residential
Residual Oil	Residential
Distillate Oil	Residential
Natural Gas	Residential
Miscellaneous Fuels	Residential (kerosene and LPG)

3.13.1 Technical Approach:

The CO, NO_x, PM-10, TSP, SO₂, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, the activity indicator for bituminous coal was expressed in million short tons and the emission factors were expressed in metric pounds/short ton. The activity indicator for anthracite coal was expressed in thousand short tons and the emission factors were expressed in metric pounds/short ton. For residual oil, distillate oil, kerosene, and LPG, activity indicators were expressed in million gallons and emission factors were expressed in metric pounds/thousand gallons. The activity indicator for natural gas was expressed in billion cubic feet and the emission factors were expressed in metric pounds/million cubic feet. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.13.2 Activity Indicator:

The activity indicator for anthracite coal combustion was the residential consumption of anthracite coal. This value was determined by extrapolating residential consumption of anthracite coal for the previous year based on the change in the number of dwelling units in the Northeastern United States having coal as the main fuel for space heating. Data concerning the number of dwelling units was obtained from Reference 1. The calculation of the residential anthracite coal consumption is summarized in the equation below.

$$\text{Anthracite Coal}_{R,i} = \text{Anthracite Coal}_{R,i\&1} \times \frac{\text{Dwelling Units}_i}{\text{Dwelling Units}_{i\&1}}$$

where: R = residential consumption
i = year under study

The activity indicator for bituminous coal and lignite combustion was the residential consumption of bituminous coal and lignite. This value was determined by estimating the quantity of all coal consumed by all dwelling units using coal as the main fuel and subtracting from this value the residential consumption of anthracite coal calculated above. The quantity of all coal consumed was calculated using the number of dwelling units using coal as the main fuel for space heating obtained from Reference 1 and a factor estimating the average annual consumption of coal per dwelling unit. This calculation is summarized in the equation below.

$$\text{Bituminous Coal}_{R,i} = (\text{Dwelling Units}_i \times 6.73 \text{ tons burned /dwelling /year}) - \text{Anthracite Coal}_{R,i}$$

where: R = residential consumption
i = year under study

The activity indicator for the residential combustion of residual oil was assumed to be zero.

The activity indicator for distillate oil combustion was the sum of the "adjusted" sales (or deliveries) for residential use of distillate oil and for farm use of other distillates as reported in Reference 2 or Reference 3.

The activity indicator for natural gas combustion was the total natural gas consumption for residential use obtained from Reference 4.

The activity indicator for kerosene combustion was the quantity of kerosene sales. This value was obtained by summing sales figures reported for the residential, commercial, and farm use categories as reported in Reference 2 or Reference 3.

The activity indicator for LPG combustion was based on the 1982 total residential sales of LPG (4,047 x 10⁶ gal). This value was extrapolated to the year under study based on the relative change in the LPG products supplied from the year 1982 (1499 x 10³ bbl/day) to the year under study. Quantities of LPG products supplied for the specific years were obtained from Reference 5. The equation below summarizes this calculation.

$$Residential\ Sales_{LPG, i} = Residential\ Sales_{LPG, 1982} \times \frac{Products\ Supplied_{LPG, i}}{Products\ Supplied_{LPG, 1982}}$$

where: i = year under study

3.13.3 Emission Factors:

The emission factors for residential anthracite coal combustion (SCC 10300103, hand-fired units) were obtained from Reference 6a for all pollutants except PM-10. The PM-10 emission factor was obtained from Reference 12. The TSP and PM-10 factors were multiplied by an ash content of 11 percent. The SO₂ factor was multiplied by a sulfur content value of 0.7 percent.

The emission factors for all pollutants except PM-10 for the combustion of bituminous coal and lignite (SCC 10300103, hand-fired units) were obtained from Reference 6b. The PM-10 emission factor was obtained from Reference 12.

The SO₂ emission factor was multiplied by the average sulfur content for all coal used by commercial users. The average sulfur content of coal was determined from the sulfur content by coal producing districts obtained for the category "All other uses" in Reference 7a. This reference provided the sulfur content values reported in 1977 and it was assumed that these values remained constant during the years 1940 through 1984. In order to obtain the average sulfur content for a specific year, the sulfur content by district was weighted by the distribution of coal by district of origin for the category "Commercial and Residential" obtained from Reference 8a or Reference 9.

No emission factors were required for residential residual oil combustion, because the activity was assumed to be zero.

The emission factors for the combustion of distillate oil were obtained from Reference 6c under the classification residential furnaces for all pollutants except PM-10. The PM-10 emission factor was obtained from Reference 12 or Table 3.1-3. The SO₂ emission factor was multiplied by the weighted average sulfur content. Sulfur contents for No. 1 and No. 2 oils were obtained from Reference 10. Weighting factors were the corresponding quantity of sales (or deliveries) to residential users as reported in Reference 2 or Reference 3. The resulting weighted average sulfur content was applied to the SO₂ emission factor.

The emission factors for all pollutants except PM-10 for natural gas combustion (SCC 1-03-006-03) were obtained from Reference 6d. The PM-10 emission factor was obtained from Reference 12.

The emission factors for residential kerosene combustion were obtained from Reference 6c under the classification residential furnace for distillate oil for all pollutants except PM-10. The PM-10 emission factor was obtained from Reference 12 or Table 3.1-3. The SO₂ emission factor was multiplied by a sulfur content of 0.075 percent.

The emission factors for LPG combustion were obtained from Reference 6e under the classification domestic/commercial for all pollutants except PM-10. The PM-10 emission factor was obtained from Reference 12. The SO₂ emission factor was multiplied by a sulfur content of 0.0013 percent.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier 2 category.

3.13.4 Control Efficiency

No control efficiencies were applied to the activity data to estimate CO, NO_x, SO₂, TSP, and VOC emissions from the sources included in this Tier 2 category.

For the residential combustion of anthracite coal, bituminous coal and lignite, natural gas, and LPG, the PM-10 control efficiencies for the years 1975 through 1984 were equal to the 1988 PM-10 control efficiencies obtained from Reference 11. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions from the combustion of these fuels. For the residential combustion of residual oil, distillate oil, and kerosene, no control efficiencies were applied to the activity data to estimate PM-10 emissions.

3.13.5 References

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- (b) Volume I, Table 1.1-1
 - (c) Volume I, Table 1.3-1
 - (d) Volume I, Table 1.4-1
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 - (a) Table entitled "Shipments of bituminous coal and lignite by district, consumer, use, and average sulfur content - 1977."
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 - (a) Table entitled "Domestic Distribution of U.S. Coal to the Residential and Commercial Sector by Origin."
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3.14 CHEMICAL AND ALLIED PRODUCT MANUFACTURING - ORGANIC CHEMICAL MANUFACTURING: 04-01

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source categories.

Category:	Subcategory:
Industrial Processes - CO Emissions	Charcoal
Industrial Processes - CO Emissions	Petrochemicals
Industrial Processes - NO _x Emissions	Charcoal
Industrial Processes - NO _x Emissions	Petrochemicals
Industrial Processes - Particulates and PM-10 Emissions	Chemical Industry (petrochemicals)
Industrial Processes - VOC Emissions	Manufacture of Petrochemicals (excluding storage and handling, and waste disposal)
Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [miscellaneous chemical products (charcoal)]

3.14.1 Technical Approach

The CO, NO_x, PM-10, TSP, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.14.2 Activity Indicator

3.14.2.1 Industrial Processes - CO Emissions

The activity indicator for charcoal manufacturing was the production figure for charcoal obtained from Reference 1.

The activities indicators for petrochemical manufacturing were the production figures for each material. Production numbers for acetic acid, dimethyl terephthalate, ethylene dichloride, formaldehyde, maleic anhydride were obtained from Reference 2 or Reference 3. Total production of acrylonitrile and phthalic anhydride was obtained from Reference 2. The production level of cyclohexanone was obtained from Reference 3. The approximate production of cyclohexanol was accounted for by multiplying the cyclohexanone production level by 2. If Reference 3 was not available, the adipic acid production was obtained from Reference 2. It was assumed that the cyclohexanol/none production reported in Reference 4 for the previous year changed in direct proportion to adipic acid production.

3.14.2.2 Industrial Processes - NO_x Emissions

The activity indicator for charcoal manufacturing was the production figure for charcoal obtained from Reference 1.

The activities indicators for petrochemical manufacturing were the production figures for each material. Total production levels of acrylonitrile and adipic acid were obtained from Reference 2. In order to determine the adiponitrile production level, the total nylon production was obtained from Reference 2. It was assumed that the year-to-year change in nylon production was proportional to year-to-year change in adiponitrile production.

3.14.2.3 Industrial Processes - Particulate and PM-10 Emissions

The activity indicators for petrochemical manufacturing were the production figure for each material. Production levels of phthalic anhydride, polyethylene, PVC, and polypropylene were obtained from Reference 2.

3.14.2.4 Industrial Processes - VOC Emissions

The activity indicators for petrochemical manufacturing processes, excluding the storage and handling and waste disposal, were the production figures for each material. Production numbers for the chemicals listed in Table 3.14-1 were obtained from Reference 2 or Reference 3. Activity indicators for the other products and fugitive subcategories were based on the industrial organic chemical production index obtained from Reference 2.

The activity indicator for charcoal manufacturing was the production figure for charcoal obtained from Reference 1.

3.14.3 Emission Factor

3.14.3.1 Industrial Processes - CO Emissions

The emission factor for charcoal (SCC 3-01-006-01) was obtained from Reference 5a.

The emission factors for acetic acid, acrylonitrile, cyclohexanol/none and ethylene dichloride, formaldehyde, and phthalic anhydride were obtained from Reference 6. The emission factor for dimethyl terephthalate (SCC 3-01-031-01) was obtained from Reference 5b. The emission factor for maleic anhydride (SCC 3-01-100-02) was obtained from Reference 5c.

3.14.3.2 Industrial Processes - NO_x Emissions

The emission factor for charcoal (SCC 3-01-006-01) was obtained from Reference 5a.

The emission factors for acrylonitrile and adiponitrile were obtained from Reference 7. The emission factor for the adipic acid (SCC 3-01-001-01) was obtained from Reference 5d.

3.14.3.3 Industrial Processes - Particulate and PM-10 Emissions

The emission factors for phthalic anhydride were determined from the emission factors for the raw material inputs of: o-xylene or naphthalene. The emission factors for o-xylene (SCC 3-01-019-02, 3-01-019-02, and 3-01-019-04) and for naphthalene (SCC 3-01-019-05, 3-01-019-06, and 3-01-019-07) were obtained from Reference 5f for TSP and from Reference 15 for PM-10. These emission factors were weighted according to the capacity figures in Reference 8, in which a table showed the capacity of phthalic anhydride production in the United States by raw material input: o-xylene or naphthalene.

The emission factors for polyethylene were the averages of the emission factors for the SCCs 3-01-018-07 and 1-01-018-12. The TSP emission factors were obtained from Reference 7 and the PM-10 emission factors were obtained from Reference 15. Emission factors for the PVC (SCC 3-01-018-01) and polypropylene (SCC 3-01-018-02) were obtained from Reference 5e for TSP and from Reference 15 for PM-10.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier 2 category.

3.14.3.4 Industrial Processes - VOC Emissions

The emission factors for the chemical products listed in Table 3.14-1 were obtained from Reference 9, with the exception of the emission factors for acetic acid, acrylic acid and acrylonitrile which were obtained

from Reference 10. Weighted average emission factors for the chemical products where more than one SCC was listed were calculated using the weighting factors given in Table 3.14-1. Where no weighting factors were given, the overall emission factor for the chemical product was the sum of the emission factors for the SCCs listed.

For the years 1940 through 1976, the VOC emission factors for other products and fugitives were obtained from Reference 11. The emission factors for the years 1982 through 1984 were obtained from Reference 6. The emission factors for the intervening years of 1977 through 1983 were derived from a linear interpolation between the values for the years 1976 and 1982.

The emission factor for charcoal (SCC 3-01-006-01) was obtained from Reference 5a.

3.14.4 Control Efficiency

3.14.4.1 Industrial Processes - CO Emissions

The control efficiency for charcoal manufacturing was derived from Reference 12 or Reference 13 using the equation below.

$$CE = \frac{(UE - AE)}{UE}$$

where: CE = control efficiency
UE = emissions before control
AE = emissions after control

No control efficiencies were applied to the activity data to estimate emissions from petrochemical production.

3.14.4.2 Industrial Processes - NO_x Emissions

No control efficiencies were applied to the activity data to estimate NO_x emissions from charcoal and petrochemical production.

3.14.4.3 Industrial Processes - Particulate and PM-10 Emissions

The TSP control efficiency for PVC production was derived from Reference 5 or Reference 6 using the same equation given above for the CO control efficiency for charcoal.

The TSP control efficiency for phthalic anhydride production was assumed to have a constant value of 0.85 for the years 1979 through 1984. The procedure used to determine the control efficiencies for the years 1940, 1950, 1960, and 1970 through 1978 is currently unavailable.

No control efficiencies were applied to the activity data to estimate TSP emissions from polyethylene and polypropylene production.

The PM-10 control efficiencies for the petrochemical emission sources for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 14. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate the PM-10 emissions.

3.14.4.4 Industrial Processes - VOC Emissions

The control efficiency for charcoal manufacturing was derived from Reference 12 or Reference 13 using the same equation given above for the CO control efficiency. No control efficiencies were applied to the activity data to estimate VOC emissions from the petrochemical manufacturing sources included in this Tier 2 category.

3.14.5 References

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Table 3.14-1. Chemical Products, SCCs, and Weighting Factors for VOC Emission Factors

Chemical Product	SCC	Weighting Factor
Acetic acid* - via Methanol - via Butane - via Acetaldehyde	3-01-132-01	.43
	3-01-132-05	.28
	3-01-132-10	.29
Acrylic acid*	3-01-132-21	
Acrylonitrile*	3-01-245-05	
Adiponitrile via Butadiene	3-01-254-10	
Benzene - Reactor - Distillation Vent	3-01-258-02	
	3-01-258-03	
Butadiene & Butylene Fractions	3-01-153-10(20)	
1,3 Butadiene	3-01-153-10(20)	
Caprolactam	3-01-210-02	
	3-01-210-03	
	3-01-210-05	
	3-01-210-06	
	3-01-210-07	
	3-01-210-08	
	3-01-210-09	
	3-01-210-10	
Chlorobenzene	3-01-301-10	
Cyclohexanone	3-01-158-01	
Cumene	3-01-156-01	
Dimethyl Terephthalate	3-01-031-01	
Ethyl Benzene	3-01-169-01	
Ethylene	3-01-197-41	
	3-01-197-43	
	3-01-197-45	
Ethylene Dichloride - oxychlorination - Direct chlorination	3-01-125-01	.996
	3-01-125-02	.004
Ethylene Glycol	3-01-251-02	
	3-01-251-03	
Ethylene Oxide	3-01-174-01	
Formaldehyde - Silver Catalyst - Mixed Oxide Catalyst	3-01-120-01	.8
	3-01-120-02	.2
Linear Alkylbenzene - Olefin process - Chlorination Process	3-01-211-02	.36
	3-01-211-03	.36
	3-01-211-04	.36
	3-01-211-22	.64
	3-01-211-23	.64
	3-01-211-24	.64
	3-01-211-25	.64

Table 3.14-1. (continued)

Chemical Product	SCC	Weighting Factor
Maleic Anhydride	3-01-100-02 3-01-100-03 3-01-100-05	
Methanol	3-01-250-02 3-01-250-03	
Methyl Methacrylate	3-01-190-02 3-01-190-03 3-01-190-04 3-01-190-10 3-01-190-11 3-01-190-12 3-01-190-13 3-01-190-14	
Nitrobenzene	3-01-195-01	
Perchloroethylene	3-01-125-20	
Phenol	3-01-202-01	
Propylene Oxide - Chlorohydrin	3-01-205-**	.53
- Isobutane	3-01-205-**	.33
- Ethylbenzene	3-01-205-**	.14
Styrene	3-01-206-01	
Toluene Diisocyanate	3-01-181-02 3-01-181-03 3-01-181-04 3-01-181-05 3-01-181-06 3-01-181-07 3-01-181-08	
Vinyl Acetate	3-01-167-02 3-01-167-03 3-01-167-04	
Vinyl Chloride	3-01-125-40	

* The emission factors for these chemical products were obtained from Reference 10. For all other chemical products, the emission factors were obtained from Reference 9.

3.15 CHEMICAL AND ALLIED PRODUCT MANUFACTURE - INORGANIC CHEMICAL MANUFACTURE: 04-02

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source categories.

Category:	Subcategory:
Industrial Processes - CO Emissions	Ammonia
Industrial Processes - CO Emissions	Titanium Dioxide (chloride process)
Industrial Processes - NO _x Emissions	Ammonia
Industrial Processes - NO _x Emissions	Nitric Acid
Industrial Processes - Particulates and PM-10 Emissions	Chemical Industry (calcium carbide and sulfuric acid)
Industrial Processes - SO ₂ Emissions	Other Industrial Processes (sulfuric acid)
Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [miscellaneous chemical products (ammonia)]

3.15.1 Technical Approach

The CO, NO_x, PM-10, TSP, SO₂, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.15.2 Activity Indicator

3.15.2.1 Industrial Processes - CO Emissions

The activity indicator for ammonia was the total quantity of ammonia production obtained from Reference 1. The activity indicator for titanium dioxide was based on the total quantity of titanium dioxide production as reported in Reference 1. It was assumed that 73 percent of total production was by chloride process. Therefore total production was multiplied by 0.73 to calculate the total titanium dioxide produced by the chloride process. For a more accurate figure for the percentage of production by the chloride process, Reference 2 should be consulted.

3.15.2.2 Industrial Processes - NO_x Emissions

The activity indicator for ammonia was the total quantity of ammonia production obtained from Reference 1. The activity indicator for nitric acid was the total production of nitric acid obtained from Reference 1.

3.15.2.3 Industrial Processes - Particulates and PM-10 Emissions

The activity indicator for calcium carbide was the total production of calcium carbide obtained from Reference 3. When data was withheld (i.e., for proprietary reasons), the previous year's data was used. The activity indicator for sulfuric acid was the total production of sulfuric acid obtained from Reference 3.

3.15.2.4 Industrial Processes - SO₂ Emissions

The activity indicator for sulfuric acid was the total production of sulfuric acid obtained from Reference 3.

3.15.2.5 Industrial Processes - VOC Emissions

The activity indicator for ammonia was the total quantity of ammonia production was obtained from Reference 1.

3.15.3 Emission Factor

3.15.3.1 Industrial Processes - CO Emissions

The emission factor for ammonia was the sum of emission factors for feedstock desulfurization (SCC 3-01-003-05), primary reformer, natural gas (SCC 3-01-003-06), and CO regenerator (SCC 3-01-003-08). These emission factors were obtained from Reference 4a. The emission factor for titanium dioxide was obtained from Reference 5 for all U.S. plants with actual CO emission source tests (SCC = 3-03-012-01).

3.15.3.2 Industrial Processes - NO_x Emissions

The emission factor for ammonia (SCC 3-01-003-06) was obtained from Reference 4a.

The emission factor for nitric acid was the weighted average of the emission factors for nitric acid production by old plants (43 lb/ton) and new plants (3 lb/ton). The weighting factors used to calculate the overall emission factor were the percentage of production from old plants and from new plants, respectively. New plant production was equal to 5 percent of the total 1970 production (380,000 tons) for each year since 1970. Old plant production was equal to the difference between total production as reported in Reference 1 and new plant production, as calculated above.

3.15.3.3 Industrial Processes - Particulates and PM-10 Emissions

The PM-10 and TSP emission factors for calcium carbide were the sum of three emission factors: electric furnace (SCC 3-05-004-01), coke dryer (SCC 3-05-004-02) and furnace room vents (SCC 3-05-004-03). The TSP emission factors were obtained from Reference 4c and the PM-10 emission factors were obtained from Reference 9. The emission factors for sulfuric acid (SCC 3-01-023-01) were obtained from Reference 4b for TSP and from Reference 9 for PM-10.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier 2 category.

3.15.3.4 Industrial Processes - SO₂ Emissions

The emission factors for sulfuric acid were based on the emission factor calculated for the year previous to the year under study and the NSPS emission factor (4 lb/ton). The weighted average of these two emission factors was based on the production levels for the year under study and the previous year as presented in the following equation:

$$EF_i = \frac{0.95 \times EF_{i-1} \times P_{i-1} + 0.05 \times EF_{NSPS} \times P_{i-1}}{P_i \times (P_i + P_{i-1})} \times P_i$$

where: EF = SO₂ emission factor
 i = year under study
 P = total production

When the production for the year under study was less than the production for the previous year, then the last term (P_i - P_{i-1}) was set to zero. New capacity for production was only assumed for a production level above the previous record high production level.

3.15.3.5 Industrial Processes - VOC Emissions

The emission factor for ammonia was the sum of emission factors for feedstock desulfurization (SCC 3-01-003-05), primary reformer, natural gas (SCC 3-01-003-06), carbon dioxide regenerator (SCC 3-01-003-08), and condensate stripper (SCC 3-01-003-09). These emission factors were obtained from Reference 4a.

3.15.4 Control Efficiency

No control efficiencies were applied to the activity data to estimate CO, NO_x, SO₂, and VOC emissions from the source included in this Tier 2 category.

The TSP control efficiencies for sulfuric acid and calcium carbide production were derived from Reference 6 or Reference 7 using the equation below.

$$CE = \frac{(UE \& AE)}{UE}$$

where: CE = control efficiency
UE = emissions before control
AE = emissions after control

The PM-10 control efficiencies for sulfuric acid and calcium carbide production for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 8. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate the PM-10 emissions.

3.15.5 References

1. *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.
2. *Chemical Economics Handbook*. Stanford Research Institute International, Menlo Park, CA.
3. *Current Industrial Reports, Inorganic Chemicals*. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Annual.
4. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - a. Volume I, Table 5.2-1
 - b. Volume I, Table 5.17-2
 - c. Volume I, Table 8.4-1

5. *Computer Retrieval, NE257 report, by Source Classification Code (SCC) from the National Emission Data System (NEDS)*. Unpublished computer report. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. February 9, 1980.
6. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
7. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
8. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.
9. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listings for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

3.16 CHEMICAL AND ALLIED PRODUCTS MANUFACTURE - POLYMER AND RESIN
MANUFACTURE: 04-03

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source categories.

Category:

Industrial Processes - VOC Emissions

Industrial Processes - VOC Emissions

Subcategory:

Plastics Manufacture (excluding fabrication)

Miscellaneous Chemical Products (synthetic fibers and synthetic rubber)

3.16.1 Technical Approach

The VOC emissions included in this category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.16.2 Activity Indicator

The activity indicators for plastics manufacture were the total production levels for each material. The total production levels of high density polyethylene, low density polyethylene, polypropylene, and polyvinyl chloride were obtained from Reference 1. The production level of polystyrene was obtained from Reference 1 as the sum of production levels for the following substances: (1) styrene-acrylonitrile, (2) polystyrene, and (3) acrylonitrile-butadiene-styrene and other styrene polymers. The production level for other plastics was obtained from Reference 1 as the sum of production levels for the following substances: (1) thermosetting resins, (2) polyamides, and (3) other vinyl resins.

The activity indicator for synthetic fibers was the quantity of total man-made fiber production obtained from Reference 1. The activity indicator for the total synthetic rubber subcategory was the production of synthetic rubber obtained from Reference 1.

3.16.3 Emission Factor

The emission factors for high density polyethylene (SCC 3-01-018-07), low density polyethylene (SCC 3-01-018-12), and polystyrene (SCC 3-01-01801) were obtained from Reference 2. The emission factors for

polypropylene (SCC 3-01-018-02) and polyvinyl chloride (SCC 3-01-018-01) were obtained from Reference 3a.

The emission factor for other plastics manufacturing was calculated by dividing the 1979 actual emissions for this source by the corresponding activity indicator. The calculation of the 1979 actual emissions for other plastics followed the steps described below.

1. The 1979 total actual emissions for the high density polyethylene, low density polyethylene, polypropylene and polystyrene subcategories were calculated using the corresponding 1979 activity indicators and emission factors.
2. The 1979 actual emissions of polyethylene terephthalate were added to the previous sum. Actual emissions of polyethylene terephthalate were estimated by multiplying the emission factor obtained from Reference 4 by the production level obtained from Reference 1 for 1979.
3. It was assumed that the sum calculated in step 2 represented 75 percent of the total emissions from all plastics. Therefore, the total emissions from all plastics in 1979 was calculated by dividing the total from step 2 by 0.75.
4. The 1979 actual emissions of high density polyethylene, low density polyethylene, polypropylene and polystyrene were subtracted from the total emission from all plastics calculated in step 3. The result was the total 1979 emissions from the other plastics category.

The emission factors for synthetic fibers was obtained from Reference 5. The emission factor for synthetic rubber was the weighted average of emission factors for the following compounds: polychloroprene, polyisoprene, butyl, nitrile, polybutadiene, ethylene propylene copolymers, styrene butadiene rubber, and "others." The styrene butadiene rubber emission factor was obtained from Reference 3a and all other emission factors were obtained from Reference 6. These emission factors were weighted by the relative quantity of each compound produced in 1979 as obtained from Reference 1.

3.16.4 Control Efficiency

Control efficiencies were applied to the activity data to estimate VOC emissions from high density polyethylene production processes, but the procedures for determining these control efficiencies are currently unavailable. No control efficiencies were applied to the activity data to estimate emissions from all other sources included in this Tier 2 category.

3.16.5 References

1. *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.
2. Criteria Pollutant Emission Factors for the 1985 NAPAP Emissions Inventory.

3. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42.* U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - a. Volume I, Table 5.13-1
4. *Polymer Manufacturing Industry - Background Information for Proposed Standards; Preliminary Draft.* EPA-450/3-83-012a. U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1984.
5. *OAQPS Data File on National Emissions.* National Air Data Branch, U.S. Environmental Protection Agency, Research Triangle Park, NC. 1984.
6. *Control Techniques for VOC Emissions from Stationary Sources.* EPA-450/3-85-008. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1985.

3.17 CHEMICAL AND ALLIED PRODUCT MANUFACTURE - AGRICULTURAL CHEMICAL MANUFACTURE: 04-04

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source category.

Category:

Industrial Processes - Particulates and PM-10 Emissions

Subcategory:

Chemical Industry [fertilizers (ammonium nitrate, diammonium phosphate, and urea)]

3.17.1 Technical Approach

The PM-10 and TSP emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1992 for TSP and for the years 1975 through 1984 for PM-10. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.17.2 Activity Indicator

The activity indicators for the manufacture of fertilizers were the production levels of the individual materials. Total production levels for ammonium nitrate and urea were obtained from Reference 1. Total production of diammonium phosphate was calculated as the sum of production levels of diammonium, monoammonium, and other ammonium phosphates obtained from Reference 2. Production was expressed in equivalent tons of phosphoric oxide, P₂O₅ content.

3.17.3 Emission Factor

The emission factors for ammonium nitrate manufacturing were the weighted averages of the emission factors for specific processes obtained from Reference 3a for TSP and from Reference 8 for PM-10. The specific processes and SCCs included in the weighted averages along with the weighting factors are presented in Table 3.17-1. Each emission factor was multiplied by the corresponding weighting factor and the products were summed.

The emission factors for diammonium phosphate production were the sum of the emission factors for following processes: (1) dryer, cooler and (2) ammoniator - granulator. The TSP emission factors were obtained from Reference 4a; the PM-10 emission factors were obtained from Reference 8.

For urea production, the emission factors were the weighted averages of emission factors for specific processes obtained from Reference 3b for TSP and from Reference 8 for PM-10. The specific processes and SCCs included in the weighted averages along with the weighting factors are presented in Table 3.17-1. Each emission factor was multiplied by the corresponding weighting factor and the products were summed.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier 2 category.

3.17.4 Control Efficiency

The TSP control efficiency for diammonium phosphate production was derived from Reference 5 or Reference 6 using the equation below:

$$CE = \frac{(UE - AE)}{UE}$$

where: CE = control efficiency
UE = emissions before control
AE = emissions after control

The TSP control efficiencies for ammonium nitrate and urea production were based on the controlled and uncontrolled emission factors from Reference 1. For ammonium nitrate production, this procedure for determining control efficiency was used for the years 1974 through 1984. For urea production, this procedure was used for the years 1979 through 1984. For the years prior to those stated above, the procedures for determining the TSP control efficiencies are currently unavailable.

The PM-10 control efficiencies for the production of these three fertilizers for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 7. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency value were

reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

3.17.5 References

1. *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.
2. *Current Industrial Reports, Fertilizer Materials*. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Annual.
3. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - a. Volume I, Table 6.8-1
 - b. Volume I, Table 6.14-1
4. *Compilation of Air Pollutant Emission Factors, Third Edition, Supplements 1 through 14, AP-42*. NTIS PB-275525. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1977.
 - b. Volume I, Table 6.10-1
5. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
6. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
7. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.
8. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listing for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

Table 3.17-1. Ammonium Nitrate Emission Factor SCCs and Weighting Factors

SCC	Description	Weighting Factor
3-01-027-04	Neutralizer (All Plants)	1
3-01-027-17(27)	Solids Evap. Concentrator (All Plants)	.6
3-01-027-18(28)	Coating Operation	.4
3-01-027-12	High Density Prilling (Solids Form.)	.36
3-01-027-22	Low Density Prilling (Solids Form.)	.18
3-01-027-07	Rotary Drum Granulators (Solids Form.)	.04
3-01-027-08	Pan Granulators (Solids Form.)	.01
3-01-027-14	High Density Prilling (Coolers/Dryers)	.36
3-01-027-24	Low Density Prilling (Coolers/Dryers)	.18
3-01-027-25	Low Density Prilling/Drying (Coolers/Dryers)	.18
3-01-027-29	Rotary Drum Granulators (Coolers/Dryers)	.032
3-01-027-30	Pan Granulator Coolers (Coolers/Dryers)	.006

Table 3.17-2. Urea Emission Factor SCCs and Weighting Factors

SCC	Description	Weighting Factor
3-01-040-02	Solution Concentration	1
3-01-040-04	Drum Granulation	.45
3-01-040-08	Nonfluid Bed Prilling (Agricultural Grade)	.07
3-01-040-09	Nonfluid Bed Prilling (Feed Grade)	.005
3-01-040-10	Fluid Bed Prilling (Agricultural Grade)	.07
3-01-040-11	Fluid Bed Prilling (Feed Grade)	.005
3-01-040-12	Rotary Drum Cooler	.045
3-01-040-06	Bagging	.045

3.18 CHEMICAL AND ALLIED PRODUCT MANUFACTURE - PAINT, VARNISH, LACQUER, AND ENAMEL MANUFACTURE: 04-05

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source category.

Category:

Industrial Processes - VOC emissions

Subcategory:

Miscellaneous Industrial Processes [miscellaneous chemical products (paint)]

3.18.1 Technical Approach

The VOC emissions included in this Tier category were the emissions from the source category listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, the activity indicator was expressed in thousand short tons and the emission factor was expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.18.2 Activity Indicator

The activity indicator for paint manufacturing was the total shipments of paint and allied products obtained from Reference 1.

3.18.3 Emission Factor

The emission factor for paint manufacturing was the sum of the emission factors for general mixing/handling (SCC 3-01-014-01) and varnish manufacture, oleoresinous (SCC 3-01-015-02) obtained from Reference 2a.

3.18.4 Control Efficiency

The control efficiency for paint manufacturing was derived from Reference 3 or Reference 4 using the equation below:

$$CE = \frac{(UE \& AE)}{UE}$$

where: CE = control efficiency

UE = emissions before control
AE = emissions after control

3.18.5 References

1. *Current Industrial Reports, Paint and Allied Products*. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Annual.
2. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - a. Volume I, Table 5.10-1
3. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
4. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

3.19 CHEMICAL AND ALLIED PRODUCT MANUFACTURE - PHARMACEUTICAL MANUFACTURE: 04-06

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source category.

Category:

Industrial Processes - VOC Emissions

Subcategory:

Miscellaneous Industrial Processes [miscellaneous chemical products (pharmaceuticals)]

3.19.1 Technical Approach

The VOC emissions included in this Tier category were the emissions from the source category listed above. Emissions were estimated from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, the activity indicator was expressed in thousand short tons and the emission factor was expressed in metric pounds/short ton.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.19.2 Activity Indicator

The activity indicator for pharmaceutical manufacturing was the production index for drugs and medicines obtained from Reference 1. The index was multiplied by 10 to obtain the activity indicator for pharmaceuticals.

3.19.3 Emission Factor

The emission factor for pharmaceutical manufacturing was 63.1 lb VOC/ton and comes from Reference 6 of section 3.16.

3.19.4 Control Efficiency

No control efficiencies were applied to the activity data to estimate VOC emissions from the manufacture of pharmaceuticals.

3.19.5 References

1. *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.

3.20 CHEMICAL AND ALLIED PRODUCTS MANUFACTURE - OTHER CHEMICAL MANUFACTURE: 04-07

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source categories.

Trends Category:

Industrial Processes - CO Emissions

Industrial Processes - PM-10 Emissions

Industrial Processes - SO₂ Emissions

Industrial Processes - VOC Emissions

Trends Subcategory:

Carbon Black Production

Chemical Industry (carbon black production, charcoal, and soap and detergent)

Other Industrial Processes (carbon black)

Miscellaneous Industrial Processes [miscellaneous chemical products (carbon black)]

3.20.1 Technical Approach

The CO, PM-10, TSP, SO₂, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators was expressed in thousand short tons and emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.20.2 Activity Indicator

3.20.2.1 Industrial Processes - CO Emissions

The activity indicators for carbon black production by the oil and gas processes were based on the total quantity of carbon black produced as reported in Reference 1. It was assumed that 90 percent of total production was by the oil process and 10 percent of total production was by the gas process. For the years 1940 through 1973, the activity of carbon black production by the channel process was obtained from Reference 2. After 1973, production by this process was assumed to be zero.

3.20.2.2 Industrial Processes - Particulates and PM-10 Emissions

The activity indicators for carbon black production by the oil and gas processes were based on the total quantity of carbon black produced obtained from Reference 1. It was assumed that 90 percent of total production was by the oil process and 10 percent of total production was by the gas process. For the years 1940 through 1973, the activity of carbon black production by the channel process was obtained from Reference 2. After 1973, production by the channel process was assumed to be zero.

The activity indicators for charcoal and soap and detergent production were based on the corresponding production figures obtained from Reference 3. Because this reference was only published every 5 years, the data from the year of publication prior to the year under study was projected to the year under study. The growth factor was based on the production index reported in Reference 1. It was calculated as the ratio between the production index for year under study and the production index for the publication year of Reference 3. The overall calculation is summarized in the equation given below.

$$\text{Activity Indicator}_i = \text{Production figure}_j \times \frac{\text{Production index}_i}{\text{Production index}_j}$$

where: i = year under study
j = year of preceding publication of Reference 2

3.20.2.3 Industrial Processes - SO₂ Emissions

The activity indicator for carbon black production was the total carbon black production obtained from Reference 1. This activity was not divided by process.

3.20.2.4 Industrial Processes - VOC Emissions

The activity indicators for carbon black production by the oil and gas processes were based on the total quantity of carbon black produced obtained from Reference 1. It was assumed that 90 percent of total production was by the oil process and 10 percent of total production was by the gas process. For the years

1940 through 1973, the activity of carbon black production by the channel process was obtained from Reference 2. After 1973, production by the channel process was assumed to be zero.

3.20.3 Emission Factor

3.20.3.1 Industrial Processes - CO Emissions

The emission factor for carbon black production by the oil process (SCC 3-01-005-04) was obtained from Reference 4a. The emission factors for carbon black production by the gas process (SCC 3-01-005-03) and the charcoal process were obtained from Reference 5.

3.20.3.2 Industrial Processes - Particulates and PM-10 Emissions

The TSP emission factors for carbon black production by the oil process (SCC 3-01-005-04) was obtained from Reference 4a. The TSP emission factors for carbon black production by the gas process (SCC 3-01-005-03) and the channel process were obtained from Reference 4c. The PM-10 emission factors for the three carbon black production processes were obtained from Reference 9.

The emission factors for charcoal were derived from the emission factors for charcoal kiln (SCC 3-01-006-03) and charcoal briquetting (3-01-006-05) obtained from Reference 4b for TSP and from Reference 9 for PM-10. The overall charcoal emission factors were the sum of the kiln emission factor and a specific percentage of the briquetting emission factor. For the years 1980 through 1984, this was 90 percent. For each preceding year through the year 1950, the percentage was decreased by one. The percentage was held constant from 1940 to 1950.

The emission factors for soap and detergent production (SCC 3-01-009-01) were obtained from Reference 4c for TSP and from Reference 9 for PM-10.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier 2 category.

3.20.3.3 Industrial Processes - SO₂ Emissions

The emission factor for carbon black production was based on the emission factor for flared furnace exhaust, oil process obtained from Reference 4a and the CO control efficiency for carbon black production by the oil process. The description of this CO control efficiency is presented in the next section. The SO₂ emission factor was calculated according to the equation given below.

$$EF_{SO_2, carbon\ black} = (CE_{CO, carbon\ black} / 0.913) \times EF_{Flared\ Furnace\ Exhaust}$$

where: EF = emission factor

CE = control efficiency, expressed as a fraction

3.20.3.4 Industrial Processes - VOC Emissions

The emission factor for carbon black production by the oil process (main vent, SCC 3-01-005-04) was obtained from Reference 4a. The emission factors for carbon black production by the gas process (main vent, SCC 3-01-005-03) and the channel process were obtained from Reference 5.

3.20.4 Control Efficiency

3.20.4.1 Industrial Processes - CO Emissions

The control efficiencies for carbon black production by both the oil process and gas process were computed from actual and uncontrolled emissions reported in Reference 6 or Reference 7 using the equation given below.

$$CE = \frac{(UE - AE)}{UE}$$

where: CE = control efficiency
UE = emissions before control
AE = emissions after control

No control efficiencies were applied to the activity data for carbon black production by the channel process.

3.20.4.2 Industrial Processes - Particulates and PM-10 Emissions

The TSP control efficiencies for carbon black production by the oil process and gas process and for soap and detergent production were derived from Reference 6 or Reference 7 using the same equation given above for the CO control efficiencies. No control efficiencies were applied to the activity data for carbon black production by the channel process.

The TSP control efficiency for charcoal production was calculated based on the control on kilns (SCC 301-006-01) for either CO, TSP, or VOC emissions obtained from Reference 6 or Reference 7. The TSP control efficiency for this process was calculated using the equation given below.

$$CE_{charcoal} = \frac{(EF_{kiln} \times CE_{kiln}) \% - (EF_{Briquetting} \times 0.9 \times 0.95)}{(EF_{kiln} \% - EF_{Briquetting} \times 0.9)}$$

where: CE = control efficiency
EF = emission factor

The PM-10 control efficiencies for carbon black, charcoal, and soap and detergent production for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 8. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

3.20.4.3 Industrial Processes - SO₂ Emissions

No control efficiencies were applied to the activity data to estimate SO₂ emissions from the carbon black production processes.

3.20.4.4 Industrial Processes - VOC Emissions

The VOC control efficiencies for carbon black production processes were 85 percent of the CO control efficiencies for the corresponding production process.

3.20.5 References

1. *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.
2. *Minerals Yearbook, Carbon Black*. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.
3. *Census of Manufactures*. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Available every five years.
4. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - a. Volume I, Table 5.3-3
 - b. Volume I, Table 5.4-1
 - c. Volume I, Table 5.15-1
5. *Compilation of Air Pollutant Emission Factors, Third Edition, Supplements 1 through 14, AP-42*. NTIS PB-275525. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1977.
6. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

7. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS).* Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
8. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.
9. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listings for Criteria Air Pollutants.* EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

3.21 METALS PROCESSING - NONFERROUS: 05-01

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source categories.

Category:	Subcategory:
Industrial Processes - CO Emissions	Primary Aluminum
Industrial Processes - Particulates and PM-10 Emissions	Primary Metals Industry (aluminum, copper, zinc, and lead)
Industrial Processes - Particulates and PM-10 Emissions	Secondary Metal Industry (aluminum, lead, and copper)
Industrial Processes - SO ₂ Emissions	Nonferrous Smelters (copper, zinc, and lead)
Industrial Processes - SO ₂ Emissions	Other Industrial Processes (primary aluminum and secondary lead)

3.21.1 Technical Approach

The CO, PM-10, TSP, and SO₂ emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.21.2 Activity Indicator

3.21.2.1 Industrial Processes - CO Emissions

Primary aluminum production was obtained from Reference 1. This production level was used as the activity indicator for primary aluminum.

3.21.2.2 Industrial Processes - Particulates and PM-10 Emissions

3.21.2.2.1 Primary Metals Industry - Aluminum —

The production of calcined alumina, obtained from Reference 2a, was the activity indicator for calcining of hydroxide. The primary aluminum production, obtained from Reference 1, was the activity indicator for material handling.

The HSS stack was assigned an activity equivalent to 18.5 percent of the total primary aluminum production. Activity of the HSS fugitive was assumed to equal to that for HSS stack. The VSS stacks was assigned an activity equivalent to 10.5 percent of the total primary aluminum production. The activity of VSS fugitives was assumed to equal to that of VSS stacks.

Stack and fugitive prebake were each assigned an activity equivalent to 71 percent of the total primary aluminum production. The activity of anode baking was assumed to equal to that of prebake.

3.21.2.2.2 Primary Metals Industry - Copper —

The activity indicator for roasting was based on the primary copper smelter production from domestic and foreign ores from Reference 3a. This reference provided the units of blister copper produced. It was assumed that of the 4 tons of copper concentrate/ton of blister, only half was roasted. Therefore, units of blister copper produced multiplied by 2 resulted in the activity indicator for roasting.

The activity indicators for smelting and converting were assumed to be equivalent. The activities were calculated in the same manner as for roasting, except it was assumed that all of the blister copper produced is smelted and converted. Therefore, units of blister copper produced multiplied by 4 resulted in the activity indicators for smelting and converting.

The total new copper smelter production figure obtained from Reference 3b was used as the activity indicator for fugitives.

3.21.2.2.3 Primary Metals Industry - Zinc —

The activity indicator for roasting was assigned the total slab zinc production obtained from the Reference 4. The production figure was converted to short tons and multiplied by 2 to account for the fact that there are 2 units of concentrate/ton slab zinc.

The activity indicator for sintering was assigned the redistilled slab zinc production obtained from Reference 4a. The activity indicator for electrolytic processes was estimated by subtracting the redistilled slab zinc production from total slab zinc production. These data were obtained from Reference 4.

The activity indicator for horizontal retort process was assume to be zero. The activity indicator for vertical retort processes was assigned the same value as used for zinc sintering.

Total slab zinc production figure obtained from Reference 4 was used as the activity for fugitive processes.

3.21.2.2.4 Primary Metals Industry - Lead —

The activities for the sintering process, blast furnaces, reverberatory furnaces, and fugitive processes were set equal to the primary refined lead production from domestic and foreign ores obtained from Reference 5.

3.21.2.2.5 Secondary Metals - Aluminum —

The activity indicator for sweating was the total consumption of all scrap by "sweated pig" and "borings and turnings" was obtained from Reference 1. Total of all scrap consumed, also from Reference 1, was the activity indicator for refining.

The activity indicator for fluxing was based on the quantities of magnesium recovered from new and old aluminum-based scrap obtained from Reference 6a. The quantities of magnesium were summed and multiplied by 4.

The activity indicator for fugitive processes was the total quantity of secondary aluminum recovered obtained from Reference 1.

3.21.2.2.6 Secondary Metals - Lead —

The data used to estimate the activity for the four lead processes were obtained from Reference 5. The pot furnace activity was estimated as 90 percent of the total consumption of lead scrap by all consumers obtained from Reference 5a. The activity indicator for reverberatory furnaces was calculated by multiplying the total consumption of lead scrap by the ratio between the quantity of lead recovered as soft lead and the total lead recovered from scrap. The activity indicator for blast furnaces was calculated by multiplying the total consumption of lead scrap by the ratio between lead recovered as antimonial lead and the total lead recovered from scrap. The total quantity of secondary lead recovered in the U.S. was used as the activity indicator for fugitive processes.

3.21.2.2.7 Secondary Metals - Copper —

The data used to estimate the activity for the four copper processes were obtained from Reference 3. The activity for wire burning was calculated as one-half of the total consumption of No. 2 wire obtained from Reference 3c. The activity for brass and bronze coating was calculated by multiplying the total consumption of scrap by the ratio between the copper recovered in alloys and the total secondary copper production. The activity for smelting was calculated by multiplying the total consumption of scrap by the ratio between the copper recovered as unalloyed copper and the total secondary copper production. The total quantity of copper recovered from all scrap was assigned the activity for fugitive processes.

3.21.2.3 Industrial Processes - SO₂ Emissions

The activity indicator for copper roasting was based on the primary copper smelter production from domestic and foreign ores from Reference 3a. This reference provided the units of blister copper produced. It was assumed that of the 4 tons of copper concentrate/ton of blister, only half were roasted. Therefore, units of blister copper produced multiplied by 2 resulted in the activity indicator for copper concentrate roasting.

The activity indicators for copper smelting and converting were assumed to be equivalent. The activities were calculated in the same manner as for the roasting category, except it was assumed that all of the blister copper produced was smelted and converted. Therefore, units of blister copper produced multiplied by 4 resulted in the activity indicators for copper smelting and converting.

The activity indicator for zinc ore roasting was assigned the total slab zinc production obtained from the Reference 4. The production figure was converted to short tons and multiplied by 2 to account for the fact that there are 2 units of concentrate/ton slab zinc.

The determination for the activity indicator for lead processing required the following steps: (1) calculation of the quantity of SO₂ removed as by-product sulfuric acid by lead plants, (2) calculation of total SO₂ emissions from lead processing, and (3) calculation of lead processing activity indicator. Each of these steps are described below.

For the first step, the quantity of by-product sulfuric acid produced from lead plants was obtained from Reference 3. This value was multiplied by the ratio of the molecular weight of SO₂ to the molecular weight of sulfuric acid (64/98), in order to obtain the amount of SO₂ removed as sulfuric acid.

The second step required the actual quantity of SO₂ emitted from lead production (SCC 3-03-010-xx) obtained from Reference 7 or 8. The amount of SO₂ removed as sulfuric acid was added to the actual amount of SO₂ emitted to calculate the total amount of SO₂ emitted by lead processing.

$$Emissions_{SO_2, lead\ proc.} = H_2SO_4_{SO_2, lead\ proc.} \% Emissions_{SO_2, actual}$$

The last step in this method calculated the production level for lead processing by using the total amount of SO₂ emitted by lead processing, converted to metric pounds, and the emission factor for lead processing. The emission factor was determined according to the description presented later in this section. The following equation was used to complete the calculation of the activity indicator for lead processing.

$$Production_{lead\ proc.} = \frac{Emission_{SO_2, lead\ proc.} \times 2000\ lb/ton}{540\ lb\ SO_2/tons\ lead\ proc.}$$

The primary aluminum production obtained from Reference 1 was the activity indicator for primary aluminum processes.

The data used to estimate the activity for the two furnace types used in secondary lead production were obtained from Reference 5. The activity indicator for reverberatory furnaces was calculated by multiplying the total consumption of lead scrap by the ratio between the quantity of lead recovered as soft lead and the total lead recovered from scrap. The activity indicator for blast furnaces was calculated by multiplying the total consumption of lead scrap by the ratio between lead recovered as antimonial lead and the total lead recovered from scrap.

3.21.3 Emission Factor

3.21.3.1 Industrial Processes - CO Emissions

The emission factor for primary aluminum was obtained from Reference 9.

3.21.3.2 Industrial Processes - Particulates and PM-10 Emissions

3.21.3.2.1 Primary Metals Industry - Aluminum —

The TSP emission factors for all aluminum production processes, with the exception of material handling, were obtained from Reference 10a. The TSP emission factor for material handling was obtained from Reference 11a. The PM-10 emission factors for all aluminum production processes were obtained from Reference 15. The SCCs corresponding to each of the production processes are presented in Table 3.21-1.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from these emission sources.

3.21.3.2.2 Primary Metals Industry - Copper —

The emission factors for roasting were the weighted averages of the emission factors for two process types listed in Table 3.21-2. The TSP emission factor was obtained from Reference 10b and the PM-10 emission factors were obtained from Reference 15. Weighting factors were the 1981 capacity for each process type as presented in Table 3.21-2.

The emission factors for smelting were the weighted averages of the emission factors for four process types. The emission factors were obtained from Reference 10b for TSP and from Reference 15 for PM-10. These emission factors were weighted using the 1981 capacity for each process. The SCCs and descriptions of the four processes along with the 1981 capacity data are presented in Table 3.21-3.

The emission factors for converting were obtained from Reference 10c for TSP and from Reference 15 for PM-10. The TSP emission factor for fugitive processes was obtained from Reference 12. The PM-10 emission factor for fugitive processes was obtained from Reference 15 or Table 3.1-3.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from these emission sources.

3.21.3.2.3 Primary Metals Industry - Zinc —

The emission factors were obtained from Reference 10c for the following processes: roasters (SCC 3-03-030-02 for multiple hearth roaster), sintering (SCC 3-03-030-03), electrolytic (SCC 3-03-030-06), and vertical retorts (SCC 3-03-030-05). The emission factor for horizontal retorts (SCC 3-03-030-xx) was obtained from Reference 11b. The PM-10 emission factors for these processes were obtained from Reference 15. The emission factors for fugitive processes were obtained from Reference 12 for TSP and from Reference 15 or Table 3.1-3 for PM-10.

The emission factors for sintering, electrolytic, horizontal retorts, vertical retorts, and fugitive processes were multiplied by 2 to account for the fact that there were 2 units of concentrate/ton of slab zinc.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from these emission sources.

3.21.3.2.4 Primary Metals Industry - Lead —

The emission factors were obtained from Reference 10d for the following processes: sintering (SCC 3-03-010-01), blast furnaces (SCC 3-03-010-02), and reverberatory furnaces, dross (SCC 3-03-010-03). The PM-10 emission factors for these processes were obtained from Reference 15. The emission factors for fugitive processes were obtained from Reference 12 for TSP and from Reference 15 or Table 3.1-3 for PM-10.

The emission factors for sintering and blast furnaces were multiplied by 2 to account for the fact that there were 2 units of concentrate/ton of slab lead.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from these emission sources.

3.21.3.2.5 Secondary Metal Industry - Aluminum —

The emission factors for sweating were the weighted averages of the emission factors for sweating furnaces (SCC 3-04-001-01) and scrap dryers (3-04-002-07). The TSP emission factors for these processes were obtained from Reference 10e and 10f; the PM-10 emission factors were obtained from Reference 15. The scrap dryer emission factors were used as surrogates. The sweating furnace emission factors were weighted by the consumption of sweated pig and the scrap dryer emission factors were weighted by the consumption of borings and turnings. Consumption data were obtained from Reference 1.

The emission factors for refining were the weighted averages of the emission factors for smelting furnace/crucible (SCC 3-04-001-02) and smelting furnace/reverberatory (3-04-001-03). The TSP emission factors were obtained from Reference 10e and the PM-10 emission factors from Reference 15. These emission factors were weighted based on Reference 7 or Reference 8.

The emission factors for fluxing (SCC 3-04-001-04) were obtained from Reference 10e for TSP and from Reference 15 for PM-10. The TSP emission factor for fugitive processes was obtained from Reference 12. The PM-10 emission factor for fugitive processes was obtained from Reference 12 or Table 3.1-3.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from these emission sources.

3.21.3.2.6 Secondary Metal Industry - Lead —

The emission factor for pot furnaces or kettle refining (SCC 3-04-004-01), reverberatory furnaces (SCC 3-04-004-02), and blast furnaces (SCC 3-04-004-03) was obtained from Reference 11c. The PM-10 emission factors for these processes were obtained from Reference 15. The fugitive processes emission factors were obtained from Reference 12. The PM-10 emission factor for fugitive processes was obtained from Reference 15 or Table 3.1-2.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from these emission sources.

3.21.3.2.7 Secondary Metal Industry - Copper —

The emission factors for wiring burning were obtained from Reference 13 for TSP and from Reference 15 for PM-10.

The emission factors for brass and bronze casting were the weighted averages of the emission factors for five casting methods added to the emission factor for a sixth method, cupola (SCC 3-04-002-12). All TSP emission factors were obtained from Reference 10f. The PM-10 emission factors were obtained from Reference 15. Operating rates obtained from Reference 9 for the five casting methods were used to calculate the weighted average emission factors. The casting methods, SCCs, and weighting factors for the five casting methods are presented in Table 3.21-4. The resulting weighted average emission factors were added to the cupola emission factors to obtain the overall brass and bronze casting PM-10 and TSP emission factors.

The emission factor for smelting were the weighted sum of the emission factors for the following four smelter types: (1) cupola, scrap copper (SCC 3-04-002-10), (2) reverberatory, scrap copper (SCC 3-04-002-14), (3) electric arc, scrap copper (SCC 3-04-002-20), and electric induction, scrap copper (SCC 3-04-002-23). These emission factors were obtained from Reference 10f for TSP and from Reference 15 for PM-10. The emission factors were summed according to the equation given below.

$$EF = EF_C \% (2 \times EF_{RF}) \% [(EF_{EA} \% EF_{EI}) / 2]$$

where: EF = emission factor
 C = cupola for scrap copper
 RF = reverberatory furnace for scrap copper
 EA = electric arc for scrap copper

EI = electric induction

The TSP emission factor for fugitive processes was obtained from Reference 11d. The PM-10 emission factor was obtained from Reference 15 or Table 3.1-3.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from these emission sources.

3.21.3.3 Industrial Processes - SO₂ Emissions

The emission factor for roasting was the weighted average of the emission factors for two process types. The emission factors were obtained from Reference 10b and were weighted using the 1981 capacity for each process type. The SCCs and descriptions of the two process types along with the 1981 capacity data are presented in Table 3.21-2. To account for fugitive emissions, 1 lb/ton was added to the weighted average emission factor.

The emission factor for copper smelting was the weighted average of the emission factors for six process types. Emission factors were obtained from Reference 10b and were weighted using the 1981 capacity for each process type. The SCCs and descriptions of the six process types along with the 1981 capacity data are presented in Table 3.21-5. The weighting factors were changed from the 1981 capacity data when an existing smelter ceased operations, a new smelter began operations, or an existing smelter was modified. This information was obtained from Reference 3a. To account for fugitive emissions, 4 lb/ton was added to the weighted average emission factor.

The emission factor for copper converting was the weighted average of the emission factors for six process types. The emission factors were obtained from Reference 10b, except for the noranda reactor emission factor which was assumed. The emission factors were weighted using the 1981 capacity for each process type. The SCCs and descriptions of the six process types along with the 1981 capacity data are presented in Table 3.21-6. To account for fugitive emissions, 130 lb/ton was added to the weighted average emission factor.

The emission factor for zinc roasting (SCC 3-03-030-02) was obtained from Reference 10d.

The emission factor for lead roasting was the sum of the emission factors for sintering (SCC 3-03-010-01) and blast furnace (SCC 3-03-010-02). These emission factors were obtained from Reference 10d.

The emission factor for primary aluminum was obtained from Reference 9.

The emission factors for secondary lead processing in reverberatory furnaces (SCCS-04-004-02) and blast furnaces (SCC 3-04-004-03) were obtained from Reference 10g.

3.21.4 Control Efficiency

3.21.4.1 Industrial Processes - CO Emissions

No control efficiencies were applied to the activity data to estimate emissions from primary aluminum production.

3.21.4.2 Industrial Processes - Particulates and PM-10 Emissions

The TSP control efficiencies for all primary metals industry production processes and all secondary metals industry production processes, except for any fugitive processes were derived from Reference 7 or Reference 8 using the equation below. For those processes where the emission factor was calculated as the weighted average of the emission factors of several process types, the control efficiency was calculated as the weighted average of the individual control efficiencies in the same manner.

$$CE = \frac{(UE - AE)}{UE}$$

where: CE = control efficiency
UE = emissions before control
AE = emissions after control

The TSP control efficiencies for the primary metals industry fugitive processes for aluminum, copper, lead and zinc production were obtained by best guess. No additional information is currently available concerning the origin of these TSP control efficiencies. The same is true for the control efficiencies for the secondary metals industry fugitive processes for aluminum, lead, and copper.

The PM-10 control efficiencies for all primary metals industry and secondary metals industry production process, excluding the fugitive processes for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 14. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency values were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

No control efficiencies were applied to the activity data to estimate PM-10 emissions from fugitive processes for either the primary metals industry or the secondary metals industry.

3.21.4.3 Industrial Processes - SO₂ Emissions

No control efficiencies were applied to the activity data to estimate SO₂ emissions from the source included in this Tier 2 category.

3.21.5 References

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Table 3.21-1. PM-10 Emission Factors SCCs for the Primary Metals Industry - Aluminum

SCC	Description
3-03-002-01	Calcining of Hydroxide
3-03-001-02	HSS - Stack
3-03-001-09	HSS - Fugitive
3-03-001-03	VSS - Stack
3-03-001-10	3-03- VSS - Fugitive
001-01	Prebake - Stack
3-03-001-08	Prebake - Fugitive
3-03-001-05	Anode Baking
3-03-001-04	Materials Handling

Table 3.21-2. PM-10 Emission Factors SCCs and Weighting Factors for the Primary Metals Industry - Copper Roaster

SCC	Description	1981 Capacity
3-03-005-02	Multiple Hearth Roaster	430
3-03-005-09	Fluidized Bed Roaster	230

Table 3.21-3. PM-10 Emission Factors SCCs and Weighting Factors for the Primary Metals Industry - Copper Smelting

SCC	Description	1981 Capacity
3-03-005-07	Reverb. Furnace w/o Roasting	636
3-03-005-31	Reverb. Furnace + Multi-Hearth Reverb. Furnace	430
3-03-005-32	+ Fluid Bed Roaster	212
	Electric Smelting Furnace	257
3-03-005-10		

Table 3.21-4. PM-10 Emission Factors SCCs and Weighting Factors for the Secondary Metals Industry - Copper Brass and Bronze Casting

SCC	Description	Weighting Factors
3-04-002-15	Reverberatory - Brass & Bronze	36
3-04-002-17	Rotary - Brass & Bronze	300
3-04-002-19	Crucible & Pot - Brass & Bronze	21
3-04-002-21	Electric Arc - Brass & Bronze	11
3-04-002-24	Electric Induction - Brass & Bronze	20

Table 3.21-5. SO₂ Emission Factors SCCs and Weighting Factors for the Primary Metals Industry - Copper Smelting

SCC	Description	1981 Capacity
3-03-005-03	Multi-Hearth + Reverb. Furnace + Convertors	405
3-03-005-07	Reverb. Furnace + Convertors	430
3-03-005-10	Electric Furnace + Convertors	212
3-03-005-25	Fluid Bed Roaster + Reverb. Furn. + Convertors	124
3-03-005-26	Flash Furnace + Cleaning Furnace + Convertor	18
3-03-005-	Fluid Bed + Electric Arc + Convertors	115

Table 3.21-6. SO₂ Emission Factors SCCs and Weighting Factors for the Primary Metals Industry - Copper Smelting

SCC	Description	Weighting Factor
3-03-005-23	Reverberatory Furnace + Convertor	405
3-03-005-24	Multi-Hearth + Reverb. + Convertor	448
3-03-005-25	Fluid Bed Roaster + Reverb. + Convertor	212
3-03-005-26	Electric Arc + Convertor	124
3-03-005-27	Flash Furn. + Cleaning Furn. + Convertor	115
3-03-005-28	Noranda Reactor + Convertor	231

3.22 METALS PROCESSING - FERROUS: 05-02

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source categories.

Categories:	Subcategories:
Industrial Processes - CO Emissions	Iron Foundries and Steel Manufacturing
Industrial Processes - NO _x Emissions	Iron and Steel (open hearth and roll and finish)
Industrial Processes - Particulates and PM-10 Emissions	Iron and Steel Industry (coke, blast furnace, sintering, open hearth, BOF, electric arc, slag, scarfing, teeming, soaking pits, reheat furnace, open dust, and ore screening)
Industrial Processes - Particulates and PM-10 Emissions	Primary Metals Industry (ferroalloys)
Industrial Processes - Particulates and PM-10 Emissions	Secondary Metals Industry (grey iron foundries and steel foundries)
Industrial Processes - SO ₂ Emissions	Other Industrial Processes (iron and steel)
Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [other processes (by-product coke and sintering)]

3.22.1 Technical Approach

The CO, NO_x, PM-10, TSP, SO₂, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators for all processes, except for iron and steel industry processes were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton. For iron and steel industrial processes emitting PM-10 and TSP, the activity indicators were expressed in million short tons and the emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.22.2 Activity Indicator

3.22.2.1 Industrial Processes - CO Emissions

The activity indicator for cupola furnaces in iron foundries was based on the combined quantity of scrap and pig iron consumed by cupola furnaces. This value was obtained from Reference 1a under the category of iron foundries and miscellaneous users. The final activity was determined by adjusting this production value to account for the fact that the emission factor used for this subcategory was in terms of the charged quantity and not the fresh feed quantity. This adjustment required dividing the production value by 0.78 to account for recycling.

The activity indicator for by-product coke from steel manufacturing was the oven production figure, expressed in thousand short tons, from Reference 2a.

The activity indicator for steel manufacturing blast furnaces was the total pig iron production including exports obtained from Reference 2b.

The activity indicator for steel manufacturing sintering was one-third of the total production of pig iron obtained from Reference 3 or Reference 2.

The activity indicators for steel manufacturing open hearth and electric arc furnace types were based on the total scrap and pig iron consumption. Reference 1 contained the total scrap and pig iron consumed by each of three furnace types (including basic oxygen) by manufacturers of pig iron and raw steel and castings. The fraction of combined quantity of scrap and pig iron consumed by each of the three furnace types was calculated. The total raw steel production reported in Reference 2b was multiplied by the fractions for the open hearth and electric arc furnaces to obtain the raw steel production for these two furnace types.

3.22.2.2 Industrial Processes - NO_x Emissions

The activity indicator for open hearth furnaces used in iron and steel manufacturing was based on the total scrap and pig iron consumption. Reference 1 contained the total scrap and pig iron consumed by each of the three furnace types (open hearth, basic oxygen, and electric arc) by manufacturers of pig iron and raw steel and castings. The fraction of the combined quantity of scrap and pig iron consumed by each of the three furnace types was calculated. The total raw steel production reported in Reference 2b was multiplied by the open hearth fraction to obtain the raw steel production for this furnace type.

The activity indicator for roll and finish processes in iron and steel manufacturing was the total raw steel production obtained from Reference 2a.

3.22.2.3 Industrial Processes - Particulates and PM-10 Emissions

3.22.2.3.1 Iron and Steel Industry —

The activity indicator for by-product coke was the oven or by-product production figure from Reference 2a. The same activity indicator was used for coal preparation and coke handling.

The activity indicator for blast furnaces was the total pig iron production obtained from Reference 2b. This value included exports.

The activity indicators for windbox, discharge, and sinter-fugitive processes were based on the total production of pig iron obtained from Reference 3 or Reference 2. The activity indicator for each process was one-third of this production value.

The activity indicators for open hearth, basic oxygen, and electric arc furnaces were based on the total scrap and pig iron consumption. Reference 1 contained the total scrap and pig iron consumed by each furnace type by manufacturers of pig iron and raw steel and castings. The fraction of the combined quantity of scrap and pig iron consumed by each furnace type was calculated. The total raw steel production reported in Reference 2b was multiplied by each fraction to obtain the raw steel production for each furnace type. These final results were used as the activity indicators for the both "stack" and "fugitive" subcategories of each furnace type.

The activity indicator for slag blast furnaces was the total quantity of iron blast furnace slag sold reported in Reference 49. The same reference was used to obtain the total quantity of steel slag sold. This value was used as the activity indicator for slag steel furnaces.

The activity indicator for scarfing was one-third of the total raw steel production obtained from Reference 2b.

The activity indicators for teeming, soaking pits, reheat furnaces, and open dust were the total raw steel production reported in Reference 2b.

The activity indicator for ore screening was the total consumption of iron ore and agglomerates obtained from Reference 3.

3.22.2.3.2 Primary Metals Industry (ferroalloys) —

The activity indicator for ferrosilicon was the net gross weight production obtained from Reference 5a. The silicon manganese activity indicator was assumed to be 42.1 percent of the net production of ferrosilicon. The activity indicator for the ferromanganese, electric furnaces was assumed to be 57.9 percent of the net production of ferrosilicon. For the ferromanganese, blast furnace, the activity indicator was assumed to be zero.

The activity indicator for silicon metal was the production value obtained from Reference 6a. The activity indicator for other ferroalloys was the sum of the gross weight production figures for chromium alloys, ferrocolumbium, ferrophosphorus and other ferroalloys as reported in Reference 5a. For ferroalloy material handling, the total gross weight production of all ferroalloys obtained from Reference 5a was used as the activity indicator.

3.22.2.3.3 Secondary Metals Industry —

The activity indicator for cupola furnaces at grey iron foundries was based on the combined quantity of scrap and pig iron consumed by cupola furnaces. This value was obtained from Reference 1a under the category of iron foundries and miscellaneous users. The final activity was determined by adjusting this production value to account for the fact that the emission factor was in terms of the charged quantity and not the fresh feed quantity. This adjustment required dividing the production value by 0.78 to account for recycling.

The activity indicator for electric induction furnaces at grey iron foundries was based on the combined quantity of iron and steel scrap and pig iron consumed in electric furnaces. This value was obtained from Reference 1a under the category of iron foundries and miscellaneous users. The final activity indicator was adjusted to account for recycling by dividing the consumption value by 0.78 to account for recycling.

The activity indicator for iron fugitive processes at grey iron foundries was the sum of the activity indicators for the cupola and electric induction furnaces.

The activity indicators for electric arc and steel-fugitive processes at steel foundries were both based on the combined quantity of iron and steel scrap and pig iron consumed. This value was obtained from Reference 1a under the category of manufacturers of steel casting. The final activity indicators used were the consumption value divided by 0.78 to account for recycling.

3.22.2.4 Industrial Processes - SO₂ Emissions

The activity indicator for coking in iron and steel manufacturing was the oven production figure obtained from Reference 2a.

The activity indicators for sintering in iron and steel manufacturing was based on the total production of pig iron obtained from Reference 3 or Reference 2.

The activity indicator for open hearth furnaces in iron and steel manufacturing was based on the total scrap and pig iron consumption. Reference 1 contained the total scrap and pig iron consumed by each furnace type (open hearth, basic oxygen, and electric arc) by manufacturers of pig iron and raw steel and castings. The fraction of the combined quantity of scrap and pig iron consumed by each of the three furnace types was calculated. Total raw steel production reported in Reference 2b was multiplied by the fraction for open hearth furnaces to obtain the raw steel production for this furnace type.

The activity indicator for roll and finish processes was the total raw steel production obtained from Reference 2b.

3.22.2.5 Industrial Processes - VOC Emissions

The activity indicator for by-product coke was the oven production figure obtained from Reference 2a. The activity indicator for sintering was based on the total production of pig iron obtained from Reference 3 or Reference 2.

3.22.3 Emission Factor

3.22.3.1 Industrial Processes - CO Emissions

The emission factor for iron foundries (SCC 3-04-003-01) was obtained from Reference 7a.

The emission factor for by-product coke from steel manufacturing was the sum of the emission factors for three separate processes: charging (SCC 3-03-003-02), pushing (SCC 3-03-003-03) and oven/door leaks (SCC 3-03-003-08). These emission factors were obtained from Reference 7b. The units of the emission factor were changed from quantity of coal charged to quantity of coke produced by using the relationship that one ton of coal charged produces 0.7 tons of coke.

The emission factors for steel manufacturing windbox sintering (SCC 3-03-008-13), basic oxygen furnaces (SCC 3-03-009-13 and 3-03-009-14), and electric arc furnaces (SCC 3-03-009-04 and 3-03-009-08) were obtained from Reference 7c.

The uncontrolled emission factor for steel manufacturing blast furnaces was obtained from Reference 19a. The control emission factor was calculated by applying the control efficiency as shown in the equation below:

$$EF_{controlled} = EF_{uncontrolled} \times (1 - CE)$$

where: EF = emission factor
CE = control efficiency

For the years 1970 through 1984, the control efficiency for blast furnaces was assumed to be 0.999. The control efficiencies for the years 1960, 1950, and 1940 were 0.995, 0.990, and 0.975, respectively.

3.22.3.2 Industrial Processes - NO_x Emissions

3.22.3.2.1 Iron and Steel Industry —

The emission factor for open hearths was calculated by dividing the emissions by the operating rate as reported in Reference 8.

The emission factor for roll and finish was based on the emissions from the fuels used in this process divided by the process operating rate. The fuels used in this process were coke oven gas, residual oil, and

natural gas. The emissions from roll and finish processes were assumed to be the difference between the total NO_x emissions from iron and steel processes and the NO_x emissions from open hearth furnaces.

The total NO_x emissions from all iron and steel processes using coke oven gas, residual oil, and natural gas were the sum of the separate emissions from the three fuels. Emissions were calculated by multiplying the quantity of fuel consumed by the fuel specific emission factor. The quantity of coke oven gas consumed by iron and steel processes was assumed to be 40 percent of the total annual coke oven gas production as reported in Reference 9. The quantity of residual oil consumed was calculated by multiplying the quantity of raw steel production obtained from Reference 2b by a factor converting tons of steel produced to the gallons of residual oil consumed (0.00738×10^6 gal/10³ ton steel). The quantity of natural gas consumed was calculated in the same manner as was the quantity of residual oil consumed, except that a conversion factor of 4.25×10^6 cu. ft gas consumed/10³ ton steel was used.

The NO_x emission factor for the combustion of coke oven gas was obtained from Reference 7. The emission factors for the combustion of residual oil, and natural gas were obtained from Reference 7h (industrial boilers) and 7i (small industrial boilers), respectively. Based on these emission factors and the fuel consumption data, the NO_x emissions from the combustion of coke oven gas, residual oil, and natural gas were calculated.

The sum of these emissions was the total NO_x emissions from the iron and steel processes. The quantity of emissions from the open hearth furnaces was calculated by multiplying the activity indicator by the emission factor. The origin of these data were described earlier in this section. The difference between the total NO_x emissions and the open hearth furnace emissions was assumed to be the emissions from the roll and finish process. The emission factor for this process was calculated by dividing the emissions by the total steel produced obtained from Reference 11a.

3.22.3.3 Industrial Processes - Particulates and PM-10 Emissions

3.22.3.3.1 Iron and Steel Industry —

The PM-10 and TSP emission factors for by-product coke were based on the sum of the emission factors for following six SCCs: 3-03-003-02, 3-03-003-03, 3-03-003-04, 3-03-003-06, 3-03-003-08, and 3-03-003-14. The TSP emission factors for these SCCs were obtained from Reference 7b, with the exception of SCC 3-03-003-04. The emission factor for this SCC was obtained from Reference 19b. The PM-10 emission factors of the six SCCs were obtained from Reference 13. The sum of these emission factors for PM-10 and TSP were divided by 0.7 to convert the emission factors from the amount of coal charged to the amount of coke produced.

The TSP emission factor for coal preparation and coke handling was obtained from Reference 7. The PM-10 emission factor was obtained from Reference 10. The TSP emission factors for the beehive process for the years 1940 through 1975 were obtained from Reference 7. The PM-10 emission factors for this process for all years and the TSP emission factor after 1975 were assumed to be zero.

The TSP emission factors for blast furnaces were the sum of the emission factors reported in Reference 20a for the SCCs 3-03-008-01 and 3-03-008-02. The PM-10 emission factors for these two SCCs were obtained from Reference 13.

The emission factors for windbox (SCC 3-03-0080-13) and discharge (SCC 3-03-008-14) were obtained from Reference 7d for TSP and from Reference 13 for PM-10. The windbox emission factors were after coarse particle removal. The emission factors for fugitive processes (SCC 3-03-008-19) were obtained from Reference 10 for TSP and from Reference 13 for PM-10.

The TSP emission factor for the open hearth furnaces, stack subcategory (SCC 3-03-009-01) was obtained from Reference 7d. The open hearth furnace, fugitive subcategory TSP emission factor was obtained from Reference 20. The PM-10 emission factors for these sources were obtained from Reference 13.

The TSP emission factor for the basic oxygen furnaces, stack subcategory (SCC 3-03-009-13) was obtained from Reference 7d. The basic oxygen furnace, fugitive subcategory TSP emission factor was obtained from Reference 10. The PM-10 emission factors for these sources were obtained from Reference 13.

The emission factors for the electric arc furnaces, stack subcategory were based on the emission factors for carbon steel, stack (SCC 3-03-009-04) and alloy steel, stack (SCC 3-03-009-08) obtained from Reference 7d for TSP and from Reference 13 for PM-10. Weighted average PM-10 and TSP emission factors were calculated from these emission factors. Weighting factors were the relative production levels of carbon and alloy steel as reported in Reference 11a. For the electric arc furnace, fugitive subcategory, PM-10 and TSP emission factors were obtained from Reference 13 and Reference 10, respectively.

The PM-10 and TSP emission factors for slag blast furnaces and steel furnaces were obtained from Reference 13 and Reference 10, respectively.

The emission factors for scarfing (SCC 3-03-009-32) were obtained from Reference 7d for TSP and from Reference 13 for PM-10.

The PM-10 and TSP emission factors for teeming, soaking pits, reheat furnaces, open dust, and ore screening were obtained from Reference 13 and Reference 10, respectively.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from these emission sources.

3.22.3.3.2 Primary Metals Industry (ferroalloys) —

The emission factors for ferrosilicon were based on the emission factors for the following three electric smelting processes: 50 percent Fe Si (SCC 3-03-006-01), 75 percent Fe Si (SCC 3-03-006-02), and 90 percent Fe Si (SCC 3-03-006-03). The TSP emission factors for these processes were obtained from Reference 7e. The PM-10 emission factors were obtained from Reference 13. Weighed averages of these PM-10 and TSP emission factors were calculated using ferrosilicon production levels obtained from Reference 6 as weighting factors.

The PM-10 and TSP emission factors for silicon manganese (SCC 3-03-006-05), ferromanganese, electric furnaces (SCC 3-03-007-01), and silicon metal (SCC 3-03-006-04) subcategories were obtained from Reference 13 and Reference 7e, respectively. The activity for ferromanganese, blast furnaces was assumed to be zero and, therefore, no emission factor was necessary. The emission factors for other ferroalloys and ferroalloy material handling were obtained from Table 3.1-3. The emission factors for other ferroalloys were based on engineering judgement and those for ferroalloy material handling were based on data from Reference 12.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from these emission sources.

3.22.3.3.3 Secondary Metals —

The PM-10 and TSP emission factors for cupola furnaces (SCC 3-04-003-01) and electric induction furnaces (SCC 3-04-003-03) at grey iron foundries were obtained from Reference 7f. The emission factors for fugitive processes were the sum of the emission factors for all processes reported emitting to the atmosphere in Reference 19c. It was assumed that the magnesium treatment applied to only 20 percent of the production. The PM-10 emission factor for fugitive processes was obtained from Reference 13 or Table 3.1-3.

The PM-10 and TSP emission factors for steel foundries electric arc furnaces (SCC 3-04-007-01) at steel foundries were obtained from Reference 7g. The TSP emission factor for fugitive processes was the sum of the emission factors for all processes, except for magnesium treatment, reported emitting to the atmosphere in Reference 19c. The PM-10 emission factor for fugitive processes was obtained from Reference 13 or Table 3.1-3.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from these emission sources.

3.22.3.4 Industrial Processes - SO₂ Emissions

The emission factor for coking in iron and steel manufacturing was based on the emission factors for six processes. Charging (SCC 3-03-003-02) and interfering (SCC 3-03-003-06) emission factors were obtained from Reference 7b. Emission factors for pushing (SCC 3-03-003-03), quenching (SCC 3-03-003-04), oven/door leaks (SCC 3-03-003-08) and topside leaks (SCC 3-03-003-14) were obtained from Reference 13. Emission factors from all six processes were summed and the result was multiplied by 0.7 to convert the factors from the amount of coal consumed to the amount of coke produced.

The emission factor for sintering in iron and steel manufacturing was calculated by dividing the emissions by the production rate as reported in Reference 8. This same procedure was used to calculate the open hearth emission factor.

The emission factor for roll and finish in iron and steel manufacturing was based on the emissions from the fuels used in this process divided by the process operating rate. The fuels used in this process were coke oven

gas and residual oil. The emissions from the roll and finish process were assumed to be the difference between the total SO₂ emissions from iron and steel processes and the SO₂ emissions from open hearth furnaces.

Total SO₂ emissions from all iron and steel processes using coke oven gas and residual oil were the sum of the separate emissions from the two fuels. The emissions were calculated by multiplying the quantity of fuel consumed by the fuel specific emission factor. The quantity of coke oven gas consumed by the iron and steel processes was assumed to be 40 percent of the total annual coke oven gas production as reported in Reference 9. The quantity of residual oil consumed was calculated by multiplying the quantity of raw steel production obtained from Reference 2b by a factor converting tons of steel produced to the gallons of residual oil consumed (0.00738×10^6 gal/10³ ton steel).

The SO₂ emission factor for the combustion of coke oven gas was obtained from Reference 7. The emission factor for the combustion of residual oil was obtained from Reference 7i and multiplied by the sulfur content obtained yearly for No. 6 fuel oil from Reference 14. Based on these emission factors and the fuel consumption data, the SO₂ emissions from the combustion of coke oven gas and residual oil were calculated.

Summing of these emissions resulted in the total SO₂ emissions from the iron and steel processes. The quantity of emissions from the open hearth furnaces was calculated by multiplying the activity indicator by the emission factor. The origin of these data were described earlier in this section. The difference between total SO₂ emissions and open hearth furnace emissions was assumed to be the emissions from the roll and finish processes. The emission factor for this process was calculated by dividing the emissions by the quantity of raw steel produced obtained from Reference 8.

3.22.3.5 Industrial Processes - VOC Emissions

The emission factor for coking was based on the emission factors for six processes. Charging (SCC 3-03-003-02) and pushing (SCC 3-03-003-03), and oven/door leaks (SCC 3-03-003-08) emission factors were obtained from Reference 7b. Emission factors for quenching (SCC 3-03-003-04), interfering (SCC 3-03-003-06) and topside leaks (SCC 3-03-003-14) were obtained from Reference 15. The emission factors from all six processes were summed and the result was multiplied by 0.7 to convert the factors from the amount of coal consumed to the amount of coke produced.

The VOC emission factor for windbox sintering (SCC 3-03-008-13) was obtained from Reference 15.

3.22.4 Control Efficiency

The control efficiencies for several processes were derived from the actual and uncontrolled emissions reported in Reference 16 or Reference 17 using the equation given below.

$$CE = \frac{(UE \& AE)}{UE}$$

where: CE = control efficiency
 UE = uncontrolled emissions
 AE = actual emissions

3.22.4.1 Industrial Processes - CO Emissions

The control efficiency for iron foundries was derived from Reference 16 or Reference 17 using the equation given above.

The control efficiency for steel manufacturing basic oxygen furnaces was computed from Reference 16 or Reference 17 using the equation given above. For blast furnaces, the percentage control efficiency was assumed to be 99.9 percent. This was taken into account in the calculation of the CO emission factor and, therefore, no separate control efficiency was used. For all other steel manufacturing processes, no control efficiencies were applied to the activity data to estimate the CO emissions.

3.22.4.2 Industrial Processes - NO_x Emissions

No control efficiencies were applied to the activity data to estimate NO_x emissions from the iron and steel manufacturing processes included in this Tier 2 category.

3.22.4.3 Industrial Processes - Particulates and PM-10 Emissions

3.22.4.3.1 Iron and Steel Industry —

The TSP control efficiencies for by-product coke production were derived from Reference 16 or Reference 17 using the equation given above. The control efficiencies for the beehive process for the years 1940, 1950, 1960, and 1970 through 1975 and for coal preparation/coke handling processes for the years 1976 through 1984 were based on the estimated control efficiency reported in Reference 10. These TSP control efficiencies were adjusted according to engineering judgement.

The PM-10 control efficiencies for by-product coke production for the years 1975 through 1984 were based on the 1985 PM-10 control efficiency obtained from Reference 18. During these years, any changes in the TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate the PM-10 emissions from by-product coke production. No control efficiencies were applied to the activity data to estimate PM-10 emissions from the beehive process or the coal preparation/coke handling processes.

For blast furnaces, the TSP control efficiencies for the years 1973 through 1984 were assumed to 0.996. No procedure for determining the control efficiencies for the years 1940, 1950, 1960, and 1970 through 1972 is currently available. The PM-10 control efficiencies for the years 1975 through 1984 were equal to the 1985

PM-10 control efficiency obtained from Reference 18. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions from blast furnaces.

The TSP control efficiencies for the windbox and discharge processes were derived from Reference 16 or Reference 17 using the equation given above. The control efficiencies for sinter-fugitive processes were based on the estimated control efficiency reported in Reference 10. This control efficiency was adjusted annually based on engineering judgement. The PM-10 control efficiencies for these three processes for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 18. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

The TSP control efficiencies for the stack processes of open hearth, basic oxygen, and electric arc furnaces were derived from Reference 16 or Reference 17 using the equation given above. The control efficiencies for the fugitive processes of the basic oxygen and electric arc furnaces were based on the estimated control efficiencies reported in Reference 10. The control efficiency for the fugitive processes of the basic oxygen furnace was assumed to be zero for all years.

The PM-10 control efficiencies for the stack processes of these three furnace types for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 18. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions. No control efficiencies were applied to the activity data to estimate PM-10 emissions from the fugitive processes of all three furnace types.

The TSP control efficiencies for slag blast and slag steel furnaces were based on the estimated control efficiencies reported in Reference 10. The yearly variations in these control efficiencies are assumed to be the results of adjustments made based on engineering judgement.

The PM-10 control efficiencies for slag steel furnaces for the years 1975 through 1984 were based on the 1988 PM-10 control efficiency obtained from Reference 18. During these years, any changes in the TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions. No control efficiencies were applied to the activity to estimate PM-10 emissions from slag blast furnaces.

The TSP control efficiencies for scarfing were derived from Reference 16 or Reference 17 using the equation above. The PM-10 control efficiencies for the years 1975 through 1984 were based on the 1988 PM-10 control efficiency obtained from Reference 18. During these years, any changes in the TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions for scarfing.

No control efficiencies were applied to the activity data to estimate PM-10 and TSP emissions from teeming, soaking pits, and reheat furnaces.

The TSP control efficiencies for open dust and ore screening were based on the estimated control efficiencies reported in Reference 10. The yearly variations in these control efficiencies are assumed to be the results of adjustments made based on engineering judgement. No control efficiencies were applied to the activity data to estimate PM-10 emissions from open dust and ore screening.

3.22.4.3.2 Primary Metals Industry (ferroalloys) —

The TSP control efficiencies for all production processes, except other ferroalloy production and ferroalloy material handling processes were derived from Reference 16 or Reference 17 using the equation given above. The TSP control efficiencies for ferroalloy production and ferroalloy material handling processes were based on a best guess.

The PM-10 control efficiencies for ferrosilicon, silicon manganese, and silicon metal production and the ferromanganese electric furnace for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 18. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

No control efficiencies were applied to the activity data to estimate PM-10 emissions from ferromanganese blast furnace, other ferroalloy production, and ferroalloy material handling processes.

3.22.4.3.3 Secondary Metals Industry —

The TSP control efficiencies for all grey iron and steel foundry processes were derived from Reference 16 or Reference 17 using the equation given above.

The PM-10 control efficiencies for all grey iron and steel foundry processes, excluding the fugitive processes for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 18. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

No control efficiencies were applied to the activity data to estimate PM-10 emissions from the fugitive processes of grey iron and steel foundries.

3.22.4.4 Industrial Processes - SO₂ Emissions

No control efficiencies were applied to the activity data to estimate SO₂ emissions from the iron and steel manufacturing processes included in this Tier 2 category.

3.22.4.5 Industrial Processes - VOC Emissions

No control efficiencies were applied to the activity data to estimate VOC emissions from the by-product coke and sintering processes included in this Tier 2 category.

3.22.5 References

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3.23 METALS PROCESSING - NOT ELSEWHERE CLASSIFIED: 05-03

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source categories.

Category:	Subcategory:
Industrial Processes - Particulates and PM-10 Emissions	Mining Operations (iron ore mining, taconite processing, bauxite crushing, copper ore crushing, zinc ore crushing, lead ore crushing)

3.23.1 Technical Approach

The PM-10 and TSP emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1992 for TSP and for the years 1975 through 1984 for PM-10. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.23.2 Activity Indicator

The activity indicator for iron ore mining was the total quantity of crude iron ore mined obtained from Reference 1. The activity indicator for taconite processing was the quantity of pellet production (agglomerates) obtained from Reference 1a. The activity indicator for bauxite crushing was the consumption of crude and dried bauxite (domestic and foreign ores combined) reported in Reference 2. The activity indicator for copper ore crushing was the gross weight of copper ore produced on a dry weight basis obtained from Reference 3a.

The activity indicator for zinc ore crushing was the gross weight of zinc ore produced on a dry weight basis reported in Reference 4a. The activity indicator for lead ore crushing was the gross weight of lead ore produced on a dry weight basis obtained from Reference 4.

3.23.3 Emission Factor

The TSP emission factors for iron ore mining were obtained from Reference 5. The TSP emission factors for taconite processing were the sum of the emission factors for nine individual processes obtained from Reference 6a. The processes and SCCs are listed in Table 3.23-1. The TSP emission factors were obtained from Reference 6b for bauxite crushing (SCC 3-03-000-01). The PM-10 emission factors for these sources were obtained from Reference 10.

The TSP emission factors for zinc ore crushing and lead ore crushing were obtained from Reference 6c. The PM-10 emission factors were obtained from Reference 10 or Table 3.1-3.

The emission factors for copper ore crushing were the sum of the emission factors for seven individual processes. These processes and the corresponding SCCs are listed in Table 3.23-2. The TSP emission factors were obtained from Reference 5 with the exception of the copper ore crushing emission factors which were obtained from Reference 6c. The PM-10 emission factors for all seven processes were obtained from Reference 10 or Table 3.1-3.

3.23.4 Control Efficiency

The TSP control efficiencies for taconite processing and bauxite crushing were derived from Reference 7 or Reference 8 using the equation given below:

$$CE = \frac{(UE \& AE)}{UE}$$

where: CE = control efficiency
UE = emissions before control
AE = emissions after control

The TSP control efficiencies for copper, zinc, and lead ore crushing were based on a best guess. No additional basis for the yearly variations in these control efficiencies is currently available.

The PM-10 control efficiencies for taconite processing and bauxite crushing for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 9. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

No control efficiencies were applied to the activity data to estimate PM-10 emissions from iron ore mining and copper, zinc, and lead ore crushing.

3.23.5 References

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2. *Minerals Yearbook*, Bauxite and Alumina. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.
3. *Minerals Yearbook*, Copper. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.
 - a. Table entitled "Salient Copper Statistics."
4. *Minerals Yearbook*, Lead. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.
 - a. Table entitled "Production of Lead and Zinc in Terms of Recoverable Metals, in U.S. in 19xx, by State."
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8. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
9. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.

10. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listings for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

Table 3.23-1. PM-10 and TSP Emission Factors' SCCs for Taconite Processing

SCC	Description
3-03-023-01	Primary Crushing
3-03-023-02	Fines Crushing
3-03-023-04	Ore Transfer
3-03-023-07	Bentonite Storage
3-03-023-08	Bentonite Blending
3-03-023-09	Traveling Grate Feed
3-03-023-10	Traveling Grate Discharge
3-03-023-12	Indurating Furnace
3-03-023-16	Pellet Transfer

Table 3.23-2. PM-10 and TSP Emission Factors' Processes for Copper Ore Crushing

Description
Open pit/overburden removal
Drill/blast
Loading
Truck dumping
Transfer/conveying
Copper Ore Crushing
Storage

3.24 PETROLEUM AND RELATED INDUSTRIES - OIL AND GAS PRODUCTION: 06-01

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source categories.

Category:	Subcategory:
Industrial Processes - SO ₂ Emissions	Other Industrial Processes [sulfur recovery plants (natural gas fields)]
Industrial Processes - VOC Emissions	Petroleum Marketing and Production (crude oil production and natural gas liquids)

3.24.1 Technical Approach

The SO₂ and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, the activity indicator for SO₂ emissions from natural gas fields was expressed in thousand short tons and the emission factor was expressed in metric pounds/short ton. For VOC emissions from crude oil production and natural gas liquids, the activity indicators were expressed in millions barrels and the emission factors were expressed in metric pounds/thousand barrels.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1984 for both pollutants.

3.24.2 Activity Indicator

The activity indicator for the SO₂ emissions from natural gas fields was the quantity of sulfur recovered by natural gas plants obtained from Reference 1. The activity indicator for VOC emissions from crude oil production was the total U.S. field production including lease condensate obtained from Reference 2a. The activity indicator for VOC emissions from natural gas liquids category was the total field production of natural gas plant liquids was obtained from Reference 2a.

3.24.3 Emission Factor

The SO₂ emission factor for natural gas fields was based on the actual emissions for the SCCs 3-01-032-01 through 3-01-032-04. These emission data were summed and divided by the sum of the corresponding operating rates. All data was obtained from Reference 3 or Reference 4.

The VOC emission factor for crude oil production was obtained from Reference 5. The VOC emission factor for natural gas liquids was obtained from Reference 5.

3.24.4 Control Efficiency

No control efficiencies were applied to the activity data to estimate the SO₂ and VOC emissions from the sources included in this Tier 2 category.

3.24.5 References

1. *Minerals Industry Surveys, Sulfur*. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Monthly.
2. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
(a) Table 1
3. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
4. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
5. *Control Techniques for VOC Emissions from Stationary Sources*. EPA-450/3-85-008. U.S. Environmental Protection Agency, Research Triangle Park, NC. September, 1985.

3.25 PETROLEUM AND RELATED INDUSTRIES - PETROLEUM REFINERIES AND RELATED INDUSTRIES: 06-02

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source categories.

Category:	Subcategory:
Industrial Processes - CO Emissions	Petroleum Refineries
Industrial Processes - NO _x Emissions	Petroleum Refineries (FCC, TCC, and flares)
Industrial Processes - Particulates and PM-10 Emissions	Miscellaneous Process Sources (petroleum refining)
Industrial Processes - SO ₂ Emissions	Other Industrial Processes [sulfur recovery plants (refineries) and petroleum refineries (FCC, TCC, and flares)]
Industrial Processes - VOC Emissions	Petroleum Refinery Process Operation (refinery operations, compressors, blow down systems, process drains, vacuum jets, cooling towers, and miscellaneous)

3.25.1 Technical Approach

The CO, NO_x, PM-10, TSP, SO₂, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators for CO, NO_x, PM-10, TSP, and SO₂ emissions were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton. For VOC emissions, activity indicators were expressed in millions barrels and emission factors were expressed in metric pounds/thousand barrels. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.25.2 Activity Indicator

3.25.2.1 Industrial Processes - CO Emissions

The activity indicators for FCC and TCC in petroleum refineries were based on the separate FCC and TCC capacities. The TCC capacity was obtained from Reference 1 as the value reported in the "other" category for catalytic cracking fresh feed charge capacity. (Sum of values for individual refineries.) The FCC capacity was not available directly, but was calculated as the difference between the total capacity and the TCC capacity. Total capacity of catalytic cracking fresh feed in bbl/stream day was obtained from Reference 1. This value was converted to bbl/calendar year by multiplying by 328.5 (365 days/year x 0.9 calendar day/stream day).

The FCC and TCC capacities were converted to throughput data using the refinery operating ratio. This ratio was obtained from Reference 2a and converted to a percentage. Capacities were multiplied by this refinery operating percentage to obtain the corresponding throughputs. The FCC and TCC throughputs were used as the activity indicators.

3.25.2.2 Industrial Processes - NO_x Emissions

The activity indicators for FCC and TCC in petroleum refineries were based on the separate FCC and TCC capacities. The TCC capacity was obtained from Reference 1 as the value reported in the "other" category for catalytic cracking fresh feed charge capacity. (Sum of values for individual refineries.) The FCC capacity was not available directly, but was calculated as the difference between total capacity and TCC capacity. Total capacity of catalytic cracking fresh feed in bbl/stream day was obtained from Reference 1. This value was converted to bbl/calendar year by multiplying by 328.5 (365 days/year x 0.9 calendar day/stream day).

The FCC and TCC capacities were converted to throughput data using the refinery operating ratio. This ratio was obtained from Reference 2a and converted to a percentage. Capacities were multiplied by this refinery operating percentage to obtain the corresponding throughputs. The FCC and TCC throughputs were used as the activity indicators.

The activity indicator for flares in petroleum refineries was based on total refinery crude capacity in bbl/calendar day obtained from Reference 1. This value was multiplied by 365 to convert it to an annual value. The activity indicator was calculated by multiplying the capacity by the VOC control efficiency for blow down systems, expressed as a percentage. The derivation of this control efficiency is described in section 3.25.4.4.

3.25.2.3 Industrial Processes - Particulates and PM-10 Emissions

The activity indicators for FCC and TCC in petroleum refineries were based on the separate FCC and TCC capacities. The TCC capacity was obtained from Reference 1 as the value reported in the "other" category. The FCC capacity was not available directly, but was calculated as the difference between total capacity and TCC capacity. Total capacity of catalytic cracking fresh feed in bbl/stream day was obtained from Reference 1. This value was converted to bbl/calendar year by multiplying by 328.5 (365 days/year x 0.9 calendar day/stream day).

The FCC and TCC capacities were converted to throughput data using the refinery operating ratio. This ratio was obtained from Reference 2a and converted to a percentage. Capacities were multiplied by this refinery operating percentage to obtain the corresponding throughputs. The FCC and TCC throughputs were used as the activity indicators.

3.25.2.4 Industrial Processes - SO₂ Emissions

The activity indicator for sulfur recovery plants at refineries was the quantity of sulfur recovered by petroleum refineries obtained from Reference 3.

The activity indicators for FCC and TCC in petroleum refineries were based on the separate FCC and TCC capacities. The TCC capacity was obtained from Reference 1 as the value reported in the "other" category. The FCC capacity was not available directly, but was calculated as the difference between total capacity and TCC capacity. Total capacity of catalytic cracking fresh feed in bbl/stream day was obtained from Reference 1. This value was converted to bbl/calendar year by multiplying by 328.5 (365 days/year x 0.9 calendar day/stream day).

The FCC and TCC capacities were converted to throughput data using the refinery operating ratio. This ratio was obtained from Reference 2a and converted to a percentage. Capacities were multiplied by this refinery operating percentage to obtain the corresponding throughputs. The FCC and TCC throughputs were used as the activity indicators.

The activity indicator for flares in petroleum refineries was based on the total refinery crude capacity in bbl/calendar day obtained from Reference 1. This value was multiplied by 365 to convert it to an annual value. The activity indicator was calculated by multiplying the capacity by the VOC control efficiency for blow down systems, expressed as a percentage. The derivation of this control efficiency is described in section 3.25.4.4.

3.25.2.5 Industrial Processes - VOC Emissions

The activity indicators for FCC and TCC in petroleum refineries were based on the separate FCC and TCC capacities. The TCC capacity was obtained from Reference 1 as the value reported in the "other" category. The FCC capacity was not available directly, but was calculated as the difference between total capacity and TCC capacity. Total capacity of catalytic cracking fresh feed in bbl/stream day was obtained from Reference 1. This value was converted to bbl/calendar year by multiplying by 328.5 (365 days/year x 0.9 calendar day/stream day).

The FCC and TCC capacities were converted to throughput data using the refinery operating ratio. This ratio was obtained from Reference 2a and converted to a percentage. Capacities were multiplied by this refinery operating percentage to obtain the corresponding throughputs. The FCC and TCC throughputs were used as the activity indicators.

The activity indicators for the petroleum refinery process operations of compressor, blow down systems, process drains, cooling towers, and miscellaneous processes were the total crude capacity reported in Reference 1. The capacity, expressed in bbl/calendar day, was multiplied by 365 to convert it to an annual figure. The activity indicator for vacuum jets was the total vacuum distillation capacity obtained from Reference 1. The capacity, expressed in bbl/stream day, was multiplied by the following factor to convert it to an annual value: 365 days/year x 0.95 calendar day/stream day.

3.25.3 Emission Factor

3.25.3.1 Industrial Processes - CO Emissions

The emission factors for FCC and TCC in petroleum refineries were obtained from Reference 4a for SCCs 3-06-002-01 and 3-06-003-01, respectively. In this reference, TCC was categorized as moving-bed catalytic cracking units.

3.25.3.2 Industrial Processes - NO_x Emissions

The emission factors for FCC, TCC, and flares in petroleum refineries were obtained from Reference 4a for SCCs 3-06-002-01, 3-06-003-01, and 3-06-004-01, respectively. In this reference, TCC was categorized as moving-bed catalytic cracking units and flares were categorized as blow down system with vapor recovery.

3.25.3.3 Industrial Processes - Particulates and PM-10 Emissions

The TSP emission factors for FCC and TCC in petroleum refineries were obtained from Reference 4a for SCCs 3-06-002-01 and 3-06-003-01, respectively. In this reference, TCC was categorized as moving-bed catalytic cracking units. The PM-10 emission factors for these sources were obtained from Reference 11. For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from these emission sources.

3.25.3.4 Industrial Processes - SO₂ Emissions

The emission factor for sulfur recovery plants at refineries was based on SCCs 3-01-032-01 through 3-01-032-04. These emission data were summed and divided by the sum of the corresponding operating rates. All data was obtained from Reference 5 or Reference 6.

The emission factors for FCC, TCC, and flares in petroleum refineries were obtained from Reference 4a for SCCs 3-06-002-01, 3-06-003-01, and 3-06-004-01, respectively. In this reference, TCC was categorized as moving-bed catalytic cracking units and flares were categorized as blow down system with vapor recovery.

3.25.3.5 Industrial Processes - VOC Emissions

The emission factors for FCC and TCC in petroleum refineries were obtained from Reference 1. These emission factors were converted to a reactive basis using the profile SDM 306002 obtained from Reference 7.

The emission factors for the petroleum refinery process operations of blow down systems, process drains, vacuum jets, cooling towers, and miscellaneous processes were obtained from Reference 1. The emission factor for compressors was obtained from Reference 8.

The emission factors were converted to a reactive basis using profiles from Reference 7, except for the emission factor for vacuum jets for which the profile was obtained from Reference 9. Compressors, blow down systems, process drains, and cooling towers were converted to a reactive basis using the profiles SDM 202002, SDM 306009, SDM 306005, and SDM 306007, respectively, obtained from Reference 7. The emission factor for miscellaneous processes was converted using the profiles SDM 306008A, 8P, 8Y 8Z (Aug), and 8N.

3.25.4 Control Efficiency

3.25.4.1 Industrial Processes - CO Emissions

The control efficiencies for FCC and TCC in petroleum refineries were derived from the actual and uncontrolled emissions reported in Reference 5 or Reference 6 according to the equation below.

$$CE = \frac{(UE \& AE)}{UE}$$

where: CE = control efficiency
UE = uncontrolled emissions
AE = actual (controlled) emissions

3.25.4.2 Industrial Processes - NO_x Emissions

No control efficiencies were applied to the activity data to estimate the NO_x emissions from the petroleum refinery sources included in this Tier 2 category.

3.25.4.3 Industrial Processes - Particulates and PM-10 Emissions

The TSP control efficiencies for FCC and TCC in petroleum refineries were derived from the actual and uncontrolled emissions reported in Reference 5 or Reference 6 according to the equation given above for CO control efficiencies. The PM-10 control efficiencies for these processes for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 10. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

3.25.4.4 Industrial Processes - VOC Emissions

The control efficiencies for FCC and TCC in petroleum refineries were assumed to be 95 percent of the corresponding CO control efficiencies.

For the years 1970 through 1984, the emission factors for the petroleum refinery process operations of blow down systems, process drains, and vacuum jets were based on the controlled and uncontrolled emission factors. The controlled emission factors were estimated using weighted averages of emission factors for "old" refinery capacity (pre-1970) and "new" refinery capacity where the "old" and "new" capacities for used as weighting factors. A detailed description of the calculation procedure is presented below.

The first step in this procedure was the development of the breakdown of the refineries capacity into "old" and "new". For blow down systems and process drains, the total crude oil capacity of refineries was obtained from Reference 1 for the year under study and for the previous year. The difference between total capacity for the year under study and capacity from the previous year was assumed to be the new capacity for the year under study. If the difference was negative, the new capacity was assumed to be zero.

In order to calculate the old capacity, the NSPS capacity was calculated. This was done by adding the new capacity for the year under study to 1 percent of the total capacity from the previous year. This sum, the NSPS capacity, was subtracted from the total capacity for the year under study, resulting in the old capacity.

The same procedure was used to estimate the old and new capacities for vacuum jets. In place of the total crude oil capacity, the total vacuum distillation capacity obtained from Reference 1 was used.

For each of the three processes, two controlled emission factors were used to calculate a weighted average controlled emission factor. The average 1970 emission factor represented the emission rate of older operations and, therefore, was weighted by the old capacity. The NSPS emission factor, applicable to newer operation, was weighted by the new capacity. The 1970 and NSPS emission factors for each subcategory are

presented in Table 3.25-1, along with the corresponding uncontrolled emission factors. The calculation of the weighted average controlled emission factors is summarized in the equation given below.

$$EF_{Controlled} = \frac{(Capacity_{old} \times EF_{old}) \% (Capacity_{new} \times EF_{new})}{(Capacity_{old} \% Capacity_{new})}$$

where: EF = emission factor

The control efficiency for each process was calculated as the percentage difference between the controlled emission factor calculated according to the methodology above and the uncontrolled emission factors presented in Table 3.25-1. This calculation is summarized in the equation given below.

$$CE = \frac{(EF_{Uncontrolled} - EF_{Controlled})}{EF_{Uncontrolled}}$$

where: CE = control efficiency
EF = emission factor

For the years 1940, 1950, and 1960, the procedure for determining the control efficiencies for blow down systems, process drains, and vacuum jets is currently unavailable.

No control efficiencies were applied to the activity data to estimate VOC emissions from compressors, cooling towers, or miscellaneous processes used in petroleum refinery process operations.

3.25.5 References

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2. *Survey of Current Business*. Bureau of Economic Analysis, U.S. Department of Commerce, Washington, DC. Annual.
 - (a) Table containing information on Petroleum, Coal, and Products
3. *Minerals Industry Surveys*, Sulfur. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Monthly.
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 - (a) Volume I, Table 9.1-1

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6. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
7. *Volatile Organic Compound (VOC) Species Data Manual*. EPA-450/4-80-015. U.S. Environmental Protection Agency, Research Triangle Park, NC. July 1980.
8. *Air Pollution Aspects of Petroleum Refining*. PHS-763. U.S. Public Health Service, Washington, DC.
9. *Control Techniques Guidelines*. EPA-450/2-77-025. U.S. Environmental Protection Agency, Washington, DC. 1977.
10. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.
11. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listings for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

Table 3.25-1. Emission Factors Used in the Calculation of the Control Efficiencies for the Blow Down Systems, Process Drains, and Vacuum Jets Subcategories

Subcategories	Emission Factors (lb/10 ⁶ bbl)		
	1970	NSPS	Uncontrolled
Blow down Systems	178.84	5.26	263
Process Drains	205.2	57	570
Vacuum Jets	108.75	0	145

3.26 PETROLEUM AND RELATED INDUSTRIES - ASPHALT MANUFACTURING: 06-03

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source categories.

Category:	Subcategory:
Industrial Processes - Particulates and PM-10 Emissions	Mineral Products Industry [asphalt batching (dryers and fugitive) and asphalt roofing (blowing and felt saturation)]
Industrial Processes - VOC Emissions	Petroleum Refinery Process Operation (asphalt blowing)

3.26.1 Technical Approach

The PM-10, TSP, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators for TSP and PM-10 emissions were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton. For VOC emissions, the activity indicator was expressed in millions barrels and the emission factor was expressed in metric pounds/thousand barrels. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies for VOC were used for the years 1940, 1950, 1960, and 1970 through 1984 and for TSP for the years through 1992. For PM-10, these procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.26.2 Activity Indicator

The total amount of asphalt and road oil supplied, expressed in barrels, was obtained from Reference 1 and was multiplied by 2.29. This result was used as the TSP and PM-10 activity indicators for the asphalt batching operations of dryers and fugitive processes. The activity indicators for the asphalt roofing operations of blowing and felt saturation were the total domestic consumption of asphalt obtained from Reference 2.

The VOC activity indicator for asphalt blowing was the total crude capacity, expressed in barrels/day obtained from Reference 3. This daily value was multiplied by 365 to convert to an annual figure.

3.26.3 Emission Factor

The PM-10 and TSP emission factors for asphalt batching dryers were the weighted average of the emission factors for rotary dryers, conventional plant (SCC 3-05-002-01), drum dryers, and drum mix plant (SCC 3-05-002-05). The TSP emission factors were obtained from References 4a and 4b and the PM-10 emission factors were obtained from Reference 9. These emission factors were weighted by the number of records in Reference 5 or Reference 6 corresponding to the rotary and drum dryer SCCs.

The PM-10 and TSP emission factors for asphalt batching fugitive processes were obtained from Reference 9 and Reference 7, respectively.

The TSP emission factors for blowing operations for asphalt roofing were obtained from Reference 4c for saturant (SCC 3-05-001-01) and coating (SCC 3-05-001-02). The PM-10 emission factors were obtained from Reference 9. Weighted averages of these two emission factors were calculated by weighting the saturant emission factor by 95 percent and the coating emission factor by 5 percent.

The TSP emission factors for felt saturation operations in asphalt roofing were obtained from Reference 4c for dipping only (SCC 3-05-001-03) and dipping/spraying (SCC 3-05-001-04). The PM-10 emission factors were obtained from Reference 9. Weighted average of these emission factors were calculated by weighting the dipping only emission factors by two-thirds and the dipping/spraying emission factors by one-third.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier 2 category.

The VOC emission factor for asphalt blowing was obtained from Reference 4.

3.26.4 Control Efficiency

The TSP control efficiencies for asphalt batching dryers were the weighted average of the control efficiencies for drum and rotary dryers derived from Reference 5 or Reference 6 using the equation given below. These control efficiencies were weighted in the same manner as the drum and rotary dryer emission factors.

$$CE = \frac{(UE \& AE)}{UE}$$

where: CE = control efficiency
 UE = uncontrolled emissions
 AE = controlled emissions

The 1980 TSP control efficiency for asphalt batching fugitive processes was calculated using data from Reference 3 for the SCCs 3-05-002-03 and 3-05-002-04. For subsequent years, it was assumed that the fugitive control efficiencies changed in proportion to the changes in dryer control efficiencies. No procedure for determining the control efficiencies prior to 1980 is currently available.

The TSP control efficiencies for blowing operations in asphalt roofing were the weighted averages of the control efficiencies for saturant and coating derived from Reference 5 or Reference 6 using the equation given above. These individual control efficiencies were weighted in the same manner as the saturant and coating emission factors.

The TSP control efficiencies for felt saturation operation in asphalt roofing were the weighted averages of the control efficiencies for dipping and dipping/spraying derived from Reference 5 or Reference 6 using the equation given above. These individual control efficiencies were weighted in the same manner as the dipping and dipping/spraying emission factors.

The PM-10 control efficiencies for asphalt batching dryers and for blowing and felt saturation operations for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 8. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency values were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions from asphalt roofing operations or asphalt batching fugitive processes.

No control efficiencies were applied to the activity data to estimate VOC emissions from asphalt blowing.

3.26.5 References

1. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
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 - c. Volume I, Table 8.2-1
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6. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS).* Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
7. *Assessment of Fugitive Particulate Emission Factors for Industrial Processes.* EPA-450/3-78-107. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1978.
8. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.
9. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listings for Criteria Air Pollutants.* EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

3.27 OTHER INDUSTRIAL PROCESSES - AGRICULTURE, FOOD, AND KINDRED PRODUCTS: 07-01

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source categories.

Category:

Subcategory:

Industrial Processes - Particulates and PM-10 Emissions

Agricultural Industries [cotton ginning, cattle feedlots, alfalfa dehydrators, country elevators, terminal elevators, feed mills, grain milling (wheat, corn-dry, corn-wet, rice, soybeans)]

Industrial Processes - VOC Emissions

Miscellaneous Industrial Processes [other processes (bakeries, fermentation, and vegetable oil)]

3.27.1 Technical Approach

The PM-10, TSP, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, the activity indicators were expressed in thousand short tons and the emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies for VOC were used for the years 1940, 1950, 1960, and 1970 through 1984 and for TSP for the years through 1992. For PM-10, these procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating the emissions based on activity indicators, emission factors, and control efficiencies.

3.27.2 Activity Indicator

3.27.2.1 Industrial Processes - Particulates and PM-10 Emissions

The activity indicator for cotton ginning was the number of running bales obtained from Reference 1a.

The cattle feedlot activity indicator was based on the number of cattle and calves slaughtered, expressed in thousands, reported in Reference 1b. This value was multiplied by 0.46 to determine the final activity indicator.

The activity indicator for alfalfa dehydrators was total production obtained from Reference 2.

The activity indicators for country elevators and terminal elevators were based on the total production of five major grains. Total production of sorghum was obtained from Reference 3. Total productions of wheat, corn, oats, and barley were each obtained from Reference 1b. Production figures for each grain were converted from bushels to total weight using the conversion factors listed in Table 3.27-1. The production figures for the five grains were summed and multiplied by 0.8. This grain production by weight was the activity indicator for both country elevators and terminal elevators.

The activity indicator for feed mills is the total consumption of wheat, corn, oats, barley, sorghum, and alfalfa meal. When the year under study was a census year, total consumption data (SIC 2048) was obtained from Reference 2. For a noncensus year, grain consumption by feed mills was estimated using the total grain production as determined for the country elevator subcategory. Total production was multiplied by the ratio of total grain production to total grain consumption data (SIC 2048) obtained for the previous census year.

The activity indicator for the wheat milling was the total quantity of grindings of wheat expressed in thousands of bushels reported in Reference 1a. The quantity was converted to weight using the wheat conversion factor presented in Table 3.27-1.

The activity indicator for the dry corn milling was the total production of dry corn. When the year under study was a census year, the total dry corn production was obtained from Reference 2. For noncensus years, the dry corn production was calculated by multiplying the total corn production obtained from Reference 1b for the year under study by the factor 0.021. For the years 1940 through 1973, this multiplicative factor, as well as a procedure for determining the factor, is currently unavailable.

The activity indicator for wet corn milling was determined in the same manner as dry corn milling. The only difference being the use of 0.059 as the multiplicative factor for noncensus years after 1974.

The activity indicator for rice was the total rice production. The production figure was obtained as the total shipments from mills in southern states and California or the total production reported in Reference 1b.

The activity indicator for soybeans was based on the total soybean production as obtained from Reference 3. This value was converted from bushels to weight using the conversion factor for wheat given in Table 3-27-

1. It was assumed that 70 percent of the total production was domestic consumption. The final activity indicator for soybeans represented only the domestic consumption.

3.27.2.2 Industrial Processes - VOC Emissions

The activity indicator for bakeries was the production of wheat flour obtained from Reference 1b. This value, expressed in thousand sacks, was multiplied by 27.21 tons bread baked/10⁶ sacks.

The activity indicator for the fermentation processes was based on the stocks of distilled spirits and production of beer reported in Reference 1b. Stocks of distilled spirits were converted to metric pounds by the factor 0.1814 metric lb/gal. Beer production figure was converted to metric pound using the factor 0.06 metric lb/bbl. The activity indicator was the sum of distilled spirits and beer production figures.

The activity indicator for vegetable oil subcategory was the refined oil production for soybean, cotton seed, corn, and coconut obtained from Reference 4.

3.27.3 Emission Factor

3.27.3.1 Industrial Processes - Particulates and PM-10 Emissions

The emission factors for cotton ginning were the sum of the emission factors for the following four processes: unloading fan (3-02-004-01), seed cotton cleaning system (SCC 3-02-004-02), stick/burr machine (SCC 3-02-004-03), and miscellaneous (SCC 3-02-004-04). These emission factors were obtained from Reference 5a for TSP and from Reference 9 for PM-10.

The PM-10 and TSP emission factors for cattle feedlots (SCC 3-02-020-01) were obtained from Reference 9 and Reference 5b, respectively.

The emission factors for alfalfa dehydrator were the sum of the emission factors from three processes: primary cyclone and dryer (SCC 3-02-001-02), meal collector (SCC 3-02-001-03), and pellet cooler (SCC 3-02-001-04). The emission factors for these processes were obtained from Reference 5c for TSP and from Reference 9 for PM-10.

The emission factors for country elevators were the sum of the emission factors from six process listed in Table 3.27-2. The emission factors for terminal elevators were the sum of the emission factors from seven process listed in Table 3.27-3. The PM-10 and TSP emission factors for the elevator processes were obtained from Reference 9 and Reference 5d, respectively.

The emission factors for feed mills were the sum of the emission factors from five process listed in Table 3.27-4. The emission factors for these processes were obtained from Reference 5e for TSP and from Reference 9 for PM-10.

The PM-10 and TSP emission factors for wheat milling were based on the emission factors obtained from Reference 9 and Reference 5e, respectively, for the following three processes: receiving (SCC 3-02-007-31), precleaning/handling (SCC 3-02-007-32), and millhouse (3-02-007-34). It was assumed that a 99 percent control applied to the millhouse emission factor. The resulting controlled emission factors for the millhouse process were added to the other emission factors to obtain the final PM-10 and TSP emission factors.

The PM-10 and TSP emission factors for dry corn were the sum of the emission factors obtained from Reference 9 and Reference 5e, respectively, for the following four processes: receiving (SCC 3-02-007-41), drying (SCC 3-02-007-42), precleaning/handling (SCC 3-02-007-43), and cleaning (3-02-007-44). The emission factors for wet corn were the sum of the emission factors for the following three processes: receiving (SCC 3-02-007-51), handling (SCC 3-02-007-52), and cleaning (3-02-007-53). The TSP emission factors were obtained from Reference 5e; the PM-10 emission factors were obtained from Reference 9.

The PM-10 and TSP emission factors for rice were the sum of the emission factors obtained from Reference 9 and Reference 5e, respectively, for the following processes: receiving (SCC 3-02-007-71) and precleaning/handling (SCC 3-02-007-72).

The emission factors for soybeans were the sum of the emission factors from 10 processes listed in Table 3.27-5. The emission factors for these processes were obtained from Reference 5e for TSP and from Reference 9 for PM-10.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier 2 category.

3.27.3.2 Industrial Processes - VOC Emissions

The emission factor for bakeries was weighted average of the emission factors for sponge dough (SCC 3-02-032-01) and straight dough (SCC 3-02-032-02). These emission factors were obtained from Reference 5f. The weighting factor for sponge dough was 0.915 and for straight dough was 0.085.

The emission factor for fermentation processes was based on the assumption of complete evaporation of all volatile compounds (i.e. the emission factor was 2000 lb/ton).

The emission factor for vegetable oil was based on the 1979 emission estimates obtained from the EPA's Emission Standards and Engineering Division. The total emissions were divided by the 1977 production rate to obtain the emission factor for vegetable oil. The source of the 1977 production rate is currently unavailable.

3.27.4 Control Efficiency

3.27.4.1 Industrial Processes - Particulates and PM-10 Emissions

The TSP control efficiencies for all agricultural industrial processes, excluding country and terminal elevators, were derived from Reference 6 or Reference 7 using the equation below.

$$CE = \frac{(UE \& AE)}{UE}$$

where: CE = control efficiency
 UE = uncontrolled emissions
 AE = actual (controlled) emissions after

The TSP control efficiencies for country and terminal elevators were the weighted average of the control efficiencies for the SCCs given in Table 3.27-2 and Table 3.27-3, respectively. These individual control efficiencies were derived from Reference 6 or Reference 7 using the equation given above. The final country and terminal elevator control efficiencies were calculated using weighting factors obtained in Reference 5d.

The PM-10 control efficiencies for all agricultural industry emission sources for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 8. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

3.27.4.2 Industrial Processes - VOC Emissions

No control efficiencies were applied to the activity data to estimate VOC emissions from bakeries, fermentation processes, and vegetable oil production.

3.27.5 References

1. *Survey of Current Business*. Bureau of Economic Analysis, U.S. Department of Commerce, Washington, DC.
 - (a) Table containing information on "textile products."
 - (b) Table containing information on "food and kindred products."
2. *Census of Manufactures*. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Available every 5 years.
3. *Crop Production*. GPO 20-B-S/N001/028/80029/1. Crop Reporting Board Economic Statistics & Cooperative Service, U.S. Department of Agriculture, Washington, DC. Monthly.
4. *Current Industrial Reports, Fats and Oil*. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Annual.
5. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - a. Volume I, Table 6.3-1

- b. Volume I, Table 6.15-1
 - c. Volume I, Table 6.1-1
 - d. Volume I, Table 6.4-5 (column 3)
 - e. Volume I, Table 6.4-6
 - f. Volume I, Section 6.13
6. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem.* Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
 7. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS).* Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
 8. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.
 9. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listings for Criteria Air Pollutants.* EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

Table 3.27-1. Conversion of Grain Volume (in bushels) to Weight (in pounds)

Grain	lb/bu
Wheat	60
Corn	56
Oats	32
Barley	48
Sorghum	56

Table 3.27-2. PM-10 and TSP Emission Factor SCCs for Country Elevators

SCC	Description
3-02-006-03	Cleaning
3-02-006-04	Drying
3-02-006-05	Unloading (receiving)
3-02-006-06	Loading (shipping)
3-02-006-09	Removal from bins
3-02-006-10	Headhouse (legs)

Table 3.27-3. PM-10 and TSP Emission Factor SCCs for Terminal Elevators

SCC	Description
3-02-005-03	Cleaning
3-02-005-04	Drying
3-02-005-05	Unloading (receiving)
3-02-005-06	Loading (shipping)
3-02-005-09	Tripper (gallery belt)
3-02-005-10	Removal from bins
3-02-005-11	Headhouse (legs)

Table 3.27-4. PM-10 and TSP Emission Factor SCCs for Feed Mills

SCC	Description
3-02-008-02	Receiving
3-02-008-03	Shipping
3-02-008-04	Handling
3-02-008-05	Grinding
3-02-008-06	Pellet Coolers

Table 3.27-5. PM-10 and TSP Emission Factor SCCs for Soybean Milling

SCC	Description
3-02-007-81	Receiving
3-02-007-82	Handling
3-02-007-84	Drying
3-02-007-85	Cracking/Dehulling
3-02-007-86	Hull Grinding
3-02-007-87	Bean Conditioning
3-02-007-88	Flaking
3-02-007-89	Meal Dryer
3-02-007-90	Meal Cooler
3-02-007-91	Bulk Loading

3.28 OTHER INDUSTRIAL PROCESSES - WOOD, PULP AND PAPER, AND PUBLISHING PRODUCTS: 07-03

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source categories.

Category:	Subcategory:
Industrial Processes - CO Emissions	Kraft Pulp and Paper
Industrial Processes - NO _x Emissions	Kraft Pulp
Industrial Processes - Particulates and PM-10 Emissions	Miscellaneous Process Sources (Pulp and Paper, Semi-Chemical, Plywood, and Lumber)
Industrial Processes - SO ₂ Emissions	Other Industrial Processes (Kraft Pulp Production and Sulfite)

3.28.1 Technical Approach

The CO, NO_x, PM-10, TSP, and SO₂ emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.28.2 Activity Indicator

For CO and NO_x emissions, the activity indicator for kraft pulp and paper was the production value reported for sulfate obtained from Reference 1. For SO₂ emissions, the activity indicator for kraft pulp production and sulfite was the combined production of sulfate and sulfite at kraft mills and sulfite mills obtained from Reference 1.

The TSP and PM-10 activity indicators for the two pulp and paper production processes were obtained from Reference 1. The activity indicator for kraft pulp was the production value reported for sulfate and the indicator for sulfite was the production value reported for sulfite.

The TSP and PM-10 activity indicators for the two semi-chemical processes were based on the total semi-chemical wood pulp production obtained from Reference 2. It was assumed that indicator for recovery furnaces was one-third of the total production while the indicator for fluid bed reactors was 15 percent of the total production.

The TSP and PM-10 activity indicator for plywood was the softwood plywood production obtained from Reference 3a. When this reference was not available, the total plywood production was estimated using the total plywood production from Reference 4 for the census year preceding the year under study. The combined total production values of plywood from southern pine and douglas fir were obtained from Reference 2 for the census year and the year under study. Total plywood production was projected to the year under study using the equation given below.

$$P_{\text{plywood},i} = P_{\text{plywood},j} \times \frac{P_{(\text{pine \% fir}),i}}{P_{(\text{pine \% fir}),j}}$$

where: i = year under study
j = census year
P = production

The TSP and PM-10 activity indicator for lumber was total lumber production obtained from Reference 5 or Reference 2.

3.28.3 Emission Factor

The CO emission factor for kraft pulp and paper processes was the sum of the emission factors for recovery furnaces (SCC 3-07-001-04) and lime kilns (SCC 3-07-001-06) obtained from Reference 6a.

The NO_x emission factor for kraft pulp processes was calculated by dividing the actual emissions by the operating rate. These values were obtained from Reference 7.

The PM-10 and TSP emission factors for the kraft process in pulp and paper production were the sum of the emissions factors for the following three processes: recovery furnaces/direct contact evaporators (SCC 3-07-001-04), smelt tanks (SCC 3-07-001-05), and lime kilns (SCC 3-07-001-06). These PM-10 and TSP emission factors were obtained from Reference 13 and Reference 14a.

The TSP emission factor for the sulfite process in pulp and paper production was obtained from Reference 8. The PM-10 emission factor was obtained from Table 3.1-3.

The TSP emission factors for the two semi-chemical processes of recovery furnaces and fluid red reactors were obtained from Reference 9. The PM-10 emission factor was obtained from Reference 13 or Table 3.1-3.

The TSP emission factor for plywood was obtained from Reference 8. The PM-10 emission factor was obtained from Table 3.1-3.

The TSP emission factor for lumber was calculated by dividing the actual emissions reported in Reference 7 by the 1977 lumber production reported in Reference 2. The PM-10 emission factor was obtained from Reference 13 or Table 3.1-3.

The SO₂ emission factor for kraft pulp production and sulfite was the weighted sum of the emission factors for kraft pulp production and for sulfite mills. The emission factor for kraft pulp production was obtained from Reference 14a. The sulfite mills emission factor was calculated from the controlled and uncontrolled sulfite mills emission factors of 20 lb/ton and 52 lb/ton, respectively. These emission factors were obtained from Reference 8. Assuming the particulate control efficiency was 0.90 for sulfite mills, the controlled emission factor was multiplied by 0.9 and the uncontrolled emission factor by 0.1. The resulting products were summed. Weighting factors for summing the emission factors for kraft pulp production and sulfite mills were the relative production levels obtained from Reference 1.

3.28.4 Control Efficiency

No control efficiencies were applied to the activity data to estimate CO, NO_x, or SO₂ emissions from the pulp and paper sources included in this Tier 2 category.

The TSP control efficiencies for the pulp and paper, plywood, and lumber production processes were derived from Reference 10 or Reference 11 using the equation below. The TSP control efficiencies for the semi-chemical processes were assumed to be equal to the control efficiencies for the kraft process in pulp and paper production.

$$CE = \frac{(UE \& AE)}{UE}$$

where: CE = control efficiency
 UE = uncontrolled emissions
 AE = actual (controlled) emissions after

The PM-10 control efficiencies for kraft processes in pulp and paper production and fluid red reactors in semi-chemical production for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 12. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

No control efficiencies were applied to the activity data to estimate PM-10 emissions from sulfite processes in pulp and paper production and recovery furnaces in semi-chemical production. For plywood and lumber production, no control efficiencies were applied in the estimation of TSP and PM-10 emissions.

3.28.5 References

1. *Current Industrial Reports, Pulp, Paper and Board*. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Annual.
2. *Survey of Current Business*. Bureau of Economic Analysis, U.S. Department of Commerce, Washington, DC. Annual.
3. *Current Industrial Reports, Softwood Plywood*
 (a) Table: Production, Quantity and Value of Shipments of Softwood Plywood
4. *Census of Manufactures*. U.S. Department of Commerce, Bureau of the Census, Washington, DC. (available every 5 years)
5. *Current Industrial Reports, Lumber Production and Mill Stocks*. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Annual.
6. *Compilation of Air Pollutant Emission Factors, Third Edition, Supplements 1 through 14, AP-42*. NTIS PB-275525. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1977.
 a. Volume I, Table 10.1.2-1

7. *Computer Retrieval, NE257 report, by Source Classification Code (SCC) from the National Emission Data System (NEDS)*. Unpublished computer report. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. February 9, 1980.
8. *Compilation of Air Pollutant Emission Factors, Third Edition, and Supplements 1-14, AP-42*. NTIS PB-275525. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1977.
9. *Particulate Pollution System Study*. U.S. Environmental Protection Agency. Prepared by Midwest Research Institute, Kansas City, MO. 1970.
10. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
11. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
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14. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - a. Volume I, Table 10.1-1

3.29 OTHER INDUSTRIAL PROCESSES - RUBBER AND MISCELLANEOUS PLASTIC PRODUCTS: 07-04

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source category.

Category:

Industrial Processes - VOC Emissions

Subcategory:

Miscellaneous Industrial Processes [other processes (tires)]

3.29.1 Technical Approach

The VOC emissions included in this Tier category were the emissions from the source category listed above. Emissions were estimated from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, the activity indicator was expressed in thousand short tons and the emission factor was expressed in metric pounds/short ton.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.29.2 Activity Indicator

The activity indicator for tires was the production of pneumatic casing obtained from Reference 1a.

3.29.3 Emission Factor

The VOC emission factor for tires was the sum of the emission factors for the processes listed in Table 3.29-1. These emission factors were expressed as lbs/1,000 tires. The summed emission factor was converted to lbs/ton, assuming that 1,000 tires weigh one ton.

3.29.4 Control Efficiency

No control efficiencies were applied to the activity data to estimate VOC emissions from tire production.

3.29.5 References

1. *Survey of Current Business*. Bureau of Economic Analysis, U.S. Department of Commerce, Washington, DC.
 - (a) Table containing information on "rubber and rubber products."

2. *Control Techniques Guidelines*. EPA-450/2-77-025. U.S. Environmental Protection Agency, Washington, DC. 1977.

Table 3.29-1. VOC Emissions Factor SCCs for Tire Production

SCC	Description
3-08-001-01	Undertread & Sidewall Cementing
3-08-001-02	Bead Dipping
3-08-001-03	Bead Swabbing
3-08-001-04	Tire Building
3-08-001-05	Tread End Cementing
3-08-001-06	Green Tire Spraying
3-08-001-07	Tire Curing

3.30 OTHER INDUSTRIAL PROCESSES - MINERAL PRODUCTS: 07-05

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source categories.

Category:	Subcategory:
Industrial Processes - CO Emissions	Asphalt Roofing and Lime
Industrial Processes - NO _x Emissions	Cement Manufacturing Glass and Manufacturing Lime
Industrial Processes - Particulates and PM-10 Emissions	Mineral Products Industry [Cement Manufacturing (kilns, grinders, fugitive), Bricks, Clay Sintering, Concrete Batching, Fiber Glass (furnace, forming and curing), Glass, Gypsum Manufacturing (dryer and calciner), and Lime Manufacturing (kilns and fugitive)] Mining Operations [Coal Mining (surface mining, coal handling, thermal dryers, and pneumatic dryers), Sand and Gravel, Stone and Rock Crushing, Phosphate Rock (drying or calcining, grinding, and material handling), Clays, and Potash] Chemical Industry [Fertilizers (rock pulverization)]
Industrial Processes - SO ₂ Emissions	Other Industrial Processes (Cement Manufacturing, Glass Manufacturing and Lime Processing)
Industrial Processes - VOC Emissions	Miscellaneous Industrial Processes [Other Processes (glass manufacturing)]

3.30.1 Technical Approach

The CO, NO_x, PM-10, TSP, SO₂, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.30.2 Activity Indicator

3.30.2.1 Industrial Processes - CO Emissions

The activity indicator for asphalt roofing was the total domestic consumption obtained from Reference 1.

The activity indicators for kiln and fugitive processes in lime production were the lime production obtained from Reference 2.

3.30.2.2 Industrial Processes - NO_x Emissions

The activity indicator for cement manufacturing was the total quantity of cement production as obtained from Reference 3.

The activity indicator for glass manufacturing was based on the sum of total production of flat glass obtained from Reference 4 and the net packed weight of glass containers obtained from Reference 5. The resulting value was multiplied by 1.10 to account for miscellaneous glass products.

The activity indicator for lime kiln and fugitive processes was the lime production obtained from Reference 2.

3.30.2.3 Industrial Processes - Particulates and PM-10 Emissions

3.30.2.3.1 Mineral Products Industry —

The activity indicators for the three cement manufacturing processes were the total quantity of cement production as obtained from Reference 3.

The total brick production, expressed in millions of bricks, was obtained from Reference 6. The quantity was multiplied by 6.5 lb/brick. To this value was added the sum of the sewer pipes and fittings production value and the structural facing tile production value as reported in Reference 6a. The final result was the activity indicator for bricks.

The activity indicator for clay sintering was the quantity of common clay and shale used in lightweight aggregate production as reported Reference 7.

The activity indicator for concrete batching was based on the sum of the total shipments of portland cement to concrete product manufacturers and to ready-mix plants as reported in Reference 3a. The resulting sum was multiplied by 7.5.

The activity indicators for the furnace, forming, and curing processes of fiber glass production were the production of textile type and wool type glass fiber obtained from Reference 8.

The activity indicator for glass was based on the sum of the flat glass production value obtained from Reference 4 and the net packed weight of glass containers obtained from Reference 5. The resulting value was multiplied by 1.10 to account for miscellaneous glass products.

The activity indicator for calciners used in gypsum manufacturing was the quantity of calcined gypsum produced as reported in Reference 9. For dryers used in gypsum manufacturing, the activity indicator was one-half of the total quantity produced.

The activity indicators for kilns and fugitive processes used in lime manufacturing were the lime production figure obtained from Reference 2.

3.30.2.3.2 Mining Operations —

The activity indicator for surface coal mining was the total coal production by surface mining methods obtained from Reference 10 or from Reference 11.

For coal handling, the activity indicator was the sum of the quantity of coal cleaned and crushed and screened as reported in Reference 10. For years when these data were not reported, the value was extrapolated from latest available data based on the total coal production.

The activity indicator for coal mining thermal dryers was the quantity of coal thermally dried obtained from Reference 10. For years when these data were not available, the value was extrapolated from previous year's data, based on the change in the total coal production from Reference 10.

For coal mining, pneumatic dryers, the activity indicator was the quantity of coal processed obtained from Reference 10. For years when these data were not available, the value was extrapolated from the previous year's data based on the change in the total coal production from Reference 10.

The activity indicator for sand and gravel was the sum of the total production of sand and gravel for construction and for industrial purposes obtained from Reference 12. The total production of stone and rock crushing was obtained from Reference 13. The activity indicators for the three phosphate rock processing operations were the marketable production of phosphate rock obtained from Reference 14.

The activity indicator for clays was the total domestic clay sold or used by producers as reported in Reference 7.

The activity indicator for potash was the total potash production, expressed in potassium oxide (K₂O) equivalent, and was obtained from Reference 2.

3.30.2.3.3 Chemical Industry —

The activity indicator for rock pulverization for fertilizers was the sum of the phosphate rock sales of single superphosphate and triple superphosphate obtained from Reference 14.

3.30.2.4 Industrial Processes - SO₂ Emissions

The activity indicators for the three cement manufacturing processes were the total quantity of cement production as obtained from Reference 3.

The activity indicator for glass manufacturing was based on the sum of the flat glass production value obtained from Reference 4, and the net packed weight of glass containers obtained from Reference 5. The resulting value was multiplied by 1.10 to account for miscellaneous glass products.

The activity indicators for the lime kiln and fugitive processes were the lime production figure obtained from Reference 2.

3.30.2.5 Industrial Processes - VOC Emissions

The activity indicator for glass manufacturing was based on the sum of the flat glass production value obtained from Reference 4, and the net packed weight of glass containers obtained from Reference 5. The resulting value was multiplied by 1.10 to account for miscellaneous glass products.

3.30.3 Emission Factor

3.30.3.1 Industrial Processes - CO Emissions

The emission factor for asphalt roofing was the weighted average of the emission factors for controlled plants (2.85 lb/ton) and uncontrolled plants (0.22 lb/ton). The weighting factors were the fraction of plants with controls and the fraction of plants without controls. The fraction of plants with controls was calculated by dividing the TSP control efficiency for the category Industrial Processes - PM-10 Emissions [Mineral Products Industry (asphalt roofing - blowing)] by 0.956. All other plants were assumed to operate without controls. The overall emission factor calculation is summarized below:

$$EF = \left[2.85 \times \left(\frac{CE_{TSP}}{0.956} \right) \right] + \left[0.22 \times \left(1 - \frac{CE_{TSP}}{0.956} \right) \right]$$

where: CE_{TSP} = TSP control efficiency for the category Industrial Processes - PM-10 Emissions [Mineral Products Industry (asphalt roofing - blowing)]

The emission factor for lime manufacturing (SCC 3-05-016-04) was obtained from Reference 16a.

3.30.3.2 Industrial Processes - NO_x Emissions

The emission factor for cement manufacturing (SCC 3-05-006-06) was obtained from Reference 16b.

The emission factor for glass manufacturing was the weighted average of the emission factors for three glass types as reported in Reference 16c. A list of the glass types, SCCs and weighting factors are presented in Table 3.30-1.

The emission factor for lime was the weighted average of the emission factors for the SCCs 3-05-016-xx. These emission factors and the corresponding weighting factors were obtained from Reference 22.

3.30.3.3 Industrial Processes - Particulates and PM-10 Emissions

3.30.3.3.1 Mineral Products Industry —

The PM-10 and TSP emission factors for kilns used in cement manufacturing were the weighted average of the emission factors for the dry process kilns (SCC 3-05-006-06) and the wet process kilns (SCC 3-05-007-06). These emission factors were obtained from Reference 16b for TSP and Reference 21 for PM-10. The weighting factors were the relative capacity of the wet process and of the dry process as reported in Reference 3.

The emission factors for grinders used in cement manufacturing were the weighted average of the emission factors for the dry process clinker grinder (SCC 3-05-006-17) and the wet process clinker grinder (SCC 3-05-007-17). The PM-10 and TSP emission factors were obtained from Reference 21 and Reference 16b, respectively, and were weighted by the relative capacity of the wet process and of the dry process as reported in Reference 3.

The TSP emission factors for cement manufacturing fugitive processes were obtained from Reference 18. The PM-10 emission factor was obtained from Reference 21 or Table 3.1-3.

The PM-10 and TSP emission factors for bricks was the sum of the emission factors for materials handling and for kilns. The emission factors for material handling were obtained from Reference 18 for TSP and from Reference 21 or Table 3.1-3 for PM-10. The PM-10 and TSP emission factors for kilns were the weighted average of the SCCs listed in Table 3.30-2 and were obtained from Reference 21 and Reference 16d, respectively. The weighting factors were based on References 19 or 20.

The emission factors for clay sintering were the sum of the emission factors for the five processes listed in Table 3.30-3. These represent the processing of raw clay and shale combined. The raw clay sintering and finished product processing and screening emission factors for TSP were obtained from Reference 16e. The

emission factors for crushing and screening and transfer and conveying were obtained from Reference 21. The storage emission factor was assumed to be 0.3 lb/ton for TSP and zero for PM-10.

The PM-10 and TSP emission factors for concrete batching (SCC 3-05-011-01) were obtained from Reference 21 and Reference 16f, respectively. The values were converted from lb/yd³ to lbs/ton using the factor 0.5.

The emission factors for furnaces used in fiber glass manufacturing were the weighted average of the emission factors for the furnace types listed in Table 3.30-4. The emission factors for these furnace types were obtained from Reference 16g for TSP and from Reference 21 for PM-10. The weighting factors were based on the operating rates obtained from Reference 19 or 20 for these types of furnaces.

The emission factors for fiber glass forming and curing processes were the weighted average of the emission factors for three processes. The TSP emission factor for the rotary spun wool type (SCC 3-05-012-04) was obtained from Reference 17a. The TSP emission factors for the flame attenuation wool type (SCC 3-05-012-08) and the textile type (SCC 3-05-012-014) were obtained from Reference 16g. The PM-10 emission factors for the three processes were obtained from Reference 21. The weighting factors were based on the operating rates obtained from Reference 19 or 20 for these three processes.

The emission factors for glass were based on the emission factors for three types of glass: container glass, melting furnace (SCC 3-05-014-02), flat glass, melting furnace (SCC 3-05-014-03), and pressed and blown glass, melting furnace (SCC 3-05-014-04). These emission factors were obtained from Reference 16c for TSP and From Reference 21 for PM-10. The weighted averages of these emission factors were calculated using the following weighting factors: 0.75 for container glass, 0.15 for flat glass, and 0.1 for blown and pressed glass.

The PM-10 and TSP emission factors for gypsum manufacturing dryers (SCC 3-05-015-01) and calciners (SCC 3-05-015-11) were obtained from Reference 21 and Reference 17b, respectively. For calciners, it was assumed that all calciners were continuous kettle calciners.

The emission factors for lime manufacturing kilns were the weighted average of the emission factors for two types of kilns: vertical kilns (SCC 3-05-016-03) and rotary kilns (SCC 3-05-016-04). These PM-10 and TSP emission factors were obtained from Reference 21 and Reference 16h, respectively, and were weighted using the data from Reference 22. The PM-10 and TSP emission factors for the fugitive processes were obtained from Reference 18 or Table 3.1-3.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier 2 category.

3.30.3.3.2 Mining Operations —

The PM-10 and TSP emission factors for surface mining and coal handling were obtained from Reference 18. The emission factors for thermal dryers (SCC 3-05-010-01) were obtained from Reference 16i for TSP

and from Reference 21 for PM-10. The pneumatic dryers emission factors were based on engineering judgement and are presented in Table 3.1-3.

The TSP emission factor for sand and gravel was obtained from Reference 17c. The PM-10 emission factor was obtained from Reference 21 or Table 3.1-3.

The emission factors for stone and rock crushing were the weighted averages of the emission factors for the processes listed in Table 3.30-5. The PM-10 and TSP emission factors for these processes were obtained from Reference 21 and Reference 17d, respectively, and were weighted by the number of records in Reference 19 or Reference 20, except for miscellaneous operations process (SCC 3-05-020-06). Emission factors for this process were added to the weighted average of the emission factors of the other four processes.

The emission factors for phosphate rock drying or calcining processes were the weighted average of the emission factors for drying (SCC 3-05-019-01) and calcining (SCC 3-05-019-05) processes. The PM-10 and TSP emission factors were obtained from Reference 21 and Reference 16j, respectively, and were weighted by the 1974 production of phosphate rock reported in Reference 14a. It was assumed that phosphate rock production from Florida represented the drying processes and production from the western States represented the calcining process.

The emission factors for phosphate rock grinding (SCC 3-05-019-02) and material handling (SCC 3-05-019-03) were obtained from Reference 16j for TSP and from Reference 21 for PM-10.

The emission factors for clays were the weighted averages of the emission factors for three processes: drying (SCC 3-05-008-01), grinding (SCC 3-05-008-02), and storage (SCC 3-05-008-03). The PM-10 and TSP emission factors were obtained from Reference 21 and Reference 16k, respectively. Weighting factors were 0.7 for the drying process, 1 for the grinding process and 0.5 for the storage process.

The TSP emission factor for potash was calculated by dividing actual emissions reported in Reference 22 by total production of potash, expressed in potassium oxide (K₂O) equivalent weights, obtained from Reference 7. The PM-10 emission factor was obtained from Reference 21.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier 2 category.

3.30.3.3.3 Chemical Industry —

The PM-10 and TSP emission factors for rock pulverization (SCC 3-05-019-02) were obtained from Reference 21 and Reference 23, respectively. For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier 2 category.

3.30.3.4 Industrial Processes - SO₂ Emissions

The emission factor for cement manufacturing was based on the uncontrolled SO₂ emissions, the total cement production, and the SO₂ control efficiency for cement kilns. The uncontrolled emissions were produced

by mineral sources and by the combustion of fuels used to fire the kilns. The uncontrolled emission factors for the mineral sources and the combustion of coal, residual oil, and distillate oil are presented in Table 3.30-6. The uncontrolled emissions from mineral sources were calculated using the emission factor and the total cement production obtained from Reference 3.

The uncontrolled emissions from coal combustion were calculated using the emission factor, the coal consumed by cement plants obtained from Reference 3, and the sulfur content of the coal. The sulfur content was the average sulfur content for all coal shipped to industrial plants. The average sulfur content of coal was determined from the sulfur content by coal producing districts obtained for the category "Other industrial uses and retail dealers" in Reference 10a. This reference provided the sulfur content values reported in 1977 and it was assumed that these values remained constant during the years 1940 through 1984. In order to obtain the average sulfur content for a specific year, the sulfur content by district was weighted by the distribution of coal by district or origin for the category "Other Industrial" obtained from Reference 25 or 26.

The uncontrolled emissions from residual oil were calculated using the emission factor, the residual oil consumed by cement plants, and the sulfur content of the oil. The quantity of residual oil consumed by cement plants was assumed to be two-thirds of the total oil consumed by cement plants as reported in Reference 3. The sulfur content for residual oil was for No. 6 fuel oil obtained from Reference 27.

The uncontrolled emissions from distillate oil were calculated using the emission factor, the residual oil consumed by cement plants, and the sulfur content of the oil. The quantity of distillate oil consumed by cement plants was assumed to be one-third of the total oil consumed by cement plants as reported in Reference 3. The sulfur content for distillate oil was assumed to be 0.3 percent.

The uncontrolled emission factor for cement manufacturing was determined by dividing the total uncontrolled emissions from mineral sources and fuel combustion by the total cement production obtained from Reference 3. These calculations are summarized in the equation below:

$$EF_{SO_2, controlled} = \frac{E_{SO_2, uncontrolled}}{P_{cement}} \times (1 - CE_{SO_2, kilns})$$

where: EF = emission factor
 E = emissions
 P = production
 CE = control efficiency

The SO₂ control efficiency for kilns was interpolated from the TSP control efficiency for cement kilns. The TSP control efficiency is described in section 3.30.4.3. The interpolation of the SO₂ control efficiency from the TSP control efficiency was made using the following two reference points: TSP control efficiency of 0.99 corresponded to a SO₂ control efficiency of 0.1375 and TSP control efficiency of 0.95 corresponded to a SO₂ control efficiency of 0.12.

The SO₂ emission factor for glass manufacturing was the weighted average of the emission factor for the three types of glass: container glass, furnace (SCC 3-05-014-02), flat glass, furnace (SCCS-05-014-03), and blown glass, furnace (SCC 3-05-014-04). These emission factors were obtained from Reference 16c. The weighting factors were 0.75 for container glass, 0.15 for flat glass, and 0.1 for blown glass.

The SO₂ emission factor for lime processing was calculated by dividing the total actual SO₂ emissions by the lime production rate. These values were obtained from Reference 22.

3.30.3.5 Industrial Processes - VOC Emissions

The VOC emission factor for glass manufacturing was the weighted average of the emission factor for the three types of glass: container glass, furnace (SCC 3-05-014-02), flat glass, furnace (SCCS-05-014-03), and blown glass, furnace (SCC 3-05-014-04). These emission factors were obtained from Reference 16c. The weighting factors were 0.75 for container glass, 0.15 for flat glass, and 0.1 for blown glass.

3.30.4 Control Efficiency

3.30.4.1 Industrial Processes - CO, NO_x, SO₂, and VOC Emissions

No control efficiencies were applied to the activity data to estimate CO, NO_x, SO₂, or VOC emissions from the sources included in this Tier 2 category.

3.30.4.2 Industrial Processes - Particulates and PM-10 Emissions

3.30.4.2.1 Mineral Products Industry —

The TSP control efficiencies for all Mineral Products Industry production processes, except the fugitive processes, were derived from Reference 19 or Reference 20 using the equation given below. For any process where the emission factor was the weighted average of more specific emission factors, the control efficiency was calculated in the same manner. The more specific control efficiencies were derived using the equation given below.

$$CE = \frac{(UE \& AE)}{UE}$$

where: CE = control efficiency
UE = emissions before control
AE = emissions after control

The TSP control efficiencies for the fugitive processes in cement manufacturing and lime manufacturing were based on a best guess.

The PM-10 control efficiencies for all mineral products industry production processes, except the fugitive processes, for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from

Reference 24. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate the PM-10 emissions.

No control efficiencies were applied to the activity data to estimate PM-10 emissions from the fugitive processes in cement and lime manufacturing.

3.30.4.2.2 Mining Operations —

The TSP control efficiencies for all mining operations processes, except those described below, were derived from Reference 19 or Reference 20 using the equation given for the Mineral Products Industry processes. For any process where the emission factor was the weighted average of more specific emission factors, the control efficiency was calculated in the same manner. The more specific control efficiencies were derived using the equation given above.

For coal mining, pneumatic dryers, the TSP control efficiencies for the years 1980 through 1984 were obtained from Reference 23. No procedure for determining the control efficiencies for the years prior to 1980 is currently available.

The TSP control efficiency for clay production was the weighted average of the control efficiencies for the drying, grinding, and storage processes obtained from Reference 19 or Reference 20. The weighted average of these individual process control efficiencies was calculated in the same manner described for the clay emission factor. No procedure for determining the yearly variation in the control efficiencies is currently available.

The TSP control efficiency for potash production for the years 1981 through 1984 was assumed to be a constant value of 0.80. This value was based on a best guess. For the years prior to 1981, no control efficiency was applied to the activity data to estimate TSP emissions from potash production.

The PM-10 control efficiencies for coal mining thermal dryers, stone and rock crushing, phosphate rock production processes, clay production, and potash production for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 24. During these years, any changes in the corresponding TSP control efficiencies from the 1985 TSP control efficiency value were reflected in the PM-10 control efficiencies. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

3.30.4.2.3 Chemical Industry —

For rock pulverization, the TSP control efficiencies for the years 1974 through 1984 were obtained from Reference 23. For the years prior to 1974, no procedure to determine the TSP control efficiencies is currently available.

The PM-10 control efficiencies for rock pulverization for the years 1975 through 1984 were equal to the 1988 PM-10 control efficiency obtained from Reference 24. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

3.30.5 References

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5. *Current Industrial Reports, Glass Containers*. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Annual.
6. *Current Industrial Reports, Clay Construction Products*. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Annual.
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 - c. Volume I, Table 8.13-1
 - d. Volume I, Table 8.3-1
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Table 3.30-1. NO_x Emission Factor SCCs and Weighting Factors for Glass Manufacturing

SCC	Description	Weighting Factor
3-05-014-02	Container Glass: Melting Furnace	.75
3-05-014-03	Flat Glass: Melting Furnace	.15
3-05-014-04	Blown Glass: Melting Furnace	.10

Table 3.30-2. PM-10 and TSP Emission Factor SCCs for Kilns Used in Brick Manufacturing

SCC	Description
3-05-003-11	Curing and firing - gas fired tunnel kiln
3-05-003-12	Curing and firing - oil fired tunnel kiln
3-05-003-13	Curing and firing - coal fired tunnel kiln
3-05-003-14	Gas fired periodic kiln
3-05-003-15	Oil fired periodic kiln
3-05-003-16	Coal fired periodic kiln

Table 3.30-3. PM-10 and TSP Emission Factor SCCs for Clay Sintering

SCC	Description
3-05-009-03	Raw clay sintering
3-05-009-04	Crushing and screening
3-05-009-05	Transfer and conveying Storage
3-05-009-08	Finished product processing & screening

Table 3.30-4. PM-10 and TSP Emission Factor SCCs for Fiber Glass Furnaces

SCC	Description
3-05-012-01	Glass Furnace Wool - Regenerative
3-05-012-02	Glass Furnace Wool - Recuperative
3-05-012-03	Glass Furnace Wool - Electric
3-05-012-07	Glass Furnace Wool - Unit Melter
3-01-012-11	Glass Furnace Textile - Regenerative
3-05-012-12	Glass Furnace Textile - Recuperative
3-05-012-13	Glass Furnace Textile - Unit Melter

Table 3.30-5. PM-10 and TSP Emission Factor SCCs for Stone and Rock Crushing

SCC	Description
3-05-020-01	Primary Crushing
3-05-020-02	Secondary Crushing
3-05-020-03	Tertiary Crushing
3-05-020-04	Recrushing/Screening
3-01-020-06	Miscellaneous Operations

Table 3.30-6. Uncontrolled SO₂ Emissions Factors for Cement Manufacturing

Fuel	Emission Factor
Mineral Source	10.2 lb/ton cement produced
Coal	30.45 lb/ton coal consumed
Residual Oil	124.5 lb/1,000 gal residual oil consumed
Distillate Oil	112.35 lb/1,000 gal distillate oil consumed

3.31 SOLVENT UTILIZATION - DEGREASING: 08-01

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source category.

Category:

Industrial Processes - VOC Emissions

Subcategory:

Miscellaneous Industrial Processes [Other Processes (degreasing)]

3.31.1 Technical Approach

The VOC emissions included in this Tier category were the emissions from the source category listed above. Emissions were estimated from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, the activity indicator was expressed in thousand short tons and the emission factor was expressed in metric pounds/short ton.

The procedures for determining the activity indicator and emission factor were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.31.2 Activity Indicator

The activity indicator for degreasing was the weighted sum of the total consumption of six solvents as reported in References 1, 2 and 3. These solvents are listed in Table 3.31-1, along with the corresponding weighting factors, expressed as percentages, and references for consumption information.

$$Activity = \sum_{i=1}^n (S_i \times U_i)$$

where: S_i = total production/sales of solvent

U_i = fraction of S_i for end use as degreasing solvent (the "weighting factor" of Table 3.31-1)

3.31.3 Emission Factor

For this category, it was assumed that all of the solvents evaporated. Therefore, the VOC emission factor for degreasing was 2,000 lb/ton.

3.31.4 Control Efficiency

No control efficiencies were applied to the activity data to estimate VOC emissions from degreasing.

3.31.5 References

1. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
2. *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.
3. *Synthetic Organic Chemicals, United States Production and Sales*. USITC Publication 1745. U.S. International Trade Commission, Washington, DC. Annual.

Table 3.31-1. Solvents and Weighting Factors for Degreasing

Solvent	Weighting Factor (%)	Consumption References
Special Naphtha	6.7	1
Perchloroethylene	16.3	2
Trichloroethylene	98	3
Monochlorobenzene	20	3
Cyclohexanone	1	3
EB Glycol Ether	9	3

3.32 SOLVENT UTILIZATION - GRAPHIC ARTS: 08-02

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source category.

Category:

Industrial Processes - VOC Emissions

Subcategory:

Miscellaneous Industrial Processes [Other Processes (graphic arts)]

3.32.1 Technical Approach

The VOC emissions included in this Tier category were the emissions from the source category listed above. Emissions were estimated from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, the activity indicator was expressed in thousand short tons and the emission factor was expressed in metric pounds/short ton.

The procedures for determining the activity indicator and emission factor were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.32.2 Activity Indicator

The activity indicator for graphics arts was the weighted sum of the total consumption of four solvents, as reported in References 1, 2, and 3. These solvents are listed in Table 3.32-1, along with the corresponding weighting factors, expressed as percentages, and references for consumption information. To account for miscellaneous solvent usage, 1.8 percent of the weighted sum was added to obtain the final activity.

$$Activity = \sum_{i=1}^n (S_i \times U_i)$$

where: S_i = total production/sales of solvent

U_i = fraction of S_i for end use as degreasing solvent (the "weighting factor" of Table 3.32-1)

3.32.3 Emission Factor

For this category, it was assumed that all of the solvents evaporated. Therefore, the VOC emission factor for graphic arts was 2,000 lb/ton.

3.32.4 Control Efficiency

No control efficiencies were applied to the activity data to estimate VOC emissions from graphic arts.

3.32.5 References

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2. *Synthetic Organic Chemicals, United States Production and Sales*. USITC Publication 1745. U.S. International Trade Commission, Washington, DC. Annual.
3. *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.

Table 3.32-1. Solvents and Weighting Factors for Graphic Arts

Solvent	Weighting Factor (%)	Consumption References
Special Naphtha	6.4	1
Ethyl Acetate	20	2
Ethyl Benzene	0.025	3
EE Glycol Ether	5	2

3.33 SOLVENT UTILIZATION - DRY CLEANING: 08-03

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source category.

Category:

Industrial Processes - VOC Emissions

Subcategory:

Miscellaneous Industrial Processes [Other Processes (dry cleaning)]

3.33.1 Technical Approach

The VOC emissions included in this Tier category were the emissions from the source category listed above. Emissions were estimated from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, the activity indicator was expressed in thousand short tons and the emission factor was expressed in metric pounds/short ton.

The procedures for determining the activity indicator and emission factor were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.33.2 Activity Indicator

The activity indicator for dry cleaning was the weighted sum of the total consumption of two solvents, as reported in References 1 and 2. These solvents are listed in Table 3.33-1, along with the corresponding weighting factors, expressed as percentages, and references for consumption information.

3.33.3 Emission Factor

For this category, it was assumed that all of the solvents evaporated. Therefore, the VOC emission factor for dry cleaning was 2,000 lb/ton.

3.33.4 Control Efficiency

No control efficiencies were applied to the activity data to estimate VOC emissions from dry cleaning.

3.33.5 References

1. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
2. *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.

Table 3.33-1. Solvents and Weighting Factors for Dry Cleaning

Solvent	Weighting Factor (%)	Consumption References
Special Naphtha	2	1
Perchloroethylene (93.4%)	58.9	2

3.34 SOLVENT UTILIZATION - SURFACE COATINGS: 08-04

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source category.

Trends Category:

Industrial Processes - VOC Emissions

Trends Subcategory:

Surface Coating Operations,
Miscellaneous Industrial Processes [other processes (adhesives)], and
Miscellaneous Organic Solvent Extraction (architectural coating, auto refinishing, and other solvent use)

3.34.1 Technical Approach

The VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above, except for the Miscellaneous Organic Solvent Evaporation (other solvent use) subcategory. One-half of the VOC emissions for this subcategory are included in this Tier 2 category. Emissions were estimated from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.34.2 Activity Indicator

The activity indicator for adhesives was the weighted sum of the total consumption of the three following solvents: special naphtha, methyl ethyl ketone (MEK), and methyl isobutyl ketone (MIBK). The consumption data for special naphtha was obtained from Reference 1, MEK was obtained from Reference 2, and MIBK was obtained from Reference 3. The weighting factors for the three solvents were 1, 2.1, and 0.7, respectively. The activity indicator for this source category was the sum of the weighted consumption values.

The activity indicator for architectural coating processes was based on the quantity of paint shipped obtained from Reference 4 for the paint types listed in Table 3.34-1. The quantity of paint shipped was multiplied by the corresponding solvent content given in Table 3.34-1 for each paint type. The solvent content for the architectural coatings n. s. k. type was the weighted average of the solvent content values for the other architectural coating paint types subcategories. The weighting factors were the ratio of the quantity of paint shipped for the specific paint type divided by the total quantity of paint shipped for all of the architectural coating paint types. The activity indicator for this source category was the total amount of solvent contained in the total quantity of paint shipped for all paint types.

The activity indicator for auto refinishing was the quantity of paint shipped multiplied by a solvent content value of 11.95 lb/gal. The quantity of paint shipped was obtained from Reference 4 under the category "Automotive, other transportation and machinery refinish paints, and enamels, including primers."

The activity indicator for other solvent uses was based on the production of the solvents listed in Table 3.34-2, along with the references for these data values. The production values were converted to gallons and then to pounds using the conversion factors 43 gallons/barrel and 6.5 pounds/gallon, respectively. Each solvent production value was multiplied by the corresponding percentage consumption presented in Table 3.34-2 to obtain the solvent consumption. The values presented in Table 3.34-2 under "Solvent Consumption" were used when the referenced data was unavailable. The amount of each solvent included in this source category was the product of the solvent consumption and the corresponding percent miscellaneous solvent presented in Table 3.34-2. These products were summed and an additional 1.8 percent was added to account for miscellaneous solvents. This final result was the activity indicator for the other solvent use subcategory.

The activity indicators for the fourteen surface coating operations listed in Table 3.34-3 were based on the quantity of paint shipped obtained from Reference 4. For aircraft, railroads, and other metal products, the quantity of paint shipped was multiplied by 72.7, 27.3, and 6.5, respectively, to determine the quantity of paint included in those subcategories. The quantity of paint shipped was multiplied by the corresponding solvent content given in Table 3.34-3 for operation. The activity indicator for maintenance coatings subcategory was the sum of the activity for the interior and exterior paints as listed in Table 3.34-3.

The activity indicator for fabric coating operations was based on the textile production index obtained from Reference 1 or Reference 2. The index for 1983 and 1984 was multiplied by an adjustment factor of 3.96.

The activity indicator for plastics parts surface coating operations was based on the rubber and plastic production index obtained from Reference 1 or Reference 2. The index for 1983 and 1984 was multiplied by an adjustment factor of 0.59. For the years 1970 through 1982, the annual indices were multiplied by an adjustment factor of 0.254. Prior to 1970, the activity was assumed to be zero for plastics parts coating surface.

The activity indicator for paper coating operations was the quantity of solvents used in the production of paper and in the production of pressure tape and labels. The amount of solvents used in the production of paper was based on the quantity of paper produced as reported in Reference 4 under the classification "paper, paperboard, film and foil finishes". This production value was multiplied by the solvent content value of 38.8 lb/gal to obtain the quantity of solvent used in the production of paper.

The quantity of solvents used in the production of pressure tape and labels was based on the consumption of the four solvents listed in Table 3.34-4. The quantity of each solvent produced was obtained from the references provided in Table 3.34-4. Each production value was multiplied by the percent consumption to determine the quantity of solvent consumed and the percent of solvent use to determine the amount of each solvent used in the production of pressure tape and labels. These values are presented in Table 3.34-4. The total quantity of solvents used was the sum of the quantities of the individual solvents.

The final activity indicator for paper coating operations was the sum of the quantity of solvent used in the production of paper and in the production of pressure tape and labels.

The activity indicator for miscellaneous surface coating processes was sum of the quantities of solvents used for the three processes listed in Table 3.34-5 and the quantity of solvent "slop". The quantities of solvents used for the three processes listed in Table 3.34-5 were calculated from the quantity of paint shipped for each process obtained from Reference 4. Each of these production values were multiplied by the corresponding percentage of solvent consumed and solvent content. The resulting solvent quantities were summed over the three processes.

To this total was added solvent "slop". This quantity was based on the difference between the following two values: (1) total quantity of specific solvents consumed by surface coating operations and (2) quantity of solvents consumed by all within the surface coating operations. The first value was based on the production level of each solvent listed in Table 3.34-6 as reported in the references indicated. Production values were converted to gallons and then to pounds using the conversion factors 43 gallons/barrel and 6.5 pounds/gallon, respectively. Each solvent production value was multiplied by the corresponding percentage consumption presented in Table 3.34-6 to obtain the solvent consumption. The values presented in Table 3.34-6 under "Solvent Consumption" were used when the referenced data was unavailable. The amount of each solvent included was the product of the solvent consumption and the corresponding percent surface coating use presented in Table 3.34-6. These products were summed and an additional 1.8 percent was added to account for miscellaneous solvents. This final result was the total quantity of solvents consumed by surface coating operations.

The second value was the sum of the quantity of solvents consumed for operations listed in Table 3.34-7. In some cases, the solvents consumed by specific processes are excluded. The solvent "slop" value was calculated by subtracting this second value from the first value, as described above.

The final activity indicator for the miscellaneous surface coating processes was the sum of the quantity of solvents consumed by the three specific processes and from solvent "slop".

3.34.3 Emission Factor

For all source categories included in this Tier 2 category, it was assumed that all of the solvents evaporated completely. Therefore, the VOC emission factors for all operations were 2,000 lb/ton.

Beginning in 1970, the emission factors for the following operations were scaled by annual average control efficiencies: large appliances, magnet wire, automobiles, cans, metal coils, paper, fabric, metal furniture, wood furniture, plastic parts, aircraft, machinery, other metal products, and miscellaneous processes. An adequate procedure for determining the individual control efficiencies applied to the emission factors for each operation is currently unavailable.

3.34.4 Control Efficiency

No control efficiencies were applied to the activity data to estimate VOC emissions from surface coating operations included in this Tier 2 category.

3.34.5 References

1. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
2. *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.
3. *Synthetic Organic Chemicals, United States Production and Sales*. USITC Publication 1745. U.S. International Trade Commission, Washington, DC. Annual.
4. *Current Industrial Reports, Paint and Allied Products*. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Annual.

Table 3.34-1. Determination of Activity Indicator for Architectural Coating Processes:
Paint Types

Paint Type Category	Paint Type Subcategory	Solvent Content (lb/gal)
Architectural Coatings	Exterior Solvent Type	36.
	Exterior Water Type	.54
	Interior Solvent Type	3.3
	Interior Water Type	.56
	Architectural lacquers	5.0
	Architectural coatings n.s.k.	a
Traffic marking paints		3.89
Special purpose coatings n.s.k.		5.0
Aerosols		5.0

Table 3.34-2. Determination of Activity Indicator for Miscellaneous Organic Solvent
Extraction (other solvent use): Included Solvents

Compound	Solvent Production Reference	% Solvent Consumption	Solvent Consumption*	% Other Solvent Use
Special Naphthas	2	100	5461.6	5.2
n-Butanol	3	100	1269.0	0.4
Isobutanol	4	100	181.207	3.1
Butyl Acetates	4	84.2	212.4	40
Perchloroethylene	3	93.4	358.7	1
p-dichlorobenzene	4	100	90.3	90
Ethanol	3	100	549.0	35.6
EB Gly Ether	4	100	413.0	7
DM Gly Ether	4	100	46.9	30
Isopropanol	3	42	579.6	21.4
Methanol	3	95.3	7610.7	2.8
Miscellaneous**			565.9	

* Use default values used in the event that more appropriate numbers are not available.

** Compute Miscellaneous solvents consumption as 1.8 percent of the total consumption of all other solvents

Table 3.34-3. Determination of Activity Indicators for 14 Surface Coating Operations: Solvent Contents and Reference 4 Categories

Surface Coating Operation	Reference 4 Category	Solvent Content (lb/gal)
Large Appliances	Appliance, heating equipment, & air conditioner finishes	7.35
Magnet Wire	Electrical insulating coatings	8.48
Automobiles	Automobile finishes	6.95
Cans	Container and closure finishes	4.93
Metal Coils	Sheet, strip, and coil coatings, including siding	3.15
Metal Furniture	Nonwood furniture and fixture finishes, including business equipment finishes	8.61
Wood Furniture	Wood furniture, cabinet, and fixture finishes	20.78
Flat Wood Products	Wood and composition board flat stock finishes	4.50
Large ships	Marine Paints	5.65
Machinery	Machinery and equipment finishes, including road building equipment and farm	6.63
Maintenance Coatings	Industrial new construction & maintenance paints: Interior	5.66
	Industrial new construction & maintenance paints: Exterior	6.30
Aircraft	Other Transportation Equipment	0.5
Railroads	Other Transportation Equipment	3.83
Other Metal Products	Other Industrial Product Finishes	19.98

Table 3.34-4. Determination of Activity Indicator for Production of Pressure Tape and Labels: Solvents Used

Solvent Category	Reference	% Solvent Consumption	% Solvent Use
Special Naphthas	2	100	10.3
Butyl Acetate	4	84.2	42.3
MEK	3	100	15.8
MIBK	4	100	4.2

Table 3.34-5. Determination of the Activity Indicator for Miscellaneous Surface Coating Operations: Solvent Use in Three Processes

Process by Reference 4 category	% Solvent Consumed	Solvent Content (lb/gal)
Other Industrial Product Finishes	93.5	19.98
Product Finishes for OEM (n.s.k.)	100.0	19.98
Truck, bus, and RV	100.0	6.95

Table 3.34-6. Determination of Activity Indicator for Miscellaneous Surface Coatings Operations: Solvent Consumptions for Determination of Solvent "Slop"

Compound	Solvent Production Reference	% Solvent Consumption	Solvent Consumption*	% Surface Coating Use
Special Naphthas	2	100	5461.6	48.7
Acetone	3	89	1976.7	15.4
n-Butanol	3	100	1269.0	15.3
Isobutanol	4	100	181.207	16.7
Butyl Acetates	4	84.2	212.4	60
Cyclohexanone	4	100	1043.64	3.5
Ethyl Acetate	4	70	190.5	65
Ethanol	3	100	549.0	17.1
Ethylbenzene	3	100	8987.0	0.4
Propylene Glycol	3	100	800.0	5.7
EM Gly Ether	4	100	83.493	47
EE Gly Ether	4	100	117.8	40
EB Gly Ether	4	100	413.0	52
DM Gly Ether	4	100	46.9	70
DE Gly Ether	4	100	38.1	50
DB Gly Ether	4	100	9037	30
Isopropanol	3	42	579.6	21.2
Methyl Ethyl Ketone, MEK	3	100	473.0	85.4
Methyl Isobutyl Ketone, MIBK	4	100	426.9	71.9
Miscellaneous**			565.9	

* Use default values in the event that more appropriate numbers are not available.

** Compute Miscellaneous solvents consumption as 1.8 percent of the total consumption of all other solvents.

Table 3.34-7. Determination of Activity Indicator for Miscellaneous Surface Coatings Operations: Solvent Consumptions for All Surface Coating Operations for the Determination of Solvent "Slop"

Category	Subcategory	Excluded Sources
Surface Coating Operations	Large Appliances Automobiles Cans Metal Coils Paper Metal Furniture Wood Furniture Flat Wood Products Large Ships Aircraft Railroads Machinery Other Metal Products Miscellaneous Processes Maintenance Coatings	Pressure Tapes & Labels
Miscellaneous Organic Solvent Extraction	Architectural Coatings Auto Refinishing	Solvent "slop"

3.35 SOLVENT UTILIZATION - OTHER INDUSTRIAL: 08-05

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source category.

Category:

Industrial Processes - VOC Emissions

Subcategory:

Miscellaneous Industrial Processes [Other Processes (waste solvent recovery, miscellaneous organic solvent use, and solvent extraction) and Plastics Manufacturing (fabrication)]

3.35.1 Technical Approach

The VOC emissions included in this Tier category were the sum of the emissions from the Miscellaneous Industrial Processes (other processes - waste solvent recovery) source category multiplied by 0.78 and the emissions from the other source categories listed above. Emissions were estimated from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.35.2 Activity Indicator

The activity indicator for waste solvent recovery processes was assumed to be zero.

The activity indicator for miscellaneous organic solvent uses was the weighted sum of the total consumption of eight solvents, as reported in References 1, 2, and 3. These solvents are listed in Table 3.35-1, along with the corresponding weighting factors, expressed as percentages, and references for consumption information. To account for miscellaneous solvent usage, 7.1 percent of the weighted sum was added to obtain the final activity.

The activity indicator for solvent extraction processes was the weighted sum of the total consumption of two solvents, as reported in References 1, 2, and 3. These solvents are listed in Table 3.35-2, along with the corresponding weighting factors, expressed as percentages, and references for consumption information.

The activity indicator for plastics fabrication processes was the weighted sum of the total consumption of three solvents, as reported in References 1, 2, and 3. These solvents are listed in Table 3.35-3 along with the corresponding weighting factors, expressed as percentages, and references for consumption information.

3.35.3 Emission Factor

The VOC emission factor for waste solvent recovery processes was the sum of the emission factors for the five sources presented in Table 3.35-4. These emission factors were obtained from Reference 4a.

For miscellaneous organic solvent uses, solvent extraction processes, and plastics fabrication processes it was assumed that all of the solvents evaporated completely. Therefore, the VOC emission factors for these categories were 2,000 lb/ton.

3.35.4 Control Efficiency

No control efficiencies were applied to the activity data to estimate VOC emissions from the source included in this Tier 2 category.

3.35.5 References

1. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
2. *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.
3. *Synthetic Organic Chemicals, United States Production and Sales*. USITC Publication 1745. U.S. International Trade Commission, Washington, DC. Annual.
4. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - a. Volume I, Table 4.7-1

Table 3.35-1. Determination of Activity Indicator for Miscellaneous Organic Solvent Uses: Solvents, Weighting Factors, and References

Solvent	Weighting Factor (%)	Consumption References
Special Naphtha	1	1
Acetone (89.0%)	0.5	2 or 3
O-Dichloro-benzene	25	2 or 3
Ethanol	5.8	2
Ethylbenzene	0.075	2
EE Glycol Ether	12	3
EB Glycol Ether	12	3
Methanol (95.3%)	4.7	2

Table 3.35-2. Determination of Activity Indicator for Solvent Extraction Processes:
Solvents, Weighting Factors, and References

Solvent	Weighting Factor (%)	Consumption References
Methyl Ethyl Ketone	12.5	2
Methyl Isobutyl Ketone	8.9	3

Table 3.35-3. Determination of Activity Indicator for Plastics Fabrication Processes: Solvents, Weighting
Factors, and References

Solvent	Weighting Factor (%)	Consumption References
Special Naphtha	6.5	1
Ethyl Acetate	12	3
Ethylbenzene	0.25	2

Table 3.35-4. VOC Emission Factor SCCs for Waste Solvent Recovery
Processes

SCC	Description
4-90-002-01	Storage Tank Vent
4-90-002-02	Condenser Vent
4-90-002-03	Incinerator Stack
4-90-002-04	Solvent Spillage
4-90-002-05	Solvent Loading

3.36 SOLVENT UTILIZATION - NONINDUSTRIAL: 08-06

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source category.

Category:

Industrial Processes - VOC Emissions

Subcategory:

Miscellaneous Industrial Processes [Other Processes (fabric scouring)]
Miscellaneous Organic Solvent Evaporation (Cutback Asphalt Paving, Pesticides, and Other Solvent Use)

3.36.1 Technical Approach

The VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above, except for the Miscellaneous Organic Solvent Evaporation (other solvent use) category. One-half of the VOC emissions for this source category are included in this Tier 2 category. Emissions were estimated from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.36.2 Activity Indicator

The activity indicator for fabric scouring was the consumption of perchloroethylene, obtained from Reference 1, multiplied by 0.062.

The activity indicator for cutback asphalt paving were based on the total quantity of cutback asphalt obtained from Reference 2. For years since 1980, production figures for cutback paving asphalts reported in Reference 3 were used to update the 1980 emissions. It was assumed that the 1980 emissions were proportional to changes in cutback paving asphalt production.

The activity indicator for pesticides was the weighted sum of the total consumption of six solvents, as reported in References 4, 5, and 6. These solvents are listed in Table 3.36-1, along with the corresponding weighting factors, expressed as percentages, and references for consumption information.

The activity indicator for other solvent uses was based on the consumption of eleven solvents, as reported in References 4, 5, and 6. These solvents are listed in Table 3.36-2, along with the corresponding references for the consumption information. Consumption value for each solvent was converted to million pounds by using the following conversion factors: 42 gallons/barrel and 6.5 pounds/gallon. The consumption data for each

solvent was multiplied by the general consumption weighting factor and by the miscellaneous solvent use weighting factor in order to obtain the consumption of each solvent included within this category. Weighted solvent consumptions were summed and an additional 1.8 percent was added to account for miscellaneous solvent use.

3.36.3 Emission Factor

For all sources included in this Tier 2 category, it was assumed that solvents evaporated completely. Therefore, the VOC emission factors for fabric scouring, cutback asphalt paving, pesticides, and other solvent uses.

3.36.4 Control Efficiency

No control efficiencies were applied to the activity data to estimate VOC emissions from the source included in this Tier 2 category.

3.36.5 References

1. *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.
2. *Energy Data Reports, Sales of Asphalt in 1980*. U.S. Department of Energy, Washington, DC. June 1981.
3. *Asphalt Usage United States & Canada*. The Asphalt Institute, College Park, MD. Annual.
4. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
5. *Synthetic Organic Chemicals, United States Production and Sales*. USITC Publication 1745. U.S. International Trade Commission, Washington, DC. Annual.

Table 3.36-1. Determination of Activity Indicator for Pesticides: Solvents, Weighting Factors, and References

Solvent	Weighting Factor (%)	Consumption References
Special Naphthas	3.3	4
Isobutanol	3.2	5
m-chlorobenzene	30.0	5
Ethyl Benzene	0.19	1
EB Glycol Ether	13.0	5
MIBK	2.3	5

Table 3.36-2. Determination of Activity Indicator for Other Solvent Uses of Miscellaneous Organic Solvents: Solvents, Weighting Factors, and References

Solvent	General Consumption Weighting Factor (%)	Miscellaneous Consumption Weighting Factor (%)	Consumption References
Special Naphthas	100	5.2	4
n-Butanol	100	0.4	1
Isobutanol	100	3.1	5
Butyl Acetates	84.2	40.0	5
Perchloroethylene	93.4	1.0	1
p-dichlorobenzene	100	90.0	5
Ethanol	100	35.6	1
EB Glyco Ether	100	7.0	5
DM Glyco Ether	100	30.0	5
Isopropanol	42	21.4	1
Methanol	95.3	2.8	1

3.37 STORAGE AND TRANSPORT - BULK TERMINALS AND PLANTS: 09-01

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source category.

Category:

Industrial Processes - VOC Emissions

Subcategory:

Petroleum Marketing and Production [Bulk Gasoline Terminals (transfer and storage) and Gasoline Bulk Plants (transfer and storage)]

3.37.1 Technical Approach

The VOC emissions included in this Tier category were the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million barrels and emission factors were expressed in metric pounds/thousand barrels. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.37.2 Activity Indicator

The activity indicators for bulk gasoline terminal transfer and storage were the production of finished motor gasoline obtained from Reference 1a. This quantity was reported under the heading "Disposition: Products Supplied."

The activity indicators for bulk gasoline plant transfer and storage were 30 percent of the production of finished motor gasoline obtained from Reference 1a. This quantity was reported under the heading "Disposition: Products Supplied."

3.37.3 Emission Factor

For the years 1970 through 1984, the emission factors for all source categories included in this Tier 2 category were based on 1980 emissions data obtained from Reference 2 and 1979 production data from Reference 1. A more detailed procedure is currently unavailable.

For the years 1960, 1950, and 1940, the emission factors for all source categories, except for transport at bulk gasoline terminals, steadily increased from the 1970 value. No procedure for determining these emission factors is currently available.

3.37.4 Control Efficiency

No control efficiencies were applied to the activity data to estimate VOC emissions from transfer and storage at gasoline bulk plants. For the years 1974 through 1984, control efficiencies were applied to the activity data to estimate emissions from transfer and storage at gasoline bulk terminals. No procedure for determining these control efficiencies is currently available.

3.37.5 References

1. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
 - a. Table entitled, "Supply and Disposition of Crude Oil and Petroleum Products."
2. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. June 12, 1980.

3.38 STORAGE AND TRANSPORT - PETROLEUM AND PETROLEUM PRODUCT STORAGE:
09-02

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source category.

Category:

Industrial Processes - VOC Emissions

Subcategory:

Petroleum Marketing and Production [Gasoline Storage at Refineries, Crude Oil Storage (oil field storage and refinery storage), and Other Products (jet naphtha storage, jet naphtha transfer, kerosene storage, and distillate oil storage)]

3.38.1 Technical Approach

The VOC emissions included in this Tier category were the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million barrels and emission factors were expressed in metric pounds/thousand barrels. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.38.2 Activity Indicator

The activity indicator for gasoline storage at refineries was the production of finished gasoline obtained from Reference 1a.

The activity indicators for crude oil field storage was the total U.S. field production including lease condensate obtained from Reference 1b.

The activity indicators for crude refinery storage was the crude oil input to refineries obtained from Reference 1c.

The activity indicators for both jet naphtha transfer and jet naphtha storage were the production of naphtha-type jet fuel obtained from Reference 1c. The activity indicators for kerosene storage was the sum of kerosene-type jet fuel and kerosene obtained from Reference 1c. The activity indicator for distillate oil storage was the quantity of distillate fuel oil obtained from Reference 1c. These quantities were reported under the heading "Disposition: Products Supplied."

3.38.3 Emission Factor

For the years 1970 through 1984, the emission factors for crude oil storage at refineries, gasoline storage at refineries, jet naphtha storage, jet naphtha transfer, kerosene storage, and distillate oil storage were based on 1980 emissions data from Reference 2 and 1979 petroleum production data from Reference 1. A more detailed procedure is currently unavailable.

For the years 1960, 1950, and 1940, emission factors for crude oil storage at refineries and gasoline storage at refineries steadily increased from the 1970 value. The emission factors of the other sources listed above remained constant at the 1970 value. No procedure for determining these changing emission factors is currently available.

For the years 1970 through 1984, the emission factor for crude oil storage at oil fields was based on the typical losses from storage tank types. The losses were calculated using equations and typical values from Reference 3. The losses from the different tank types were weighted based on data from Reference 2. A more detailed procedure is currently unavailable. The emissions factors for the years 1960, 1950, and 1940 increased steadily over the 1970 value. No procedure for determining these emission factors is currently available.

3.38.4 Control Efficiency

No control efficiencies were applied to the activity data to estimate VOC emissions from the source included in this Tier 2 category, except for gasoline storage at refineries. For the years 1974 through 1984, control efficiencies were applied to the activity data to estimate emissions from gasoline storage at refineries. No procedure is currently available to determine these control efficiencies.

3.38.5 References

1. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
 - a. Table entitled, "Refinery Production of Petroleum Products by PAD District."
 - b. Table 1
 - c. Table entitled, "Supply and Disposition of Crude Oil and Petroleum Products."
2. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. June 12, 1980.
3. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.

3.39 STORAGE AND TRANSPORT - PETROLEUM AND PETROLEUM PRODUCT TRANSPORT: 09-03

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source category.

Category:

Industrial Processes - VOC Emissions

Subcategory:

Petroleum Marketing and Production [Refinery Product Loading (gasoline tank car and tanker and barge) Crude Oil Loading (tank car/truck, ship and barge, and tanker ballasting)]

3.39.1 Technical Approach

The VOC emissions included in this Tier category were the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million barrels and emission factors were expressed in metric pounds/thousand barrels. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.39.2 Activity Indicator

The activity indicator for refinery product loading of tankers and barges was the total movement of finished motor gasoline between the following PAD districts: from PAD III to PAD I, from PAD II to PAD II, from PAD III to PAD V, and from PAD V to PAD III. This information was obtained from Reference 1a.

The activity indicator for refinery product loading of gasoline tank cars was assumed to be 3.35 percent of the total U.S. production of finished gasoline obtained from Reference 1b.

The activity indicator for crude oil loading of tank cars/trucks was the total receipts of domestic tank cars and domestic trucks. The activity indicator for ship and barge loading was the total receipts of domestic crude oil on tankers and barges. The activity indicator for the tanker ballasting was one-half of the total receipts of domestic crude oil on tankers and barges added to the total receipts of foreign crude oil on tankers and barges. Information required for these activity indicators was obtained from Reference 1c.

3.39.3 Emission Factor

The emission factors for all sources included in this Tier 2 category were based on 1980 emissions data from Reference 2 and 1979 petroleum production data from Reference 1. The emission factors were constant for all years. More detailed procedures are currently unavailable.

3.39.4 Control Efficiency

No control efficiencies were applied to the activity data to estimate VOC emissions from the source included in this Tier 2 category, except for gasoline transfer at refineries. For the years 1974 through 1984, control efficiencies were applied to activity to estimate emissions from gasoline transfer at refineries. No procedure for determining these control efficiencies is currently available.

3.39.5 References

1. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
 - a. Table entitled, "Movements of Crude Oil and Petroleum by Tanker and Barge Between PAD District"
 - b. Table entitled, "Refinery Production of Petroleum Products by PAD District."
 - c. Table entitled, "Refinery Receipts of Crude Oil by Method of Transportation."
2. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. June 12, 1980.

3.40 STORAGE AND TRANSPORT - SERVICE STATIONS: STAGE I: 09-04

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source category.

Category:

Industrial Processes - VOC Emissions

Subcategory:

Petroleum Marketing and Production [Gasoline Service Stations (loading or stage 1)]

3.40.1 Technical Approach

The VOC emissions included in this Tier category were the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, the activity indicator was expressed in million barrels and the emission factor was expressed in metric pounds/thousand barrels. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.40.2 Activity Indicator

The activity indicator for gasoline service station loading or Stage 1 was the production of finished motor gasoline obtained from Reference 1a. This quantity was reported under the heading "Disposition: Products Supplied."

3.40.3 Emission Factor

The emission factor for gasoline service station loading for the years 1970 through 1984 was based on the 1980 emission data from Reference 2 and 1979 petroleum production data from Reference 1. A more detailed procedure is currently unavailable.

For the years 1960, 1950, and 1940, the emission factors steadily increased from the 1970 value. No procedure for determining these emission factors is currently available.

3.40.4 Control Efficiency

For the years 1978 through 1984, control efficiencies were applied to the activity to estimate VOC emissions from gasoline station loading. No procedure for determining these control efficiencies is currently available.

3.40.5 References

1. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
 - a. Table entitled, "Supply and Disposition of Crude Oil and Petroleum Products."
2. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. June 12, 1980.

3.41 STORAGE AND TRANSPORT - SERVICE STATIONS: STAGE II: 09-05

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source category.

Category:

Industrial Processes - VOC Emissions

Subcategory:

Petroleum Marketing and Production [Gasoline Service Stations (unloading or stage 2)]

3.41.1 Technical Approach

The VOC emissions included in this Tier category were the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million barrels and emission factors were expressed in metric pounds/thousand barrels. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.41.2 Activity Indicator

The activity indicator for gasoline service station unloading or stage 2 was the production of finished motor gasoline obtained from Reference 1a. This quantity was reported under the heading "Disposition: Products Supplied."

3.41.3 Emission Factor

The emission factor for gasoline service station unloading was based on 1980 emissions data from Reference 2 and 1979 petroleum production data from Reference 1. This value was used for all years. More detailed procedure is currently unavailable.

3.41.4 Control Efficiency

For the years 1979 through 1984, control efficiencies were applied to the activity data to estimate VOC emissions from gasoline service station unloading. No procedure for determining these control efficiencies is currently available.

3.41.5 References

1. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
 - a. Table entitled, "Supply and Disposition of Crude Oil and Petroleum Products."
2. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. June 12, 1980.

3.42 STORAGE AND TRANSPORT - ORGANIC CHEMICAL STORAGE: 09-07

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source category.

Category:

Industrial Processes - VOC Emissions

Subcategory:

Miscellaneous Industrial Products [Other Processes (waste solvent recovery)]
Manufacturing of Petrochemicals (Waste Disposal)]

3.42.1 Technical Approach

The VOC emissions included in this Tier category were the sum of the emissions from the Miscellaneous Industrial Processes (other processes - waste solvent recovery) source category multiplied by 0.22 and the emissions from the other source categories listed above. Emissions were estimated from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, the activity indicators were expressed in thousand short tons and the emission factors were expressed in metric pounds/short tons.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.42.2 Activity Indicator

The activity indicator for miscellaneous industrial waste solvent recovery was assumed to be zero.

The activity indicator for waste disposal in petrochemical manufacturing was based on the industrial organic chemical production index obtained from Reference 1.

3.42.3 Emission Factor

The VOC emission factor for waste solvent recovery was the sum of the emission factors for the five source listed in Table 3.42-1. Emission factors for these sources were obtained from Reference 2a.

The emission factor for waste disposal in petrochemical manufacturing was obtained from Reference 3.

3.42.4 Control Efficiency

No control efficiencies were applied to the activity data to estimate VOC emissions from the source included in this Tier 2 category.

3.42.5 References

1. *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.
2. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - a. Volume I, Table 4.7-1
3. *Organic Chemical Manufacturing, Volume 1: Program Report*. EPA-450/3-80-023. U.S. Environmental Protection Agency, Research Triangle Park, NC. December 1980.

Table 3.42-1. VOC Emission Factor SCCs for Waste Solvent Recovery

SCC	Description
4-90-002-01	Storage Tank Vent
4-90-002-02	Condenser Vent
4-90-002-03	Incinerator Stack
4-90-002-04	Solvent Spillage
4-90-002-04	Solvent Loading

3.43 WASTE DISPOSAL AND RECYCLING - INCINERATION: 10-01

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source category.

Category:

Solid Waste Disposal

Subcategory:

Incineration (Municipal, Residential, Commercial/Institutional, and Conical Woodwaste)

3.43.1 Technical Approach

The CO, NO_x, PM-10, TSP, SO₂, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emission factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million short tons and emission factors were expressed in metric pounds/short ton. All control efficiencies were expressed as dimensionless fractions.

The procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating emissions based on activity indicators, emission factors, and control efficiencies.

3.43.2 Activity Indicator

The activity indicator for municipal incineration was the sum of the operating rates for the SCCs 5-01-001-01 and 5-01-001-02 obtained from Reference 1 or 2.

The activity indicator for residential incineration was the operating rate for residential on-site incineration obtained from Reference 3.

The activity indicator for commercial/industrial incineration was based on the sum of the operating rates provided in Reference 1 or 2 for the following SCCs: 5-02-001-01, 5-02-001-02, 5-03-001-01, and 5-03-001-02. The total operating rates for these SCCs were calculated for the year under study and for the previous year. The activity indicator for the year under study was determined by scaling the activity indicator for the previous year with the rate of the total operating rates for the year under study and the previous year. The equation below summarizes this calculation.

$$AI_i = AI_{i\&1} \times \left(\frac{OR_i}{OR_{i\&1}} \right)$$

where: i = year
 AI = activity indicator
 OR = total operating rates

The activity indicator for conical woodwaste incineration was the sum of the operating rates for the SCCs 5-02-001-05 and 5-03-001-05 obtained from Reference 1 or 2.

3.43.3 Emission Factor

The emission factors for all pollutants except PM-10 and VOC for municipal incineration were obtained from Reference 4a for the starved air category. The TSP emission factor represented controlled emissions and, therefore, a separate TSP control efficiency was not used for this category. The PM-10 emission factor was obtained from Reference 6. The source of the VOC emission factor for this source is currently unavailable.

The emission factors for the residential category were the weighted average of the emission factors for the two types of domestic single chamber incinerators. These emission factors were obtained from Reference 4b for all pollutants except PM-10. The PM-10 emission factors for these incinerators were obtained from Reference 6 or Table 3.1-3. The weighting factor for the incinerator without a primary burner was 0.9 and with a primary burner was 0.1.

The emission factor for the commercial/institutional category were the weighted average of the emission factors for the two combustor types: multiple chamber (SCC 5-02-001-01) and single chamber (SCC 5-02-001-02). These emission factors for all pollutants except PM-10 were obtained from Reference 4c. The PM-10 emission factors were obtained from Reference 6. The weighting factor for the multiple chamber combustor was 0.85 and for the single chamber burner was 0.15.

The emission factors for all pollutants except PM-10 for the conical woodwaste category (SCC 5-02-001-05) were obtained from Reference 4d. The PM-10 emission factor was obtained from Reference 6.

3.43.4 Control Efficiency

No control efficiencies were applied to the activity data to estimate CO, NO_x, SO₂, TSP, or VOC emissions from solid waste disposal processes.

The PM-10 control efficiencies for incineration of municipal and commercial and industrial waste for the years 1975 through 1984 were based on the 1988 PM-10 control efficiencies obtained from Reference 5. For the years 1940 through 1974, no control efficiencies were used to estimate PM-10 emissions.

3.43.5 References

1. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
2. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
3. *Standard Computer Retrievals, NE260 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
4. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - a. Volume I, Table 2.1-1
 - b. Volume I, Table 2.1-4
 - c. Volume I, Table 2.1-3
 - d. Volume I, Table 2.3-1
5. Barnard, William R. and Patricia M. Carlson. "PM-10 Emission Control Efficiency Calculations for Emissions Trends." Prepared for Arch A. MacQueen, U.S. Environmental Protection Agency, Research Triangle Park, NC. October 1990.
6. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listings for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

3.44 WASTE DISPOSAL AND RECYCLING - OPEN BURNING: 10-02

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source category.

Category:

Solid Waste Disposal

Subcategory:

Open Burning (dumps and on-site)

3.44.1 Technical Approach

The CO, NO_x, PM-10, TSP, SO₂, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million short tons and emission factors were expressed in metric pounds/short ton.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating emissions based on activity indicators and emission factors.

3.44.2 Activity Indicator

The activity indicator for open burning dumps was the sum of the operating rates for open burning dumps (SCCs 5-01-002-01 and 5-01-002-02) obtained from Reference 1 or 2.

The activity indicator for on-site open burning was the sum of the operating rate for open burning (SCCs 5-02-002-01, 5-02-002-02, 5-03-002-01, 5-03-002-02, 5-03-002-03, and 5-03-002-04) obtained from Reference 3.

3.44.3 Emission Factor

The emission factors for all pollutants except PM-10 for both open burning sources were obtained from Reference 4a. The PM-10 emission factors were obtained from Reference 5.

3.44.4 Control Efficiency

No control efficiencies were applied to the activity data to estimate emissions from solid waste disposal processes.

3.44.5 References

1. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
2. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
3. *Standard Computer Retrievals, NE260 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
4. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - a. Volume I, Table 2.4-1
5. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listing for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

3.45 WASTE DISPOSAL AND RECYCLING - OTHER: 10-07

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source category.

Category:

Industrial Processes - VOC Emissions

Subcategory:

Manufacturing of Petrochemicals (waste disposal)

3.45.1 Technical Approach

The VOC emissions included in this Tier category were the emissions from the source category listed above. Emissions were estimated from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, the activity indicator was expressed in thousand short tons and the emission factor was expressed in metric pounds/short tons.

The procedures for determining activity indicator and emission factor were used for the years 1940, 1950, 1960, and 1970 through 1984.

3.45.2 Activity Indicator

The activity indicators for the disposal of waste from the manufacture of petrochemicals was based on the industrial organic chemical production index obtained from Reference 1.

3.45.3 Emission Factor

The VOC emission factor for this source category was obtained from Reference 2.

3.45.4 Control Efficiency

No control efficiencies were applied to the activity data to estimate VOC emissions from solid waste disposal processes.

3.45.5 References

1. *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.
2. *Organic Chemical Manufacturing, Volume 1: Program Report*. EPA-450/3-80-023. U.S. Environmental Protection Agency, Research Triangle Park, NC. December 1980.

3.46 HIGHWAY VEHICLES: 11

The emissions for all Tier 2 categories under this Tier 1 category were determined by the 1940-1984 Methodology for the following source category:

Category:	Subcategory:
Highway Vehicles	Gasoline [Passenger Cars (LDGV), Light Duty Trucks 1 (LDGT1), Light Duty Trucks 2 (LDGT2), Heavy Duty Trucks (HDGV), and Motorcycles (MC)] Diesel [Passenger Cars (LDDV), Light Trucks (LDDT), and Heavy Duty Trucks (HDDV)]

3.46.1 Technical Approach

Highway vehicle emissions for the years 1940, 1950, and 1960 were estimated at the national level for CO, NO_x, and VOC (modeled as nonmethane organic gases (NMOG)). The emissions were based on vehicles miles traveled (VMT) and mobile emission factors. The emissions were calculated for eight vehicle types (five gasoline-powered vehicle types and three diesel-powered vehicle types, as listed above) and three road types (limited access roads, urban roads, and rural roads).

3.46.2 Activity Indicator

The activity indicator was national VMT data for each vehicle type and road type as shown in Tables 3.46-1, 3.46-2, and 3.46-3 for 1940, 1950, and 1960, respectively. These data were developed from VMT data from Reference 1 and redistributed by vehicle type and road type using information from References 2 and 3.

Difficulty arises in determining the VMT due to the fact that the EPA vehicle classifications do not correspond directly to the classifications reported in Highway Statistics, Reference 1. As a result, the reported VMTs will need to be reclassified.

The following procedures were performed except for those instances where the data was not available then assumptions were made. These assumptions were not documented and therefore cannot be included in this report.

Step 1.

Tables VM-1 and VM-2 from the latest version of Highway Statistics, Reference 1 were obtained.

Step 2.

The total national VMTs for each EPA vehicle classification were calculated as follows:

For LDDV: The latest issue of the Market Data Book, Reference 3 was obtained. From this document, the total number of original sales of diesel passenger cars for the latest model year were extracted. The estimate of the number of LDDV surviving by calendar year since 1968 was calculated as follows:

$$LDDV \text{ surviving by model year} = \left[\begin{array}{c} \text{passenger car survival} \\ \text{rate by age} \end{array} \right] \times \left[\begin{array}{c} LDDV \text{ original} \\ \text{sales by model year} \end{array} \right]$$

Where the passenger car survival rates were found in Reference 2.

For LDGV: The total VMT for LDDV was subtracted from the total passenger car VMT reported in VM-1 to get the total number of VMT for LDGV.

For LDGT1, LDGT2, and HDGV: The number of truck sales by weight category was obtained from Reference 2. For example, in the 1986 edition these values were in the two tables entitled "Retail Sales of New Trucks by Gross Vehicle Weight and Body Type" and "Total Retail Sales of New Trucks in the United States." The U.S. factory sales of domestic trucks was obtained from Reference 2. It was assumed that all imports are in the 0 - 6,000-lb class. The sales of each truck class were calculated as follows:

$$Sales \text{ LDGT1} = RS_{0 \text{ to } 6K} \% I \& DFS_{0 \text{ to } 6K}$$

$$Sales \text{ LDGT2} = RS_{6 \text{ to } 10K} \& VCC \& M \& 0.05 \times CP \& DFS_{6 \text{ to } 10K} \& DT_{10 \text{ to } 14K}$$

$$Sales \text{ HDGT} = VCC \% M \% 0.05 \times CP \& HDDT \% RS_{>10K}$$

$$Sales \text{ LDDT} = DFS_{0 \text{ to } 6k} \% 0.1 \times DFS_{6 \text{ to } 10k}$$

$$Sales \text{ HDDT} = 0.9 \times DFS_{6 \text{ to } 10k} \% DFS_{10 \text{ to } 14k} \% DFS_{14 \text{ to } 16k} \\ \% DFS_{16 \text{ to } 19.5k} \% DFS_{19.5 \text{ to } 26k} \% DFS_{26 \text{ to } 33k} \% DFS_{733k}$$

where: RS = retail sales of domestic trucks
 I = retail sales of import trucks
 DFS = factory sales of diesel trucks
 VCC = retail sales of van cutaway chassis
 M = retail sales of multistops
 CP = retail sales of conventional pickups
 HDDT = sales HDDT, also calculated above.

Step 3.

This next step converted the original sales of trucks into the number of trucks actually operating. For each of the past 20 years, the ratio of the total number of trucks operating to the total number of sales was calculated using the table entitled "Trucks in Operation by Model Year" from Reference 2. The number of trucks in each category operating by model year was then calculated by multiplying the ratio for the given year by the estimated retail sales for the year of interest. The following equation was used:

$$LDGT1 = RS_{iLDGT1} \times \frac{TT_i}{TRS_i}$$

where: LDGT1 = number of trucks in this category
 RS_{ixxx} = retail sales for year i and truck type xxx
 TT_i = total number of trucks operating for year i from Reference 2
 TRS_i = total retail sales of trucks for year i.

The same procedure was repeated for each vehicle classification.

Note: The MVMA report, Reference 2, may only give operating and sales statistics for the past 16 years. Yet, this must be completed for the past 20 years. This can be done by estimating the number of trucks in operation for the i-16th through i-19th years as follows:

$$\text{Model yr } i-16 \text{ trucks in operation in calendar year } i \left[1 - \left(\frac{\text{Model yr } i-14 \text{ trucks in operation}}{\text{Model yr } i-14 \text{ trucks in operation}} \times \frac{\text{Model yr } i-15 \text{ trucks in operation}}{\text{Model yr } i-14 \text{ trucks in operation}} \right) \right] \times \text{Model yr } i-15 \text{ trucks in operation}$$

Step 4.

The total number of VMT by vehicle class is calculated next. This was done by multiplying the number of trucks for each year by the corresponding VMT value. The exception to this procedure was the calculation for HDDT, in which the average of all factory sales data available in each weight class was used to weight the VMT subtotals. The following equation was used:

$$HDDT' = \frac{VMT_{HDD\&2B} \times 0.9 \times \text{avg}[DFS_{HDD\&2B}] \% VMT_{LHDD} \times \text{avg}[DFS_{LHDD}] + VMT_{MHDD} \times \text{avg}[DFS_{MHDD}] \% VMT_{HHDD} \times \text{avg}[DFS_{HHDD}]}{0.9 \times \text{avg}[DFS_{HDD\&2B}] \% \text{avg}[DFS_{LHDD}] \% \text{avg}[DFS_{MHDD}] \% \text{avg}[DFS_{HHDD}]}$$

where: VMT = vehicle miles travelled
 avg (DFS) = "U.S. factory sales of diesel trucks" data available from MVMA, Reference 9, for respective weight class weighted by information on trucks in use by age, available from MVMA, Reference 2.

The totals were then sum on each vehicle type. The estimates were then normalized to the total number of VMT reported in VM-1 for all trucks and buses. This was done by multiplying each of the total VMTs for each truck category by the ratio of the total VMT reported in VM-1 to the total VMT estimated above.

Step 5.

Next the fraction of the VMT reported for "Other Urban" in Table VM-1 for 55 MPH and 19.6 MPH was calculated as follows.

$$OU_{55MPH} = \frac{\text{Other Freeways} \% \text{Other Principal Arterial}}{\text{Other Urban}}$$

$$OU_{19.6MPH} = \frac{\text{Minor Arterial} \% \text{Collector} \% \text{Local}}{\text{Other Urban}}$$

where: OU = Other Urban VMT obtained from Table VM-1.

All other values obtained from Table VM-2.

Step 6.

The total VMTs by vehicle type were then divided into 3 road speed categories: 55 MPH, 45 MPH, and 19.6 MPH. For each vehicle type, the VMTs were added together for all road speed categories and the fraction of total VMT represented by each speed category was computed using the following formulas:

$$Fraction_{55MPH,i} = \text{Interstate Rural}_i \% \text{Other Rural}_i \% \text{Interstate Urban}_i \% OU_{55MPH} \times \text{Other Urban}_i$$

$$\text{Fraction}_{45\text{MPH},i} = \frac{\text{Other Rural}_i}{\text{Total Rural and Urban}_i}$$

$$\text{Fraction}_{19.6\text{ MPH}} = \frac{OU_{19.6\text{ MPH}} \times \text{Other Urban}_i}{\text{Total Rural and Urban}_i}$$

where: i = vehicle type (personal passenger vehicles, 2-axle 4-tire single unit trucks, combination trucks)
 $OU_{55\text{MPH}}$ = value calculated in above equations
 $OU_{19.6\text{MPH}}$ = value calculated in above equations

All other values taken from Table VM-1.

The fractions computed for the VMTs for "Personal Passenger Vehicles" were used to represent the distribution of VMT for LDGV, LDDV, and MC by road speed categories. The fractions were then multiplied by the total VMT for those categories to obtain VMT for each road speed category for each vehicle class. The fraction computed for "2-axle, 4-tire single-unit trucks" was used to distribute total VMT for LDGT1, LDGT2, and LDDT. The fractions computed for "combinations" were used to distribute HDDT and HDGT. As a final QA check, the VMT for each road speed category and MOBILE3 vehicle class was summed to verify that the total VMT agreed with the total VMT in Table VM-1.

3.46.3 Emission Factors

The emission factors for CO, NO_x, and NMOG, were determined using EPA's MOBILE5 model as documented in Reference 4. This model required information on the following parameters: calendar year, vehicle speeds, temperature, vehicle operating mode, vehicle registration distribution, Reid vapor pressure (RVP), and altitude. For the years 1940, 1950, and 1960, national annual average conditions were used as inputs into MOBILE5 to determine national emission factors for each unique combination of vehicle type, vehicle speed, and altitude.

The earliest calendar year for which highway vehicle emission factors can be estimated using MOBILE5 is 1960. Therefore, the emission factors for 1940, 1950, and 1960 were all modeled using a calendar year of evaluation of 1960. The use of 1960 as the calendar year for each of these years gives reasonable results since no emission standards were in place before 1960.

Three speeds were modeled in each of the years evaluated. A single speed was selected to represent each of three road classes — urban, rural, and limited access roads. In 1940 and 1950, the speeds modeled to correspond with each of these road classes were 19.6 mph for urban roads, 35 mph for rural roads, and 45

mph for limited access roads. In 1960, the modeled speeds were 19.6 mph for urban roads, 45 mph for rural roads, and 55 mph for limited access roads.

Two sets of temperature data were used in the modeling. For low altitude areas, the average maximum daily temperature modeled was 65°F and the average minimum daily temperature modeled was 41°F. For high altitude areas, the average maximum daily temperature modeled was 62°F and the average minimum daily temperature modeled was 38°F. These temperatures were selected to be representative of national average daily temperature conditions for low and high altitude areas.

In all of the MOBILE5 modeling, the operating mode assumptions of the Federal Test Procedure (FTP) were used. In the FTP operating mode, 20.6 percent of all VMT is accumulated in the cold start mode, 27.3 percent of all VMT is accumulated in the hot start mode, and 52.1 percent of all VMT is accumulated in the hot stabilized mode.

A national registration distribution was developed for 1970 based on the cars and trucks in operation by model year obtained from Reference 2 and on truck sales data from References 2 and 3. This registration distribution was used in determining the emission factors for the years 1940, 1950, and 1960 and is presented in Table 3.46-4.

The gasoline volatility, or RVP for the years 1940, 1950 and 1960 was modeled at 10.1 psi. Separate emission factors were calculated for high and low altitude areas.

Based on these input values for each year, the MOBILE5 model produced year-specific CO, NO_x, and NMOG emission factors for each combination of vehicle type, road type, and altitude.

The emission factors for PM-10, SO₂, and TSP are presented in Table 3.46-5. The procedure for determining these emission factors is currently unavailable.

3.46.4 Calculation of Emissions

Average national emission factors for CO, NO_x, and NMOG by vehicle type and road type were calculated by weighting the high and low altitude emission factors by the proportion of the VMT estimated for each of these two altitude groups. It was estimated that 93.5 percent of national VMT was accumulated in low altitude areas and the remaining 6.5 percent of VMT was accumulated in high altitude areas. These national average emission factors by vehicle type and road type were then multiplied by the corresponding national VMT by vehicle type and road type to estimate total national annual emissions for CO, NO_x, and NMOG from highway vehicles in 1940, 1950, and 1960.

The national annual PM-10, SO₂, and TSP emissions were calculated using the total VMT and emission factors by vehicle type as presented in Tables 3.46-1, 3.46-2, 3.46-3 and 3.46-5.

3.46.5 References

1. *Highway Statistics*. Federal Highway Administration, U.S. Department of Transportation, Washington, DC. Annual.
2. *AAMA Motor Vehicle Facts and Figures 19xx*. American Automobile Manufacturers Association of the United States, 1620 Eye Street, N.W., Suite 1000, Washington, DC. Annual.
3. *19xx Market Data Book*. Automotive News. 965 E. Jefferson Ave., Detroit, MI. Annual.
4. *User's Guide to MOBILE5 (Mobile Source Emissions Model), Chapter 2*. Draft. Office of Mobile Sources, U.S. Environmental Protection Agency, Ann Arbor, MI. December 1992.

Table 3.46-1. 1940 VMT by Road Type

Vehicle Type	VMT (billion miles per year)			
	Limited Access Roads	Urban Roads	Rural Roads	Total VMT
Gasoline				
Passenger Cars	93.4	96.6	59.1	249.1
Light duty Trucks 1	9.8	7.7	8.5	26.0
Light duty Trucks 2	2.5	1.9	2.1	6.5
Heavy duty Trucks	8.5	6.1	5.4	20.0
Motorcycles	0.2	0.1	0.1	0.4
Diesel				
Passenger Cars	0.0	0.0	0.0	0.0
Light Trucks	0.0	0.0	0.0	0.0
Heavy duty Trucks	0.0	0.0	0.0	0.0
Total	114.4	112.4	75.2	302.0

Table 3.46-2. 1950 VMT by Road Type

Vehicle Type	VMT (billion miles per year)			
	Limited	Urban	Rural	Total
	Access Roads	Roads	Roads	VMT
Gasoline				
Passenger Cars	147.0	127.2	87.8	362.0
Light duty Trucks 1	17.1	11.9	14.1	43.1
Light duty Trucks 2	4.3	2.9	3.5	10.7
Heavy duty Trucks	16.8	9.5	11.6	37.9
Motorcycles	0.6	0.6	0.4	1.6
Diesel				
Passenger Cars	0.0	0.0	0.0	0.0
Light Trucks	0.0	0.0	0.0	0.0
Heavy duty Trucks	1.6	0.6	0.7	2.9
Total	187.4	152.7	118.1	458.2

Table 3.46-3. 1960 VMT by Road Type

Vehicle Type	VMT (billion miles per year)			
	Limited	Urban	Rural	Total
	Access Roads	Roads	Roads	VMT
Gasoline				
Passenger Cars	256.8	184.5	144.8	586.1
Light duty Trucks 1	24.5	15.0	19.2	58.7
Light duty Trucks 2	6.1	3.8	4.7	14.6
Heavy duty Trucks	21.7	9.0	12.7	43.4
Motorcycles	1.0	0.6	0.4	2.0
Diesel				
Passenger Cars	0.0	0.0	0.0	0.0
Light Trucks	0.0	0.0	0.0	0.0
Heavy duty Trucks	7.9	2.7	2.3	12.9
Total	318.0	215.6	184.1	717.7

Table 3.46-4. National Vehicle Registration Distribution used in Determining Emission Factors for the Years 1940, 1950, and 1960

Number of Years Preceding Current Year	Vehicle Types							
	LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT	HDDV	MC
-1	0.081	0.085	0.1	0.058	0.081	0.085	0.104	0.133
-2	0.111	0.119	0.122	0.077	0.111	0.119	0.132	0.145
-3	0.105	0.094	0.109	0.071	0.105	0.094	0.11	0.138
-4	0.102	0.093	0.094	0.082	0.102	0.093	0.114	0.116
-5	0.099	0.085	0.086	0.072	0.099	0.085	0.098	0.123
-6	0.096	0.078	0.072	0.073	0.096	0.078	0.085	0.114
-7	0.089	0.073	0.068	0.07	0.089	0.073	0.08	0.069
-8	0.082	0.063	0.058	0.066	0.082	0.063	0.062	0.044
-9	0.068	0.052	0.048	0.061	0.068	0.052	0.048	0.024
-10	0.05	0.04	0.037	0.053	0.05	0.04	0.033	0.009
-11	0.036	0.036	0.034	0.052	0.036	0.036	0.03	0.084
-12	0.024	0.03	0.028	0.042	0.024	0.03	0.025	0.001
-13	0.014	0.025	0.023	0.035	0.014	0.025	0.019	0
-14	0.01	0.024	0.022	0.034	0.01	0.024	0.017	0
-15	0.008	0.02	0.018	0.027	0.008	0.02	0.014	0
-16	0.006	0.02	0.019	0.029	0.006	0.02	0.01	0
-17	0.006	0.016	0.016	0.025	0.006	0.016	0.006	0
-18	0.006	0.018	0.017	0.028	0.006	0.018	0.004	0
-19	0.005	0.013	0.014	0.021	0.005	0.013	0.004	0
-20	0.001	0.003	0.003	0.004	0.001	0.003	0.001	0
-21	0.001	0.003	0.002	0.003	0.001	0.003	0.001	0
-22	0	0.002	0.002	0.003	0	0.002	0.001	0
-23	0	0.002	0.002	0.002	0	0.002	0.001	0
-24	0	0.002	0.001	0.002	0	0.002	0	0
-25	0.001	0.005	0.005	0.009	0.001	0.005	0.001	0

Table 3.46-5. PM-10, TSP, and SO₂ Highway Vehicles Emission Factors for 1940, 1950, and 1960

Vehicle Type	PM-10 (lb/thousand VMT)			TSP (lb/thousand VMT)			SO ₂ (lb/thousand VMT)		
	1940	1950	1960	1940	1950	1960	1940	1950	1960
Gasoline									
Passenger Cars	1.28	1.21	1.42	1.36	1.28	1.5	NA	NA	NA
Light duty Trucks 1	1.3	1.24	1.46	1.38	1.32	1.54	NA	NA	NA
Light duty Trucks 2	1.37	1.27	1.35	1.53	1.41	1.51	NA	NA	NA
Heavy duty Trucks	2.88	2.69	3.15	2.88	2.69	3.15	0.1	0.81	0.54
Motorcycles	0	0	0.77	0	0	0.77	NA	NA	NA
Diesel									
Passenger Cars	NA	NA	NA	NA	NA	NA	NA	NA	NA
Light Trucks	NA	NA	NA	NA	NA	NA	NA	NA	NA
Heavy duty Trucks	NA	6.51	2.39	NA	6.51	2.30	NA	NA	NA

3.47 OFF-HIGHWAY - NONROAD GASOLINE: 12-01

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source categories.

Category:	Subcategory:
Other Off-Highway	Gasoline (Farm Tractors, Other Farm Equipment, construction, Snowmobiles, Small Utility Engines, Heavy Duty General Utility Engines, Motorcycles)
Vessels	Gasoline

3.47.1 Technical Approach

The CO, NO_x, PM-10, TSP, SO₂, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. For all pollutants except PM-10, the emissions were estimated from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million gallons and emission factors were expressed in metric pounds/thousand gallons.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, and 1960 for CO, NO_x, SO₂, and VOC and for TSP the procedures were used for the years 1940, 1950, 1960, and 1970 through 1992.

The estimation of PM-10 emissions for the years 1940, 1950, and 1960 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating the emissions based on activity indicators and emission factors.

The 1975 PM-10 emissions were determined using the 1975 activity indicators as described in section 3.47.2 and the 1975 PM-10 emission factors. The PM-10 emission factors for all sources except gasoline-powered heavy duty general utility engines were determined from the corresponding TSP emission factors and the particle size distributions obtained from Reference 7a. For snowmobiles and motorcycles, the size distribution for unleaded gasoline was used. For the other gasoline-powered engines, the leaded gasoline size distribution was used. The emission factor for gasoline-powered heavy duty general utility engines was obtained for SCC 2-02-003-01 from Reference 10.

3.47.2 Activity Indicator

The activity indicator for gasoline-powered farm tractors was based on the 1973 gasoline consumption by farm tractors. The 1973 consumption was adjusted to the year under study using the ratio of the quantity of gasoline consumed by all agricultural equipment in 1973 to the quantity in the year under study. These data were obtained from Reference 2a.

$$GC_{Tractor, i} = GC_{Tractor, 1973} \times \frac{GC_{Agriculture, i}}{GC_{Agriculture, 1973}}$$

where: i = year under study
GC = gasoline consumption

The activity indicator for other gasoline-powered farm equipment was based on gasoline consumption. Gasoline consumption by other farm equipment was assumed to be equivalent to 8.52 percent of the quantity of gasoline consumed by farm tractors as determined by the preceding procedure.

The activity indicator for gasoline-powered construction equipment was the total gasoline consumption by construction equipment as reported in Reference 2.

The activity indicator for gasoline-powered snowmobiles was based on the 1973 gasoline consumption by snowmobiles as reported in Reference 1. The 1973 consumption data was adjusted to the year under study using the ratio of the number of snowmobile registrations in 1973 and in the year under study as reported in Reference 3. The following formula summarizes this procedure.

$$GC_{Snowmobiles, i} = GC_{Snowmobiles, 1973} \times \frac{R_{Snowmobiles, i}}{R_{Snowmobiles, 1973}}$$

where: i = year under study
GC = gasoline consumption
R = registration of snowmobiles

The activity indicator for small utility gasoline engines was based on the 1980 gasoline consumption by small engines (533×10^6 gallons). The 1980 consumption data was adjusted to the year under study using the ratio of the number of single unit dwellings in 1980 and in the year under study. The number of single unit dwellings in 1980 was obtained from Reference 4. For the year under study, the number of single unit dwellings was estimated by adjusting the number of single unit dwellings in 1980 with the number of new one-family structures started each year between 1980 and the year under study. The number of new one-family structure started was obtained from Reference 5 for each year. The following formula summarizes this procedure.

$$GC_{Small\ Engines, i} = 533 \times 10^6 \text{ gal} \times \frac{Single\ Unit\ Dwellings_i}{Single\ Unit\ Dwellings_{1980}}$$

where: i = year under study
 GC = gasoline consumption

The activity indicator for heavy duty general utility gasoline engines was the total gasoline consumed by the industrial commercial category obtained from Reference 2.

The activity indicator for motorcycles was the gasoline consumption calculated from the number of motorcycles, the average annual off-highway mileage traveled, and the median estimated average miles per gallon. The motorcycle population and the off-highway mileage were obtained from Reference 6. The average miles per gallon (MPG) was assumed to be 44.0. The following equation summarizes this calculation.

$$GC_{Motorcycles} = Number\ of\ Motorcycles \times \frac{Off\&\ Highway\ Mileage}{MPG}$$

The activity indicator for gasoline-powered vessels was the total quantity of gasoline consumed by the marine sector (private and commercial) from Reference 2a.

3.47.3 Emission Factor

The emission factors for gasoline-powered farm tractors and other farm equipment were obtained from Reference 7b for all pollutants except PM-10. The VOC emission factors were multiplied by the reactive VOC fraction of 0.918, based on data for profile 90-6021D from Reference 5.

The emission factors for all pollutants, except PM-10, for gasoline construction equipment were the weighted averages of the emission factors for five equipment types. These equipment types and corresponding weighting factors are listed in Table 3.47-1. Emission factors for each equipment type were obtained from Reference 7c. The VOC emission factor was multiplied by the reactive VOC fraction of 0.918. This fraction was based on data for profile 90-6021D from Reference 8.

The emission factors for snowmobiles were obtained from Reference 7d for all pollutants except PM-10. The VOC emission factors were multiplied by the reactive VOC fraction of 0.918, based on data for profile 90-6021D from Reference 8.

The emission factors for all pollutants, except PM-10, for small gasoline utility engines were the weighted averages of the emission factors for five equipment types. These equipment types and corresponding weighting factors are listed in Table 3.47-2. Emission factors for each type were obtained from Reference 7e. The VOC

emission factor was multiplied by the reactive VOC fraction of 0.918, based on data for profile 90-6021D from Reference 8.

The emission factors for heavy duty general utility gasoline engines were obtained from Reference 7f for all pollutants except PM-10. The VOC emission factors were multiplied by the reactive VOC fraction of 0.918, based on data for profile 90-6021D from Reference 8.

The emission factors for all pollutants, except PM-10, for motorcycles were obtained from the MOBILE 2 (1978 version) model. Specific parameters used in the model are provided in Table 3.47-3. Resulting emission factors, expressed as grams/vehicle miles traveled (VMT) were converted to lbs/1,000 gal using the factor 20.8.

The CO, NO_x, SO₂, and VOC emission factors for gasoline-powered vessels were the weighted averages of the emission factors for inboard and outboard motors. The emission factors were obtained from Reference 7g and 7h. Two sets of weighting factors were used for each type of motor. The first weighting factors were the number of registered inboard and outboard motorboats obtained from Reference 9. The second weighting factors accounted for the greater fuel consumption per hour of operation for inboards (2.55) than for outboards (1.55). The equation below summarizes the calculation of the emission factors:

$$EF = \frac{[(EF_{in} \times R_{in} \times 2.55) \% (EF_{out} \times R_{out} \times 1.55)]}{[(R_{in} \times 2.55) \% (R_{out} \times 1.55)]}$$

where: EF = emission factor
 R = number of registrations
 in = inboards
 out = outboards

The VOC emission factor was multiplied by the reactive VOC fraction of 0.9172. This fraction was based on data for profile 9-60-21B from Reference 8. The TSP emission factor for gasoline powered vessels was assumed to be zero.

For the years 1940, 1950, and 1960, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier 2 category.

3.47.4 Control Efficiency

No control efficiencies were applied to the activity data to estimate emissions from nonroad gasoline vehicles and engines.

3.47.5 References

1. *Exhaust Emissions from Uncontrolled Vehicles and Related Equipment Using Internal Combustion Engines*. U.S. Environmental Protection Agency. Prepared by Southwest Research Institute, San Antonio, TX, under Contract No. EHS-70-108. October 1973.
2. *Highway Statistics*. Federal Highway Administration, U.S. Department of Transportation, Washington, DC. Annual.
 - a. Table MF-24
3. International Snowmobile Industry Association, 7535 Little River Turnpike, Suite 330, Annandale, VA 22003. Contact: Roy Muth (703) 273-9606.
4. *American Housing Survey, Current Housing Reports, Series H-150-83*. Bureau of the Census, U.S. Department of Commerce, Washington DC. Biennial.
5. *Survey of Current Business*. Bureau of Economic Analysis, U.S. Department of Commerce, Washington, DC. Annual.
6. Motorcycle Industry Council, Inc., 19xx Motorcycle Statistical Annual. Costa Mesa, CA. Annual.
7. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - a. Volume II, Table 2-20, Appendix L
 - b. Volume II, Table II-6-2
 - d. Volume II, Table II-8-1
 - e. Volume II, Table II-5-1
 - f. Volume I, Table 3.3-1
 - g. Volume II, Table II-3.5
 - h. Volume II, Table II-4.1
8. *Volatile Organic Compound (VOC) Species Data Manual*. EPA-450/4-80-015. U.S. Environmental Protection Agency, Research Triangle Park, NC. July 1980.
9. *Boating Registration Statistics*. National Marine Manufacturers Association, 401 N. Michigan Avenue, Suite 1150, Chicago, IL. Annual.
10. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listing for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

Table 3.47-1. Emission Factor Equipment Types and Weighting Factors for Gasoline Construction Equipment

Equipment Type	Weighting Factor, based on consumption in 1,000 gal/year
Wheel Tractor	94,774
Motor Grader	12,240
Wheel Loader	104,726
Roller	147,439

Table 3.47-2. Emission Factor Equipment Types and Weighting Factors for Gasoline Small Utility Gasoline Engines

Engine Type	Weighting Factor, based on percentage consumption
Wheel Tractor (2-stroke)	0.065
Motor Grader (4-stroke)	0.935

Table 3.47-3. MOBILE 2 (1978 version) Parameters for Calculation of Emission Factors for Motorcycles

Altitude	Low
Speed	19.6 MPH
Ambient Temp.	57EF
Hot Start/Cold Start Percentages	Zero
All other variables	default values

3.48 OFF-HIGHWAY - NONROAD DIESEL: 12-02

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source category.

Category:

Other Off-Highway

Subcategory:

Diesel (Farm Tractors, Other Farm Equipment, Construction, Heavy Duty General Utility Engines)

3.48.1 Technical Approach

The CO, NO_x, PM-10, TSP, SO₂, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. For all pollutants except PM-10, the emissions were estimated from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million gallons and emission factors were expressed in metric pounds/thousand gallons.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, and 1960 for CO, NO_x, SO₂, and VOC and for TSP the procedures were used for the years 1940, 1950, 1960, and 1970 through 1992.

The estimation of PM-10 emissions for the years 1940, 1950, and 1960 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating emissions based on activity indicators and emission factors.

The 1975 PM-10 emissions were determined using the 1975 activity indicators as described in section 3.48.2 and the 1975 PM-10 emission factors. The PM-10 emission factors for all sources, except diesel-powered heavy duty general utility engines were determined from the corresponding TSP emission factor and the particle size distribution obtained from Reference 3a. The emission factor for diesel-powered heavy duty general utility engines was obtained from Reference 5 for SCC 2-02-001-02.

3.48.2 Activity Indicator

The activity indicators for diesel farm tractors and other diesel farm equipment were based on the adjusted total sales (or deliveries) of diesel fuel used on farms obtained from Reference 1a or 2a. It was assumed that

95.5 percent of this quantity was consumed by farm tractors and 4.5 percent was consumed by other farm equipment.

The activity indicator for diesel construction equipment was the adjusted total sales (or deliveries) of off-highway diesel distillate fuel oil for use in construction from Reference 1b or 2b.

The activity indicator for heavy-duty general utility diesel engines was the sum of the adjusted total sales (or deliveries) of off-highway diesel distillate fuel oil for other uses and of diesel for military uses. These data was obtained from Reference 1b or 2b.

3.48.3 Emission Factor

The emission factors for all pollutants except PM-10 for farm diesel tractors and other farm diesel equipment were obtained from Reference 3b. The VOC emission factors were multiplied by the reactive VOC fraction of 0.952, based on data for profile 90-7021 from Reference 4.

For diesel construction equipment, the emission factors for all pollutants except PM-10 were the weighted averages of the emission factors for nine equipment types. These equipment types and the corresponding weighting factors are listed in Table 3.48-1. Emission factors for each equipment type were obtained from Reference 3c. The VOC emission factor was multiplied by the reactive VOC fraction of 0.952, based on data for profile 90-7021 from Reference 4.

The emission factors for heavy duty general utility diesel engines were obtained from Reference 3d for all pollutants except PM-10. The VOC emission factors were multiplied by the reactive VOC fraction of 0.952, based on data for profile 90-7021 from Reference 4.

For the years 1940, 1950, and 1960, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier 2 category.

3.48.4 Control Efficiency

No control efficiencies were applied to the activity data to estimate emissions from nonroad diesel vehicles and engines

3.48.5 References

1. *Petroleum Marketing Monthly*. DOE/EIA-0380(xx/01). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
 - a. Table entitled "Deliveries for Farm Use: Distillate Fuel Oil and Kerosene"
 - b. Table entitled "Deliveries for Military Use: Distillate Fuel Oil and Residual Fuel Oil; Deliveries for Off-Highway Use: Diesel"

2. *Fuel Oil and Kerosene Sales 19xx*. DOE/EIA-0535(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
 - a. Table entitled "Adjusted Sales for Farm Use: Distillate Fuel Oil and Kerosene."
 - b. Table entitled "Adjusted Sales for Military Use: distillate Fuel Oil and Residual Fuel Oil; Adjusted Sales for Off-Highway Use: Diesel."

3. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - a. Volume II, Table 2-2, Appendix L,
 - b. Volume II, Table II-6-2
 - c. Volume II, Table II-7-1
 - d. Volume II, Table 3.3-1

4. *Volatile Organic Compound (VOC) Species Data Manual*. EPA-450/4-80-015. U.S. Environmental Protection Agency, Research Triangle Park, NC. July 1980.

5. *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listing for Criteria Air Pollutants*. EPA-450/4-90-003. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. March 1990.

Table 3.48-1. Emission Factor Equipment Types and Weighting Factors for Diesel Construction Equipment

Equipment Type	Weighting Factor, based on consumption in 1,000 gal/year
Tracklaying Tractor	912,279
Wheel Tractor	846,035
Wheeled Dozer	47,077
Scraper	621,523
Motor Grader	164,368
Wheeled Loader	753,511
Tracklaying Loader	229,680
Off-Highway Truck	470,550
Roller	30,180

3.49 OFF-HIGHWAY - AIRCRAFT: 12-03

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source category.

Category:

Aircraft

Subcategory:

FAA Facilities
Military Facilities
Other Facilities - General Aviation

3.49.1 Technical Approach

The CO, NO_x, PM-10, TSP, SO₂, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. For all pollutants except PM-10, the emissions were estimated from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand LTO cycles and emission factors were expressed in metric pounds/LTO cycle.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, and 1960 for CO, NO_x, SO₂, and VOC and for TSP the procedures were used for the years 1940, 1950, 1960, and 1970 through 1992.

The estimation of PM-10 emissions for the years 1940, 1950, and 1960 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating PM-10 emissions based on activity indicators and emission factors.

The 1975 PM-10 emissions were determined using the 1975 activity indicators as described in section 3.49.2 and the 1975 PM-10 emission factor obtained from Table 3.1-3.

3.49.2 Activity Indicator

The activity indicators for commercial, air taxi, general aviation, and military aircraft using FAA facilities were the landings and take-offs (LTOs). The total airport operations reported in Reference 1 for each aircraft category were divided by 2 in order to obtain the number of LTO cycles.

The activity indicator for general aviation aircraft using military facilities was assumed to be a constant 1200 LTOs.

The activity indicator for military aircraft using military facilities was based on the military LTOs at military facilities from the year preceding the year under study. Total military LTOs from the year preceding were calculated as the sum of military LTOs from military facilities and from FAA facilities. Total LTOs were projected to the year of study by using the ratio between total flying hours for active U.S. military aircraft flying in the continental United States for the year under study and for the preceding year. Total flying hours data were obtained from Reference 2. From the resulting total military LTOs for the year under study, military LTOs from FAA facilities were subtracted in order to determine military LTOs from military facilities for the year under study. The procedure for determining the military LTOs from FAA facilities was described previously. This overall calculation of the activity indicator is summarized in the equation given below.

$$MLTO_{MF, i} = (MLTO_{FAA, i-1} \% MLTO_{MF, i-1}) \times \left[\frac{FH_i}{FH_{i-1}} \right] + MLTO_{FAA, i}$$

where: MLTO = military LTO
 MF = military facilities
 FAA = FAA facilities
 FH = total flying hours
 i = year under study

The activity indicator for general aviation aircraft using other facilities was based on the assumption that civil aircraft average 250 LTO cycles per year. Total general aviation LTOs were estimated by multiplying the number of registered civil aircraft, excluding gliders, blimps, and balloons, by the average LTO cycles per year. The number of registered civil aircraft was obtained from Reference 3. From this total was subtracted the general aviation LTOs at FAA facilities and at military facilities. These values were determined using procedures described previously. This calculation is summarized in the equation below.

$$GA_{OF} = (AC \times 250 \text{ cycles/year}) - GA_{FAA} - GA_{MF}$$

where: GA = General Aviation LTOs
 AC = Number of U.S. registered civil aircraft, excluding gliders, blimps, and balloons
 OF = Other Facilities
 FAA = FAA Facilities
 MF = Military Facilities

3.49.3 Emission Factor

The emission factors for all pollutants except PM-10 for commercial aircraft using FAA facilities were the weighted averages of the emission factors for each commercial aircraft type. These emission factors are presented in Table 3.49-1. The weighting factors were the estimated LTO's for each aircraft type.

In order to estimate the LTO's for each aircraft type, the estimated number of LTOs by aircraft type from the year preceding the year under study were projected to the year under study. This projection was accomplished for each aircraft type using the ratio of the number of aircraft in operation in the year under study to the number in the the preceding year. These values were obtained from Reference 3. The estimated number of LTO's by aircraft type for the preceding year were obtained by using this same methodology on data from the preceding year.

The estimated LTOs by aircraft type for the year under study were normalized to the actual total number of LTO's as reported in Reference 1. These normalized LTOs for each aircraft type were the weighting factor used to calculate the weight average emission factors for commercial aircraft using FAA facilities.

The emission factors for all pollutants except PM-10 for air taxis using FAA facilities were the weighted averages of the emission factors for each air taxi aircraft type. These emission factors are presented in Table 3.49-2. Weighting factors were the estimated number of each air taxi aircraft type as reported in Reference 3.

The emission factors for all pollutants except PM-10 for general aviation aircraft using FAA facilities were the weighted averages of the emission factors for each aviation aircraft type. These emission factors are presented in Table 3.49-3. Weighting factors were the estimated number of flying hours for each aircraft type obtained from Reference 2a. It was assumed that the number of flying hours was proportional to the number of LTO cycles.

The emission factors for all pollutants except PM-10 for military aircraft using FAA facilities were the weighted averages of the emission factors for each military aircraft type. These emission factors are presented in Table 3.48-4. Weighting factors were the estimated number of flying hours for each military aircraft type obtained from Reference 2b. It was assumed that the number of flying hours was proportional to the number of LTO cycles.

The emission factors for all pollutants except PM-10 for military aircraft using military facilities were the same factors as were used for military aircraft using FAA facilities. The emission factors for all pollutants except PM-10 for general aviation aircraft using military facilities were the same factors as were used for general aviation aircraft using FAA facilities.

The emission factors for all pollutants except PM-10 for general aviation aircraft using other facilities were the same factors as were used for general aviation aircraft using FAA facilities.

For the years 1940, 1950, and 1960, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier 2 category.

3.49.4 Control Efficiency

No control efficiencies were applied to the activity data to estimate emissions from aircraft.

3.49.5 References

1. *FAA Air Traffic Activity FY 19xx*. Federal Aviation Administration, U.S. Department of Transportation, Washington, DC. Annual.
 - a. Table 4, "Airport Operations at Airports with FAA-Operated Traffic Control Towers by Region and by State and Aviation Category."
2. *FAA Aviation Forecasts Fiscal Years 19xx-19xx*. Federal Aviation Administration, U.S. Department of Transportation, Washington, DC. Annual.
 - a. Table 9
 - b. Table 23
3. *Census of U.S. Civil Aircraft, Calendar Year 19xx*. Federal Aviation Administration, U.S. Department of Transportation, Washington, DC. Annual.
 - a. Table 1.1. For Regional, use number of registered aircraft, Table 3.2.

Table 3.49-1. Emission Factors for Commercial Aircraft using FAA Facilities

Commercial Aircraft	Emission Factors (lbs/LTO)				
	CO	NO _x	VOC*	SO ₂	TSP
BAC 111	103.63	15.04	71.19	1.7	1.46
Boeing 707	262.64	25.68	214.53	4.28	4.52
Boeing 727	55.95	29.64	13.21	3.27	1.17
Boeing 737	37.3	19.76	8.81	2.18	0.78
Boeing 747	145.1	10.52	42.37	7.55	5.2
L1011	124.7	78.98	71.71	5.3	3.9
DC8	262.64	25.68	214.53	3.27	1.17
DC9	37.3	19.76	8.81	2.18	0.78
DC10	116.88	49.59	46.3	4.98	0.21
General					1.0

* Reactive VOC (already adjusted).

Table 3.49-2. Emission Factors for Air Taxis using FAA Facilities

Air Taxi Aircraft	Emission Factor (lbs/LTO)				
	CO	NO _x	VOC*	SO ₂	TSP
Turbojets	50.26	26.63	11.87	2.94	1.05
Turboprops	7.16	0.82	4.99	0.18	0.46
Pistons	100 **	0.6**	3.2**	0.02**	0.3**
General					

* VOC adjustment factor is 0.983 for turbojets and 0.929 for pistons.

**Assumed values used for pistons.

Table 3.49-3. Emission Factors for General Aviation Aircraft using FAA Facilities

General Aviation Aircraft	Emission Factor (lbs/LTO)				
	CO	NO _x	VOC*	SO ₂	TSP
Piston:					
Single Engine	11.35	0.02	0.23	0	0.02
Multi-Engine	64.67	0.075	1.35	0	0.02
Turboprop	6.76	0.92	6.46	0.17	0.46
Turbojet	54.36	2.02	6.62	0.74	0.5**
Rotocraft Piston	11.35	0.02	0.23	0	0.02
Rotocraft Turbine	13.33	4.34	2.75	0.26	0.4
General					

* Reactive VOC (already adjusted),

**Particulate emission factor for Turbojet is best guess estimate.

Table 3.49-4. Emission Factors for Military Aircraft using FAA Facilities

Military Aircraft	Emission Factor (lbs/LTO)				
	CO	NO _x	VOC*	SO ₂	TSP
Jet (fixed wing)	52.4	9.65	29	1.56	28
Turboprop	23.2	14.1	11.6	0.74	0.46
Piston	53.2	0.29	5.5	0.033	0.28
Helicopter	13.33	4.34	2.75	0.26	0.4
General					

*Reactive VOC (already adjusted).

3.50 OFF-HIGHWAY - VESSELS: 12-04

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source category.

Category:

Marine Vessels

Subcategory:

Residual Fuel Oil
Diesel Oil
Coal

3.50.1 Technical Approach

The CO, NO_x, PM-10, TSP, SO₂, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. For all pollutants except PM-10, the emissions were estimated from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million gallons and emission factors were expressed in metric pounds/thousand gallons.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, and 1960 for CO, NO_x, SO₂, and VOC and for TSP the procedures were used for the years 1940, 1950, 1960, and 1970 through 1992.

The estimation of PM-10 emissions for the years 1940, 1950, and 1960 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating PM-10 emissions based on activity indicators and emission factors.

The 1975 PM-10 emissions were determined using the 1975 activity indicators as described in section 3.50.2 and the 1975 PM-10 emission factors obtained from Table 3.1-3.

3.50.2 Activity Indicator

The activity indicator for residual fuel oil was the "adjusted" quantity of residual fuel oil delivered for transportation use, vessel bunkering obtained from Reference 1a or Reference 2a.

The activity indicator for diesel oil was the "adjusted" quantity of distillate fuel oil (for diesel) delivered for transportation use, vessel bunkering obtained from Reference 1a or Reference 2a.

The procedure for determining the activity for the years 1940, 1950, and 1960 is currently unavailable. The activity indicator for coal was assumed to be zero after 1979.

3.50.3 Emission Factor

The emission factors for all pollutants except PM-10 for residual fuel oil were based on the emission factors for residual oil-fired commercial steamships obtained from Reference 3a. The emission factors were presented separately for three modes of operation; hotelling, cruise, and full power. Weighted averages of these emission factors were calculated for each pollutant based on the relative amount of time vessels spend operating under these different modes. It was assumed that 80 percent of the time was spent hotelling and 20 percent was spent under full power.

The VOC emission factor was converted to the reactive VOC emission factor by using the factor for profile 101004 obtained from Reference 4.

The emission factors for all pollutants except PM-10 for diesel oil were weighted averages of the emission factors for diesel-fired vessels operating underway and operating under auxiliary power. Weighting factors were based on the relative amount of time the ships spent operating in these modes: 20 percent under auxiliary power and 80 percent underway. The final VOC emission factor was converted to the reactive VOC emission factor by using the factor for profile 907021 obtained from Reference 4.

The emission factors for diesel-fired vessels under auxiliary power were the averages of the emission factors for diesel-fired vessels operating under auxiliary power at 50 percent load. The emission factors for all pollutants except for TSP were obtained from Reference 3b and were averaged over the four output ratings. The average TSP emission factor was obtained from Reference 3c.

The emission factors for diesel-fired vessels underway were the weighted averages of the emission factors for commercial motorships and distillate oil-fired commercial steamships. The emission factors were weighted by the relative population of motorships and steamships. It was assumed that of the overall fleet of diesel-fired vessels, 75 percent were motorships and 25 percent were steamships.

The emission factors for commercial motorships were the averages of the emission factors for the river, Great Lakes, and coastal waterway classifications. The emission factors for all pollutants except for TSP were obtained from Reference 3d and were averaged over the three waterway classifications. The average TSP emission factor was assumed to be equal to the emission factor railroad locomotive obtained from Reference 3e.

The emission factors for commercial distillate oil-fired steamships were the weighted averages of the emission factors for two modes of operations: hotelling and full power. These emission factors were obtained from Reference 3a. The emission factors were weighted by the relative time the steamship spent operating

under these two modes. It was assumed that steamship spent 80 of the time hotelling and 20 percent at full power.

The emission factors for all pollutants for coal combustion by marine vessels after 1979 were assumed to have a value of zero. The procedure for determining the activity for the years 1940, 1950, and 1960 is currently unavailable.

For the years 1940, 1950, and 1960, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier 2 category.

3.50.4 Control Efficiency

No control efficiencies were applied to the activity data to estimate emissions from marine vessels.

3.50.5 References

1. *Petroleum Marketing Monthly*. DOE/EIA-0380(xx/01). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
 - a. Table A13 and A14
2. *Fuel Oil and Kerosene Sales 19xx*. DOE/EIA-0535(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
 - a. Table A13 and A14
3. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - a. Volume II, Table II-3-2
 - b. Volume II, Table II-3-4
 - c. Volume II, Table 3.3-1
 - d. Volume II, Table II-3-1
 - e. Volume II, Table II-2-1
4. *Volatile Organic Compound (VOC) Species Data Manual*. EPA-450/4-80-015. U.S. Environmental Protection Agency, Research Triangle Park, NC. July 1980.

3.51 OFF-HIGHWAY - RAILROAD: 12-05

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source category.

Category:

Railroad

Subcategory:

Diesel
Residual Fuel Oil
Coal

3.51.1 Technical Approach

The CO, NO_x, PM-10, TSP, SO₂, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. For all pollutants except PM-10, the emissions were estimated from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million gallons and emission factors were expressed in metric pounds/thousand gallons.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, and 1960 for CO, NO_x, SO₂, and VOC and for TSP the procedures were used for the years 1940, 1950, 1960, and 1970 through 1992.

The estimation of PM-10 emissions for the years 1940, 1950, and 1960 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating emissions based on activity indicators and emission factors.

The 1975 PM-10 emissions were determined using the 1975 activity indicators as described in section 3.51.2 and the 1975 PM-10 emission factors obtained from Table 3.1-3.

3.51.2 Activity Indicator

The activity indicator for the combustion of diesel fuel by locomotives was the "adjusted" quantity of distillate fuel oil deliveries for transportation use (railroads) obtained from Reference 1 or Reference 2.

The activity indicator for the combustion of residual fuel oil by locomotives was based on the "adjusted" quantity of residual fuel oil sales to the "All Other" end use category from Reference 1 or Reference 2. It was assumed that the ratio of fuel consumption by railroads to the fuel consumption included in the "All Other" end

use category (which includes railroads) is 8.83×10^{-4} . Therefore, the activity indicator was the value obtained from Reference 1 or Reference 2 multiplied by 8.83×10^{-4} .

The activity indicator for the combustion of coal was the quantity of U.S. coal distribution by "transportation" obtained from Reference 3a. It was assumed that "transportation" as defined in Reference 3 represented the locomotive category.

3.51.3 Emission Factor

The emission factors for diesel fuel combustion by locomotives were obtained from Reference 4a for all pollutants except PM-10. The VOC emission factor was multiplied by 0.952 to account for the reactive portion.

For the combustion of residual fuel oil, the emission factors for all pollutants except PM-10 and VOC were obtained from Reference 4a. The VOC emission factor was obtained from Reference 4b and was multiplied of 0.952 to account for the reactive portion. The SO₂ factor was multiplied by the sulfur content value of 1.34.

The emission factors for all pollutants except PM-10 for the combustion of coal were obtained from Reference 4c. In this reference, the TSP factor was listed as the spreader stoker emission factor. The SO₂ emission factor was multiplied by a sulfur content value of 2.0.

For the years 1940, 1950, and 1960, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier 2 category.

3.51.4 Control Efficiency

No control efficiencies were applied to the activity data to estimate emissions from railroads.

3.51.5 References

1. *Petroleum Marketing Monthly*. DOE/EIA-0380(xx/01). Energy Information Administration, U.S. Department of Energy, Washington, DC. January issue.
2. *Fuel Oil and Kerosene Sales 19xx*. DOE/EIA-0535(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
3. *Coal Distribution January-December 19xx*. DOE/EIA-0125(xx/4Q). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
 - a. Table entitled "Distribution of U.S. Coal by Origin, Destination, and Consumer"
4. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.

- a. Volume II, Table II-2-1
- b. Volume I, Table 1.3-1 (Industrial Residual Oil Boilers)
- c. Volume I, Table 1.1-1 (Bituminous Coal Hand-fired Units)

3.52 MISCELLANEOUS - OTHER COMBUSTION: 14-02

The emissions for this Tier 2 category were determined by the 1940-1984 Methodology for the following source categories.

Category:	Subcategory:
Forest Fires and Prescribed Burning	Wildfires
	Prescribed Burning
Other Miscellaneous Sources	Agricultural Burning
	Structural Fires
	Coal Refuse Burning

3.52.1 Technical Approach

The CO, NO_x, PM-10, TSP, SO₂, and VOC emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator and emission factor. In order to utilize these values in the *Trends* spreadsheets, activity indicators for wildfires and prescribed burning were expressed in acres and emission factors were expressed in metric pounds/thousand short tons. For the other miscellaneous sources, activity indicators were expressed in thousand short tons and emission factors were expressed in metric pounds/short ton.

The procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1984 for all pollutants except TSP, for which the procedures were used for the years through 1992, and PM-10, for which the procedures were used for the years 1975 through 1984. For some source categories, the PM-10 emissions exceeded the TSP emissions as calculated by the procedures presented in this section. Because this represents a physical impossibility, a more realistic estimate of the PM-10 emissions was assumed to be the TSP emissions value.

The estimation of PM-10 emissions for the years prior to 1975 was based on the relative change in TSP emissions from the 1975 value according to the following equation:

$$PM\&10\ Emissions_{year} = PM\&10\ Emissions_{1975} \times \frac{TSP\ Emissions_{year}}{TSP\ Emissions_{1975}}$$

This calculation was used in place of estimating the emissions based on activity indicators and emission factors.

3.52.2 Activity Indicator

The activity indicator for wildfires is the sum of protected and unprotected land areas burned for each of the five regions. These regions are defined in Table 3.52-1. The area of protected land burned was obtained from Reference 1. Default values used for the unprotected land area burned are given in Table 3.52-2.

For the years 1978 through 1984, the activity indicator for prescribed burning was the acreage burned in 1978 reported in Reference 2. The data are reported for two regions: Southern and Western. It was assumed that the acreage burned remained constant for the years 1978 through 1984. No procedure for determining the acreage burned for the years prior to 1978 is currently available.

The activity indicator for agricultural burning was based on the total quantity of agricultural products burned in 1974 as reported in Reference 3. Because no data were available after 1974, the activity indicators for this category for the years after 1974 were assumed to be the same as that for 1974.

The activity indicator for structural fires was based on the total number of building fires as reported in Reference 4. It was assumed that 6.8 tons of material is burned for every building fire. Alternatively, an estimate of the quantity of material burned was obtained from Reference 5.

The activity indicator for coal refuse burning was based on the estimated total quantity of coal refuse in 1971 from Reference 6. It was assumed that this quantity had been steadily declining over the period after the report was published. A rough approximation was deemed sufficient.

3.52.3 Emission Factor

The emission factors for wildfires were composed of two factors: fuel loading and pollutant yield. The fuel loading related the area of land burned to the quantity of vegetation consumed by fire. The fuel loading data were specific to five regions of the United States. The States included in each region are listed in Table 3.52-1. The pollutant yield related the amount of a given pollutant emitted to the amount of vegetation consumed by fire. The information on these two factors was obtained from Reference 7a except the pollutant yield for PM-10 which was obtained from Table 3.1-2.

The emission factors for prescribed fires were composed of two factors: fuel loading and pollutant yield. These factors were defined in the same manner as for the wild fire category. The fuel loading was specific to two regions of the United States. The information on these two factor was obtained from Reference 6, except for the SO₂, NO_x, and PM-10 pollutant yield values. The SO₂ and NO_x pollutant yields were assumed to be the same as the pollutant yields for wildfires and, therefore, were obtained from Reference 7a. The PM-10 pollutant yield was obtained from Table 3.1-3.

The emission factors for all pollutants except PM-10 for agricultural burning were the average of the emission factors for burning sugar cane and field crops. These emission factors were obtained from Reference 7b, except for the NO_x emission factors which were obtained from Reference 7c. The PM-10 emission factor was obtained from Table 3.1-3.

The emission factors for all pollutants except PM-10 for structural burning were obtained from Reference 8. These emission factors were for open burning and were adjusted using engineering judgment. The PM-10 emission factor was obtained from Table 3.1-3.

The emission factors for all pollutants except PM-10 for coal refuse burning were obtained from Reference 8. These emission factors were for open burning and were adjusted using engineering judgment. The PM-10 emission factor was obtained from Table 3.1-3.

For the years prior to 1975, emission factors were not employed in the estimation of PM-10 emissions from the sources included in this Tier 2 category.

3.52.4 Control Efficiency

No control efficiencies were applied to the activity data to estimate emissions from the sources included in this Tier 2 category.

3.52.5 References

1. *The National Forest Fire Report*. Forest Service, U.S. Department of Agriculture. Annual.
2. *Source Assessment Prescribed Burning*. EPA-600/2-79-019H, U.S. Environmental Protection Agency, Research Triangle Park, NC. 1979.
3. *Emissions Inventory from Forest Wildfires, Forest Managed Burns, and Agricultural Burns*. EPA-450/3-74-062. U.S. Environmental Protection Agency, Research Triangle Park, NC. November 1974.
4. *Statistical Abstract of the United States*. Bureau of the Census, U.S. Department of Commerce, Washington, DC. Annual.
5. National Fire Protection Association, Boston, MA.
6. *Information Circular 8515*. U.S. Bureau of Mines, U.S. Department of the Interior, Washington, DC. 1971.
7. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - a. Volume I, Section 11.1
 - b. Volume I, Table 2.4-5
8. *Compilation of Air Pollutant Emission Factors, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. February 1972.

9. *OAQPS Data File on National Emissions*. National Air Data Branch, U.S. Environmental Protection Agency, Research Triangle Park, NC. 1984.

Table 3.52-1. States Comprising Regions for Wild Fires Acreage Burned Information

Rocky Mountain	Pacific	East	North Central	South
Arizona	Alaska	Connecticut	Illinois	Arkansas
Colorado	California	Delaware	Indiana	Florida
Idaho	Guam	Maine	Iowa	Georgia
Kansas	Hawaii	Maryland	Michigan	Kentucky
Montana	Oregon	Massachusetts	Minnesota	Louisiana
Nebraska	Washington	New Hampshire	Missouri	Mississippi
Nevada		New Jersey	Ohio	North Carolina
New Mexico		New York	Wisconsin	Oklahoma
North Dakota		Pennsylvania		South Carolina
South Dakota		Rhode Island		Tennessee
Utah		Vermont		Texas
Wyoming		West Virginia		Virginia

Table 3.52-2. Land Area Burned on Unprotected Lands

Region	Acreage (thousands of acres)
Rocky Mountain	198.1
Pacific	184.8
East	65.1
North Central	296.0
South	1,584.1

SECTION 4.0

NATIONAL CRITERIA POLLUTANT ESTIMATES 1985 - 1993 METHODOLOGY

Each year the U.S. Environmental Protection Agency (EPA) prepares national estimates for assessing trends in criteria pollutant emissions. In the past, the emissions were estimated using consistent top-down methodologies employing national statistics on economic activity, material flows, etc., for the years 1940 to the current year of the report. Although emissions prepared in this way were useful for evaluating changes from year to year, they did not provide a geographically detailed measure of emissions for any given year. Bottom-up inventories, where emissions are derived at the plan or county level, are extremely useful in many applications, such as inputs into atmospheric models. During the past several years, changes have been made to the methodologies in order to produce emissions for the *National Air Pollutant Emission Trends, 1900-1993*¹ (*Trends*) report, starting at the county level, which both represent a bottom-up inventory and allow for an evaluation of changes in emissions from year to year. For future *Trends* reports, these methodological changes will allow the incorporation of even more detailed SIP data for ozone nonattainment areas.

4.1 INTRODUCTION

The carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO₂), and volatile organic compound (VOC) emissions presented in this report for the years 1985 through 1993 have been estimated using a methodology based on the methodology developed for the *Interim* Inventories, with several exceptions. The *Interim* methodology was developed to produce the inventories for the years 1987 through 1991 and is presented in the *Regional Interim Emission Inventories (1987-1991)*.² A similar methodology was developed for the preparation of a national 1990 particulate matter inventory as documented in the *Development of the OPPE Particulate Programs Implementation Evaluation System*.³ In order to generate the necessary emissions for the *Trends* report, the *Interim* methodology has been expanded to generate CO, NO_x, SO₂, and VOC emissions for the years 1985 and 1986, as well as particulate matter less than 10 microns (PM-10) emissions for the years 1985 through 1989 and 1991. The 1992 and 1993 emissions for all pollutants, except lead (Pb), and all source categories, except for steam generated fossil-fuel electric utility units, highway vehicles, wildfire, and most fugitive dust sources, have been projected from the 1990 emissions using growth factors created by the EPA's prereleased E-GAS, version 2.0.⁴

4.1.1 Lead Emissions

The Pb emissions for the years 1985 through 1992 have been estimated using the methodologies presented in section 5.0 of this report. The weighted emission factors and control efficiencies were assumed to be constant from 1990 to 1993. The 1993 preliminary estimates were made by growing the 1992 activity data by one of two methods applied to the appropriate source category. The first of these two methods used a

quadratic regression with weighted 20-year specific source category activity data. The other method used a linear regression with weighted 7-year activity data. This second method was applied to source categories where the trend in the activity data has changed significantly over the past 10 years.

A detailed description of the methodology used to generate the CO, NO_x, VOC, SO₂, and PM-10 emissions for the years 1985 through 1993 is presented in this section. The methodology is divided into subsection based on similar approaches in estimating the emissions. At the beginning of each subsection the Tier 1 category or below if necessary is listed. Table 4.1-1 outlines which subsections to use for which tier category. If a Tier 2 category is not listed it is currently not estimated within the Emission Trends Inventory.

4.1.2 Carbon Monoxide, Nitrogen Oxides, Volatile Organic Compounds, Sulfur Dioxide, and Particulate Matter (PM-10) Emissions

Emissions were developed at the county and Source Classification Code (SCC) level for most source categories. These emissions are then summed to the Tier level. There are 4 levels in the tier categorization. The first and second level, respectively referred to as Tier 1 and Tier 2 are the same for each of the sic criteria pollutants and are listed in Table 4.1-2. The third level, Tier 3 is unique for each of the six pollutants. The fourth level is the SCC level. The match-up between SCC and all three tier levels is located in the file Tierv1_6.dbf located on EPA's Office of Air Quality Planning and Standards (OAQPS) Technology Transfer Network (TTN) Emission Inventories/Emission Factor Information (CHEIF) electronic bulletin board [(919) 541-5742]. The prior version Tierv1_5.dbf was used for the Emission Trends Inventory. Table 4.1-3 list the Tier 1 and Tier 2 codes and names with the associated SCC and SCC description. Because of space the SCC descriptions have been truncated.

Even though the emissions were derived at the SCC level, the growth indicators for the point sources for 1985 -1991 were assigned except for stationary fuel combustion sources, at the SIC level. A match-up between 2 digit SICs and SCCs as well as Tier category is impossible, since the SICs are defined at the plant level but the SCCs are defined at the process level. Therefore, the same SIC could show up in two or more Tier 1 categories. For example, Plant A produces and stores Adipic Acid. This plant would be assigned the SIC of 28 (Chemical and Allied Product). The manufacturing section of the plant would be assigned an SCC of 3-01-001-03 and would be included in the Tier 1 equal to 04 (Chemical and Allied Product Manufacturing). The section of the plant where the adipic acid is stored would be assigned an SCC of 3-01-001-02 and would be included in the Tier 1 equal to 09 (Storage and Transport). Therefore, in order to use the following methodology for the years 1985 to 1991, one needs to know the SCC to determine which Tier category methodology to apply and the SIC to know which growth indicator to choose.

4.1.3 References

1. National Air Pollutant Emission Trends, 1900-1993, EPA-454/R-94-027. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1994.
2. Regional Interim Emission Inventories (1987-1991), Volume I: Development Methodologies. EPA-454/R-93-021a. U.S. Environmental Protection Agency, Research Triangle Park, NC. May 1993.

3. Development of the OPPE Particulate Programs Implementation Evaluation System, Final, Prepared for the Office of Policy, Planning and Evaluation/Office of Policy Analysis, U.S. Environmental Protection Agency, under EPA Contract No. 68-D3-0035, Work Assignment No. 0-10, Washington, DC. July 1994.
4. Economic Growth Analysis System: User's Guide, Version 2.0. EPA-600/R-94-139b. Joint Emissions Inventory Oversight Group, U.S. Environmental Protection Agency, Research Triangle Park, NC. August 1994.

Table 4.1-1. Section 4.0 Structure

Subsection	Tier 1	Tier 2
4.1 Introduction		
4.2 Fuel Combustion - Electric Utility	Fuel Combustion - Electric Utility (01)	Majority of Coal (01), Oil (02), and Gas (03). The point level - steam generated fossil fuel sources.
4.3 Primarily Industrial	Fuel Combustion - Electric Utility	Other [(04), mainly gas turbines], Internal Combustion (05), The area source level - steam generated Coal (01), Oil (02), Gas (03).
	Fuel Combustion - Industrial (02)	All
	Chemical & Allied Product Manufacturing (04)	All
	Metals Processing (05)	All
	Petroleum & Related Industries (06)	All
	Other Industrial Processes (07)	All
	Storage & Transport (09)	All
	Waste Disposal & Recycling	All
	Miscellaneous (14)	Health services (05)
4.4 Other Combustion	Other Combustion (03)	All
	Miscellaneous (14)	Other combustion (02)
4.5 Solvents	Solvent Utilization (08)	All
4.6 Highway Vehicles	Highway Vehicles (11)	All
4.7 Off-highway	Off-highway (12)	All
4.8 Fugitive Dust	Natural Sources (13)	Geogenic [(02), wind erosion only]
	Miscellaneous (14)	Agriculture & Forestry [(01), agricultural crops and livestock only] Fugitive dust (07)

NOTE: Number in parenthesis is Tier code.

Table 4.1-2. Major Source Categories

TIER 1	TIER 2
FUEL COMBUSTION-ELECTRIC UTILITIES	Coal Oil Gas Other Internal Combustion
FUEL COMBUSTION-INDUSTRIAL	Coal Oil Gas Other Internal Combustion
FUEL COMBUSTION-OTHER	Commercial / Institutional Coal Commercial / Institutional Oil Commercial / Institutional Gas Misc. Fuel Combustion (except residential) Residential Wood Residential Other
CHEMICAL & ALLIED PRODUCT MFG.	Organic Chemical Mfg. Inorganic Chemical Mfg. Polymer & Resin Mfg. Agricultural Chemical Mfg. Paint, Varnish, Lacquer, Enamel Mfg. Pharmaceutical Mfg. Other Chemical Mfg.
METALS PROCESSING	Nonferrous Ferrous Not elsewhere classified (NEC)
PETROLEUM & RELATED INDUSTRIES	Oil & Gas Production Petroleum Refineries & Related Industries Asphalt Manufacturing
OTHER INDUSTRIAL PROCESSES	Agriculture, Food, & Kindred Products Textiles, Leather, & Apparel Products Wood, Pulp & Paper, & Publishing Products Rubber & Miscellaneous Plastic Products Mineral Products Machinery Products Electronic Equipment Transportation Equipment Construction Miscellaneous Industrial Processes
SOLVENT UTILIZATION	Degreasing Graphic Arts Dry Cleaning Surface Coating Other Industrial

Table 4.1-2. (continued)

TIER 1

TIER 2

Nonindustrial
Solvent Utilization (NEC)

(continued)

Table 4.1-2. (continued)

TIER 1	TIER 2
STORAGE & TRANSPORT	<ul style="list-style-type: none"> Bulk Terminals & Plants Petroleum & Petroleum Product Storage Petroleum & Petroleum Product Transport Service Stations: Stage I Service Stations: Stage II Service Stations: Breathing & Emptying Organic Chemical Storage Organic Chemical Transport Inorganic Chemical Storage Inorganic Chemical Transport Bulk Materials Storage Bulk Materials Transport
WASTE DISPOSAL & RECYCLING	<ul style="list-style-type: none"> Incineration Open Burning Publicly Owned Treatment Works Industrial Waste Water Treatment Storage and Disposal Facility Landfills Other
HIGHWAY VEHICLES	<ul style="list-style-type: none"> Light-Duty Gas Vehicles & Motorcycles Light-Duty Gas Trucks Heavy-Duty Gas Vehicles Diesels
OFF-HIGHWAY	<ul style="list-style-type: none"> Nonroad Gasoline Nonroad Diesel Aircraft Marine Vessels Railroads
NATURAL SOURCES	<ul style="list-style-type: none"> Biogenic Geogenic Miscellaneous (lightning, freshwater, saltwater)
MISCELLANEOUS	<ul style="list-style-type: none"> Agriculture & Forestry Other Combustion (forest fires) Catastrophic / Accidental Releases Repair Shops Health Services Cooling Towers Fugitive Dust

NOTE(S): Refer to section 6 for a description of source categories. For the purposes of this report, forest fires are considered anthropogenic sources although many fires are caused by nature.

Table 4.1-3. Tier 1 and Tier 2 Match-up with Source Classification Codes

Tier 1: 01 FUEL COMB. ELEC. UTIL.

Tier 2: 01 Coal

10100101 - 10100306 External Combustion Boilers Electric Generation
 2101001000 - 2101003000 Stationary Source Fuel Combustion Electric Utility

Tier 2: 02 Oil

10100401 - 10100505 External Combustion Boilers Electric Generation
 2101004000 Stationary Source Fuel Combustion Electric Utility Distillate Oil Total:
 2101004001 Stationary Source Fuel Combustion Electric Utility Distillate Oil All Bo
 2101005000 Stationary Source Fuel Combustion Electric Utility Residual Oil Total: A

Tier 2: 03 Gas

10100601 - 10100702 External Combustion Boilers Electric Generation
 2101006000 Stationary Source Fuel Combustion Electric Utility Natural Gas Total: Bo
 2101006001 Stationary Source Fuel Combustion Electric Utility Natural Gas All Boile
 2101010000 Stationary Source Fuel Combustion Electric Utility Process Gas Total: Al

Tier 2: 04 Other

10100801 - 10101302 External Combustion Boilers Electric Generation
 2101007000 - 2101009000 Stationary Source Fuel Combustion Electric Utility

Tier 2: 05 Internal Combustion

20100101 - 20101031 Internal Combustion Engines Electric Generation
 2101004002 Stationary Source Fuel Combustion Electric Utility Distillate Oil All I.
 2101006002 Stationary Source Fuel Combustion Electric Utility Natural Gas All I.C.

Tier 1: 02 FUEL COMB. INDUSTRIAL

Tier 2: 01 Coal

10200101 - 10200307 External Combustion Boilers Industrial
 10500102 External Combustion Boilers Space Heaters Industrial Coal **
 2102001000 Stationary Source Fuel Combustion Industrial Anthracite Coal Total: All
 2102002000 Stationary Source Fuel Combustion Industrial Bituminous/Subbituminous Coa
 2390001000 Industrial Processes In-Process Fuel Use Anthracite Coal Total
 2390002000 Industrial Processes In-Process Fuel Use Bituminous/Subbituminous Coal T
 39000189 - 39000399 In-Process Fuel Use In-Process Fuel Use

Tier 2: 02 Oil

10200401 - 10200505 External Combustion Boilers Industrial
 10201403 External Combustion Boilers Industrial CO Boiler Distillate Oil
 10201404 External Combustion Boilers Industrial CO Boiler Residual Oil
 10500105 External Combustion Boilers Space Heaters Industrial Distillate Oil
 2102004000 Stationary Source Fuel Combustion Industrial Distillate Oil Total: Boile
 2102005000 Stationary Source Fuel Combustion Industrial Residual Oil Total: All Boi
 2390004000 Industrial Processes In-Process Fuel Use Distillate Oil Total
 2390005000 Industrial Processes In-Process Fuel Use Residual Oil Total
 30190001 Chemical Manufacturing Fuel Fired Equipment Process Heaters Distillate O
 30190002 Chemical Manufacturing Fuel Fired Equipment Process Heaters Residual Oil
 30190011 Chemical Manufacturing Fuel Fired Equipment Incinerators Distillate Oil
 30190012 Chemical Manufacturing Fuel Fired Equipment Incinerators Residual Oil
 30290001 Food and Agriculture Fuel Fired Equipment Process Heaters Distillate Oil
 30290002 Food and Agriculture Fuel Fired Equipment Process Heaters Residual Oil
 30390001 Primary Metal Production Fuel Fired Equipment Process Heaters Distillate
 30390002 Primary Metal Production Fuel Fired Equipment Process Heaters Residual O
 30390011 Primary Metal Production Fuel Fired Equipment Incinerators Distillate Oi
 30390012 Primary Metal Production Fuel Fired Equipment Incinerators Residual Oil
 30390021 Primary Metal Production Fuel Fired Equipment Flares Distillate Oil (No.
 30390022 Primary Metal Production Fuel Fired Equipment Flares Residual Oil
 30490001 Secondary Metal Production Fuel Fired Equipment Process Heaters Distilla
 30490002 Secondary Metal Production Fuel Fired Equipment Process Heaters Residual
 30490011 Secondary Metal Production Fuel Fired Equipment Incinerators Distillate
 30490012 Secondary Metal Production Fuel Fired Equipment Incinerators Residual Oi
 30490021 Secondary Metal Production Fuel Fired Equipment Flares Distillate Oil (N
 30490022 Secondary Metal Production Fuel Fired Equipment Flares Residual Oil
 30490031 Secondary Metal Production Fuel Fired Equipment Furnaces Distillate Oil

Table 4.1-3. (continued)

30490032	Secondary Metal Production	Fuel Fired Equipment	Furnaces	Residual Oil
30500207	Mineral Products	Mineral Products	Asphaltic Concrete	Asphalt Heater: Res
30500208	Mineral Products	Mineral Products	Asphaltic Concrete	Asphalt Heater: Dis
30590001	Mineral Products	Fuel Fired Equipment	Process Heaters	Distillate Oil (No
30590002	Mineral Products	Fuel Fired Equipment	Process Heaters	Residual Oil
30590011	Mineral Products	Fuel Fired Equipment	Incinerators	Distillate Oil (No. 2
30590012	Mineral Products	Fuel Fired Equipment	Incinerators	Residual Oil
30600101	Petroleum Industry	Petroleum Industry	Process Heaters	OIL FIRED **
30600103	Petroleum Industry	Petroleum Industry	Process Heaters	Oil Fired
30600111	Petroleum Industry	Petroleum Industry	Process Heaters	Oil Fired (>100 MM
30600901	Petroleum Industry	Petroleum Industry	Flares	
30600902	Petroleum Industry	Petroleum Industry	Flares	
30609901	Petroleum Industry	Petroleum Industry	Incinerators	Distillate Oil (No. 2
30609902	Petroleum Industry	Petroleum Industry	Incinerators	Residual Oil
30790001	Pulp & Paper and Wood Products	Fuel Fired Equipment	Process Heaters	Dist
30790002	Pulp & Paper and Wood Products	Fuel Fired Equipment	Process Heaters	Resi
30790011	Pulp & Paper and Wood Products	Fuel Fired Equipment	Incinerators	Distill
30790012	Pulp & Paper and Wood Products	Fuel Fired Equipment	Incinerators	Residua
30790021	Pulp & Paper and Wood Products	Fuel Fired Equipment	Flares	Distillate Oi
30790022	Pulp & Paper and Wood Products	Fuel Fired Equipment	Flares	Residual Oil
30890001	Rubber and Miscellaneous Plastics Products	Rubber and Miscellaneous Plasti		
30890002	Rubber and Miscellaneous Plastics Products	Rubber and Miscellaneous Plasti		
30890011	Rubber and Miscellaneous Plastics Products	Rubber and Miscellaneous Plasti		
30890012	Rubber and Miscellaneous Plastics Products	Rubber and Miscellaneous Plasti		
30990001	Fabricated Metal Products	Fabricated Metal Products	Process Heaters	Dist
30990002	Fabricated Metal Products	Fabricated Metal Products	Process Heaters	Resi
30990011	Fabricated Metal Products	Fabricated Metal Products	Incinerators	Distill
30990012	Fabricated Metal Products	Fabricated Metal Products	Incinerators	Residua
31000401 - 31000403	Oil and Gas Production	Oil and Gas Production	Process Heaters	
31000411 - 31000413	Oil and Gas Production	Oil and Gas Production	Steam Generators	
31390001	Electrical Equipment	Electrical Equipment	Process Heaters	Distillate Oil
31390002	Electrical Equipment	Electrical Equipment	Process Heaters	Residual Oil
39000402 - 39000599	In-Process Fuel Use	In-Process Fuel Use		
39990001	Miscellaneous Manufacturing Industries	Miscellaneous Manufacturing Industr		
39990002	Miscellaneous Manufacturing Industries	Miscellaneous Manufacturing Industr		
39990011	Miscellaneous Manufacturing Industries	Miscellaneous Manufacturing Industr		
39990012	Miscellaneous Manufacturing Industries	Miscellaneous Manufacturing Industr		
39990021	Miscellaneous Manufacturing Industries	Miscellaneous Manufacturing Industr		
39990022	Miscellaneous Manufacturing Industries	Miscellaneous Manufacturing Industr		
40201002	Surface Coating Operations	Surface Coating Operations	Coating Oven Heater	
40201003	Surface Coating Operations	Surface Coating Operations	Coating Oven Heater	
40290011	Surface Coating Operations	Surface Coating Operations	Incinerator/Afterbu	
40290012	Surface Coating Operations	Surface Coating Operations	Incinerator/Afterbu	
49090011	Organic Solvent Evaporation - Miscellaneous	Fuel Fired Equipment	Incinera	
49090012	Organic Solvent Evaporation - Miscellaneous	Fuel Fired Equipment	Incinera	
49090021	Organic Solvent Evaporation - Miscellaneous	Fuel Fired Equipment	Flares	
49090022	Organic Solvent Evaporation - Miscellaneous	Fuel Fired Equipment	Flares	
50390005	Solid Waste Disposal	Industrial	Auxillary Fuel/No Emissions	Distillate O
Tier 2: 03 Gas				
10200601 - 10200799	External Combustion Boilers	Industrial		
10201401	External Combustion Boilers	Industrial	CO Boiler	Natural Gas
10201402	External Combustion Boilers	Industrial	CO Boiler	Process Gas
10500106	External Combustion Boilers	Space Heaters	Industrial	Natural Gas
2102006000	Stationary Source Fuel Combustion	Industrial	Natural Gas	Total: Boilers
2102006001	Stationary Source Fuel Combustion	Industrial	Natural Gas	All Boiler Type
2102010000	Stationary Source Fuel Combustion	Industrial	Process Gas	Total: All Boil
2390006000	Industrial Processes	In-Process Fuel Use	Natural Gas	Total
2390010000	Industrial Processes	In-Process Fuel Use	Process Gas	Total

Table 4.1-3. (continued)

30190003	Chemical Manufacturing	Fuel Fired Equipment	Process Heaters	Natural Gas
30190004	Chemical Manufacturing	Fuel Fired Equipment	Process Heaters	Process Gas
30190013	- 30190099	Chemical Manufacturing	Fuel Fired Equipment	
30290003	Food and Agriculture	Fuel Fired Equipment	Process Heaters	Natural Gas
30390003	Primary Metal Production	Fuel Fired Equipment	Process Heaters	Natural Ga
30390004	Primary Metal Production	Fuel Fired Equipment	Process Heaters	Process Gas
30390013	Primary Metal Production	Fuel Fired Equipment	Incinerators	Natural Gas
30390014	Primary Metal Production	Fuel Fired Equipment	Incinerators	Process Gas
30390023	Primary Metal Production	Fuel Fired Equipment	Flares	Natural Gas
30390024	Primary Metal Production	Fuel Fired Equipment	Flares	Process Gas
30490003	Secondary Metal Production	Fuel Fired Equipment	Process Heaters	Natural
30490004	Secondary Metal Production	Fuel Fired Equipment	Process Heaters	Process
30490013	Secondary Metal Production	Fuel Fired Equipment	Incinerators	Natural Gas
30490014	Secondary Metal Production	Fuel Fired Equipment	Incinerators	Process Gas
30490023	Secondary Metal Production	Fuel Fired Equipment	Flares	Natural Gas
30490024	Secondary Metal Production	Fuel Fired Equipment	Flares	Process Gas
30490033	Secondary Metal Production	Fuel Fired Equipment	Furnaces	Natural Gas
30490034	Secondary Metal Production	Fuel Fired Equipment	Furnaces	Process Gas
30500206	Mineral Products	Mineral Products	Asphaltic Concrete	Asphalt Heater: Nat
30590003	Mineral Products	Fuel Fired Equipment	Process Heaters	Natural Gas
30590013	Mineral Products	Fuel Fired Equipment	Incinerators	Natural Gas
30590023	Mineral Products	Fuel Fired Equipment	Flares	Natural Gas
30600102	Petroleum Industry	Petroleum Industry	Process Heaters	GAS FIRED **
30600104	- 30600106	Petroleum Industry	Petroleum Industry	Process Heaters
30600108	Petroleum Industry	Petroleum Industry	Process Heaters	Landfill Gas-Fired
30600903	Petroleum Industry	Petroleum Industry	Flares	Natural Gas
30600904	Petroleum Industry	Petroleum Industry	Flares	Process Gas
30609903	Petroleum Industry	Petroleum Industry	Incinerators	Natural Gas
30609904	Petroleum Industry	Petroleum Industry	Incinerators	Process Gas
30790003	Pulp & Paper and Wood Products	Fuel Fired Equipment	Process Heaters	Natu
30790013	Pulp & Paper and Wood Products	Fuel Fired Equipment	Incinerators	Natural
30790023	Pulp & Paper and Wood Products	Fuel Fired Equipment	Flares	Natural Gas
30890003	Rubber and Miscellaneous Plastics Products	Rubber and Miscellaneous Plasti		
30890013	Rubber and Miscellaneous Plastics Products	Rubber and Miscellaneous Plasti		
30890023	Rubber and Miscellaneous Plastics Products	Rubber and Miscellaneous Plasti		
30990003	Fabricated Metal Products	Fabricated Metal Products	Process Heaters	Natu
30990013	Fabricated Metal Products	Fabricated Metal Products	Incinerators	Natural
30990023	Fabricated Metal Products	Fabricated Metal Products	Flares	Natural Gas
31000205	Oil and Gas Production	Oil and Gas Production	Natural Gas Production	Fla
31000404	Oil and Gas Production	Oil and Gas Production	Process Heaters	Natural Ga
31000405	Oil and Gas Production	Oil and Gas Production	Process Heaters	Process Ga
31000414	Oil and Gas Production	Oil and Gas Production	Steam Generators	Natural G
31000415	Oil and Gas Production	Oil and Gas Production	Steam Generators	Process G
31390003	Electrical Equipment	Electrical Equipment	Process Heaters	Natural Gas
39000602	- 39000799	In-Process Fuel Use	In-Process Fuel Use	
39990003	Miscellaneous Manufacturing Industries	Miscellaneous Manufacturing Industr		
39990004	Miscellaneous Manufacturing Industries	Miscellaneous Manufacturing Industr		
39990013	Miscellaneous Manufacturing Industries	Miscellaneous Manufacturing Industr		
39990014	Miscellaneous Manufacturing Industries	Miscellaneous Manufacturing Industr		
39990023	Miscellaneous Manufacturing Industries	Miscellaneous Manufacturing Industr		
39990024	Miscellaneous Manufacturing Industries	Miscellaneous Manufacturing Industr		
40201001	Surface Coating Operations	Surface Coating Operations	Coating Oven Heater	
40290013	Surface Coating Operations	Surface Coating Operations	Incinerator/Afterbu	
40290023	Surface Coating Operations	Surface Coating Operations	Flares	Natural Gas
49090013	Organic Solvent Evaporation - Miscellaneous	Fuel Fired Equipment	Incinera	
49090023	Organic Solvent Evaporation - Miscellaneous	Fuel Fired Equipment	Flares	
50390006	Solid Waste Disposal	Industrial	Auxillary Fuel/No Emissions	Natural Gas

Tier 2: 04 Other

Table 4.1-3. (continued)

10200801 - 10201302 External Combustion Boilers Industrial
10500110 - 10500114 External Combustion Boilers Space Heaters Industrial
2102007000 - 2102009000 Stationary Source Fuel Combustion Industrial
2390007000 - 2390009000 Industrial Processes In-Process Fuel Use
30290005 Food and Agriculture
30500209 Mineral Products Mineral Products Asphaltic Concrete Asphalt Heater: L P
30600107 Petroleum Industry Petroleum Industry Process Heaters LPG Fired
30600199 Petroleum Industry Petroleum Industry Process Heaters Other Not Classifi
30600905 Petroleum Industry Petroleum Industry Flares Liquified Petroleum Gas
30600999 Petroleum Industry Petroleum Industry Flares NOT CLASSIFIED **
30609905 Petroleum Industry Petroleum Industry Incinerators Liquified Petroleum G
30890004 Rubber and Miscellaneous Plastics Products Rubber and Miscellaneous Plastics
39000801 - 39001399 In-Process Fuel Use In-Process Fuel Use
40201004 Surface Coating Operations Surface Coating Operations Coating Oven Heater
50390010 Solid Waste Disposal Industrial Auxillary Fuel/No Emissions Liquified Pe

Tier 2: 05 Internal Combustion
20200101 - 20201002 Internal Combustion Engines Industrial
2102006002 Stationary Source Fuel Combustion Industrial Natural Gas All I.C. Engine

Tier 1: 03 FUEL COMB. OTHER

Tier 2: 01 Commercial/Institutional Coal
10300101 - 10300309 External Combustion Boilers Commercial/Institutional
10500202 External Combustion Boilers Space Heaters Commercial-Institutional Coal
2103001000 Stationary Source Fuel Combustion Commercial/Institutional Anthracite Coa
2103002000 Stationary Source Fuel Combustion Commercial/Institutional Bituminous/Sub
2199001000 - 2199003000 Stationary Source Fuel Combustion Total Area Source Fuel Combustion

Tier 2: 02 Commercial/Institutional Oil
10300401 - 10300504 External Combustion Boilers Commercial/Institutional
10500205 External Combustion Boilers Space Heaters Commercial-Institutional Disti
20300101 Internal Combustion Engines Commercial/Institutional Distillate Oil (Dies
20300102 Internal Combustion Engines Commercial/Institutional Distillate Oil (Dies
2103004000 Stationary Source Fuel Combustion Commercial/Institutional Distillate Oil
2103005000 Stationary Source Fuel Combustion Commercial/Institutional Residual Oil
2199004000 - 2199005000 Stationary Source Fuel Combustion Total Area Source Fuel Combustion
50190005 Solid Waste Disposal Government Auxillary Fuel/No Emissions Distillate O
50290005 Solid Waste Disposal Commercial/Institutional Auxillary Fuel/No Emissions

Tier 2: 03 Commercial/Institutional Gas
10300601 - 10300799 External Combustion Boilers Commercial/Institutional
10500206 External Combustion Boilers Space Heaters Commercial-Institutional Natur
20300201 - 20300702 Internal Combustion Engines Commercial/Institutional
2103006000 Stationary Source Fuel Combustion Commercial/Institutional Natural Gas T
2199006000 - 2199006002 Stationary Source Fuel Combustion Total Area Source Fuel Combustion Natural Gas
50190006 Solid Waste Disposal Government Auxillary Fuel/No Emissions Natural Gas
50290006 Solid Waste Disposal Commercial/Institutional Auxillary Fuel/No Emissions

Tier 2: 04 Misc. Fuel Comb. (Except Residential)
10300901 - 10301303 External Combustion Boilers Commercial/Institutional
10500209 - 10500214 External Combustion Boilers Space Heaters Commercial-Institutional
20190099 Internal Combustion Engines Miscellaneous Flares Heavy Water
20301001 - 20400402 Internal Combustion Engines
2103007000 - 2103011010 Stationary Source Fuel Combustion Commercial/Institutional
2199007000 Stationary Source Fuel Combustion Total Area Source Fuel Combustion Liqui
2199009000 - 2199011000 Stationary Source Fuel Combustion Total Area Source Fuel Combustion
28888801 - 28888803 Internal Combustion Engines Fugitive Emissions Other Not Classified Specify in Comments
50190010 Solid Waste Disposal Government Auxillary Fuel/No Emissions Liquified Pe
50290010 Solid Waste Disposal Commercial/Institutional Auxillary Fuel/No Emissions

Tier 2: 05 Residential Wood
2104008000 - 2104008053 Stationary Source Fuel Combustion Residential Wood
2199008000 Stationary Source Fuel Combustion Total Area Source Fuel Combustion Wood

Tier 2: 06 Residential Other

Table 4.1-3. (continued)

2104001000 - 2104007000 Stationary Source Fuel Combustion Residential
2104011000 Stationary Source Fuel Combustion Residential Kerosene Total: All Heater

Tier 1: 04 CHEMICAL & ALLIED PRODUCT MFG

Tier 2: 01 Organic Chemical Mfg

2301000000 Industrial Processes Chemical Manufacturing: SIC 28 All Process Total
2301040000 Industrial Processes Chemical Manufacturing: SIC 28
30100101 Chemical Manufacturing Chemical Manufacturing Adipic Acid General
30100103 - 30100105 Chemical Manufacturing Chemical Manufacturing Adipic Acid
30100107 - 30100199 Chemical Manufacturing Chemical Manufacturing Adipic Acid
30100601 - 30100699 Chemical Manufacturing Chemical Manufacturing Charcoal Manufacture
30101901 - 30101907 Chemical Manufacturing Chemical Manufacturing Phthalic Anhydride
30103101 - 30103104 Chemical Manufacturing Chemical Manufacturing Terephthalic Acid/Dimethyl Terephthalate
30103180 Chemical Manufacturing Chemical Manufacturing Terephthalic Acid/Dimethyl
30103199 Chemical Manufacturing Chemical Manufacturing Terephthalic Acid/Dimethyl
30103402 - 30103499 Chemical Manufacturing Chemical Manufacturing
30104201 - 30104203 Chemical Manufacturing Lead Alkyl Mfg. Na/Pb Alloy Process
30104301 Chemical Manufacturing Lead Alkyl Mfg. Electrolytic Process General: Elec
30109101 - 30110099 Chemical Manufacturing Chemical Manufacturing
30112001 - 30112780 Chemical Manufacturing Chemical Manufacturing
30113201 - 30121009 Chemical Manufacturing
30121080 - 30130107 Chemical Manufacturing Chemical Manufacturing
30130110 - 30181001 Chemical Manufacturing Chemical Manufacturing
30184001 Chemical Manufacturing Chemical Manufacturing General Processes Distilla

Tier 2: 02 Inorganic Chemical Mfg

2301010000 Industrial Processes Chemical Manufacturing: SIC 28 Industrial Inorganic
2301010010 Industrial Processes Chemical Manufacturing: SIC 28 Industrial Inorganic
30100801 Chemical Manufacturing Chemical Manufacturing Chloro-Alkali Production L
30100802 Chemical Manufacturing Chemical Manufacturing Chloro-Alkali Production L
30100805 Chemical Manufacturing Chemical Manufacturing Chloro-Alkali Production A
30100899 Chemical Manufacturing Chemical Manufacturing Chloro-Alkali Production O
30101101 Chemical Manufacturing Chemical Manufacturing Hydrochloric Acid Rotary K
30101199 - 30101203 Chemical Manufacturing Chemical Manufacturing
30101206 Chemical Manufacturing Chemical Manufacturing Hydrofluoric Acid Tail Gas
30101299 Chemical Manufacturing Chemical Manufacturing Hydrofluoric Acid Other No
30102101 - 30102319 Chemical Manufacturing
30102322 Chemical Manufacturing Sulfuric Acid Contact Process Process Equipment L
30102399 Chemical Manufacturing Sulfuric Acid Contact Process Other Not Classifie
30103201 - 30103299 Chemical Manufacturing Chemical Manufacturing Elemental Sulfur Production
30103501 - 30103553 Chemical Manufacturing Chemical Manufacturing Inorganic Pigments
30103599 - 30103903 Chemical Manufacturing Chemical Manufacturing
30107001 Chemical Manufacturing Inorganic Chem. Mfg. General Processes Fugitive L
30111201 - 30111401 Chemical Manufacturing Chemical Manufacturing

Tier 2: 03 Polymer & Resin Mfg

2301030000 Industrial Processes Chemical Manufacturing: SIC 28
30101801 - 30101807 Chemical Manufacturing Plastics Production Specific Products
30101809 Chemical Manufacturing Plastics Production Specific Products Extruder
30101812 - 30101814 Chemical Manufacturing Plastics Production Specific Products
30101817 - 30101820 Chemical Manufacturing Plastics Production Specific Products
30101822 - 30101839 Chemical Manufacturing Plastics Production Specific Products
30101842 - 30101863 Chemical Manufacturing
30101870 - 30101882 Chemical Manufacturing Chemical Manufacturing
30101885 - 30101892 Chemical Manufacturing
30101899 Chemical Manufacturing Plastics Production General Processes Other Not C
30102401 - 30102424 Chemical Manufacturing Syn. Org. Fiber Mfg.
30102426 Chemical Manufacturing Syn. Org. Fiber Mfg. General Processes Equipment
30102499 - 30102611 Chemical Manufacturing
30102613 - 30102699 Chemical Manufacturing

Tier 2: 04 Agricultural Chemical Mfg

Table 4.1-3. (continued)

30100305 - 30100399	Chemical Manufacturing	Chemical Manufacturing	Ammonia Production
30101301 - 30101399	Chemical Manufacturing	Chemical Manufacturing	Nitric Acid
30101601	Chemical Manufacturing	Chemical Manufacturing	Phosphoric Acid: Wet Proces
30101603 - 30101799	Chemical Manufacturing	Chemical Manufacturing	
30102701 - 30102708	Chemical Manufacturing	Chemical Manufacturing	Ammonium Nitrate Production
30102710 - 30102801	Chemical Manufacturing	Chemical Manufacturing	
30102806 - 30102820	Chemical Manufacturing	Chemical Manufacturing	Normal Superphosphate
30102822 - 30102825	Chemical Manufacturing	Chemical Manufacturing	Normal Superphosphate
30102906 - 30102920	Chemical Manufacturing	Chemical Manufacturing	Triple Superphosphate
30102922 - 30103002	Chemical Manufacturing	Chemical Manufacturing	
30103004 - 30103099	Chemical Manufacturing	Chemical Manufacturing	Ammonium Phosphates
30103301 - 30103399	Chemical Manufacturing	Chemical Manufacturing	Pesticides
30104001 - 30104006	Chemical Manufacturing	Chemical Manufacturing	Urea Production
30104008 - 30104013	Chemical Manufacturing	Chemical Manufacturing	Urea Production
30104501	Chemical Manufacturing	Chemical Manufacturing	Organic Fertilizer General
30113004	Chemical Manufacturing	Chemical Manufacturing	Ammonium Sulfate Rotary Dr
30113005	Chemical Manufacturing	Chemical Manufacturing	Ammonium Sulfate Fluid Bed
Tier 2: 05 Paint, Varnish, Lacquer, Enamel Mfg			
30101401 - 30101403	Chemical Manufacturing	Chemical Manufacturing	Paint Manufacture
30101499 - 30101599	Chemical Manufacturing	Chemical Manufacturing	
Tier 2: 06 Pharmaceutical Mfg			
2301020000	Industrial Processes	Chemical Manufacturing: SIC 28	
30106001 - 30106009	Chemical Manufacturing	Chemical Manufacturing	Pharmaceutical Preparations
30106011 - 30106099	Chemical Manufacturing	Chemical Manufacturing	Pharmaceutical Preparations
Tier 2: 07 Other Chemical Mfg			
30100501 - 30100507	Chemical Manufacturing	Chemical Manufacturing	Carbon Black Production
30100509	Chemical Manufacturing	Chemical Manufacturing	Carbon Black Production Fu
30100599	Chemical Manufacturing	Chemical Manufacturing	Carbon Black Production Ot
30100701 - 30100799	Chemical Manufacturing	Chemical Manufacturing	
30100901 - 30101014	Chemical Manufacturing		
30101021	Chemical Manufacturing	Explosives	Trinitrotoluene Continuous Process: Ni
30101022	Chemical Manufacturing	Explosives	Trinitrotoluene Continuous Process: Ni
30101099	Chemical Manufacturing	Explosives	Trinitrotoluene Other Not Classified
30102001 - 30102099	Chemical Manufacturing	Chemical Manufacturing	Printing Ink Manufacture
30104101 - 30104199	Chemical Manufacturing	Chemical Manufacturing	Nitrocellulose
30105001	Chemical Manufacturing	Chemical Manufacturing	Adhesives GENL/COMPND UNK*
30111103	Chemical Manufacturing	Chemical Manufacturing	Asbestos Chemical BRAKE LI
30111199	Chemical Manufacturing	Chemical Manufacturing	Asbestos Chemical NOT CLAS
30188801 - 30188805	Chemical Manufacturing	Chemical Manufacturing	Fugitive Emissions Specify in Comments Field
30199998	Chemical Manufacturing	Chemical Manufacturing	Other Not Classified Speci
30199999	Chemical Manufacturing	Chemical Manufacturing	Other Not Classified Speci
Tier 1: 05 METALS PROCESSING			
Tier 2: 01 Non-Ferrous Metals Processing			
2304050000	Industrial Processes	Secondary Metal Production: SIC 33	Nonferrous Foundr
30300001	Primary Metal Production	Aluminum Ore Bauxite	Crushing/Handling
30300002	Primary Metal Production	Aluminum Ore Bauxite	Drying Oven
30300101 - 30300201	Primary Metal Production	Primary Metal Production	
30300502 - 30300518	Primary Metal Production	Primary Metal Production	Primary Copper Smelting
30300521 - 30300599	Primary Metal Production	Primary Metal Production	Primary Copper Smelting
30301001 - 30301010	Primary Metal Production	Primary Metal Production	Lead Production
30301014	Primary Metal Production	Primary Metal Production	Lead Production Sinter
30301015	Primary Metal Production	Primary Metal Production	Lead Production Sinter
30301017 - 30301025	Primary Metal Production	Primary Metal Production	Lead Production
30301099 - 30301499	Primary Metal Production	Primary Metal Production	
30303002 - 30303008	Primary Metal Production	Primary Metal Production	Zinc Production
30303010	Primary Metal Production	Primary Metal Production	Zinc Production Sinter
30303011	Primary Metal Production	Primary Metal Production	Zinc Production Zinc C
30303014 - 30303099	Primary Metal Production	Primary Metal Production	Zinc Production

Table 4.1-3. (continued)

30400101 - 30400299 Secondary Metal Production
30400401 - 30400699 Secondary Metal Production Secondary Metal Production
30400801 - 30400899
30401001 - 30401099 Secondary Metal Production Secondary Metal Production Nickel Production
30404001 Secondary Metal Production Secondary Metal Production Lead Cable Coating
36000101 Printing and Publishing Typesetting Typesetting (Lead Remelting) Remelti

Tier 2: 02 Ferrous Metals Processing

2303020000 Industrial Processes Primary Metal Production: SIC 33 Iron & Steel Foundr
30300302 - 30300304 Primary Metal Production Primary Metal Production By-Product Coke Manufacturing
30300306 - 30300308 Primary Metal Production Primary Metal Production By-Product Coke Manufacturing
30300310 - 30300315 Primary Metal Production Primary Metal Production By-Product Coke Manufacturing
30300331 - 30300401 Primary Metal Production Primary Metal Production
30300601 - 30300611 Primary Metal Production Ferroalloy Open Furnace
30300615 - 30300802 Primary Metal Production
30300808 Primary Metal Production Iron Production Blast Furnace Slag Slag Crushin
30300813 - 30300819 Primary Metal Production Iron Production Sintering
30300824 - 30300826 Primary Metal Production Iron Production Blast Furnaces
30300899 - 30300914 Primary Metal Production
30300916 - 30300999 Primary Metal Production Primary Metal Production Steel Production
30302301 - 30302303 Primary Metal Production Primary Metal Production Taconite Iron Ore Processing
30302306 Primary Metal Production Primary Metal Production Taconite Iron Ore Proce
30302308 Primary Metal Production Primary Metal Production Taconite Iron Ore Proce
30302311 - 30302315 Primary Metal Production Primary Metal Production Taconite Iron Ore Processing
30400301 - 30400355 Secondary Metal Production Secondary Metal Production Gray Iron Foundries
30400358 - 30400399 Secondary Metal Production Secondary Metal Production Gray Iron Foundries
30400701 - 30400720 Secondary Metal Production Secondary Metal Production Steel Foundries
30400722 Secondary Metal Production Secondary Metal Production Steel Foundries Mu
30400724 - 30400799 Secondary Metal Production Secondary Metal Production Steel Foundries
30400901 Secondary Metal Production Secondary Metal Production Malleable Iron Ann
30400999 Secondary Metal Production Secondary Metal Production Malleable Iron Oth
30405001 Secondary Metal Production Secondary Metal Production Miscellaneous Casti
30405099 Secondary Metal Production Secondary Metal Production Miscellaneous Casti

Tier 2: 03 Metals Processing NEC

2303000000 Industrial Processes Primary Metal Production: SIC 33 All Processes Tota
2304000000 Industrial Processes Secondary Metal Production: SIC 33 All Processes To
30302401 - 30302411 Primary Metal Production Metal Mining General Processes
30388801 - 30388805 Primary Metal Production Primary Metal Production Fugitive Emissions Specify in Comments Field
30399999 Primary Metal Production Primary Metal Production Primary Metal Productio
30402001 - 30402211 Secondary Metal Production Secondary Metal Production
30404901 - 30404999 Secondary Metal Production Secondary Metal Production Miscellaneous Casting and Fabricating Wax
Burnout Oven
30488801 - 30488805 Secondary Metal Production Secondary Metal Production Fugitive Emissions Specify in Comments Field
30499999 Secondary Metal Production Secondary Metal Production Secondary Metal Pro

Tier 1: 06 PETROLEUM & RELATED INDUSTRIES

Tier 2: 01 Oil & Gas Production

2310000000 - 2310030000 Industrial Processes Oil & Gas Production: SIC 13
31000101 - 31000103 Oil and Gas Production Oil and Gas Production Crude Oil Production
31000199 - 31000204 Oil and Gas Production Oil and Gas Production
31000206 - 31000299 Oil and Gas Production Oil and Gas Production Natural Gas Production
31088801 - 31088805 Oil and Gas Production Oil and Gas Production Fugitive Emissions Specify in Comments Field

Tier 2: 02 Petroleum Refineries & Related Industries

2306000000 Industrial Processes Petroleum Refining: SIC 29 All Processes Total
30600201 - 30600822 Petroleum Industry Petroleum Industry
30601001 - 30601599 Petroleum Industry Petroleum Industry
30610001 - 30699999 Petroleum Industry Petroleum Industry

Tier 2: 03 Asphalt Manufacturing

2306010000 Industrial Processes Petroleum Refining: SIC 29 Asphalt Paving/Roofing Ma
30500101 - 30500202 Mineral Products Mineral Products

Table 4.1-3. (continued)

30500204 Mineral Products Mineral Products Asphaltic Concrete Cold Aggregate Hand
30500205 Mineral Products Mineral Products Asphaltic Concrete Drum Dryer: Hot Asp
30500211 Mineral Products Mineral Products Asphaltic Concrete Rotary Dryer-Conven
30500299 Mineral Products Mineral Products Asphaltic Concrete SEE COMMENT **

Tier 1: 07 OTHER INDUSTRIAL PROCESSES

Tier 2: 01 Agriculture, Food, & Kindred Products

2302000000 - 2302080000 Industrial Processes Food & Kindred Products: SIC 20
2801600000 Miscellaneous Area Sources Agriculture Production - Crops Country Grain E
30200101 - 30200504 Food and Agriculture Food and Agriculture
30200512 - 30200604 Food and Agriculture Food and Agriculture
30200611 - 30200705 Food and Agriculture Food and Agriculture
30200712 - 30200714 Food and Agriculture Food and Agriculture Durum Milling
30200722 - 30200730 Food and Agriculture Food and Agriculture
30200732 - 30200734 Food and Agriculture Food and Agriculture Wheat Milling
30200742 - 30200745 Food and Agriculture Food and Agriculture Corn: Dry Milling
30200752 - 30200754 Food and Agriculture Food and Agriculture Corn: Wet Milling
30200756 Food and Agriculture Food and Agriculture Corn: Wet Milling Milling
30200760 Food and Agriculture Food and Agriculture Oat Milling General
30200772 - 30200774 Food and Agriculture Food and Agriculture Rice Milling
30200782 - 30200790 Food and Agriculture Food and Agriculture Soybean Mills
30200799 Food and Agriculture Food and Agriculture NOT CLASSIFIED SEE COMMENTS **
30200801 Food and Agriculture Food and Agriculture Barley Feed General **
30200804 - 30201919 Food and Agriculture
30201999 - 30203104 Food and Agriculture
30203201 - 30288805 Food and Agriculture
30299998 Food and Agriculture Food and Agriculture Other Not Classified Other Not
30299999 Food and Agriculture Food and Agriculture Other Not Classified Other Not

Tier 2: 02 Textiles, Leather, & Apparel Products

32099997 - 33088805

Tier 2: 03 Wood, Pulp & Paper, & Publishing Products

2307000000 Industrial Processes Wood Products: SIC 24 All Processes Total
2307020000 - 2307060000 Industrial Processes Wood Products: SIC 24
30700101 - 30702099 Pulp & Paper and Wood Products Pulp & Paper and Wood Products
30703003 - 30788898 Pulp & Paper and Wood Products Pulp & Paper and Wood Products
30799998 Pulp & Paper and Wood Products Pulp & Paper and Wood Products Other Not C
30799999 Pulp & Paper and Wood Products Pulp & Paper and Wood Products Other Not C

Tier 2: 04 Rubber & Miscellaneous Plastic Products

2308000000 Industrial Processes Rubber/Plastics: SIC 30 All Processes Total
30800101 - 30800108 Rubber and Miscellaneous Plastics Products Rubber and Miscellaneous Plastics Products Tire Manufacture
30800120 - 30800802 Rubber and Miscellaneous Plastics Products Rubber and Miscellaneous Plastics Products
30800901 Rubber and Miscellaneous Plastics Products Rubber and Miscellaneous Plasti
30899999 Rubber and Miscellaneous Plastics Products Rubber and Miscellaneous Plasti

Tier 2: 05 Mineral Products

2305000000 - 2305080000 Industrial Processes Mineral Processes: SIC 32
2325000000 - 2325050000 Industrial Processes Mining & Quarrying: SIC 14
30500301 Mineral Products Mineral Products Brick Manufacture Raw Material Drying
30500302 Mineral Products Mineral Products Brick Manufacture Raw Material Grindin
30500304 - 30500405 Mineral Products Mineral Products
30500499 - 30500606 Mineral Products Mineral Products
30500609 - 30500611 Mineral Products Mineral Products Cement Manufacturing: Dry Process
30500613 Mineral Products Mineral Products Cement Manufacturing: Dry Process Raw
30500614 Mineral Products Mineral Products Cement Manufacturing: Dry Process Clin
30500617 Mineral Products Mineral Products Cement Manufacturing: Dry Process Clin
30500699 Mineral Products Mineral Products Cement Manufacturing: Dry Process Othe
30500706 Mineral Products Mineral Products Cement Manufacturing: Wet Process Kiln
30500709 - 30500711 Mineral Products Mineral Products Cement Manufacturing: Wet Process
30500714 Mineral Products Mineral Products Cement Manufacturing: Wet Process Clin
30500717 Mineral Products Mineral Products Cement Manufacturing: Wet Process Clin

Table 4.1-3. (continued)

30500799 - 30500802	Mineral Products	Mineral Products
30500810 - 30500904	Mineral Products	Mineral Products
30500907 - 30500909	Mineral Products	Mineral Products Clay & Fly Ash Sintering
30500915 - 30501007	Mineral Products	
30501010	Mineral Products	Coal Cleaning Material Handling Crushing
30501012	Mineral Products	Coal Cleaning Material Handling Screening
30501013	Mineral Products	Coal Cleaning Material Handling Air Tables
30501017	Mineral Products	Coal Cleaning Material Handling Secondary Crushing
30501022	Mineral Products	Mineral Products Surface Mining Operations Drilling/Bl
30501034	Mineral Products	Mineral Products Surface Mining Operations Coal Seam: D
30501035	Mineral Products	Mineral Products Surface Mining Operations Blasting: Co
30501099	Mineral Products	Mineral Products Surface Mining Operations Other Not Cl
30501101	Mineral Products	Mineral Products Concrete Batching General (Non-fugitiv
30501112	Mineral Products	Mineral Products Concrete Batching Mixing: Wet
30501113	Mineral Products	Mineral Products Concrete Batching Mixing: Dry
30501120 - 30501215	Mineral Products	
30501223 - 30501503	Mineral Products	
30501505 - 30501507	Mineral Products	Mineral Products Gypsum Manufacture
30501511 - 30501513	Mineral Products	Mineral Products Gypsum Manufacture
30501515 - 30501517	Mineral Products	Mineral Products Gypsum Manufacture
30501519 - 30501606	Mineral Products	Mineral Products
30501609	Mineral Products	Mineral Products Lime Manufacture Hydrator: Atmospheric
30501611	Mineral Products	Mineral Products Lime Manufacture Prodcut Cooler
30501612	Mineral Products	Mineral Products Lime Manufacture Pressure Hydrator
30501616 - 30501902	Mineral Products	Mineral Products
30501905 - 30502006	Mineral Products	Mineral Products
30502008 - 30502010	Mineral Products	Mineral Products Stone Quarrying/Processing
30502012 - 30502105	Mineral Products	Mineral Products
30502201 - 30502501	Mineral Products	Mineral Products
30502508 - 30503103	Mineral Products	Mineral Products
30503108	Mineral Products	Mineral Products Asbestos Mining Overburden Stripping
30503109	Mineral Products	Mineral Products Asbestos Mining Ventilation of Process
30503199 - 30504010	Mineral Products	Mineral Products
30504024	Mineral Products	Mineral Products Mining & Quarrying of Nonmetallic Miner
30504030 - 30504034	Mineral Products	Mineral Products Mining & Quarrying of Nonmetallic Minerals
30504099 - 30509101	Mineral Products	Mineral Products
30515001 - 30588805	Mineral Products	Mineral Products
30599999	Mineral Products	Mineral Products Mineral Products: Other Not Classified
Tier 2: 06	Machinery Products	
2309000000 - 2309100260	Industrial Processes	Fabricated Metals: SIC 34
30900198 - 30988805	Fabricated Metal Products	Fabricated Metal Products
30999997 - 30999999	Fabricated Metal Products	Fabricated Metal Products Other Not Classified Other Not Classified
Tier 2: 07	Electronic Equipment	
31399999	Electrical Equipment	Electrical Equipment Other Not Classified Other Not
Tier 2: 08	Transportation Equipment	
31400901	Transportation Equipment	Transportation Equipment Automobiles/Truck Assem
31401101 - 31499999	Transportation Equipment	Transportation Equipment
Tier 2: 09	Construction	
2311000020	Industrial Processes	Construction: SIC 15 - 17 All Processes Demolition
2311000030	Industrial Processes	Construction: SIC 15 - 17 All Processes Blasting
2311000080	Industrial Processes	Construction: SIC 15 - 17 All Processes Welding Ope
2311010020	Industrial Processes	Construction: SIC 15 - 17 General Building Construct
2311010030	Industrial Processes	Construction: SIC 15 - 17 General Building Construct
2311010080	Industrial Processes	Construction: SIC 15 - 17 General Building Construct
2311020020	Industrial Processes	Construction: SIC 15 - 17 Heavy Construction Demoli
2311020030	Industrial Processes	Construction: SIC 15 - 17 Heavy Construction Blasti
2311020080	Industrial Processes	Construction: SIC 15 - 17 Heavy Construction Weldin
2311030020	Industrial Processes	Construction: SIC 15 - 17 Road Construction Demolit

Table 4.1-3. (continued)

2311030030	Industrial Processes	Construction: SIC 15 - 17	Road Construction	Blastin
2311030080	Industrial Processes	Construction: SIC 15 - 17	Road Construction	Welding
2311040080	Industrial Processes	Construction: SIC 15 - 17	Special Trade Construction	
31100199 - 31100202	Building Construction	Building Construction		
31100299	Building Construction	Building Construction	Construction: Special Trade C	
Tier 2: 10 Miscellaneous Industrial Processes				
2312000000	Industrial Processes	Machinery: SIC 35	All Processes	Total
2312050000	Industrial Processes	Machinery: SIC 35	Metalworking Machinery: Tool & Die	
2399000000	Industrial Processes	Industrial Processes: NEC	Industrial Processes: NEC	
31299999	Machinery, Miscellaneous	Machinery, Miscellaneous	Miscellaneous Machinery	
31501002	Photographic Equipment	Photographic Equipment	Photocopying Equipment Mfg.	
31501003	Photographic Equipment	Photographic Equipment	Photocopying Equipment Mfg.	
39999989 - 39999999	Miscellaneous Manufacturing Industries	Miscellaneous Manufacturing Industries		
Tier 1: 08 SOLVENT UTILIZATION				
Tier 2: 01 Degreasing				
2415000000 - 2415365999	Solvent Utilization	Degreasing		
40100201 - 40100399	Organic Solvent Evaporation	Degreasing		
40188801 - 40188898	Organic Solvent Evaporation	Degreasing	Fugitive Emissions	Specify in Comments Field
Tier 2: 02 Graphic Arts				
2425000000 - 2425040999	Solvent Utilization	Graphic Arts		
40500101 - 40500601	Printing/Publishing	Printing Process		
40500801 - 40588805	Printing/Publishing	Printing Process		
Tier 2: 03 Dry Cleaning				
2420000000 - 2420020999	Solvent Utilization	Dry Cleaning		
40100101 - 40100199	Organic Solvent Evaporation	Dry Cleaning	Dry Cleaning	
Tier 2: 04 Surface Coating				
2401001000 - 2401990999	Solvent Utilization	Surface Coating		
2440020000	Solvent Utilization	Miscellaneous Industrial	Adhesive (Industrial) Applic	
40200101 - 40200706	Surface Coating Operations	Surface Coating Operations	Surface Coating Application - General	
40200710 - 40200998	Surface Coating Operations	Surface Coating Operations		
40201101	Surface Coating Operations	Surface Coating Operations	Fabric Coating Coa	
40201103	Surface Coating Operations	Surface Coating Operations	Fabric Coating Coa	
40201105 - 40201303	Surface Coating Operations	Surface Coating Operations		
40201305 - 40201403	Surface Coating Operations	Surface Coating Operations		
40201405 - 40201503	Surface Coating Operations	Surface Coating Operations		
40201505 - 40201603	Surface Coating Operations	Surface Coating Operations		
40201605 - 40201703	Surface Coating Operations	Surface Coating Operations		
40201705 - 40201803	Surface Coating Operations	Surface Coating Operations		
40201805 - 40201903	Surface Coating Operations	Surface Coating Operations		
40201999 - 40202003	Surface Coating Operations	Surface Coating Operations		
40202005 - 40202103	Surface Coating Operations	Surface Coating Operations		
40202105 - 40202203	Surface Coating Operations	Surface Coating Operations		
40202205 - 40202303	Surface Coating Operations	Surface Coating Operations		
40202305 - 40202403	Surface Coating Operations	Surface Coating Operations		
40202405 - 40202503	Surface Coating Operations	Surface Coating Operations		
40202505 - 40202603	Surface Coating Operations	Surface Coating Operations		
40202605 - 40288805	Surface Coating Operations			
40299995 - 40299999	Surface Coating Operations	Surface Coating Operations	Surface Coating - Miscellaneous	
Tier 2: 05 Other Industrial				
2430000000 - 2440000999	Solvent Utilization			
40100401	Organic Solvent Evaporation	Degreasing	Knit Fabric Scouring w/ Chlorinate	
40100499	Organic Solvent Evaporation	Degreasing	Knit Fabric Scouring w/ Chlorinate	
49000101 - 49000199	Organic Solvent Evaporation	Miscellaneous	Solvent Extraction Processes	
49000202	Organic Solvent Evaporation	Miscellaneous	Waste Solvent Recovery Operatio	
49000206 - 49000599	Organic Solvent Evaporation	Miscellaneous		
49099998	Organic Solvent Evaporation	Miscellaneous	Miscellaneous Volatile Organic	
49099999	Organic Solvent Evaporation	Miscellaneous	Miscellaneous Volatile Organic	
Tier 2: 06 Nonindustrial				

Table 4.1-3. (continued)

2460000000 - 2465900000	Solvent Utilization
Tier 2: 07	Solvent Utilization NEC
2495000000 - 2495000999	Solvent Utilization All Solvent User Categories All Processes
Tier 1: 09	STORAGE & TRANSPORT
Tier 2: 01	Bulk Terminals & Plants
2501050000 - 2501050900	Storage & Transport Petroleum & Petroleum Product Storage Bulk Stations/Terminals: Breathing Loss
40400101 - 40400271	Bulk Terminals/Plants Petroleum Storage Tanks
40400401 - 40400498	Bulk Terminals/Plants Petroleum Storage Tanks Underground Tanks
Tier 2: 02	Petroleum & Petroleum Product Storage
2275900000 - 2275900102	Mobile Sources Aircraft Refueling: All Fuels
2275900201	Mobile Sources Aircraft Refueling: All Fuels Underground Tank: Total
2501000000 - 2501010900	Storage & Transport Petroleum & Petroleum Product Storage
2501060000	Storage & Transport Petroleum & Petroleum Product Storage Gasoline Servic
2501060200	Storage & Transport Petroleum & Petroleum Product Storage Gasoline Servic
2501070000	Storage & Transport Petroleum & Petroleum Product Storage Diesel Service
2501070200	Storage & Transport Petroleum & Petroleum Product Storage Diesel Service
2501995000 - 2501995180	Storage & Transport Petroleum & Petroleum Product Storage All Storage Types: Working Loss
31000104	Oil and Gas Production Oil and Gas Production Crude Oil Production Crude
31000105	Oil and Gas Production Oil and Gas Production Crude Oil Production Crude
40300101 - 40399999	Petroleum Product Storage (Refineries Oil and Gas Fie
40400301 - 40400305	Bulk Terminals/Plants Petroleum Storage Tanks Oil Field Storage of Crude Oil
Tier 2: 03	Petroleum & Petroleum Product Transport
2505000000 - 2505040180	Storage & Transport Petroleum & Petroleum Product Transport
40600101 - 40600299	Transportation and Marketing of Petroleum Products
40688801 - 40688805	Transportation and Marketing of Petroleum Products Transportation and Marketing of Petroleum Products
	Fugitive Emissions Specify in Comments Field
Tier 2: 04	Service Stations: Stage I
2501060050 - 2501060053	Storage & Transport Petroleum & Petroleum Product Storage Gasoline Service Stations
2501070050 - 2501070053	Storage & Transport Petroleum & Petroleum Product Storage Diesel Service Stations
40600301 - 40600399	Transportation and Marketing of Petroleum Products Gasoline Retail Operations Stage I
Tier 2: 05	Service Stations: Stage II
2501060100 - 2501060103	Storage & Transport Petroleum & Petroleum Product Storage Gasoline Service Stations
2501070100 - 2501070103	Storage & Transport Petroleum & Petroleum Product Storage Diesel Service Stations
40600401 - 40600499	Transportation and Marketing of Petroleum Products Filling Vehicle Gas Tanks Stage II
Tier 2: 06	Service Stations: Breathing & Emptying
2275900202	Mobile Sources Aircraft Refueling: All Fuels Underground Tank: Breathing
2501060201	Storage & Transport Petroleum & Petroleum Product Storage Gasoline Servic
2501070201	Storage & Transport Petroleum & Petroleum Product Storage Diesel Service
Tier 2: 07	Organic Chemical Storage
2510000000 - 2510995405	Storage & Transport Organic Chemical Storage
30100102	Chemical Manufacturing Chemical Manufacturing Adipic Acid Raw Material S
30100106	Chemical Manufacturing Chemical Manufacturing Adipic Acid Drying, Loadin
30100508	Chemical Manufacturing Chemical Manufacturing Carbon Black Production Ba
30101404	Chemical Manufacturing Chemical Manufacturing Paint Manufacture Raw Mate
30101602	Chemical Manufacturing Chemical Manufacturing Phosphoric Acid: Wet Proces
30101808	Chemical Manufacturing Plastics Production Specific Products Monomer and
30101810	Chemical Manufacturing Plastics Production Specific Products Conveying
30101811	Chemical Manufacturing Plastics Production Specific Products Storage
30101815	Chemical Manufacturing Plastics Production Specific Products Pellet Silo
30101816	Chemical Manufacturing Plastics Production Specific Products Transferring
30101821	Chemical Manufacturing Plastics Production Specific Products Extruding/
30101840	Chemical Manufacturing Plastics Production Specific Products Polyester/A
30101864	Chemical Manufacturing Chemical Manufacturing Polyethylene Pellet Silo/S
30101865	Chemical Manufacturing Chemical Manufacturing Polyethylene Transferring /
30101883	Chemical Manufacturing Chemical Manufacturing Polyurethane Transferring/
30101893	Chemical Manufacturing Plastics Production General Processes Raw Materia
30101894	Chemical Manufacturing Plastics Production General Processes Solvent Sto
30102425	Chemical Manufacturing Syn. Org. Fiber Mfg. General Processes Fiber Stor

Table 4.1-3. (continued)

30102427	Chemical Manufacturing	Syn. Org. Fiber Mfg.	General Processes	Solvent St
30102612	Chemical Manufacturing	Chemical Manufacturing	Synthetic Rubber (Manufactu	
30102709	Chemical Manufacturing	Chemical Manufacturing	Ammonium Nitrate Production	
30103003	Chemical Manufacturing	Chemical Manufacturing	Ammonium Phosphates	Screen
30103105	Chemical Manufacturing	Chemical Manufacturing	Terephthalic Acid/Dimethyl	
30104007	Chemical Manufacturing	Chemical Manufacturing	Urea Production	Bulk Loadi
30106010	Chemical Manufacturing	Chemical Manufacturing	Pharmaceutical Preparations	
30130108	Chemical Manufacturing	Chemical Manufacturing	Chlorobenzene	DCB Crystal
30183001	Chemical Manufacturing	Chemical Manufacturing	General Processes	Storage/
30201920	Food and Agriculture	Veg. Oil Processing	General Processes	Solvent Stora
30800109	Rubber and Miscellaneous Plastics Products	Rubber and Miscellaneous Plasti		
30800110	Rubber and Miscellaneous Plastics Products	Rubber and Miscellaneous Plasti		
30800803	Rubber and Miscellaneous Plastics Products	Rubber and Miscellaneous Plasti		
31501001	Photographic Equipment	Photographic Equipment	Photocopying Equipment	Mfg.
40200707	Surface Coating Operations	Surface Coating Operations	Surface Coating App	
40201104	Surface Coating Operations	Surface Coating Operations	Fabric Coating	Coa
40201304	Surface Coating Operations	Surface Coating Operations	Paper Coating	Coat
40201404	Surface Coating Operations	Surface Coating Operations	Surface Coating of	
40201504	Surface Coating Operations	Surface Coating Operations	Magnet Wire	Surface
40201604	Surface Coating Operations	Surface Coating Operations	Surface Coating of	
40201704	Surface Coating Operations	Surface Coating Operations	Metal Can	Coating
40201804	Surface Coating Operations	Surface Coating Operations	Metal Coil	Coating
40201904	Surface Coating Operations	Surface Coating Operations	Wood Furniture	Surf
40202004	Surface Coating Operations	Surface Coating Operations	Metal Furniture	Sur
40202104	Surface Coating Operations	Surface Coating Operations	Surface Coating of	
40202204	Surface Coating Operations	Surface Coating Operations	Surface Coating of	
40202304	Surface Coating Operations	Surface Coating Operations	Surface Coating of	
40202404	Surface Coating Operations	Surface Coating Operations	Surface Coating of	
40202504	Surface Coating Operations	Surface Coating Operations	Surface Coating of	
40202604	Surface Coating Operations	Surface Coating Operations	Surface Coating of	
40500701	Printing/Publishing	Printing Process	Printing	Solvent Storage: General
40700401 - 40799998	Organic Chemical Storage			
49000201	Organic Solvent Evaporation	Miscellaneous	Waste Solvent Recovery Operatio	
49000204	Organic Solvent Evaporation	Miscellaneous	Waste Solvent Recovery Operatio	
49000205	Organic Solvent Evaporation	Miscellaneous	Waste Solvent Recovery Operatio	
Tier 2: 08 Organic Chemical Transport				
2515000000 - 2515040405	Storage & Transport	Organic Chemical Transport		
30101866	Chemical Manufacturing	Chemical Manufacturing	Polyethylene	Packing/Shipp
30101884	Chemical Manufacturing	Chemical Manufacturing	Polyurethane	Packing/Shipp
40899995 - 40899999	Organic Chemical Transportation	Organic Chemical Transportation	Specify Liquid	
Tier 2: 09 Inorganic Chemical Storage				
2520000000 - 2520995040	Storage & Transport	Inorganic Chemical Storage		
30100804	Chemical Manufacturing	Chemical Manufacturing	Chloro-Alkali Production	C
30101198	Chemical Manufacturing	Chemical Manufacturing	Hydrochloric Acid	Handling
30101204	Chemical Manufacturing	Chemical Manufacturing	Hydrofluoric Acid	Fluorspa
30101205	Chemical Manufacturing	Chemical Manufacturing	Hydrofluoric Acid	Fluorspa
30102321	Chemical Manufacturing	Sulfuric Acid	Contact Process	Storage Tank Vent
30102803 - 30102805	Chemical Manufacturing	Chemical Manufacturing	Normal Superphosphate	
30102821	Chemical Manufacturing	Chemical Manufacturing	Normal Superphosphate	Den
30102903 - 30102905	Chemical Manufacturing	Chemical Manufacturing	Triple Superphosphate	
30102921	Chemical Manufacturing	Chemical Manufacturing	Triple Superphosphate	Den
30103554	Chemical Manufacturing	Chemical Manufacturing	Inorganic Pigments	Conveyi
30104204	Chemical Manufacturing	Lead Alkyl Mfg.	Na/Pb Alloy Process	Sludge Pits
30107002	Chemical Manufacturing	Inorganic Chem. Mfg.	General Processes	Storage/Tr
30121010	Chemical Manufacturing	Chemical Manufacturing	Caprolactum	Ammonium Sulfa
30187001 - 30188599	Chemical Manufacturing	Inorganic Chemical Storage		
Tier 2: 10 Inorganic Chemical Transport				
2525000000 - 2525040040	Storage & Transport	Inorganic Chemical Transport		

Table 4.1-3. (continued)

30100803	Chemical Manufacturing	Chemical Manufacturing	Chloro-Alkali Production	C
30102320	Chemical Manufacturing	Sulfuric Acid	Contact Process	Tank Car and Truck
Tier 2: 11 Bulk Materials Storage				
2530000000 - 2530050120	Storage & Transport	Bulk Materials Storage		
2650000004	Waste Disposal, Treatment, & Recovery	Scrap & Waste Materials	Scrap & Was	
30200505 - 30200511	Food and Agriculture	Food and Agriculture	Feed and Grain Terminal Elevators	
30200605 - 30200610	Food and Agriculture	Food and Agriculture	Feed and Grain Country Elevators	
30200751	Food and Agriculture	Food and Agriculture	Corn: Wet Milling	Grain Receiv
30200755	Food and Agriculture	Food and Agriculture	Corn: Wet Milling	Bulk Loading
30200771	Food and Agriculture	Food and Agriculture	Rice Milling	Grain Receiving
30200781	Food and Agriculture	Food and Agriculture	Soybean Mills	Grain Receiving
30200791	Food and Agriculture	Food and Agriculture	Soybean Mills	Bulk Loading
30200802	Food and Agriculture	Food and Agriculture	Feed Manufacture	Grain Receivi
30200803	Food and Agriculture	Food and Agriculture	Feed Manufacture	Shipping
30203105 - 30203111	Food and Agriculture	Food and Agriculture	Export Grain Elevators	
30300003	Primary Metal Production	Aluminum Ore	Bauxite	Fine Ore Storage
30300305	Primary Metal Production	Primary Metal Production	By-Product Coke Manufac	
30300309	Primary Metal Production	Primary Metal Production	By-Product Coke Manufac	
30300316	Primary Metal Production	Primary Metal Production	By-Product Coke Manufac	
30300613	Primary Metal Production	Ferroalloy	Open Furnace	Raw Material Storage
30300614	Primary Metal Production	Ferroalloy	Open Furnace	Raw Material Transfer
30300804	Primary Metal Production	Iron Production	Blast Furnace Slag	Loader: Hi-S
30300805	Primary Metal Production	Iron Production	Blast Furnace Slag	Loader: Low-
30300809 - 30300812	Primary Metal Production	Iron Production		
30300820 - 30300823	Primary Metal Production	Iron Production		
30300827	Primary Metal Production	Iron Production	Blast Furnaces	Lump Ore Unloadi
30300841	Primary Metal Production	Iron Production	Miscellaneous Matl. Handlng	Flu
30300842	Primary Metal Production	Iron Production	Miscellaneous Matl. Handlng	Ble
30300915	Primary Metal Production	Primary Metal Production	Steel Production	Hot M
30301011 - 30301013	Primary Metal Production	Primary Metal Production	Lead Production	
30301016	Primary Metal Production	Primary Metal Production	Lead Production	Sinter
30301026	Primary Metal Production	Primary Metal Production	Lead Production	Sinter
30302304	Primary Metal Production	Primary Metal Production	Taconite Iron Ore Proce	
30302305	Primary Metal Production	Primary Metal Production	Taconite Iron Ore Proce	
30302307	Primary Metal Production	Primary Metal Production	Taconite Iron Ore Proce	
30302309	Primary Metal Production	Primary Metal Production	Taconite Iron Ore Proce	
30302310	Primary Metal Production	Primary Metal Production	Taconite Iron Ore Proce	
30302316	Primary Metal Production	Primary Metal Production	Taconite Iron Ore Proce	
30303009	Primary Metal Production	Primary Metal Production	Zinc Production	Raw Ma
30303012	Primary Metal Production	Primary Metal Production	Zinc Production	Raw Ma
30400356	Secondary Metal Production	Secondary Metal Production	Gray Iron Foundries	
30400357	Secondary Metal Production	Secondary Metal Production	Gray Iron Foundries	
30400721	Secondary Metal Production	Secondary Metal Production	Steel Foundries	Sa
30400723	Secondary Metal Production	Secondary Metal Production	Steel Foundries	Co
30500203	Mineral Products	Mineral Products	Asphaltic Concrete	Storage Piles
30500303	Mineral Products	Mineral Products	Brick Manufacture	Storage of Raw Mater
30500406	Mineral Products	Mineral Products	Calcium Carbide	Circular Charging: Co
30500607	Mineral Products	Mineral Products	Cement Manufacturing: Dry Process	Raw
30500608	Mineral Products	Mineral Products	Cement Manufacturing: Dry Process	Raw
30500612	Mineral Products	Mineral Products	Cement Manufacturing: Dry Process	Raw
30500615	Mineral Products	Mineral Products	Cement Manufacturing: Dry Process	Clin
30500616	Mineral Products	Mineral Products	Cement Manufacturing: Dry Process	Clin
30500618	Mineral Products	Mineral Products	Cement Manufacturing: Dry Process	Ceme
30500619	Mineral Products	Mineral Products	Cement Manufacturing: Dry Process	Ceme
30500707	Mineral Products	Mineral Products	Cement Manufacturing: Wet Process	Raw
30500708	Mineral Products	Mineral Products	Cement Manufacturing: Wet Process	Raw
30500712	Mineral Products	Mineral Products	Cement Manufacturing: Wet Process	Raw
30500715	Mineral Products	Mineral Products	Cement Manufacturing: Wet Process	Clin

Table 4.1-3. (continued)

30500716	Mineral Products	Mineral Products	Cement Manufacturing: Wet Process	Clin
30500718	Mineral Products	Mineral Products	Cement Manufacturing: Wet Process	Ceme
30500719	Mineral Products	Mineral Products	Cement Manufacturing: Wet Process	Ceme
30500803	Mineral Products	Mineral Products	Ceramic Clay Mfg.	Storage
30500905	Mineral Products	Mineral Products	Clay & Fly Ash Sintering	Raw Clay/ Sha
30500906	Mineral Products	Mineral Products	Clay & Fly Ash Sintering	Raw Clay/Shal
30500910	Mineral Products	Mineral Products	Clay & Fly Ash Sintering	Expanded Shal
30501008	Mineral Products	Coal Cleaning	Material Handling	Unloading
30501009	Mineral Products	Coal Cleaning	Material Handling	Raw Coal Storage
30501011	Mineral Products	Coal Cleaning	Material Handling	Coal Transfer
30501014 - 30501016	Mineral Products	Coal Cleaning	Material Handling	
30501021	Mineral Products	Mineral Products	Surface Mining Operations	Overburden R
30501023	Mineral Products	Mineral Products	Surface Mining Operations	Loading
30501030	Mineral Products	Mineral Products	Surface Mining Operations	Topsoil Remo
30501032	Mineral Products	Mineral Products	Surface Mining Operations	Topsoil Unlo
30501033	Mineral Products	Mineral Products	Surface Mining Operations	Overburden
30501036 - 30501038	Mineral Products	Mineral Products	Surface Mining Operations	
30501040 - 30501043	Mineral Products	Mineral Products	Surface Mining Operations	
30501048	Mineral Products	Mineral Products	Surface Mining Operations	Overburden R
30501106 - 30501111	Mineral Products	Mineral Products	Concrete Batching	
30501114	Mineral Products	Mineral Products	Concrete Batching	Transferring: Convey
30501115	Mineral Products	Mineral Products	Concrete Batching	Storage: Bins/ Hoppe
30501221	Mineral Products	Fiberglass Mfg.	Raw Materials Handling	Raw Material: Un
30501222	Mineral Products	Fiberglass Mfg.	Raw Materials Handling	Raw Material: St
30501504	Mineral Products	Mineral Products	Gypsum Manufacture	Conveying
30501508 - 30501510	Mineral Products	Mineral Products	Gypsum Manufacture	
30501514	Mineral Products	Mineral Products	Gypsum Manufacture	Storage Bins: Stucc
30501518	Mineral Products	Mineral Products	Gypsum Manufacture	Mixers/Conveyors
30501607	Mineral Products	Mineral Products	Lime Manufacture	Raw Material Transfer
30501608	Mineral Products	Mineral Products	Lime Manufacture	Raw Material Unloadin
30501610	Mineral Products	Mineral Products	Lime Manufacture	Raw Material Storage
30501613 - 30501615	Mineral Products	Mineral Products	Lime Manufacture	
30501903	Mineral Products	Mineral Products	Phosphate Rock	Transfer/Storage
30501904	Mineral Products	Mineral Products	Phosphate Rock	Open Storage
30502007	Mineral Products	Mineral Products	Stone Quarrying/Processing	Open Storang
30502106	Mineral Products	Mineral Products	Salt Mining	Conveying
30502502	Mineral Products	Mineral Products	Sand/Gravel	Aggregate Storage
30502503	Mineral Products	Mineral Products	Sand/Gravel	Material Transfer and Conv
30502505 - 30502507	Mineral Products	Mineral Products	Sand/Gravel	
30503104 - 30503107	Mineral Products	Mineral Products	Asbestos Mining	
30503110	Mineral Products	Mineral Products	Asbestos Mining	Stockpiling
30503111	Mineral Products	Mineral Products	Asbestos Mining	Tailing Piles
30504020 - 30504023	Mineral Products	Mineral Products	Mining & Quarrying of Nonmetallic Minerals	
30504025	Mineral Products	Mineral Products	Mining & Quarrying of Nonmetallic Miner	
30504036	Mineral Products	Mineral Products	Mining & Quarrying of Nonmetallic Miner	
30510001 - 30510599	Mineral Products	Mineral Products		
30703001	Pulp & Paper and Wood Products	Pulp & Paper and Wood Products	Miscellaneous	
30703002	Pulp & Paper and Wood Products	Pulp & Paper and Wood Products	Miscellaneous	
Tier 2: 12	Bulk Materials Transport			
2535000000 - 2535030140	Storage & Transport	Bulk Materials Transport		
30200711	Food and Agriculture	Food and Agriculture	Durum Milling	Grain Receiving
30200721	Food and Agriculture	Food and Agriculture	Rye Milling	Grain Receiving
30200731	Food and Agriculture	Food and Agriculture	Wheat Milling	Grain Receiving
30200741	Food and Agriculture	Food and Agriculture	Corn: Dry Milling	Grain Receiving
30501044	Mineral Products	Mineral Products	Surface Mining Operations	Train Loading
31100203	Building Construction	Building Construction	Construction: Demolition of S	
31100204	Building Construction	Building Construction	Construction: Demolition of S	

Tier 1: 10 WASTE DISPOSAL & RECYCLING

Table 4.1-3. (continued)

Tier 2: 01 Incineration

2601000000 - 2601030000 Waste Disposal, Treatment, & Recovery On-Site Incineration
30101015 Chemical Manufacturing Explosives Trinitrotoluene Batch Process: Red Wat
30101023 Chemical Manufacturing Explosives Trinitrotoluene Continuous Process: Re
31307001 Electrical Equipment Electrical Equipment Electrical Windings Reclamation
31307002 Electrical Equipment Electrical Equipment Electrical Windings Reclamation
31401001 Transportation Equipment Transportation Equipment Brake Shoe Debonding S
31401002 Transportation Equipment Transportation Equipment Brake Shoe Debonding M
49000203 Organic Solvent Evaporation Miscellaneous Waste Solvent Recovery Operatio
50100101 - 50100103 Solid Waste Disposal Government Municipal Incineration
50100505 - 50100517 Solid Waste Disposal Government Other Incineration
50200101 - 50200105 Solid Waste Disposal Commercial/Institutional Incineration: General
50200301 - 50200507 Solid Waste Disposal Commercial/Institutional
50300101 - 50300109 Solid Waste Disposal Industrial Incineration
50300501 Solid Waste Disposal Industrial Incineration Hazardous Waste
50300506 Solid Waste Disposal Industrial Incineration Sludge

Tier 2: 02 Open Burning

2610000000 - 2610030000 Waste Disposal, Treatment, & Recovery Open Burning
50100201 Solid Waste Disposal Government Open Burning Dump General Refuse
50100202 Solid Waste Disposal Government Open Burning Dump Vegetation Only
50200201 Solid Waste Disposal Commercial/Institutional Open Burning Wood
50200202 Solid Waste Disposal Commercial/Institutional Open Burning Refuse
50300201 - 50300205 Solid Waste Disposal Industrial Open Burning

Tier 2: 03 POTW

2630000000 Waste Disposal, Treatment, & Recovery Wastewater Treatment All Categories
2630020000 Waste Disposal, Treatment, & Recovery Wastewater Treatment Public Owned
50100701 - 50100704 Solid Waste Disposal Government Sewage Treatment

Tier 2: 04 Industrial Waste Water

2630010000 Waste Disposal, Treatment, & Recovery Wastewater Treatment Industrial To
30182001 - 30182003 Chemical Manufacturing Chemical Manufacturing General Processes

Tier 2: 05 TSDF

2640000000 - 2640020004 Waste Disposal, Treatment, & Recovery TSDFs
50300801 - 50300899 Solid Waste Disposal Industrial Treatment, Storage, Disposal Facilities

Tier 2: 06 Landfills

2620000000 - 2620030000 Waste Disposal, Treatment, & Recovery Landfills
50100401 Solid Waste Disposal Government Landfill Dump Unpave Road Traffic
50200601 Solid Waste Disposal Commercial/Institutional Landfill Dump Waste Gas Fl
50200602 Solid Waste Disposal Commercial/Institutional Landfill Dump Municipal: F
50300601 - 50300603 Solid Waste Disposal Industrial Landfill Dump

Tier 2: 07 Other

2630030000 Waste Disposal, Treatment, & Recovery Wastewater Treatment Residential/Su
2650000000 - 2650000003 Waste Disposal, Treatment, & Recovery Scrap & Waste Materials Scrap & Waste Materials
2660000000 Waste Disposal, Treatment, & Recovery Leaking Underground Storage Tanks L
50100601 - 50100604 Solid Waste Disposal Government Fire Fighting
50200901 Solid Waste Disposal Commercial/Institutional Asbestos Removal General
50300701 Solid Waste Disposal Industrial Liquid Waste General
50300901 Solid Waste Disposal Industrial Asbestos Removal General

Tier 1: 11 HIGHWAY VEHICLES

Tier 2: 01 Light-Duty Gas Vehicles & Motorcycles

2201001000 - 2201001334 Mobile Sources Highway Vehicles - Gasoline Light Duty Gasoline Vehicles (LDGV)
2201080000 - 2201080334 Mobile Sources Highway Vehicles - Gasoline Motorcycles (MC)

Tier 2: 02 Light-Duty Gas Trucks

2201020000 - 2201060334 Mobile Sources Highway Vehicles - Gasoline

Tier 2: 03 Heavy-Duty Gas Vehicles

2201070000 - 2201070334 Mobile Sources Highway Vehicles - Gasoline (HDGV)

Tier 2: 04 Diesels

2230001000 - 2230070334 Mobile Sources Highway Vehicles - Diesel

Tier 1: 12 OFF-HIGHWAY

Table 4.1-3. (continued)

Tier 2: 01 Non-Road Gasoline
2260000000 - 2265008010 Mobile Sources
2282005000 - 2282020025 Mobile Sources Marine Vessels, Recreational

Tier 2: 02 Non-Road Diesel
2270000000 - 2270008010 Mobile Sources Off-Highway Vehicle Diesel

Tier 2: 03 Aircraft
2275000000 - 2275070000 Mobile Sources Aircraft

Tier 2: 04 Marine Vessels
2280001000 - 2280004040 Mobile Sources Marine Vessels, Commercial
2283000000 - 2283004020 Mobile Sources Marine Vessels, Military

Tier 2: 05 Railroads
2285002000 - 2285002010 Mobile Sources Railroads Diesel

Tier 1: 13 NATURAL SOURCES

Tier 2: 01 Biogenic
2701000000 - 2701480000 Natural Sources Biogenic
2740020000 - 2740040010 Natural Sources Miscellaneous

Tier 2: 02 Geogenic
2730001000 - 2730100001 Natural Sources Geogenic

Tier 2: 03 Miscellaneous
2740001000 Natural Sources Miscellaneous Lighting Total

Tier 1: 14 MISCELLANEOUS

Tier 2: 01 Agriculture & Forestry
2307010000 Industrial Processes Wood Products: SIC 24 Logging Operations Total
2801000001 - 2801000008 Miscellaneous Area Sources Agriculture Production - Crops Agriculture - Crops
2805000000 - 2805015001 Miscellaneous Area Sources Agriculture Production - Livestock

Tier 2: 02 Other Combustion
2801500000 Miscellaneous Area Sources Agriculture Production - Crops Agricultural Fi
2801520000 Miscellaneous Area Sources Agriculture Production - Crops Orchard Heaters
2810001000 - 2810050000 Miscellaneous Area Sources Other Combustion
30101030 Chemical Manufacturing Explosives Trinitrotoluene Open Burning: Waste

Tier 2: 03 Catastrophic/Accidental Releases
2275900103 Mobile Sources Aircraft Refueling: All Fuels Spillage
2830000000 - 2830010000 Miscellaneous Area Sources Catastrophic/Accidental Releases

Tier 2: 04 Repair Shops
2840000000 - 2841010050 Miscellaneous Area Sources

Tier 2: 05 Health Services
2850000000 - 2850000030 Miscellaneous Area Sources Health Services Hospitals
31502001 - 31502089 Health Services Health Services Hospitals

Tier 2: 06 Cooling Towers
2820000000 - 2820020000 Miscellaneous Area Sources Cooling Towers
38500101 - 38500210 Cooling Tower Cooling Tower

Tier 2: 07 Fugitive Dust
2275085000 Mobile Sources Aircraft Unpaved Airstrips Total
2294000000 - 2296010000 Mobile Sources
2311000000 Industrial Processes Construction: SIC 15 - 17 All Processes Total
2311000010 Industrial Processes Construction: SIC 15 - 17 All Processes Land Cleari
2311000040 - 2311000070 Industrial Processes Construction: SIC 15 - 17 All Processes
2311000100 - 2311010010 Industrial Processes Construction: SIC 15 - 17
2311010040 - 2311010070 Industrial Processes Construction: SIC 15 - 17 General Building Construction
2311010100 - 2311020010 Industrial Processes Construction: SIC 15 - 17
2311020040 - 2311020070 Industrial Processes Construction: SIC 15 - 17 Heavy Construction
2311020100 - 2311030010 Industrial Processes Construction: SIC 15 - 17
2311030040 - 2311030070 Industrial Processes Construction: SIC 15 - 17 Road Construction
2311030100 Industrial Processes Construction: SIC 15 - 17 Road Construction Wind Er
2311040000 Industrial Processes Construction: SIC 15 - 17 Special Trade Construction
2311040100 Industrial Processes Construction: SIC 15 - 17 Special Trade Construction
2650000005 Waste Disposal, Treatment, & Recovery Scrap & Waste Materials Scrap & Was
30300519 Primary Metal Production Primary Metal Production Primary Copper Smelting

Table 4.1-3. (continued)

30300831 - 30300834 Primary Metal Production Iron Production Fugitive Emissions: Roads
30302321 Primary Metal Production Primary Metal Production Taconite Iron Ore Proce
30302322 Primary Metal Production Primary Metal Production Taconite Iron Ore Proce
30501024 Mineral Products Mineral Products Surface Mining Operations Hauling
30501031 Mineral Products Mineral Products Surface Mining Operations Scrapers: Tr
30501039 Mineral Products Mineral Products Surface Mining Operations Hauling: Hau
30501045 - 30501047 Mineral Products Mineral Products Surface Mining Operations
30501049 - 30501090 Mineral Products Mineral Products Surface Mining Operations
30502011 Mineral Products Mineral Products Stone Quarrying/Processing Hauling
30502504 Mineral Products Mineral Products Sand/Gravel Hauling
31100101 - 31100103 Building Construction Building Construction Construction: Building Contractors
31100205 Building Construction Building Construction Construction: Demolition of S
31100206 Building Construction Building Construction Construction: Demolition of S

4.2 FUEL COMBUSTION - ELECTRIC UTILITY

The emissions from the combustion of fuel by electric utilities have been divided into two classifications: (1) steam generated fossil-fuel units (boiler) and (2) nonsteam generated fossil-fuel units such as gas turbines (GT) and internal combustion (IC) engines. Two very different methodologies have been used to estimate the emissions for these two classes; each is described separately in this report. The fossil-fuel steam generated methodology is described in this section; the GT and IC methodology is described in section 4.3.

The emissions from fossil-fuel steam electric utility units for the years 1985 through 1992 have been based on four basic factors: (1) fuel consumption, (2) emission factor, which relates the quantity of fuel consumed to the quantity of pollutant emitted, (3) fuel characteristics, such as sulfur content, ash content, and heating value of fuels, and (4) control efficiency, which indicates the amount of pollutant not removed through control methods. The fuel consumption characteristics and control efficiencies were obtained at the boiler-level, while the emission factors were specified at the SCC-level. The 1993 emissions were extrapolated from the 1992 boiler-level emissions based on the ratio of plant-level 1993 fuel consumption to 1992 fuel consumption.

It should be noted that these estimates do not include emissions from the combustion of anthracite coal which accounts for a very small percentage (< 1 percent) of the overall emissions from fuel combustion by fossil-fuel steam electric utility units.

4.2.1 1985-1992 Steam Electric Utility Emission Inventories

The Energy Information Administration (EIA) of the Department of Energy (DOE) collects monthly boiler-level data on a yearly basis from Form EIA-767 (*Steam-Electric Plant Operation and Design Report*¹). The EIA also collects plant-level fossil-fuel steam data from all electric utility plants from Form EIA-759 (*Monthly Power Plant Report*²). Currently, Form EIA-767 data are available for the years 1985 through 1992, while Form EIA-759 data are available through the year 1993. The steam component of the emission inventories for 1985 through 1992 includes data derived from these two forms. These steam components *only* include boiler-level data — not data for GT or IC engines. (The latter account for a very small share of electric utility fuel use and corresponding emissions and are included in the primarily industrial described in section 4.3.)

The *steam* emission inventory data for 1985 through 1992 are based on the aggregated monthly electric utility steam boiler-level data from Form EIA-767. All plants of at least 10 megawatts (MW) that have at least one operating boiler are required to provide this information to EIA, although the amount of data required from plants with less than 100 MW of steam-electric generating capacity is much less. For plants with a nameplate rating from 10 MW to less than 100 MW, only selected pages of the Form EIA-767 must be completed. Stack and flue information is not required for these smaller plants.

4.2.1.1 Processing Computerized Raw Data

The basis for the fossil-fuel-fired steam electric utility component of the Emission Trends inventory is the reported primary utility data collected by EIA. The data from these EIA forms are transferred to data tapes that are not initially serviceable to the public. E.H. Pechan & Associates, Inc. (Pechan) has developed

customized computer code to process these data and to account for the various characteristics of the data tapes.

4.2.1.1.1 Form EIA-767 —

Form EIA-767 data are reported by the operating utility for each plant with fossil-fuel steam boilers of 10 MW or greater. The written form is designed so that information for each plant is reported on separate pages that relate to different levels of data. The relevant data levels are as follows:

- ! Plant-level: One page for delineating the plant configuration, which establishes the number of boilers and the IDs for each boiler, as well as the associated generator(s), flue gas desulfurization (FGD) unit(s), flue(s) and stack(s). These do not necessarily have a one-to-one correspondence.
- ! Boiler-level: One page per boiler for monthly fuel consumption and quality data (for coal, oil, gas, and other), one page for regulatory data, and one page for design parameters.
- ! Generator-level: One page for data relating to up to five generators.
- ! FGD-level: One page for up to five FGD units for annual operating data and one page for each FGD unit for design parameter data.
- ! Flue- and stack-level: One page per flue-stack for design parameter data.

Processing Form EIA-767 is accomplished in a series of steps aimed at converting the computerized data into data base form. Each "page" format is reproduced on the computer file exactly as it appears on the written page of the form. The data from each "page" must be extracted from the computer file, associated with the correct boiler, and combined with all corresponding data from the other pages for that boiler.

For example, fuel-related boiler data — monthly values for each fuel burned, along with the fuel's associated sulfur, ash, and heat content — are reported on page six. These data must be aggregated for each fuel in order to produce annual estimates for each boiler before they are combined with the other data (such as control devices and efficiencies, plant location data, associated generator generation, and associated stack parameters).

After Source Classification Codes (SCCs) are assigned to each reported fuel for each boiler within a plant, the SCC-specific data are then separated so that each data base observation is on the plant-boiler-SCC level.

4.2.1.1.2 Form EIA-759 —

Form EIA-759 data are also processed in a series of steps, using a less intricate method, since the data for each plant are not reported at the boiler level, but instead are reported by prime mover (steam, hydro, IC, GT, combined cycle, for example) and fuel type.

For each plant-prime mover combination (in this case, for the steam prime mover), plant ID data, as well as monthly fuel-specific generation and consumption data, are reported. The monthly plant steam prime mover data are aggregated to annual estimates for each fuel (that has been categorized as coal, residual oil, distillate oil, natural gas, or other) and combined to produce a single annual steam plant-level data observation.

These data were utilized to "grow" the 1992 fuel and emissions data for 1993, as described later in section 4.2.2.

4.2.1.2 Emissions Algorithms

Data that were not obtained directly from the computerized data files (or converted to other measurement units) were developed by Pechan using algorithms that have been utilized since the 1980s. These variables include heat input, pollutant emissions, NO_x control efficiency, and SCC. Emission factors from AP-42³ were used in calculating emissions. The emission factor used depends upon the SCC and pollutant, as explained below.

- ! The appropriate SCC is assigned to each fuel based on its characteristics. For coal, the SCC is based on the American Society for Testing and Materials (ASTM) criteria for moisture, mineral-free matter basis (if greater than 11,500 Btu/lb, coal type is designated to be bituminous; if between 8,300 and 11,500 Btu/lb, coal type is designated to be subbituminous; and if less than 8,300 Btu/lb, coal type is designated to be lignite) and the boiler type (firing configuration and bottom type) as specified by AP-42. If both coal and oil were burned in the same boiler, it is assumed that the oil is distillate; otherwise, it is assumed to be residual. Then, based on the fuel and boiler type, the SCC is assigned. For natural gas, the SCC is based on fuel and boiler type. See Table 4.2-1 for a complete list of the relationships among fuel type, firing type, bottom type, and SCC.

The control efficiencies for NO_x and PM-10 were not available from the EIA-767 form. The following explains how they were derived.

- ! NO_x control efficiency is based on the assumption that the unit would be controlled so that its emission rate would equal its limit, expressed on an annual equivalent basis. After calculating the heat input, controlled emissions assuming compliance with the applicable standard is back-calculated. After calculating the uncontrolled NO_x emissions, the presumed net control efficiency is calculated.
- ! Since only TSP control efficiency is reported on Form EIA-767, the PM-10 Calculator⁴ was used to derive PM-10 control efficiencies. (The PM-10 Calculator estimates PM-10 control efficiencies based on the SCC and the primary and secondary control devices. The control efficiencies from the PM-10 Calculator are based on data from AP-42 for specific SCCs where available.

The SO₂ emissions were computed as controlled emissions assuming 100 percent rule effectiveness and using the sulfur content of the fuel as specified in the EIA-767 data. The PM-10 emissions were computed as controlled emissions assuming 100 percent rule effectiveness. The ash content of the fuel used to calculate uncontrolled PM-10 emissions was also specified in the EIA-767 data. The NO_x emissions were computed as

controlled emissions assuming 80 percent rule effectiveness. The CO and VOC emissions were calculated as uncontrolled emissions. The algorithms to compute controlled emissions are presented in Table 4.2-2.

Although Form EIA-767 data are collected from plants with a total plant capacity of at least 10 MW, there are fewer required data elements (identification data, boiler fuel quantity and quality data, and FGD data, if applicable) for those plants with a total capacity between 10 MW and 100 MW. Thus, missing values are introduced in these situations. Because of time constraints, most data elements are not assigned a default value other than zero. If variables for boiler firing and bottom type were missing (these are needed in the SCC assignment) the default values for wall-fired and dry bottom type are assigned.

The 1985 fuel combustion, electric utility emissions reported in the National Air Pollutant Emission Trends, 1900-1993⁵ report is based on the National Allowance Data Base Version 2.11,⁶ Acide Rain Division, U.S. EPA, released on March 23, 1993. Allocations at the Tier 3 levels are approximations only and are based on the methodology described in section 4.2.1.

4.2.2 1993 Steam Emission Inventory

The 1993 monthly computerized fossil-fuel plant-level data from Form EIA-759 are used in conjunction with 1992 Form EIA-767 data to develop the 1993 steam emission inventory file, since the 1993 Form EIA-767 data are not available. The data for the 1993 steam emission inventory are the same as those for the 1992 inventory, except that the fuel quantity and emissions variables are grown by a factor based on the ratio of the 1993 Form EIA-759 plant-level, fuel-specific data to the data for 1992.

Note that no new plants were added or subtracted from the 1992 steam inventory to produce the 1993 steam inventory. However, additional boilers were added or retired from the 1992 inventory that were considered for the 1993 Form EIA-759 plant-level data. Although these boilers would not be physically included in or excluded from the records in the 1993 steam inventory, their fuel data would be incorporated in the growth ratios and would be reflected in the 1993 data for the other boilers in the plant. As a result, the 1993 figures should be considered to be *preliminary* estimates only.

4.2.3 Augmentation Process

The VOC emissions required an additional adjustment due to the underestimation of aldehydes which occurred for the following SCCs: 10100401, 10100404, 10100501, 10100601, and 10100604. The VOC emissions were augmented according to the methodology used in the Hydrocarbon Preprocessor (HCPREP) of the Flexible Regional Emissions Data System (FREDS).⁷ This augmentation was performed on steam emission inventory for the years 1985 through 1993.

4.2.4 References

1. "Monthly Power Plant Report," Form EIA-759, data files for 1990 - 1993, U.S. Department of Energy, Energy Information Administration, Washington DC, 1994.

2. "Steam-Electric Plant Operation and Design Report," Form EIA-767, data files for 1985-1992, U.S. Department of Energy, Energy Information Administration, Washington, DC, 1994.
3. "Supplement D to Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources," AP-42, U.S. Environmental Protection Agency, Research Triangle Park, NC, September 1991.
4. Dean, T. A. and P. Carlson, PM-10 Controlled Emissions Calculator. E.H. Pechan & Associates, Inc. Contract No. 68-D0-0120 Work Assignment No. II-81. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. April 27, 1993. (TTN CHIEF BBS)
5. National Air Pollutant Emission Trends, 1900-1993, EPA-454/R-94-027. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1994.
6. The National Allowance Data Base Version 2.11: Technical Support Document, Acid Rain Division, Office of Atmospheric Programs, U.S. Environmental Protection Agency, Washington, DC, March 1993.
7. *The Flexible Regional Emissions Data System (FREDS) Documentation for the 1985 NAPAP Emission Inventory: Preparation for the National Acid Precipitation Assessment Program.* Appendix A. EPA-600/9-89-047. U.S. Environmental Protection Agency, Office of Research and Development, Air and Energy Engineering Research Laboratory, Research Triangle Park, NC. May 1989.

Table 4.2-1. Steam Electric Utility Unit Source Classification Code Relationships

Fossil-Fuel	Firing Type	Bottom Type	SCC
Coal			
Bituminous	No data	No data	10100202
		Wet	10100201
		Dry	10100202
	Wall*	No data	10100202
		Wet	10100201
		Dry	10100202
	Opposed	No data	10100202
		Wet	10100201
		Dry	10100202
	Tangential	No data	10100212
		Wet	10100201
		Dry	10100212
	Stoker	All	10100204
	Cyclone	All	10100203
	Fluidized Bed	N/A	10100217
Subbituminous	No data	No data	10100222
		Wet	10100221
		Dry	10100222
	Wall	No data	10100222
		Wet	10100221
		Dry	10100222
	Opposed	No data	10100222
		Wet	10100221
		Dry	10100222
	Tangential	No data	10100226
		Wet	10100221
		Dry	10100226
	Stoker	All	10100224
	Cyclone	All	10100223
	Lignite	No data	All
Wall		All	10100301
Opposed		All	10100301
Tangential		All	10100301
Stoker		All	10100302
Cyclone		All	10100306
			10100303

(continued)

Table 4.2-1. (continued)

Fossil-Fuel	Firing Type	Bottom Type	SCC
Residual Oil	No data	All	10100401
	Wall	All	10100401
	Opposed	All	10100401
	Tangential	All	10100404
	Stoker	All	10100401
	Cyclone	All	10100401
Distillate Oil	No data	All	10100501
	Wall	All	10100501
	Opposed	All	10100501
	Tangential	All	10100501
	Stoker	All	10100501
	Cyclone	All	10100501
Natural Gas	No data	All	10100601
	Wall	All	10100601
	Opposed	All	10100601
	Tangential	All	10100604
	Stoker	All	10100601
	Cyclone	All	10100601

*Wall firing includes front, arch, concentric, rear, side, vertical, and duct burner firing.

Table 4.2-2. Equations Used to Estimate Emissions from Electric Utility Boilers

$$E_{NO_x,b} = FC_b \times EF_{NO_x,SCC} \times (1 - RE_{NO_x} (CE_{NO_x,b})) \times UCF$$

$$E_{PM\&10,b} = FC_b \times EF_{PM\&10,SCC} \times A_f \times (1 - CE_{PM\&10,b}) \times UCF$$

$$E_{SO_2,b} = FC_b \times EF_{SO_2,SCC} \times S_f \times (1 - CE_{SO_2,b}) \times UCF$$

$$E_{VOC\ or\ CO,b} = FC_b \times EF_{VOC\ or\ CO,SCC} \times UCF$$

where:	<i>E</i>	=	estimated emission (expressed in short tons)
	<i>FC</i>	=	fuel consumption (expressed in <i>unit_f</i>)
	<i>EF</i>	=	emission factor (expressed in lbs SO ₂ / <i>unit_f</i>)
	<i>S</i>	=	sulfur content (expressed as a decimal)
	<i>A</i>	=	ash content (expressed as a decimal)
	<i>RE</i>	=	rule effectiveness (expressed as a decimal)
	<i>CE</i>	=	control efficiency (expressed as a decimal)
	<i>b</i>	=	boiler
	<i>f</i>	=	fuel type (coal, oil, gas)
	<i>UCF</i>	=	units conversion factor (1 ton/2000 lbs)
	<i>unit_{coal}</i>	=	tons burned
	<i>unit_{oil}</i>	=	1000 gallons burned
	<i>unit_{gas}</i>	=	million cubic feet burned

4.3 PRIMARILY INDUSTRIAL

The source categories falling under "Primarily Industrial" include the following Tier 1 and Tier 2 categories:

<u>Tier 1 Category</u>	<u>Tier 2 Category</u>
FUEL COMBUSTION - INDUSTRIAL	All
CHEMICAL & ALLIED PRODUCT MANUFACTURING	All
METALS PROCESSING	All
PETROLUEM & RELATED INDUSTRIES	All
OTHER INDUSTRIAL PROCESSES	All
STORAGE & TRANSPORT	All
FUEL COMBUSTION - ELECTRIC UTILITY	Gas Turbines and Internal Combustion PM-10 area source
WASTEDISPOSAL & RECYCLING	All
MISCELLANEOUS	Health Services

The 1990 emissions for these source categories were generated from both the nonutility point source and nonsolvent area source portions of the 1985 NAPAP Emissions Inventory. These 1990 emissions served as the base year from which the emissions for the years 1985 through 1989 and the years 1991 through 1993 were estimated. The emissions for the years 1985 through 1991 were estimated using historical data compiled by the /Bureau of Economic Analysis (BEA)¹ or historic estimates of fuel consumption based on the Department of Energy's (DOE) State Energy Data System (SEDS).² The 1992 and 1993 emissions were estimated using growth factors produced by the prereleased E-GAS, version 2.0³.

4.3.1 Base Year Inventory

The 1985 NAPAP Emission Inventory estimates for the **point** sources have been projected to the year 1990 based on the growth in BEA historic earnings for the appropriate state and industry¹, as identified by the 2-digit Standard Industrial Classification (SIC) code. In order to remove the effects of inflation, the earnings data were converted to 1982 constant dollars using the implicit price deflator for personal consumption expenditures (PCE).⁴ State and SIC-level growth factors were calculated as the ratio of the 1990 earnings data to the 1985 earning data. More details on growth indicators are presented in section 4.3.2.1.

The **area** source emissions from the 1985 NAPAP Emissions Inventory have been projected to the year 1990 based on BEA historic earnings data, BEA historic population data, DOE SEDS data, or other growth indicators. The specific growth indicator was assigned based on the source category. The BEA earnings data were converted to 1982 dollars as described above. The 1990 SEDS data were extrapolated from data for the years 1985 through 1989. All growth factors were calculated as the ratio of the 1990 data to the 1985 data for the appropriate growth indicator. More details on growth indicators are presented in section 4.3.2.2.

When creating the 1990 emissions inventory, changes were made to emission factors, control efficiencies, and emissions from the 1985 inventory for all sources. The PM-10 control efficiencies were obtained from the

PM-10 Calculator.⁵ In addition, rule effectiveness which was not applied in the 1985 NAPAP Emission Inventory, was applied to the 1990 emissions estimated for the point sources. The CO, NO_x, and VOC point source controls were assumed to be 80 percent effective; PM-10 and SO₂ controls were assumed to be 100 percent effective.

The 1990 emissions for CO, NO_x, SO₂, and VOC were calculated using the following steps: (1) projected 1985 controlled emissions to 1990 using the appropriate growth factors, (2) calculated the uncontrolled emissions using control efficiencies from the 1985 NAPAP Emission Inventory, and (3) calculated the final 1990 controlled emissions using revised control efficiencies and the appropriate rule effectiveness. The 1990 PM-10 emissions were calculated using the TSP emissions from the 1985 NAPAP Emission Inventory. The 1990 uncontrolled TSP emissions were estimated in the same manner as the other pollutants. From these TSP emissions, the 1990 uncontrolled PM-10 estimates were calculated by applying SCC-specific uncontrolled particle size distribution factors.⁶ The controlled PM-10 emissions were estimated in the same manner as the other pollutants. Because the majority of area source emissions for all pollutants represented uncontrolled emissions, the second and third steps were not required to estimate the 1990 area source emissions.

4.3.1.1 Control Efficiency Revisions

In the 1985 NAPAP point source estimates, control efficiencies for VOC, NO_x, CO, and SO₂ sources in Texas were judged to be too high for their process/control device combination. These high control efficiencies occurred because Texas did not ask for control efficiency information, and simply applied the maximum efficiency for the reported control device⁷. High control efficiencies lead to high future growth in modeling scenarios based on uncontrolled emissions (which are based on the control efficiency and reported actual emissions). High control efficiencies also lead to extreme increases in emissions when rule effectiveness is incorporated.

Revised VOC control efficiencies were developed for Texas for the Emission Reduction and Cost Analysis Model for VOC (ERCAM-VOC)⁸. For this analysis, revised efficiencies were also developed by SCC and control device combination for NO_x, SO₂, and CO using engineering judgement. These revised control efficiencies were applied to sources in Texas. A large number of point sources outside of Texas had VOC and CO control efficiencies that were also judged to be too high. The VOC and CO control efficiencies used for Texas were also applied to these sources.

Control efficiencies not applied in the 1985 NAPAP Emissions Inventory were incorporated in the data files for VOC emissions from gasoline marketing (stage I and vehicle refueling) were incorporated in the data files for VOC emissions from gasoline marketing (stage I and vehicle refueling) and bulk gasoline plants and terminals, since many areas already have regulations in place for controlling stage I and stage II gasoline marketing emissions. Many current State regulations require the use of Stage I controls (except at small volume service stations) to reduce emissions by 95 percent. Emissions were revised to reflect these controls in areas designated as having these requirements as part of their SIPs.⁹ Stage II vapor recovery systems are estimated to reduce emissions by 84 percent.¹⁰ Stage II controls are already in place in the District of Columbia, in St.

Louis, Missouri, and in parts of California. Stage II controls also reduce underground tank breathing/emptying losses. Emissions in these area were revised to reflect these controls.

Gasoline bulk plants and terminals are covered by existing CTGs and are included in many State regulations. Emissions were revised to reflect these controls in areas with regulation.⁹ Control efficiencies assumed for these area source categories were 51 percent for gasoline bulk plants and terminals. NAPAP area source estimates have control levels built into these emissions. These control levels were first backed out of the emissions. In areas with no controls, the emissions remained at uncontrolled levels. In areas with regulation, the uncontrolled emissions were reduced to reflect the above efficiencies.

4.3.1.2 Rule Effectiveness Assumptions

Controlled emissions for each inventory year were recalculated, assuming that reported VOC, NO_x, and CO controls were 80 percent effective. Sulfur dioxide and PM-10 controls were assumed to be 100 percent effective. The 80 percent rule effectiveness assumption was judged to be unreasonable for several VOC and CO source categories. The VOC rule effectiveness was changed to 100 percent for bulk storage tank sources that had VOC control devices of 90, 91, or 92. These three codes represent conversion to variable vapor space tank, conversion to floating roof tank, and conversion to pressurized tank, respectively. These controls were judged to be irreversible process modifications (there are SCCs which represent these type of tanks), and therefore 100 percent rule effectiveness was applied. VOC and CO rule effectiveness was changed to 100 percent for all Petroleum Industry - Fluid Catalytic Cracking Units (FCCs), SCC 30600201. AP-42 lists CO waste heat boilers as a control for these units with both CO and hydrocarbon emissions reduced to negligible levels. Since these boilers handle VOCs and CO as a fuel rather than as an emission, they are treated as a process instead of as control device, and therefore are not subject to rule effectiveness. Unfortunately, there is no control device code for CO boilers in NAPAP. In order to implement this set of revisions, all FCCs were assumed to have CO boilers. In addition, the CO rule effectiveness was changed to 100 percent for sources in 5 other SCCs that burn CO as a fuel. The CO rule effectiveness was also changed to 100 percent for sources with In-Process Fuel Use SCCs. According to AP-42, there should be no CO emissions from these sources. Emissions were not deleted from the inventory, however applying 80 percent rule effectiveness resulted in CO emissions of up to 36,000 short tons from some In-Process Fuel Use sources. Changing the rule effectiveness to 100 percent for sources in these SCCs retains the emissions, but at more reasonable levels. Table 4.3-1 lists the SCCs for which the CO rule effectiveness was changed to 100 percent.

4.3.1.3 Emission Factor Changes

The VOC emission factors for vehicle refueling were updated to reflect changes in gasoline RVP. The NAPAP gasoline marketing service station emissions were broken into two components — evaporative losses from underground tanks (stage I) and stage II vehicle refueling (including spillage). The NAPAP emissions were derived based on gasoline usage combined with the uncontrolled emissions factors from AP-42. These emission factors are as follows:

Stage I:	7.3	lbs/1000 gallons
Stage II:	11.0	lbs/1000 gallons
Spillage:	0.7	lbs/1000 gallons.

These emission factors were used to calculate the fraction of total emissions attributable to each of the components above. The total percentage is 38.4 percent for stage I emissions and 61.6 percent for stage II emission, plus spillage.

The stage II emissions were also revised to reflect changes in emission factors. Stage II emission factors are a function of gasoline RVP and temperature. Gasoline RVPs have lowered since 1985 in response to the phase I and phase II RVP regulations. MOBILE5 was used to calculate stage II emission factors for five sample states (Maryland, Illinois, New York, Texas, and North Carolina). Factors for each season were calculated based on the seasonal RVP and temperature (see Tables 4.3-2 to 4.3-4) based on engineering judgement. The national average annual factors for each inventory year are shown in Table 4.3-5. The 1987 value was used to estimate the 1985 and 1986 emissions. The 1992 and 1993 emissions used the 1990 emission factor.

In addition to updating the emission factor for stage II, underground tank breathing/emptying losses were also added to the inventory. The AP-42 emission factor of 1.0 lbs/1000 gallons was used to estimate emissions for each inventory year. Gasoline usage was back-calculated from the stage II VOC emissions and emission factor.

4.3.1.4 Emissions Calculations

A three-step process was used to calculate emissions incorporating rule effectiveness. First, base year controlled emissions are projected to the inventory year using the following formula:

$$CE_i = CE_{BY} \times (EG_i)$$

where: CE_i = controlled emissions for inventory year i
 CE_{BY} = controlled emissions for base year
 EG_i = earnings growth for inventory year i

Earnings growth (EG) is calculated as:

$$EG_i = 1 + \frac{DAT_i}{DAT_{BY}}$$

where: DAT_i = earnings data for inventory year i
 DAT_{BY} = earnings data in the base year

Second, uncontrolled emissions in the inventory year are back-calculated from the controlled emissions based on the control efficiency with the following formula:

$$UE_i = \frac{CE_i}{\left(1 - \frac{CEFF}{100}\right)}$$

where: UE_i = uncontrolled emissions for inventory year i
 CE_i = controlled emissions for inventory year i
 $CEFF$ = control efficiency (%)

Third, controlled emissions are recalculated incorporating rule effectiveness using the following formula:

$$CER_i = UC_i \times \left(1 - \left(\frac{REFF}{100}\right)\right) \times \left(\frac{CEFF}{100}\right) \times \left(\frac{EF_i}{EF_{BY}}\right)$$

where: CER_i = controlled emissions incorporating rule effectiveness
 UC_i = uncontrolled emissions
 $REFF$ = rule effectiveness (%)
 $CEFF$ = control efficiency (%)
 EF_i = emission factor for inventory year
 EF_{BY} = emission factor for base year

In many cases, the PM-10 emissions calculated based on the particle size distribution and PM-10 control efficiency was higher than the total suspended particulate (TSP) emissions. The source problem is inconsistency between the TSP control efficiencies from the 1985 NAPAP inventory and the control efficiencies determined using the PM-10 calculator. This error may have been compounded in the following steps with the values selected for particle size distribution and efficiency. In the instances where the controlled PM-10 emissions were calculated to be higher than the controlled TSP emissions, the controlled PM-10 emissions were replaced with the controlled TSP emissions. The uncontrolled PM-10 was then recalculated using the revised PM-10 emissions and the control efficiency from the PM-10 calculator. In other words, it is assumed that in these instances, virtually all of the particles above 10 microns are being controlled and that particles emitted after the control device are all particles of 10 microns or less.

The basis for replacing the PM-10 emissions with the TSP emissions in these cases is the assumption that the controlled TSP emissions from the 1985 NAPAP inventory are the best data that are available as a measure of point source particulate emissions. If the assumption was that the uncontrolled emissions were the best data available, then an adjustment to the TSP control efficiency (resulting in an increase to actual TSP emissions) would be performed rather than replacing the PM-10 emissions.

4.3.1.5 Revised Emissions

Hazardous waste Treatment Storage and Disposal Facility (TSDF) emissions were updated using a file from EPA's Emission Standards Division (ESD), created in April 1989.^{10b} This file provided estimates of TSDF emissions with longitude and latitude as the geographical indicator for each facility. The longitude and latitude were used to match each emission to the appropriate State and county.

Area source petroleum refinery fugitive emissions were re-estimated based on a revised estimate of national petroleum refinery emissions. The national petroleum refinery emissions used to estimate area source emission in the 1985 NAPAP is from the Emission Trends^{10c} report. The emissions for blowdown systems were revised to reflect the high level of control as shown in the point source inventory.

The area source petroleum refinery fugitive emissions were re-estimated using the revised national emission total by applying the methodology used to develop the 1985 NAPAP estimate.^{10d} Total county fugitive petroleum refinery emissions were determined by distributing the revised Emission Trends estimate (excluding process heaters and catalytic cracking units) based on 1985 county refinery capacity from the DOE Petroleum Supply Annual.^{10e} Refinery capacity from this publication was allocated to counties based on the designated location of the refinery. The 1985 NAPAP Emission Inventory was used to aid in the matching of refineries to location.

Total area source petroleum refinery fugitive emissions were then estimated by subtracting the point source emissions (SCCs 3-06-004 through 3-06-888) from the total county-level emissions. Negative values (indicating higher point source emissions than the totals shown for the county), were re-allocated to counties exhibiting positive emission values based on the proportion of total refinery capacity for each county to avoid double-counting of emissions. This resulted in an estimate of 351 thousand short tons for 1985 compared with the prior 1985 NAPAP estimate of 728 thousand short tons (area source refinery fugitives). This revised 1985 estimate was grown to the inventory years, as described in section 4.3.2.1.

The SO₂ emissions for 1987 through 1993 were adjusted to correct for the permanent closing of the Phelps Dodge copper smelter in Arizona in January of 1987. This adjustment was made by subtracting the 1985 emissions for State=04, County=003, and NEDS ID =0013 from the inventory for 1987 through 1993.

4.3.2 Emissions, 1985 to 1991

As explained in section 4.3.1.3, the 1990 controlled emissions were projected from the 1985 NAPAP Emissions Inventory using equations 1 through 4. For all other years (1985 to 1989 & 1991) the emissions were projected from the 1990 emissions using equations 1 and 2. Therefore the 1985 emissions estimated by this method do not match the 1985 NAPAP Emissions Inventory due to the changes made in control efficiencies and emission factors and the addition of rule effectiveness when creating the 1990 base year inventory. For refueling sources the emissions were adjusted to account for the updated emission factors for all years as described in section 4.3.1.3.

4.3.2.1 Point Source Growth

The changes in the point source emissions were equated with the changes in historic earnings by state and industry. Emissions from each point source in the 1985 NAPAP Emissions Inventory were projected to the years 1985 through 1991 based on the growth in earnings by industry (2-digit SIC code). Historical earnings data from BEA's Table SA-5¹ were used to represent growth in earnings from 1985 through 1990. (Earnings data from a different BEA source, Table SQ-5 discussed below, were used to estimate 1991 emissions.) Table SA-5 historical annual earnings data are by state and industry.

The 1985 through 1990 earnings data in Table SA-5 are in nominal dollars. In order to be used to estimate growth, these values were converted to constant dollars to remove the effects of inflation. Earnings data for each year were converted to 1982 constant dollars using the implicit price deflator for personal consumption expenditures (PCE).⁴ The PCE deflators used to convert each year's earnings data to 1982 dollars are:

<u>Year</u>	<u>1982 PCE Deflator</u>
1985	111.6
1987	114.3
1988	124.2
1989	129.6
1990	136.4

Several BEA categories did not contain a complete time series of data for the years 1985 through 1990. Because the SA-5 data must contain 1985 earnings and earnings for each inventory year (1985 through 1990) to be useful for estimating growth, a log linear regression equation was used to fill in missing data elements where possible. This regression procedure was performed on all categories that were missing at least one data point and which contained at least three data points in the time series.

Each record in the point source inventory was matched to the BEA earnings data based on the state and the 2-digit SIC. Table 4.3.6 shows the BEA earnings category used to project growth for each of the 2-digit SICs found in the 1985 NAPAP Emission Inventory. No growth in emissions was assumed for all point sources for which the matching BEA earnings data were not complete. Table 4.3.6 also shows the national average growth and earnings by industry from Table SA-5.

At the time the Emission Trends Inventory was compiled, 1991 BEA earnings data were not available in Table SA-5. Earnings data from BEA Table SQ-5¹¹ were used to estimate emissions for 1991. Table SQ-5 contains historical quarterly earnings data by state and 1-digit SIC. These data were converted to an annual constant dollars basis.

The 1991 quarterly earnings data were first summed to compute annual totals. Because the PCE deflator used to convert to constant 1982 dollars was not available for 1991, a 1987 PCE deflator¹¹ was used to

convert the 1990 and 1991 earnings data from Table SQ-5 to a 1987 constant dollar basis. The PCE deflators are as follows:

<u>Year</u>	<u>1987 PCE Deflator</u>
1990	114.7
1991	119.3

The 1991 inventory was then developed by growing the 1990 inventory based on the changes in State industry earnings (by 1-digit SIC) from 1990 to 1991. National average growth in earnings by industry is shown below in Table 4.3-7.

4.3.2.2 Area Source Growth

Emissions from the 1985 NAPAP Inventory were grown to the Emission Trends years based on historical BEA earnings data (section 4.3.2.1), historical estimates of fuel consumption², or other category-specific growth indicators. Table 4.3-8 shows the growth indicators used for each area source by NAPAP category.

The SEDS data² were used as an indicator of emissions growth for the area source fuel combustion categories and for the gasoline marketing categories shown in Table 4.3-9. (SEDS reports fuel consumption by sector and fuel type.) Since fuel consumption is the activity level used to estimate emissions for these categories, fuel consumption is a more accurate predictor of changes in emissions, compared to other surrogate indicators such as earnings or population. SEDS fuel consumption data were available through 1989. The 1990 and 1991 values were extrapolated from the 1985 through 1989 data using a log linear regression technique. In addition to projecting 1990 and 1991 data for all fuel consumption categories, the regression procedure was used to fill in missing data points for fuel consumption categories if at least three data points in the time series (1985 to 1989) were available. A summary of SEDS national fuel consumption by fuel and sector can be found in Table 4.3-9.

The last step in the creation of the area source inventory was the matching of NAPAP categories to the new AMS categories. This matching is provided in Table 4.3-10. Note that there is not always a one-to-one correspondence between NAPAP and AMS categories. For example, the gasoline marketing NAPAP category was split into two separate AMS categories representing Stage I and Stage II emissions. In addition, three NAPAP SCCs are not included in the AMS system of codes. Therefore, AMS codes were created for process emissions from pharmaceutical manufacture and synthetic fiber manufacture and for SOCOMI fugitive emissions.

4.3.3 Emissions, 1992 and 1993

The 1992 and 1993 emissions for all pollutants were estimated by applying growth factors to the 1990 emissions using a modified version of equation 1. The growth factors were obtained from the prereleased E-GAS, version 2.0.³ The E-GAS generates growth factors at the SCC-level for counties representative of all counties within each ozone nonattainment area classified as serious and above and for counties representative of

all counties within both the attainment portions and the marginal and moderate nonattainment areas within each state. The appropriate growth factors were applied by county and SCC to the 1990 emissions as shown by the following equation:

$$Emissions_{(county, SCC, year)} = Growth_{(county, SCC, year)} \times Emissions_{(county, SCC, 1990)}$$

There are approximately 150 representative counties in E-GAS and 2000 SCCs present in the base year inventory. This yields a matrix of 300,000 growth factors generated to determine a single year's inventory. To list all combinations would be inappropriate.

4.3.4 References

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7. Gill, W., Texas Air Control Board personal communication with D. Solomon, April 23, 1992
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- 10b. TSDF Inventory File, computer file transferred to E.H. Pechan & Associates, Inc., from Emission Standards Division, U.S. Environmental Protection Agency, via Alliance Technologies, Research Triangle Park, NC, April 1989.
- 10c. "National Air Pollutant Emission Estimates, 1940-1985," U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, 1986.
- 10d. "Area Source Documentation for the 1985 National Acid Precipitation Assessment Program Inventory," EPA-600/8-88-106, Air and Energy Engineering Research Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, NC, December 1988.
- 10e. "1985 Petroleum Supply Annual," DOE/EIA-0340, U.S. Department of Energy, Energy Information Administration, Office of Oil and Gas, Washington, DC, May 1986.
11. *Table SQ-5 — Quarterly State Personal Income 1987: I - 1991: IV.* Data files. Bureau of Economic Analysis, U.S. Department of Commerce, Washington, DC. 1992.
12. "Climatology of the United States," No. 81, U.S. National Oceanic and Atmospheric Administration, September 1982.

Table 4.3-1. SCCs With 100 Percent CO Rule Effectiveness

SCC	Process
30300801	Primary Metals Production - Iron Production - Blast Furnaces
30300913	Primary Metals Production - Steel Production - Basic Oxygen Furnace: Open Hood-Stack
30300914	Primary Metals Production - Steel Production - Basic Oxygen Furnace: Closed Hood-Stack
30500401	Mineral Products - Calcium Carbide - Electric Furnace (Hoods and Main Stack)
30600201	Petroleum Industry - Fluid Catalytic Cracking Units
31000205	Oil and Gas Production - Natural Gas Production - Flares
31000299	Oil and Gas Production - Natural Gas Production - Other Not Classified
39000689	In-Process Fuel Use - Natural Gas - General
39000797	In-Process Fuel Use - Process Gas - General

Table 4.3-2. July RVPs Used to Model Motor Vehicle Emission Factors

State	State Reid Vapor Pressure (psi)				
	1987	1988	1989	1990	1991
AL	10.8	10.9	8.9	8.5	8.5
AZ	8.6	8.3	8.2	8.1	8.2
AR	10.2	9.8	9.4	8.7	8.5
CA	8.6	8.5	8.4	8.1	8.2
CO	9.7	9.4	8.7	8.3	8.4
CT	10.9	11.0	8.6	8.3	8.3
DE	11.3	10.8	9.2	8.4	8.3
DC	11.0	10.8	9.1	8.2	8.1
FL	10.2	10.5	9.0	9.1	9.1
GA	10.5	10.7	8.6	8.5	8.3
ID	10.1	9.9	9.5	9.1	9.4
IL	11.1	10.6	9.5	8.6	8.8
IN	11.6	11.1	9.6	8.7	9.0
IA	10.5	10.3	9.7	9.6	9.8
KS	9.8	9.6	9.1	8.5	8.6
KY	11.3	10.9	9.5	8.7	8.8
LA	10.4	11.0	8.6	8.3	8.4
ME	10.8	11.0	8.6	8.3	8.3
MD	11.2	10.8	9.1	8.3	8.2
MA	10.8	11.0	8.6	8.3	8.3
MI	11.7	11.0	9.8	9.1	9.3
MN	10.5	10.3	9.7	9.6	9.8
MS	10.2	9.8	9.4	8.7	8.5
MO	10.0	9.7	9.3	8.6	8.6
MT	9.3	9.5	9.3	8.6	9.2
NE	10.2	9.9	9.4	9.1	9.2
NV	8.6	8.5	8.3	8.2	8.3
NH	10.8	11.0	8.6	8.3	8.3
NJ	11.3	10.9	9.0	8.4	8.3
NM	9.0	8.5	8.2	8.1	8.1
NY	11.2	11.0	8.7	8.3	8.4
NC	10.5	10.7	8.6	8.5	8.3
ND	10.5	10.3	9.7	9.6	9.8
OH	11.6	11.4	9.8	9.6	9.7
OK	9.9	9.7	8.7	8.2	8.4
OR	9.7	9.4	9.1	8.9	9.0
PA	11.4	10.9	9.3	8.6	8.5
RI	10.8	11.0	8.6	8.3	8.3
SC	10.5	10.7	8.6	8.5	8.3
SD	10.5	10.3	9.7	9.6	9.8
TN	10.4	10.5	8.8	8.5	8.3
TX	9.8	9.6	8.4	8.0	8.2
UT	9.7	9.4	8.7	8.3	8.4
VT	10.8	11.0	8.6	8.3	8.3
VA	10.9	10.8	9.0	8.3	8.1
WA	10.8	10.2	9.7	9.6	9.7
WV	11.4	11.2	9.6	9.1	9.1
WI	11.4	10.9	9.6	8.8	9.0
WY	9.5	9.4	9.0	8.4	8.8

Source: Developed from July MVMA Fuel Volatility Surveys

Table 4.3-3. 1990 Seasonal RVP (psi) by State

State	Winter	Spring	Summer	Fall
AL	12.8	10.3	9.1	9.7
AZ	10.1	8.5	8.1	8.3
AR	13.4	10.7	8.7	10.9
CA	12.3	10.1	8.1	8.7
CO	11.5	9.6	8.5	9.3
CT	13.2	10.2	8.3	10.2
DE	13.9	10.5	8.4	9.4
DC	12.2	9.1	8.2	9.1
FL	11.9	9.1	9.1	9.1
GA	12.5	10.2	9.1	9.6
ID	12.5	10.5	9.1	9.5
IL	13.7	10.5	8.6	9.6
IN	13.8	10.6	8.7	9.7
IA	13.4	11.2	10.0	11.2
KS	12.5	9.5	8.5	9.0
KY	12.9	9.6	8.7	9.6
LA	12.2	10.0	8.9	9.4
ME	13.1	10.1	8.3	10.1
MD	13.4	10.2	8.3	9.3
MA	13.1	10.1	8.3	10.1
MI	13.8	10.9	9.1	10.9
MN	13.4	11.0	9.6	10.3
MS	13.4	10.7	9.4	10.0
MO	12.4	10.7	8.6	10.2
MT	13.1	10.1	8.6	10.1
NE	13.0	10.5	9.1	9.5
NV	10.9	8.8	8.2	8.5
NH	13.1	10.1	8.3	10.1
NJ	13.8	10.5	8.4	10.5
NM	11.6	9.0	8.1	9.3
NY	13.4	10.2	8.3	10.2
NC	12.5	11.0	9.1	10.4
ND	13.4	11.8	9.6	10.9
OH	13.9	11.2	9.6	10.4
OK	13.1	9.6	8.2	8.9
OR	12.4	10.4	8.8	9.6
PA	13.9	10.6	8.6	10.6
RI	13.1	10.1	8.3	10.1
SC	12.5	11.0	9.1	10.4
SD	13.0	10.9	9.6	10.0
TN	12.7	11.1	9.1	10.5
TX	12.4	9.9	8.0	8.6
UT	11.5	10.0	8.5	9.3
VT	13.1	10.1	8.3	10.1
VA	12.1	9.1	8.2	9.1
WA	13.6	11.1	9.6	10.4
WV	13.5	10.8	9.1	9.9
WI	13.7	10.7	8.8	9.7
WY	12.2	9.8	8.4	8.8

Source: Based on RVPs from the January and July MVMA Fuel Volatility Surveys

Table 4.3-4. Seasonal Maximum and Minimum Temperatures (°F) by State

State	<u>Winter</u>		<u>Spring</u>		<u>Summer</u>		<u>Fall</u>	
	Min	Max	Min	Max	Min	Max	Min	Max
AL	42	62	57	78	72	91	58	79
AK	20	31	32	46	46	63	36	47
AZ	41	67	54	83	76	103	59	86
AR	32	53	50	73	70	92	51	75
CA	45	61	50	67	59	78	54	73
CO	18	45	34	61	56	85	37	66
CT	19	36	38	59	60	83	42	63
DE	25	42	42	62	64	84	47	66
DC	29	45	47	66	68	86	51	69
FL	52	72	62	77	73	89	65	82
GA	34	54	50	72	68	87	52	73
HI	66	81	69	83	73	87	71	86
ID	25	40	37	61	56	86	39	64
IL	17	33	39	59	62	83	43	63
IN	21	37	41	62	63	84	44	65
IA	15	31	39	59	64	84	42	63
KS	23	44	44	67	68	91	47	69
KY	27	44	45	66	66	86	47	68
LA	44	64	59	78	73	90	60	79
ME	14	33	33	52	55	76	38	59
MD	26	43	43	64	65	85	47	68
MA	25	38	41	56	63	79	48	62
MI	14	30	33	53	55	77	39	57
MN	5	24	32	51	56	78	36	54
MS	36	59	53	77	70	92	53	78
MO	22	40	44	65	66	87	52	67
MT	14	33	31	54	52	80	35	58
NE	15	35	40	62	64	86	42	65
NV	21	47	31	64	45	87	31	69
NH	12	33	32	56	54	80	36	60
NJ	25	43	41	61	62	82	46	66
NM	24	49	40	70	62	91	43	71
NY	21	36	39	57	61	81	45	62
NC	32	54	48	72	67	88	51	73
ND	1	23	30	53	54	82	31	57
OH	22	38	40	61	61	82	44	64
OK	28	50	48	71	69	91	50	73
OR	35	47	42	61	55	77	45	64
PA	24	39	41	61	62	83	45	65
RI	22	38	38	57	61	80	44	63
SC	34	58	51	76	69	91	52	76
SD	7	27	34	56	59	84	36	60
TN	31	50	50	71	69	89	51	73
TX	37	61	54	78	71	95	55	79
UT	22	40	37	62	58	89	40	66
VT	11	28	33	52	56	78	39	57
VA	31	49	47	68	67	86	51	71
WA	30	42	39	57	53	76	41	59
WV	26	44	43	66	62	84	45	67
WI	15	29	35	53	59	78	41	59
WY	17	40	30	54	52	80	34	60

U.S. NOAA "Climatology of the United States", 1982¹².

Table 4.3-5. Average Annual Service Station Stage II VOC Emission Factors

Year	Emission Factor	
	grams/gallon	lbs/1,000 gallons
1985	4.6	10.0
1986	4.6	10.0
1987	4.6	10.0
1988	4.6	10.0
1989	3.9	8.5
1990	3.6	8.0
1991	3.6	8.0
1992	3.6	8.0
1993	3.6	8.0

Table 4.3-6. Bureau of Economic Analysis's SA-5 National Changes in Earnings by Industry

Industry	SIC	Percent Growth from:			
		1985 to 1987	1987 to 1988	1988 to 1989	1989 to 1990
				14.58	-3.11
Farm	01, 02	14.67	-2.73		
Agricultural services, forestry, fisheries, and other	07, 08, 09	23.58	5.43	1.01	2.48
Coal mining	11	-17.46	-6.37	-4.16	4.73
Metal mining	10	-3.03	18.01	8.94	4.56
Nonmetallic minerals, except fuels	14	2.33	3.74	-2.79	-0.45
Construction	15	7.27	4.81	-1.36	-3.80
Food and kindred products	20	1.67	1.34	-1.20	-0.24
Textile mill products	22	8.50	-0.64	-1.39	-4.97
Apparel and other textile products	23	-1.72	1.25	-1.62	-4.22
Paper and allied products	26	2.62	0.94	-0.14	-0.39
Printing and publishing	27	7.44	5.67	-0.81	0.43
Chemicals and allied products	28	1.75	6.94	0.32	1.61
Petroleum and coal products	29	-10.82	-3.22	-3.02	1.06
Tobacco manufactures	21	-1.97	2.43	-2.43	-5.01
Rubber and miscellaneous plastic products	30	5.27	5.51	0.68	-0.14
Leather and leather products	31	-9.39	-1.64	-3.58	-2.55
Lumber and wood products	24	10.03	5.15	-3.54	-3.71
Furniture and fixtures	25	6.82	2.35	-1.46	-2.98
Primary metal industries	33	-9.09	5.32	-0.34	-3.03
Fabricated metal products	34	-4.72	2.55	-0.86	-1.91
Machinery, except electrical	35	-5.72	6.02	-0.32	-1.92
Electric and electronic equipment	36	-3.17	-18.01	-1.91	-3.22
Transportation equipment, excluding motor vehicles	37	8.44	-1.57	0.55	-1.07
Motor vehicles and equipment	371	-6.45	2.20	-2.96	-5.43
Stone, clay, and glass products	32	-0.23	-1.61	-1.96	-3.19
Instruments and related products	38	-0.04	60.65	-0.82	-2.91
Miscellaneous manufacturing industries	39	1.84	6.92	-2.21	-2.54
Railroad transportation	40	-14.13	-2.53	-3.83	-6.03
Trucking and warehousing	42	5.63	3.26	-0.20	0.99
Water transportation	44	-8.92	0.07	-1.02	2.83
Local and interurban passenger transit	41	13.45	0.51	2.14	1.44
Transportation by air	45	12.01	4.63	4.94	4.36
Pipelines, except natural gas	46	-5.21	3.67	-4.93	3.53
Transportation services	47	15.92	8.52	4.60	4.97
Communication	48	1.94	0.68	-2.81	2.07
Electric, gas, and sanitary services	49	0.07	3.05	0.63	0.39

Table 4.3-7. BEA SQ-5 National Growth In Earnings By Industry

Industry	Percent Growth from 1990 to 1991
Farm	-18.38
Agricultural services, forestry, fisheries, and other	-5.06
Coal mining	-0.75
Construction	-10.37
Manufacturing	-3.01
Nondurable goods	-0.89
Durable goods	-4.30

Table 4.3-8. Area Source Growth Indicators

NAPAP SCC	Category Description	Data Source	Growth Indicator
13	Industrial Fuel - Anthracite Coal	SEDS	Ind - Anthracite
14	Industrial Fuel - Bituminous Coal	SEDS	Ind - Bituminous
15	Industrial Fuel - Coke	BEA	Total Manufacturing
16	Industrial Fuel - Distillate Oil	SEDS	Ind - Distillate oil
17	Industrial Fuel - Residual Oil	SEDS	Ind - Residual oil
18	Industrial Fuel - Natural Gas	SEDS	Ind - Natural gas
19	Industrial Fuel - Wood	BEA	Total Manufacturing
20	Industrial Fuel - Process Gas	SEDS	Ind - LPG
21	On-Site Incineration - Residential	BEA	Population
22	On-Site Incineration - Industrial	BEA	Total Manufacturing
23	On-Site Incineration-Commercial/Institutional	BEA	Services
24	Open Burning - Residential	BEA	Population
25	Open Burning - Industrial	BEA	Total Manufacturing
26	Open Burning - Commercial/Institutional	BEA	Services
54	Gasoline Marketed	SEDS	Trans - Motor gasoline
63	Frost Control - Orchard Heaters	BEA	Farm
99	Minor Point Sources	BEA	Population
100	Publicly Owned Treatment Works	BEA	Electric, Gas, and Sanitary Services
102	Fugitive Emissions From Synthetic Organic Chemical Manufacturing	BEA	Mfg - Chemicals and Allied Products
103	Bulk Terminal and Bulk Plants	BEA	Trucking and Warehousing
104	Fugitive Emissions From Petroleum Refinery		Refinery operating cap
105	Process Emissions From Bakeries	BEA	Mfg - Food and Kindred Products
106	Process Emissions From Pharmaceutical Manufacturing	BEA	Mfg - Chemicals and Allied Products
107	Process Emissions From Synthetic Fiber Manufacturing	BEA	Mfg - Textile Mill Products
108	Crude Oil and Natural Gas Production Fields	BEA	Oil and Gas Extraction
109	Hazardous Waste Treatment, Storage, and Disposal Facilities (TSDFs)	BEA	Total Manufacturing

Table 4.3-9. SEDS National Fuel Consumption

Category	1985	1986	1987	1988	1989	1990	1991
Anthracite Coal (thousand short tons)							
Industrial	575	470	437	434	392	387	385
Bituminous Coal (thousand short tons)							
Industrial	115,854	111,119	111,695	117,729	117,112	118,322	120,414
Distillate Fuel (thousand barrels)							
Industrial	203,659	206,108	210,699	209,553	197,035	205,856	208,503
Liquefied Petroleum Gases (thousand barrels)							
Industrial	437,964	411,451	447,120	453,599	441,784	457,013	473,897
Motor Gasoline (thousand barrels)							
Transportation	2,433,592	2,507,936	2,570,047	2,627,331	2,617,450	2,703,666	2,758,444
All Sectors	2,493,361	2,567,436	2,630,089	2,685,145	2,674,669	2,760,414	2,814,398
Natural Gas (million cubic feet)							
Industrial	6,867	6,502	7,103	7,479	7,887	8,120	8,495
Residual Fuel (thousand barrels)							
Industrial	120,002	132,249	107,116	105,448	95,646	118,122	158,077

Table 4.3-10. AMS to NAPAP Source Category Correspondence

AMS		NAPAP	
SCC	Category	SCC	Category
Stationary Source Fuel Combustion			
2102001000	Industrial - Anthracite Coal (Total: All Boiler Types)	13	Industrial Fuel - Anthracite Coal
2102002000	Industrial - Bituminous/Subbituminous Coal (Total: All Boiler Types)	14	Industrial Fuel - Bituminous Coal
2102004000	Industrial - Distillate Oil (Total: Boilers & IC Engines)	16	Industrial Fuel - Distillate Oil
2102005000	Industrial - Residual Oil (Total: All Boiler Types)	17	Industrial Fuel - Residual Oil
2102006000	Industrial - Natural Gas (Total: Boilers & IC Engines)	18	Industrial Fuel - Natural Gas
2102008000	Industrial - Wood (Total: All Boiler Types)	19	Industrial Fuel - Wood
2102009000	Industrial - Coke (Total: All Boiler Types)	15	Industrial Fuel - Coke
2102010000	Industrial - Process Gas (Total: All Boiler Types)	20	Industrial Fuel - Process Gas
Industrial Processes			
2301020000	Process Emissions from Pharmaceuticals (PECHAN)	106	Process Emissions from Pharmaceutical Manufacturing
2301030000	Process Emissions from Synthetic Fiber (PECHAN)	107	Process Emissions from Synthetic Fibers Manufacturing
2301040000	SOCMI Fugitives (PECHAN)	102	Fugitive Emissions From Synthetic Organic Chemical Manufacturing
2302050000	Food & Kindred Products: SIC 20 - Bakery Products (Total)	105	Process Emissions From Bakeries
2306000000	Petroleum Refining: SIC 29 - All Processes (Total)	104	Fugitive Emissions From Petroleum Refinery Operations
2310000000	Oil & Gas Production: SIC 13 - All Processes (Total)	108	Crude Oil and Natural Gas Production Fields
2399000000	Industrial Processes: NEC	99	Minor point sources
Storage & Transport			
2501050120	Petroleum & Petroleum Product Storage - Bulk Stations/Terminals: Breathing Loss (Gasoline)	103	Bulk Terminal and Bulk Plants
2501060050	Petroleum & Petroleum Product Storage - Gasoline Service Stations (Stage I: Total)	54	Gasoline Marketed (Stage I)
2501060100	Petroleum & Petroleum Product Storage - Gasoline Service Stations (Stage II: Total)	54	Gasoline Marketed (Stage II)
2501060201	Petroleum & Petroleum Product Storage - Gasoline Service Stations (Underground Tank: Breathing & Emptying)	54	Gasoline Marketed (Breathing & Emptying) (continued)

Table 4.3-10. (continued)

AMS		NAPAP	
SCC	Category	SCC	Category
Waste Disposal, Treatment, & Recovery			
2601010000	On-Site Incineration - Industrial (Total)	22	On-Site Incineration - Industrial
2601020000	On-Site Incineration - Commercial/Institutional (Total)	23	On-Site Incineration - Commercial/Institutional
2601030000	On-Site Incineration - Residential (Total)	21	On-Site Incineration - Residential
2610010000	Open Burning - Industrial (Total)	25	Open Burning - Industrial
2610020000	Open Burning - Commercial/Institutional (Total)	26	Open Burning - Commercial/Institutional
2610030000	Open Burning - Residential (Total)	24	Open Burning - Residential
2630020000	Wastewater Treatment - Public Owned (Total)	100	Publicly-Owned Treatment Works (POTWs)
2640000000	TSDFs - All TSDF Types (Total: All Processes)	109	Hazardous Waste Treatment, Storage, and Disposal Facilities (TSDF)

4.4 OTHER COMBUSTION

The source categories falling under "Other Combustion" include the following Tier 1 and Tier 2 categories:

<u>TIER 1 CATEGORY</u>	<u>TIER 2 CATEGORY</u>
OTHER COMBUSTION	All
MISCELLANEOUS	Other Combustion

The Tier 1, Other Combustion emissions are from residential and commercial / institutional burning of all fuels except solid waste. The emissions for the miscellaneous, other combustion category include agricultural burning, forest fires/wildfires, prescribed/slash and managed burning, and structural fires. The emissions from agricultural burning and structural fires were produced using the methodology described in section 4.4.1. The methodologies used to estimate the emissions for forest fires/wildfires and prescribed/slash and managed burning are described in section 4.4.4.1.

The 1990 emissions for the majority of the source categories were generated from both the nonutility point source and nonsolvent area source portions of the 1985 NAPAP Emissions Inventory except for emissions from wildfires and prescribed burning. The 1990 emissions served as the base year from which the emissions for the years 1985 through 1989 and the years 1991 through 1993 were estimated. The emissions for the years 1985 through 1991 were estimated using historical data compiled by the Bureau of Economic Analysis (BEA)¹ or historic estimates of fuel consumption based on the DOE's State Energy Data System (SEDS).² The 1992 and 1993 emissions were estimated using growth factors produced by the prereleased E-GAS³, version 2.0.

4.4.1 1990 Base Year Inventory

The 1985 NAPAP Emission Inventory estimates for the **point** sources have been projected to the year 1990 based on the growth in BEA historic earnings for the appropriate state and industry¹, as identified by the 2-digit Standard Industrial Classification (SIC) code. In order to remove the effects of inflation, the earnings data were converted to 1982 constant dollars using the implicit price deflator for personal consumption expenditures (PCE).⁴ State and SIC-level growth factors were calculated as the ratio of the 1990 earnings data to the 1985 earning data. More details on growth indicators are presented in section 4.4.2.1.

The **area** source emissions from the 1985 NAPAP Emissions Inventory have been projected to the year 1990 based on BEA historic earnings data, BEA historic population data, DOE SEDS data, or other growth indicators. The specific growth indicator was assigned based on the source category. The BEA earnings data were converted to 1982 dollars as described above. The 1990 SEDS data were extrapolated from data for the years 1985 through 1989. All growth factors were calculated as the ratio of the 1990 data to the 1985 data for the appropriate growth indicator. More details on growth indicators are presented in section 4.4.2.2.

When creating the 1990 emissions inventory, changes were made to emission factors, control efficiencies, and emissions from the 1985 inventory for some sources. The PM-10 control efficiencies were obtained from

the PM-10 Calculator.⁵ In addition, rule effectiveness which was not applied in the 1985 NAPAP Emission Inventory, was applied to the 1990 emissions estimated for the point sources. The CO, NO_x, and VOC point source controls were assumed to be 80 percent effective; PM-10 and SO₂ controls were assumed to be 100 percent effective.

The 1990 emissions for CO, NO_x, SO₂, and VOC were calculated using the following steps: (1) projected 1985 controlled emissions to 1990 using the appropriate growth factors, (2) calculated the uncontrolled emissions using control efficiencies from the 1985 NAPAP Emission Inventory, and (3) calculated the final 1990 controlled emissions using revised control efficiencies and the appropriate rule effectiveness. The 1990 PM-10 emissions were calculated using the TSP emissions from the 1985 NAPAP Emission Inventory. The 1990 uncontrolled TSP emissions were estimated in the same manner as the other pollutants. From these TSP emissions, the 1990 uncontrolled PM-10 estimates were calculated by applying SCC-specific uncontrolled particle size distribution factors.⁶ The controlled PM-10 emissions were estimated in the same manner as the other pollutants. Because the majority of area source emissions for all pollutants represented uncontrolled emissions, the second and third steps were not required to estimate the 1990 area source emissions.

4.4.1.1 Control Efficiency Revisions

In the 1985 NAPAP point source estimates, control efficiencies for VOC, NO_x, CO, and SO₂ sources in Texas were judged to be too high for their process/control device combination. These high control efficiencies occurred because Texas did not ask for control efficiency information, and simply applied the maximum efficiency for the reported control device⁷. High control efficiencies lead to high future growth in modeling scenarios based on uncontrolled emissions (which are based on the control efficiency and reported actual emissions). High control efficiencies also lead to extreme increases in emissions when rule effectiveness is incorporated.

Revised VOC control efficiencies were developed for Texas for the Emission Reduction and Cost Analysis Model for VOC (ERCAM-VOC)⁸. For this analysis, revised efficiencies were also developed by SCC and control device combination for NO_x, SO₂, and CO using engineering judgement. These revised control efficiencies were applied to sources in Texas. A large number of point sources outside of Texas had VOC and CO control efficiencies that were also judged to be too high. The VOC and CO control efficiencies used for Texas were also applied to these sources.

4.4.1.2 Rule Effectiveness Assumptions

Controlled emissions for each inventory year were recalculated, assuming that reported VOC, NO_x, and CO controls were 80 percent effective. Sulfur dioxide and PM-10 controls were assumed to be 100 percent effective.

4.4.1.3 Emission Factor Changes

Emission factors for several sources were updated to reflect recent technical improvements in AP-42 and other emission inventory guidance documents. Emission factors for all four pollutants were updated for residential wood combustion.

AP-42 sections for residential wood combustion sources have recently been updated. With the exception of the SO₂ emission factor (which has not changed), emission factors for each pollutant have decreased. Table 4.4-1 lists the NAPAP emission factors (which reflect a combination of wood-burning devices) and the emission factors listed in the revised AP-42 sections. No data are available to weight these emission factors. Because of this, and because conventional woodstoves constitute the majority of woodstoves nationwide, these data were used to calculate *all* residential wood combustion emissions. Because conventional stove emissions are higher than other wood-burning devices, this will provide an upper bound of emissions.

4.4.1.4 Emissions Calculations

A three-step process was used to calculate emissions incorporating rule effectiveness. First, base year controlled emissions are projected to the inventory year using the following formula:

$$CE_i = CE_{BY} \times (1 + EG_i)$$

where: CE_i = controlled emissions for inventory year i
 CE_{BY} = controlled emissions for base year
 EG_i = earnings growth for inventory year i

Earnings growth (EG) is calculated as:

$$EG_i = \frac{DAT_i}{DAT_{BY}} - 1$$

where: DAT_i = earnings data for inventory year i
 DAT_{BY} = earnings data in the base year

Second, uncontrolled emissions in the inventory year are back-calculated from the controlled emissions based on the control efficiency with the following formula

$$UE_i = \frac{CE_i}{\left(1 + \frac{CEFF}{100}\right)}$$

where: UE_i = uncontrolled emissions for inventory year i
 CE_i = controlled emissions for inventory year i
 $CEFF$ = control efficiency (%)

Third, controlled emissions are recalculated incorporating rule effectiveness using the following formula:

$$CER_i = UC_i \times \left(1 - \left(\frac{REFF}{100} \right) \right) \times \left(\frac{CEFF}{100} \right) \times \left(\frac{EF_i}{EF_{BY}} \right)$$

where: CER_i = controlled emissions incorporating rule effectiveness
 UC_i = uncontrolled emissions
 $REFF$ = rule effectiveness (%)
 $CEFF$ = control efficiency (%)
 EF_i = emission factor for inventory year
 EF_{BY} = emission factor for base year

4.2.2 Emissions, 1985 to 1991

As explained in section 4.4.1.1, the 1990 controlled emissions were projected from the 1985 NAPAP Emissions Inventory using equations 1 through 4. For all other years (1985 to 1989 & 1991) the emissions were projected from the 1990 emissions using equations 1 and 2. Therefore the 1985 emissions estimated by this method do not match the 1985 NAPAP Emissions Inventory due to the changes made in control efficiencies and emission factors and the addition of rule effectiveness when creating the 1990 base year inventory.

4.4.2.1 Point Source Growth

The changes in the point source emissions were equated with the changes in historic earnings by state and industry. Emissions from each point source in the 1985 NAPAP Emissions Inventory were projected to the years 1985 through 1991 based on the growth in earnings by industry (2-digit SIC code). Historical earnings data from BEA's Table SA-5¹ were used to represent growth in earnings from 1985 through 1990. (Earnings data from a different BEA source, Table SQ-5 discussed below, were used to estimate 1991 emissions.) Table SA-5 historical annual earnings data are by state and industry.

The 1985 through 1990 earnings data in Table SA-5 are in nominal dollars. In order to be used to estimate growth, these values were converted to constant dollars to remove the effects of inflation. Earnings data for each year were converted to 1982 constant dollars using the implicit price deflator for personal consumption expenditures (PCE).⁴ The PCE deflators used to convert each year's earnings data to 1982 dollars are:

<u>Year</u>	<u>1982 PCE Deflator</u>
1985	111.6
1987	114.3
1988	124.2
1989	129.6
1990	136.4

Several BEA categories did not contain a complete time series of data for the years 1985 through 1990. Because the SA-5 data must contain 1985 earnings and earnings for each inventory year (1985 through 1990) to be useful for estimating growth, a log linear regression equation was used to fill in missing data elements where possible. This regression procedure was performed on all categories that were missing at least one data point and which contained at least three data points in the time series.

Each record in the point source inventory was matched to the BEA earnings data based on the state and the 2-digit SIC. Table 4.4-2 shows the BEA earnings category used to project growth for each of the 2-digit SICs found in the 1985 NAPAP Emission Inventory. No growth in emissions was assumed for all point sources for which the matching BEA earnings data were not complete. Table 4.4-2 also shows the national average growth and earnings by industry from Table SA-5.

At the time the Emission Trends inventory was compiled, 1991 BEA earnings data were not available in Table SA-5. Earnings data from BEA Table SQ-5⁹ were used to estimate emissions for 1991. Table SQ-5 contains historical quarterly earnings data by state and 1-digit SIC. These data were converted to an annual constant dollars basis.

The 1991 quarterly earnings data were first summed to compute annual totals. Because the PCE deflator used to convert to constant 1982 dollars was not available for 1991, a 1987 PCE deflator⁹ was used to convert the 1990 and 1991 earnings data from Table SQ-5 to a 1987 constant dollar basis. The PCE deflators are as follows:

<u>Year</u>	<u>1987 PCE Deflator</u>
1990	114.7
1991	119.3

The 1991 inventory was then developed by growing the 1990 inventory based on the changes in State industry earnings (by 1-digit SIC) from 1990 to 1991. National average growth in earnings by industry is shown below in Table 4.4-3.

4.4.2.2 Area Source Growth

Emissions from the 1985 NAPAP Inventory were grown to the Emission Trends years based on historical BEA earnings data section 4.4.2.1, historical estimates of fuel consumption², or other category-specific growth indicators. Table 4.4-4 shows the growth indicators used for each area source by NAPAP category.

The SEDS data² were used as an indicator of emissions growth for the area source fuel combustion categories shown in Table 4.4-5. (SEDS reports fuel consumption by sector and fuel type.) Since fuel consumption is the activity level used to estimate emissions for these categories, fuel consumption is a more accurate predictor of changes in emissions, compared to other surrogate indicators such as earnings or population. SEDS fuel consumption data were available through 1989. The 1990 and 1991 values were extrapolated from the 1985 through 1989 data using a log linear regression technique. In addition to projecting 1990 and 1991 data for all fuel consumption categories, the regression procedure was used to fill in missing data points for fuel consumption categories if at least three data points in the time series (1985 to 1989) were available.

Due to the year-to-year volatility in the SEDS fuel consumption data for the commercial residual oil fuel use category, the regression technique used above did not yield realistic projections for 1990 and 1991 for this category. Therefore, a different procedure was used to project 1990 and 1991 data for commercial residual oil fuel use. State-level sales volumes of residual fuel to the commercial sector were obtained from Fuel Oil and Kerosene Sales 1990¹⁰ for 1989 and 1990. Each State's growth in sales of residual fuel to the commercial sector from 1989 to 1990 was applied to that State's 1989 SEDS commercial residual fuel consumption to yield a 1990 consumption estimate. Sales data for 1991 were not yet available; the growth decline from 1990 to 1991 was assumed to be the same as from 1989 to 1990. A summary of SEDS national fuel consumption by fuel and sector can be found in Table 4.4-5.

The last step in the creation of the area source inventory was the matching of NAPAP categories to the new AMS categories. This matching is provided in Table 4.4-16. Note that there is not always a one-to-one correspondence between NAPAP and AMS categories.

4.4.3 Emissions, 1992 and 1993

The 1992 and 1993 emissions for all pollutants were estimated by applying growth factors to the 1990 emissions using a modified version of equation 1. The growth factors were obtained from the prereleased E-GAS, version 2.0.³ The E-GAS generates growth factors at the SCC-level for counties representative of all counties within each ozone nonattainment area classified as serious and above and for counties representative of all counties within both the attainment portions and the marginal and moderate nonattainment areas within each state. The appropriate growth factors were applied by county and SCC to the 1990 emissions as shown by the following equation:

$$Emissions_{(county, SCC, year)} = Growth_{(county, SCC, year)} \times Emissions_{(county, SCC, 1990)}$$

There are approximately 150 representative counties in E-GAS and 2000 SCCs present in the base year inventory. This yields a matrix of 300,000 growth factors generated to determine a single year's inventory. To list all combinations would be inappropriate.

4.4.4 Alternative Base Inventory Calculations

For two combustion sources the 1985 NAPAP Emissions Inventory was not used as the base year for some or all other years. The wildfire emissions for 1985 to 1989 are the same estimates and are equal to the 1985 NAPAP Emissions Inventory. The wildfire emissions for 1990 to 1993 are based on AP-42 emission factors and fuel loading values. The activity data was derived from the Forest Service and the Department of Interior. The Prescribed burning estimates for the years 1985 to 1993 are the same and were obtained from the U.S. Department of Agriculture.

4.4.4.1 Forest Fires/Wildfires

Since a surrogate for changes in wildfires is not available, Pechan tried to obtain wildfire emissions data. Work is currently being done for the Grand Canyon Visibility Study that will develop wildfire emissions for the 10 western states included in the study. Pechan was unable to obtain these or any emissions data from the Forest Service. What Pechan did for 1990 to 1993 was to obtain state level acres of land burned. This acreage was used in conjunction with AP-42 regional fuel loading and national emission factors presented in Table 4.4-7 to estimate emissions. For the years 1990 through 1992, the number of acres burned was obtained according to this methodology. For the 1993 emissions, the number of acres burned were determined by summing the 1993 Department of Interior (DOI) state-level acreage data¹¹ and the USDA Forest Service state-level acreage data^{12,13} averaged over the years 1990 through 1992. The state level emissions were distributed to the county-level using the same distribution as in 1985 NAPAP Emissions Inventory.

The emissions for the wildfire category were generated for the years 1985 through 1989 using the methodology described in sections 4.4.1 and 4.4.2. The base year was 1985 and the growth factor was 1. Therefore the emissions for 1985 to 1989 are the same.

4.4.4.2 Prescribed/Slash and Managed Burning

The prescribed burning emissions were based on a 1989 USDA Forest Service inventory of particulate matter and air toxics from prescribed burning¹⁴. The Forest Service inventory contained State-level totals for Total Particulate Matter, PM-10, PM-2.5, CO, carbon dioxide, methane, non-methane, and several air toxics.

The emissions for all pollutants were based on the 1989 USDA Forest Service inventory of particulate matter from prescribed burning.¹⁴ This inventory contains state-level emissions for CO, PM-10, and VOC. The NO_x and SO₂ emissions were calculated by assuming the ratio between the CO emissions to either the NO_x or SO₂ emissions in the Forest Service inventory was equal to the corresponding ratio using the 1985 NAPAP Emission Inventory. The following formula was used:

$$FS_{POL} = FS_{CO} \times \left(\frac{NAPAP_{POL}}{NAPAP_{CO}} \right)$$

where: FS_{POL} = prescribed burning (NO_x or SO_2) emissions from Forest Service
 FS_{CO} = prescribed burning CO emissions from Forest Service
 $NAPAP_{POL}$ = prescribed burning (NO_x or SO_2) emissions from 1985 NAPAP
 $NAPAP_{CO}$ = prescribed burning CO emissions from 1985 NAPAP

The resulting 1989 emissions for CO, NO_x , PM-10, SO_2 , and VOC have been used for all years between 1985 and 1993. The pollutants were distributed to the county-level using the same county-level distribution as was used in the 1985 NAPAP Inventory where forest acreage per county was obtained from local officials and State land usage maps.

4.4.5 References

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Table 4.4-1. Residential Wood Combustion Emission Factors

	Emission Factors (lbs/ton)				
	PM-10	VOC	CO	NO _x	SO _x
1985 NAPAP	39.30 ^a	85.72	242.63	2.92	0.40
AP-42 Emission Factors:					
Conventional Stoves	30.60	28.00	230.80	2.80	0.40
Noncatalytic Stoves	19.60	ND	140.80	ND	0.40
Pellet Stoves[*]	4.20	ND	39.40	13.80	0.40
Catalytic Stoves	20.40	17.20	104.80	2.00	0.40
Fireplaces	34.6	26.00	122.20	1.80	0.40

ND = no data.

^aTSP emission factor

^b Pellet stoves comprise less than 2 percent of the national population.

Table 4.4-2. Bureau of Economic Analysis's SA-5 National Changes in Earnings by Industry

Industry	SIC	Percent Growth from:			
		1985 to 1987	1987 to 1988	1988 to 1989	1989 to 1990
Wholesale trade	50, 51	5.01	5.87	2.44	-1.02
Retail trade	52 to 59	5.19	4.39	0.65	-0.94
Banking and credit agencies	60, 61	12.44	2.45	-0.33	-0.49
Insurance	63, 64	14.09	4.20	1.52	2.71
Real estate	65, 66	92.14	-6.98	-7.87	-0.48
Holding companies and investment services	67	39.05	-34.86	-12.18	16.91
Hotels and other lodging places	70	12.65	5.59	1.71	2.29
Personal services	72	7.17	2.35	7.44	5.41
Private households	88	-5.68	2.41	0.83	-3.69
Business and miscellaneous repair services	76	17.05	-17.34	5.79	4.34
Auto repair, services, and garages	75	6.65	2.46	3.00	3.93
Amusement and recreation services and motion pictures	78, 79	17.93	16.43	4.06	7.59
Health services	80	15.15	7.08	5.11	6.28
Legal services	81	20.14	9.92	4.09	4.80
Educational services	82	9.35	7.17	3.88	2.60
Social services and membership organizations	83	17.39	8.45	7.95	7.37
Miscellaneous professional services	84	11.28	5.04	7.08	4.12
Federal, civilian	91	-0.54	3.79	1.21	1.96
Federal, military	97	1.96	-1.07	-1.58	-3.19
State and local government	92 to 96	7.88	3.63	3.19	3.04

Table 4.4-3. BEA SQ-5 National Growth In Earnings By Industry

Industry	Percent Growth from 1990 to 1991
Wholesale trade	-2.55
Retail trade	-2.84
Services	1.91
Government and government enterprises	1.16
Federal, civilian	-0.49
Federal, military	-1.94
State and local	2.00

Table 4.4-4. Area Source Growth Indicators

NAPAP SCC	Category Description	Data Source	Growth Indicator
1	Residential Fuel - Anthracite Coal	SEDS	Res - Anthracite
2	Residential Fuel - Bituminous Coal	SEDS	Res - Bituminous
3	Residential Fuel - Distillate Oil	SEDS	Res - Distillate oil
4	Residential Fuel - Residual Oil		Zero growth
5	Residential Fuel - Natural Gas	SEDS	Res - Natural gas
6	Residential Fuel - Wood	BEA	Population
7	Commercial/Institutional Fuel - Anthracite Coal	SEDS	Comm - Anthracite
8	Commercial/Institutional Fuel - Bituminous Coal	SEDS	Comm - Bituminous
9	Commercial/Institutional - Distillate Oil	SEDS	Comm - Distillate oil
10	Commercial/Institutional - Residual Oil	SEDS	Comm - Residual oil
11	Commercial/Institutional - Natural Gas	SEDS	Comm - Natural gas
12	Commercial/Institutional - Wood	BEA	Services
60	Forest Wild Fires		Zero growth
61	Managed Burning - Prescribed		Zero growth
62	Agricultural Field Burning	BEA	Farm
64	Structural Fires		Zero growth
99	Minor Point Sources	BEA	Population

Table 4.4-5. SEDS National Fuel Consumption

Category	1985	1986	1987	1988	1989	1990	1991
Anthracite Coal (thousand short tons)							
Commercial	524	494	478	430	422	410	403
Residential	786	740	717	646	633	615	604
Bituminous Coal (thousand short tons)							
Commercial	4,205	4,182	3,717	3,935	3,323	3,470	3,515
Residential	2,264	2,252	2,002	2,119	1,789	1,869	1,893
Distillate Fuel (thousand barrels)							
Commercial	107,233	102,246	101,891	98,479	91,891	95,385	96,712
Residential	171,339	173,736	176,822	182,475	178,629	184,501	187,994
Motor Gasoline (thousand barrels)							
All Sectors	2,493,361	2,567,436	2,630,089	2,685,145	2,674,669	2,760,414	2,814,398
Natural Gas (million cubic feet)							
Commercial	2,432	2,318	2,430	2,670	2,719	2,810	2,928
Residential	4,433	4,314	4,315	4,630	4,777	4,805	4,922
Residual Fuel (thousand barrels)							
Commercial	30,956	39,480	41,667	42,256	35,406	27,776	28,216

Table 4.4-6. AMS to NAPAP Source Category Correspondence

AMS		NAPAP	
SCC	Category	SCC	Category
Stationary Source Fuel Combustion			
2103001000	Commercial/Institutional - Anthracite Coal (Total: All Boiler Types)	7	Commercial/Institutional Fuel - Anthracite Coal
2103002000	Commercial/Institutional - Bituminous/Subbituminous Coal (Total: All Boiler Types)	8	Commercial/Institutional Fuel - Bituminous Coal
2103004000	Commercial/Institutional - Distillate Oil (Total: Boilers & I.C. Engines)	9	Commercial/Institutional - Distillate Oil
2103005000	Commercial/Institutional - Residual Oil (Total: All Boiler Types)	10	Commercial/Institutional - Residual Oil
2103006000	Commercial/Institutional - Natural Gas (Total: Boilers & I.C. Engines)	11	Commercial/Institutional - Natural Gas
2103008000	Commercial/Institutional - Wood (Total: All Boiler Types)	12	Commercial/Institutional - Wood
2104001000	Residential - Anthracite Coal (Total: All Combustor Types)	1	Residential Fuel - Anthracite Coal
2104002000	Residential - Bituminous/Subbituminous Coal (Total: All Combustor Types)	2	Residential Fuel - Bituminous Coal
2104004000	Residential - Distillate Oil (Total: All Combustor Types)	3	Residential Fuel - Distillate Oil
2104005000	Residential - Residual Oil (Total: All Combustor Types)	4	Residential Fuel - Residual Oil
2104006000	Residential - Natural Gas (Total: All Combustor Types)	5	Residential Fuel - Natural Gas
2104008000	Residential - Wood (Total: Woodstoves and Fireplaces)	6	Residential Fuel - Wood
Miscellaneous Area Sources			
2801500000	Agriculture Production - Crops - Agricultural Field Burning (Total)	62	Agricultural Field Burning
2801520000	Agriculture Production - Crops - Orchard Heaters (Total)	63	Frost Control - Orchard Heaters
2810001000	Other Combustion - Forest Wildfires (Total)	60	Forest Wild Fires
2810015000	Other Combustion - Managed (Slash/Prescribed) Burning (Total)	61	Managed Burning - Prescribed
2810030000	Other Combustion - Structure Fires	64	Structural Fires

Table 4.4-7. Wildfires

Region	Fuel loading Tons/Acre Burned	Pollutant	Emission Factor lbs/ton
Rocky Mountain	37	TSP	17
Pacific	19	SO₂	0.15
North Central	11	NO_x	4
South	9	VOC	19.2
East	11	CO	140
		PM-10	13

States Comprising Regions

South	East	Rocky Mountain	North Central	Pacific
Alabama	Connecticut	Arizona	Illinois	Alaska
Arkansas	Delaware	Colorado	Indiana	California
Florida	Maine	Idaho	Iowa	Guam
Georgia	Maryland	Kansas	Michigan	Hawaii
Kentucky	Massachusetts	Montana	Minnesota	Oregon
Louisiana	New Hampshire	Nebraska	Missouri	Washington
Mississippi	New Jersey	Nevada	Ohio	
North Carolina	New York	New Mexico	Wisconsin	
Oklahoma	Pennsylvania	North Dakota		
South Carolina	Rhode Island	South Dakota		
Tennessee	Vermont	Utah		
Texas	West Virginia	Wyoming		
Virginia				

4.5 SOLVENT UTILIZATION

Solvent utilization emissions are included as both point and area sources in the Emission Trends inventory. Point source emissions were based on the 1985 NAPAP Emission Inventory (see section 4.5.2). The basis for the VOC area source component is a material balance on total nationwide solvent consumption. (There are no area source CO, NO_x, SO₂, and PM-10 emissions in the Emission Trends inventory.) Total nationwide solvent emissions by end-use category are estimated from national consumption figures with some adjustments to account for air pollution controls and waste management practices. The nationwide emissions are then apportioned to states and counties using census data and information on state and local regulations pertaining to solvent emissions. At this stage, county- and category-level point source emissions are deducted from the emission totals, and the balance of emissions is included in the area source solvent inventory. The following section 4.5.1 describes the development of national solvent emissions, apportionment to states and counties, and short-term projections to the timeframes covered by the Emission Trends inventory.

4.5.1 Area Source Emissions (VOC only)

Volatile organic compound emissions are estimated for area sources by first estimating national total emissions that are distributed to county and end user, described in this section and then subtracting the point source emissions, described in section 4.5.2.

4.5.1.1 Overall National Emissions Estimates

The overall **national** solvents material balance can be summarized as follows:

$$\begin{array}{r} \text{National solvent} \\ \text{emissions (by end-} \\ \text{use category)} \end{array} = \begin{array}{r} \text{National solvent} \\ \text{consumption} \end{array} - \begin{array}{r} \text{Solvents} \\ \text{destroyed by air} \\ \text{pollution} \\ \text{controls} \end{array} - \begin{array}{r} \text{Solvents conveyed} \\ \text{to waste} \\ \text{management} \\ \text{operations} \end{array}$$

(It should be noted that this overall national material balance yields total solvent emissions, including both point and area sources.)

National solvent usage estimates by end-use category were obtained from three main sources. For paints and coatings, the main source was the U.S. Paint Industry Data Base, prepared by SRI International for the National Paint and Coatings Association.¹ Solvent usage estimates for other categories were obtained from industrial solvent marketing reports.^{2,3} The base year for this activity data and for the total solvent emissions is 1989.

The solvent emission methodology is designed to incorporate pollution control and waste management information at the source category level. However, the timeframe for the Emission Trends inventory effort was too tight to permit development of category-specific information. The mass balance term for waste management was based on the U.S. Environmental Protection Agency's (EPA's) data base⁴ for hazardous waste treatment, storage, and disposal facilities (TSDF), which also forms the basis for the TSDF portion of the

Emission Trends inventory. (See section 4.3.1.5 for details on TSDF emissions.) In essence, the portion of the TSDF inventory that is attributable to solvents is deducted from the current solvents inventory in order to avoid double-counting. The TSDF deduction was apportioned evenly to all industrial categories, and amounts to about 21 percent of total solvent usage in these categories.

Solvent destruction adjustments in the nationwide material balance were based on the same assumptions used for the 1985 National Emissions Data System (NEDS) and the 1985 NAPAP Emissions Inventory. According to the data in NEDS and 1985 NAPAP Emission Inventory, approximately 16 percent of industrial surface coating emissions are assumed to be destroyed in air pollution controls.

Table 4.5-1 lists the elements in the national solvent material balance by emission source category. As discussed above, these elements are: national solvent consumption, solvent destroyed in air pollution controls, solvent sent to waste management operations, and net solvent emissions. Table 4.5-1 also summarizes the major sources of these data.

4.5.1.2 Distribution of Solvent Emissions to States and Counties

The primary tools used to distribute national solvent emissions to states and counties are 1988 census data bases.^{5,6,7} For each of the source categories listed in Table 4.5-1, state- and county-level solvent usage is assumed to be proportional to a particular census measure. For consumer end-use categories, solvent usage was distributed based on population. County-level employment data were used for commercial and industrial end-use categories. Census data on the number of farm acres treated with chemical sprays were used to distribute pesticide solvent usage. Table 4.5-2 lists the specific census data used for each emission category.

State and local regulations covering solvent emissions were also incorporated in the spatial distribution step for the solvent inventories. For an industrial or commercial end-use category, the overall spatial distribution calculation can be summarized as follows:

$$\begin{aligned}
 \text{County emissions} &= \text{National emissions} \times \frac{\text{County employment}}{\text{National employment}} \times \frac{\text{Estimated control efficiency for county}}{\text{Nationwide average control efficiency for category}} \\
 \text{(by end-use category)} &
 \end{aligned}$$

Quantitative information on state- and county-level control efficiency, rule effectiveness, and rule penetration was obtained primarily from surveys carried out under EPA's ongoing Regional Oxidant Model (ROM) modeling effort.⁸ For states outside the ROM domain, these parameters were estimated using Bureau of National Affairs regulation summaries.

4.5.1.3 Deduction of Point Source Emissions

The area source inventory is produced by deducting point source emissions from the county-level category emission totals produced in equation 2. The calculation is performed as follows:

$$\text{County-level area source emissions (by end-use category)} = \text{Total county-level emissions (equation 2)} - \text{County-level point source emissions}$$

The Aerometric Information Retrieval System (AIRS) Area/Mobile Source Subsystem (AMS) solvent categories were first matched to the corresponding point source Source Classification Codes (SCCs). Using the Emission Trends 1990 point source totals by county for each corresponding AMS SCC were calculated. These emissions were then subtracted from the total solvent emissions (the 1989 total solvent emissions were projected to 1990 as described below) to yield the area source emissions. In the cases of negative emissions (higher point source emissions than total estimated solvent emissions), the 1985 NAPAP methodology^{8b} was followed — area source emissions were set to zero.

Then the non-zero county values were readjusted so that the sum of all county area source emissions equal the difference between the total national emissions and the national point source emissions; otherwise, area source emissions are underestimated.

$$\text{All County Area Source Emissions} = \text{National Total Emissions} - \text{National Point Source Emissions}$$

4.5.1.4 Projecting Solvent Emissions to Other Inventory Years

The Emission Trends inventory includes annual area source solvent emissions for 7 calendar years (from 1985 through 1991). (Methodology used to estimate the 1992 and 1993 emissions is explained in section 4.5.2.3.) The total solvent inventory was based on 1989 activity-level data. (Spatial allocations for the solvent area source inventory were based on the 1988 census, which provides the most recent data available at the county level.) Projections to other years covered by the Emission Trends inventory are based on state-level earnings data for major industrial categories, which generally correspond to 2-digit Standard Industrial Classifications (SICs). The following algorithm is used for the emission projection:

$$\text{Projection year emissions (by county and end-use category)} = \text{Base year emissions} \times \frac{\text{Projection year earnings (by State and 2-digit SIC)}}{\text{Base year earnings}}$$

In this equation, the projection year represents the appropriate calendar year for the Emission Trends inventory (ranging from 1985 to 1991). The total solvent inventory was first projected to 1990 to complete the point source deduction described above. After deducting the point source solvents, this 1990 area source solvent data base was then scaled-back/projected to the other inventory years.

The county/source category emissions predicted using changes in BEA earnings data were then scaled according to expected changes in national solvent emissions. Annual changes in national solvent usage (by end-use category) were taken from the solvent marketing reports.^{2,3} All county-level emissions within an end-use

category were scaled by a factor so that total national emissions would be equivalent to the national solvent emissions reported in the literature.

4.5.2 Point Source Emissions

The 1990 emissions for these source categories were generated from the point source portion of the 1985 NAPAP Emissions Inventory. These 1990 emissions served as the base year from which the emissions for the years 1985 through 1989 and the years 1991 through 1993 were estimated. The emissions for the years 1985 through 1991 were estimated using historical data compiled by the BEA¹¹ or historic estimates of fuel consumption based on the Department of Energy's (DOE) State Energy Data System (SEDS).⁹ The 1992 and 1993 emissions were estimated using growth factors produced by the prereleased E-GAS, version 2.0¹⁰.

4.5.2.1 Base Year Inventory

The 1985 NAPAP Emission Inventory estimates for the **point** sources have been projected to the year 1990 based on the growth in BEA historic earnings for the appropriate state and industry,¹¹ as identified by the 2-digit Standard Industrial Classification (SIC) code.¹¹ In order to remove the effects of inflation, the earnings data were converted to 1982 constant dollars using the implicit price deflator for personal consumption expenditures (PCE).¹² State and SIC-level growth factors were calculated as the ratio of the 1990 earnings data to the 1985 earning data. More details on growth indicators are presented in section 4.5.2.2.

When creating the 1990 emissions inventory, changes were made to emission factors, control efficiencies, and emissions from the 1985 inventory for all sources. The PM-10 control efficiencies were obtained from the PM-10 Calculator.¹³ In addition, rule effectiveness which was not applied in the 1985 NAPAP Emission Inventory, was applied to the 1990 emissions estimated for the point sources. The CO, NO_x, and VOC point source controls were assumed to be 80 percent effective; PM-10 and SO₂ controls were assumed to be 100 percent effective.

The 1990 emissions for CO, NO_x, SO₂, and VOC were calculated using the following steps: (1) projected 1985 controlled emissions to 1990 using the appropriate growth factors, (2) calculated the uncontrolled emissions using control efficiencies from the 1985 NAPAP Emission Inventory, and (3) calculated the final 1990 controlled emissions using revised control efficiencies and the appropriate rule effectiveness. The 1990 PM-10 emissions were calculated using the TSP emissions from the 1985 NAPAP Emission Inventory. The 1990 uncontrolled TSP emissions were estimated in the same manner as the other pollutants. From these TSP emissions, the 1990 uncontrolled PM-10 estimates were calculated by applying SCC-specific uncontrolled particle size distribution factors.¹⁴ The controlled PM-10 emissions were estimated in the same manner as the other pollutants. Because the majority of area source emissions for all pollutants represented uncontrolled emissions, the second and third steps were not required to estimate the 1990 area source emissions.

4.5.2.1.1 Control Efficiency Revisions —

In the 1985 NAPAP point source estimates, control efficiencies for VOC, NO_x, CO, and SO₂ sources in Texas were judged to be too high for their process/control device combination. These high control efficiencies

occurred because Texas did not ask for control efficiency information, and simply applied the maximum efficiency for the reported control device. High control efficiencies lead to high future growth in modeling scenarios based on uncontrolled emissions (which are based on the control efficiency and reported actual emissions). High control efficiencies also lead to extreme increases in emissions when rule effectiveness is incorporated.

Revised VOC control efficiencies were developed for Texas for the Emission Reduction and Cost Analysis Model for VOC (ERCAM-VOC)¹⁵. For this analysis, revised efficiencies were also developed by SCC and control device combination for NO_x, SO₂, and CO using engineering judgement. These revised control efficiencies were applied to sources in Texas. A large number of point sources outside of Texas had VOC and CO control efficiencies that were also judged to be too high. The VOC and CO control efficiencies used for Texas were also applied to these sources.

4.5.2.1.2 Rule Effectiveness Assumptions —

Controlled emissions for each inventory year were recalculated, assuming that reported VOC, NO_x, and CO controls were 80 percent effective. Sulfur dioxide and PM-10 controls were assumed to be 100 percent effective.

4.5.2.1.3 Emissions Calculations —

A three-step process was used to calculate emissions incorporating rule effectiveness. First, base year controlled emissions are projected to the inventory year using the following formula:

$$CE_i = CE_{BY} \times (1 + EG_i)$$

where: CE_i = controlled emissions for inventory year i
 CE_{BY} = controlled emissions for base year
 EG_i = earnings growth for inventory year i

Earnings growth (EG) is calculated as:

$$EG_i = \frac{DAT_i}{DAT_{BY}} - 1$$

where: DAT_i = earnings data for inventory year i
 DAT_{BY} = earnings data in the base year

Second, uncontrolled emissions in the inventory year are back-calculated from the controlled emissions based on the control efficiency with the following formula

$$UE_i = \frac{CE_i}{\left(1 + \frac{CEFF}{100}\right)}$$

where: UE_i = uncontrolled emissions for inventory year i
 CE_i = controlled emissions for inventory year i
 $CEFF$ = control efficiency (%)

Third, controlled emissions are recalculated incorporating rule effectiveness using the following formula:

$$CER_i = UC_i \times \left(1 + \left(\frac{REFF}{100}\right) \times \left(\frac{CEFF}{100}\right)\right)$$

where: CER_i = controlled emissions incorporating rule effectiveness
 UC_i = uncontrolled emissions
 $REFF$ = rule effectiveness (%)
 $CEFF$ = control efficiency (%)

4.5.2.2 Emissions, 1985 to 1991

As explained in section 4.5.2.1.3, the 1990 controlled emissions were projected from the 1985 NAPAP Emissions Inventory using equations 5 through 8. For all other years (1985 to 1989 & 1991) the emissions were projected from the 1990 emissions using equations 5 and 6. Therefore the 1985 emissions estimated by this method do not match the 1985 NAPAP Emissions Inventory due to the changes made in control efficiencies and emission factors and the addition of rule effectiveness when creating the 1990 base year inventory. For refueling sources the emissions were adjusted to account for the updated emission factors for all years as described in section 4.5.2.1.3.

The changes in the point source emissions were equated with the changes in historic earnings by state and industry. Emissions from each point source in the 1985 NAPAP Emissions Inventory were projected to the years 1985 through 1991 based on the growth in earnings by industry (2-digit SIC code). Historical earnings data from BEA's Table SA-5¹¹ were used to represent growth in earnings from 1985 through 1990. (Earnings data from a different BEA source, Table SQ-5 discussed below, were used to estimate 1991 emissions.) Table SA-5 historical annual earnings data are by state and industry.

The 1985 through 1990 earnings data in Table SA-5 are in nominal dollars. In order to be used to estimate growth, these values were converted to constant dollars to remove the effects of inflation. Earnings data for each year were converted to 1982 constant dollars using the implicit price deflator for personal consumption expenditures (PCE).¹² The PCE deflators used to convert each year's earnings data to 1982 dollars are:

<u>Year</u>	<u>1982 PCE Deflator</u>
1985	111.6
1987	114.3
1988	124.2
1989	129.6
1990	136.4

Several BEA categories did not contain a complete time series of data for the years 1985 through 1990. Because the SA-5 data must contain 1985 earnings and earnings for each inventory year (1985 through 1990) to be useful for estimating growth, a log linear regression equation was used to fill in missing data elements where possible. This regression procedure was performed on all categories that were missing at least one data point and which contained at least three data points in the time series.

Each record in the point source inventory was matched to the BEA earnings data based on the state and the 2-digit SIC. Table 4.5-3 shows the BEA earnings category used to project growth for each of the 2-digit SICs found in the 1985 NAPAP Emission Inventory. No growth in emissions was assumed for all point sources for which the matching BEA earnings data were not complete. Table 4.5-3 also shows the national average growth and earnings by industry from Table SA-5.

At the time the Emission Trends inventory was compiled, 1991 BEA earnings data were not available in Table SA-5. Earnings data from BEA Table SQ-5¹⁶ were used to estimate emissions for 1991. Table SQ-5 contains historical quarterly earnings data by state and 1-digit SIC. These data were converted to an annual constant dollars basis.

The 1991 quarterly earnings data were first summed to compute annual totals. Because the PCE deflator used to convert to constant 1982 dollars was not available for 1991, a 1987 PCE deflator¹⁶ was used to convert the 1990 and 1991 earnings data from Table SQ-5 to a 1987 constant dollar basis. The PCE deflators are as follows:

<u>Year</u>	<u>1987 PCE Deflator</u>
1990	114.5
1991	119.3

The 1991 inventory was then developed by growing the 1990 inventory based on the changes in State industry earnings (by 1-digit SIC) from 1990 to 1991. National average growth in earnings by industry is shown below in Table 4.5-4.

4.5.2.3 Emissions, 1992 and 1993

The 1992 and 1993 emissions for all pollutants were estimated by applying growth factors to the 1990 emissions using a modified version of equation 5. The growth factors were obtained from the prereleased

E-GAS, version 2.0.¹⁰ The E-GAS generates growth factors at the SCC-level for counties representative of all counties within each ozone nonattainment area classified as serious and above and for counties representative of all counties within both the attainment portions and the marginal and moderate nonattainment areas within each state. The appropriate growth factors were applied by county and SCC to the 1990 emissions as shown by equation 9.

$$Emissions_{(county, SCC, year)} = Growth_{(county, SCC, year)} \times Emissions_{(county, SCC, 1990)}$$

There are approximately 150 representative counties in E-GAS and 2000 SCCs present in the base year inventory. This yields a matrix of 300,000 growth factors generated to determine a single year's inventory. To list all combinations would be inappropriate.

4.5.3 References

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Table 4.5-1. National Material Balance for Solvent Emissions

Category	Description	Solvent Usage (1,000 tpy)	Percent Destroyed by Air Pollution Controls ¹	Percent Sent to TSDFs ²	Estimated Emissions (1,000 tpy)	Source
Surface Coating						
2401001	Architectural	503	0	0	503	SRI International/ National Paint and Coatings Institute
2401005	Auto refinishing	133	0	0	133	
2401008	Traffic markings	106	0	0	106	
2401015	Flat wood coating	5	16	21	3	
2401020	Wood furniture	221	16	21	139	
2401025	Metal furniture	70	16	21	44	
2401030	Paper coating	33	16	21	21	
2401040	Can coating	156	16	21	99	
2401045	Coil coating	58	16	21	37	
2401055	Electrical insulation	48	16	21	30	
2401060	Appliances	34	16	21	21	
2401065	Machinery	130	16	21	82	
2401070	Motor vehicles (new)	134	16	21	85	
2401075	Aircraft coating	11	16	21	7	
2401080	Marine paints	29	16	21	18	
2401085	Rail equip. coating	6	16	21	4	
2401090	Misc. manufacturing	210	16	21	132	
2401100	Industrial maintenance	99	0	21	78	
2401200	Aerosols, spec. purpose	173	0	21	137	
Vapor Degreasing (Conveyorized and Open-Top)						
2415105	Furniture	9	0	21	7	Total category number from Frost & Sullivan. Industry breakdowns from EPA BDAT Report for spent solvents.
2415110	Metallurgical proc.	29	0	21	23	
2415120	Fabricated metals	97	0	21	76	
2415125	Industrial machinery	100	0	21	79	
2415130	Electrical equipment	98	0	21	77	
2415135	Transportation equip.	36	0	21	28	
2415140	Instrument mfg.	48	0	21	38	
2415145	Misc. manufacturing	17	0	21	13	
Cold Cleaner Degreasing						
2415305	Furniture	12	0	21	9	Total category number from Frost & Sullivan. Industry breakdowns from EPA BDAT Report for spent solvents.
2415310	Metallurgical proc.	8	0	21	7	
2415320	Fabricated metals	38	0	21	30	
2415325	Industrial machinery	52	0	21	41	
2415330	Electrical equipment	16	0	21	12	
2415335	Transportation equip.	12	0	21	9	
2415340	Instruments	8	0	21	6	
2415345	Misc. manufacturing	19	0	21	15	
2415355	Automobile dealers	191	0	21	151	
2415360	Automobile repair	70	0	21	55	
2415365	Other	5	0	21	4	
Other Categories						

2420010	Drycleaning (perc.)	135	0	21	107	Frost & Sullivan
2420010	Drycleaning (petroleum)	134	0	21	105	Frost & Sullivan
2420020	Coin-op drycleaning	2	0	21	1	Frost & Sullivan
2425000	Graphic arts	276	16	21	174	Frost & Sullivan
2430000	Rubber/plastics	48	16	21	30	Frost & Sullivan
2440020	Adhesives - industrial	460	0	21	363	Freedonia Group
2461021	Cutback asphalt	200	0	0	200	Asphalt Institute
2461800	Pesticides - farm	260	0	0	260	Freedonia Group
2465100	Personal products	228	0	0	228	Frost & Sullivan
2465200	Household products	186	0	0	186	Frost & Sullivan
2465400	Automotive products	650	0	0	650	Freedonia Group
2465600	Adhesives - Comml.	350	0	0	350	Frost & Sullivan

¹Based on the 1985 NEDS methodology. Does not include solvents that are captured and recycled.

²Calculated based on the TSDf sector of the 1985 NAPAP Inventory.

Table 4.5-2. Data Bases Used for County Allocation

AMS Category	Description	Allocation Data (from the Census)
Surface Coating		
2401001	Architectural	Population
2401005	Auto refinishing	Employment in SIC 7532
2401008	Traffic markings	Population
2401015	Flat wood coating	Employment in SIC 2430
2401020	Wood furniture	Employment in SIC 25
2401025	Metal furniture	Employment in SIC 25
2401030	Paper coating	Employment in SIC 26
2401040	Can coating	Employment in SIC 341
2401045	Coil coating	Employment in SIC 344
2401055	Electrical insulation	Employment in SIC 36
2401060	Appliances	Employment in SIC 363
2401065	Machinery	Employment in SIC 35
2401070	Motor vehicles (new)	Employment in SIC 371
2401075	Aircraft coating	Employment in SIC 372
2401080	Marine paints	Employment in SIC 373
2401085	Rail equip. coating	Employment in SIC 374
2401090	Misc. manufacturing	Employment in SIC 20-39
2401100	Industrial maintenance	Employment in SIC 20-39
2401200	Aerosols, spec. purpose	Population
Vapor Degreasing (ConveyORIZED and Open-Top)		
2415105	Furniture	Employment in SIC 25
2415110	Metallurgical proc.	Employment in SIC 33
2415120	Fabricated metals	Employment in SIC 34
2415125	Industrial machinery	Employment in SIC 35
2415130	Electrical equipment	Employment in SIC 36
2415135	Transportation equip.	Employment in SIC 37
2415140	Instrument mfg.	Employment in SIC 38
2415145	Misc. manufacturing	Employment in SIC 39
Cold Cleaner Degreasing		
2415305	Furniture	Employment in SIC 25
2415310	Metallurgical proc.	Employment in SIC 33
2415320	Fabricated metals	Employment in SIC 34
2415325	Industrial machinery	Employment in SIC 35
2415330	Electrical equipment	Employment in SIC 36
2415335	Transportation equip.	Employment in SIC 37
2415340	Instruments	Employment in SIC 38
2415345	Misc. manufacturing	Employment in SIC 39
2415355	Automobile dealers	Employment in SIC 55
2415360	Automobile repair	Employment in SIC 75
2415365	Other	Employment in SIC 22
Other Categories		

2420010	Drycleaning (perc.)	Employment in SIC 7216
2420010	Drycleaning (petroleum)	Employment in SIC 7216
2420020	Coin-op drycleaning	Employment in SIC 7215
2425000	Graphic arts	Employment in SIC 27
2430000	Rubber/plastics	Employment in SIC 30
2440020	Adhesives - industrial	Employment in SIC 20-39
2461021	Cutback asphalt	Population
2461800	Pesticides - farm	Farm acres treated with sprays
2465100	Personal products	Population
2465200	Household products	Population
2465400	Automotive products	Population
2465600	Adhesives - Comml.	Population

Table 4.5-3. Bureau of Economic Analysis's SA-5 National Changes in Earnings by Industry

Industry	SIC	Percent Growth from:			
		1985 to 1987	1987 to 1988	1988 to 1989	1989 to 1990
Farm	01, 02	14.67	-2.73	14.58	-3.11
Agricultural services, forestry, fisheries, and other	07, 08, 09	23.58	5.43	1.01	2.48
Coal mining	11	-17.46	-6.37	-4.16	4.53
Metal mining	10	-3.03	18.01	8.94	4.56
Nonmetallic minerals, except fuels	14	2.33	3.74	-2.79	-0.45
Construction	15	7.27	4.81	-1.36	-3.80
Food and kindred products	20	1.67	1.34	-1.20	-0.24
Textile mill products	22	8.50	-0.64	-1.39	-4.97
Apparel and other textile products	23	-1.72	1.25	-1.62	-4.22
Paper and allied products	26	2.62	0.94	-0.14	-0.39
Printing and publishing	27	7.44	5.67	-0.81	0.43
Chemicals and allied products	28	1.75	6.94	0.32	1.61
Petroleum and coal products	29	-10.82	-3.22	-3.02	1.06
Tobacco manufactures	21	-1.97	2.43	-2.43	-5.01
Rubber and miscellaneous plastic products	30	5.27	5.51	0.68	-0.14
Leather and leather products	31	-9.39	-1.64	-3.58	-2.55
Lumber and wood products	24	10.03	5.15	-3.54	-3.71
Furniture and fixtures	25	6.82	2.35	-1.46	-2.98
Primary metal industries	33	-9.09	5.32	-0.34	-3.03
Fabricated metal products	34	-4.52	2.55	-0.86	-1.91
Machinery, except electrical	35	-5.72	6.02	-0.32	-1.92
Electric and electronic equipment	36	-3.17	-18.01	-1.91	-3.22
Transportation equipment, excluding motor vehicles	37	8.44	-1.57	0.55	-1.07
Motor vehicles and equipment	371	-6.45	2.20	-2.96	-5.43
Stone, clay, and glass products	32	-0.23	-1.61	-1.96	-3.19
Instruments and related products	38	-0.04	60.65	-0.82	-2.91
Miscellaneous manufacturing industries	39	1.84	6.92	-2.21	-2.54
Railroad transportation	40	-14.13	-2.53	-3.83	-6.03
Trucking and warehousing	42	5.63	3.26	-0.20	0.99
Water transportation	44	-8.92	0.07	-1.02	2.83
Local and interurban passenger transit	41	13.45	0.51	2.14	1.44
Transportation by air	45	12.01	4.63	4.94	4.36
Pipelines, except natural gas	46	-5.21	3.67	-4.93	3.53
Transportation services	47	15.92	8.52	4.60	4.97
Communication	48	1.94	0.68	-2.81	2.07
Electric, gas, and sanitary services	49	0.07	3.05	0.63	0.39

Table 4.5-4. BEA SQ-5 National Growth In Earnings By Industry

Industry	Percent Growth from 1990 to 1991
Farm	-18.38
Agricultural services, forestry, fisheries, and other	-5.06
Coal mining	-0.75
Construction	-10.37
Manufacturing	-3.01
Nondurable goods	-0.89
Durable goods	-4.30

4.6 HIGHWAY VEHICLES

Highway vehicle emissions were calculated using a consistent methodology for all years from 1970 through 1993. Emissions were calculated by month, county, road type, and vehicle type for each of these years. Emissions of VOC, NO_x, and CO were calculated using monthly state-level emission factors from MOBILE5a by vehicle type while PM-10 and SO₂ emissions were calculated using national annual emission factors by vehicle type. This section of the procedures document discusses the methodology used for calculating highway vehicle emissions.

The activity factor that is used to estimate highway vehicle emissions is vehicle miles traveled (VMT). The first section of this chapter discusses the development of the VMT database. The next section of this chapter discusses the development of the inputs used for the MOBILE5a modeling. Estimation of the PM-10 and SO₂ emission factors are discussed next. Finally, the emission calculation procedure is discussed.

4.6.1 VMT

Using state totals for each year, VMT were allocated by county, roadway type, and vehicle type for each year between 1970 and 1993. Each state and county combination in the output files has 96 assigned SCCs representing the 6 rural and 6 urban roadway types, and 8 vehicles types. The methodology used for calculation VMT from (1) 1980 to 1992 differs from the methodology used for calculation mileage totals from (2) 1970 to 1979 and for (3) 1993. Each of the three approaches is described separately below.

4.6.1.1 Background on Highway Performance Monitoring System

The following sections describe the information contained with in Highway Performance Monitoring System (HPMS) and the problems with using this information.

4.6.1.1.1 Description of HPMS —

Highway Performance Monitoring System (HPMS)¹ is a national data collection and reporting system administered by the U.S. Department of Transportation (DOT), Federal Highway Administration (FHWA) in cooperation with state highway programs. The HPMS contains data on the mileage, extent, and usage of the various functional road systems, the condition and performance of pavements, physical attributes of roads, road capacity and improvement needs, and other data important to the structural integrity and operation of the nation's road systems. The data that make up HPMS are submitted to FHWA annually by each state highway program.

The HPMS has three main data components: (1) the universe data base, (2) the sample data base (a subset of the universe data base), and (3) the areawide data base. The universe data base contains a complete inventory of all mileage for all functional systems, except local roads. The sample data base contains more detailed information for a subset of the highway sections in the universe data base. Each record in the sample data base is part of a sample panel which can be expanded to represent the universe of highway mileage. The areawide data base contains annual state-level summaries of the major components of HPMS. Most of the

state-level data in the areawide data base are divided into rural, small urban, and individualized urban area components. Table 4.6-1 illustrates the main data components of HPMS and the type of data they contain.

The travel data in HPMS are of great interest in estimating VMT. HPMS travel data are based on samples of daily traffic counts taken at various points in a state's roadway network. These daily traffic counts are expanded to annual average daily traffic (AADT). To calculate VMT for a specific section of road, the AADT for that section of road is multiplied by the road length².

4.6.1.1.2 Problems with Using HPMS to Estimate VMT —

There are several complexities associated with using HPMS data to estimate VMT for this inventory. The county is the basic geographic unit in the 1990 Emission Trends inventory, while all data in HPMS are divided into rural, small urban, and individualized urban geographic areas. In order to use the HPMS data, a mechanism to distribute VMT from a rural, small urban, and individual urban area level to a county level had to be developed. In addition, the level of detail of reporting in the sample data base (the most detailed data base which contained VMT information) varied from state to state. Some states reported data for each individual urban area, some states reported data for all individual urban areas together, and some states reported data separately for some individual urban areas and reported data for the remaining individual urban areas together. This made distributing VMT from the sample data base to counties a difficult task. In the areawide data base, however, all states reported data for individual urban areas separately. Finally, travel data for local road systems were only contained in the areawide data base. Given the problems described above and the limited timeframe of the project, the areawide data base was used to generate county-level VMT estimates. The methodology used to generate county-level VMT estimates is described below.

4.6.1.2 Distribution of HPMS VMT, 1980 to 1992

The FHWA supplied the latest mileage and daily travel summary areawide records that were reported for the HPMS for the period 1980 through 1992. The HPMS files contain state-level summaries of miles of daily travel by functional system and by rural, small urban (population of 5,000 to 49,999), and individual urbanized (population of 50,000 and more) areas. Rural DVMT is provided on a state level for the following six roadway types: Principal arterial-interstate, other principal arterial, minor arterial, major collector, minor collector, and local. Small urban and urban area DVMT are provided for the following six roadway types: principal; arterial - interstate, principal arterial - other freeways and expressways, other principal arterial, minor arterial, collector, and local.

VMT from the HPMS areawide data base was distributed to counties based on each county's rural, small urban, and urbanized area population. Two tables in the Bureau of the Census 1980 Number of Inhabitants (CNOI) documents³ were used as the source for population data. The 1980 population data had to be used to allocate the VMT because the Census Urbanized Area boundaries were changed for the 1990 census. Although not exactly the same, the large urban area boundaries used in HPMS are based on the 1980 Census Urbanized Area boundaries. Use of the 1990 Census Urbanized Area boundaries would prevent a one-to-one match between HPMS large, urban-area VMT and urbanized area population, making VMT distribution difficult.

The two CNOI tables used to distribute VMT to counties are:

Table 3: Population of Counties by Urban and Rural Residence. This table lists the urban population living inside census-defined urbanized areas, the urban population living outside census-defined urbanized areas, and the rural population for each county.

Table 13: Population of Urban Areas. This table divides an urbanized area's population among the counties that contain portions of that urbanized area.

County-level rural VMT, small urban VMT, and urbanized area VMT were calculated separately using the following methodology. The methodology described below was performed for each functional road system.

4.6.1.2.1 Rural VMT —

- step 1. The percentage of the state's rural population in each county was calculated using county rural population data from CNOI Table 3.
- step 2. Each county's rural VMT was calculated by distributing state rural VMT from the HPMS areawide data base, based on the percentage of the state's rural population in each county using the following equation:

$$VMT_{R,C} = VMT_{R,S} \times \frac{POP_{R,C}}{POP_{R,S}}$$

where: $VMT_{R,C}$ = rural VMT in county C (calculated)
 $VMT_{R,S}$ = rural VMT, state total (HPMS)
 $POP_{R,C}$ = rural population in county C (CNOI)
 $POP_{R,S}$ = rural population, state total (CNOI)

4.6.1.2.2 Small Urban VMT —

- step 1. The percentage of the state's small urban population in each county was calculated using county urban population living outside census-defined urbanized areas from CNOI Table 3.
- step 2. Each county's small urban VMT was calculated by distributing state small urban VMT from the HPMS areawide data base based on the percentage of the state's small urban population in each county using the following equation:

$$VMT_{SU,C} = VMT_{SU,S} \times \frac{POP_{SU,C}}{POP_{SU,S}}$$

where: $VMT_{SU,C}$ = Small urban VMT in county C (calculated)
 $VMT_{SU,S}$ = Small urban VMT, state total (HPMS)
 $POP_{SU,C}$ = Small urban population in county C (CNOI)
 $POP_{SU,S}$ = small urban population, state total (CNOI)

The approach for allocation HPMS DVMT reported for individual urban area was slightly different than the approach used to allocate rural and small urban DVMT. Each urbanized area in the HPMS file is assigned a unique 3-digit code. In order to allocate DVMT totals by road type for each individual urbanize area, an urban area population file was used which provides a linkage between a given urban area code, and the corresponding population in each component county. The percentage of urban DVMT totals to obtain a total urban DVMT by roadway category for each county. Because the boundaries of urbanized and small urban areas changed from year to year, there were urban areas in the HPMS input files for which the population for component counties was not available. In these cases, the VMT for this urban area was added to the HPMS small urban VMT total by road category and allocated by small urban population ratios.

4.6.1.2.3 Urban Area VMT —

- step 1. For each urbanized area, the percentage of its population in each county containing a portion of the urbanized area using data from CNOI Table 13.
- step 2. Each county's share of an urban area's VMT was calculated by distributing urban area VMT from the HPMS areawide data base based on the percentage of the urban area's population in each county using the following equation:

$$VMT_{UA,C} = VMT_{UA,S} \times \frac{POP_{UA,C}}{POP_{UA,S}}$$

where: $VMT_{UA,C}$ = Urban area's VMT in county C (calculated)
 $VMT_{UA,S}$ = Urban area's VMT, state total (HPMS)
 $POP_{UA,C}$ = Urban area's population in county C (CNOI)
 $POP_{UA,S}$ = Urban area's population, state total (CNOI)

In a few cases, a single county contained parts of more than one urban area. For those counties, urban VMT was calculated as the sum of the county's proportion of VMT from each of the large urban areas in the county and the county's small urban VMT.

The next step in calculation was to allocate the DVMT totals in twelve rural and urban roadway categories among the 8 vehicle type categories. For each year between 1980 and 1992, a percentage distribution was calculated for each vehicle type for both the rural and urban classifications. The first step in the development of this percentage distribution was to obtain the most recent VMT totals by vehicle type and by year from FHWA's Highway Statistics.⁴ Rural and urban VMT in this publication are provided for the following vehicles types: Passenger cars, motorcycles, buses, 2-axle/4-tire single-unit trucks, other single-unit trucks, and combination trucks. (In the years prior to 1990, a VMT breakdown between passenger cars and motorcycles was not provided. A total VMT for Personal Passenger Vehicles is provided. It was assumed that the division between passenger car VMT and motor cycle VMT is the same in earlier years as was reported for 1990.) For each of the 6 vehicle type categories for which VMT is reported in Highway Statistics, a percentage of the total was calculated for both rural and urban VMT. In order to convert these percentages for the 6 HPMS categories to the 8 MOBILE5a vehicle type categories, a breakdown provided by EPA was used which reconciles the vehicle class categories used in the HPMS to those used in EPA's MOBILE model⁵. This method of conversion from HPMS categories to MOBILE5a categories is based on a matching scheme that allows states to apportion VMT as it is reported in HPMS categories to the 8 MOBILE model vehicles class categories. The apportionment percentages supplied by EPA are shown in Table 4.6-2.

After allocating HPMS DVMT totals by county, roadway category, and vehicle type, the values were converted to millions of annual VMT. Quality assurance was performed on the output files for each of the years by comparing state totals to the HPMS data provided by state. It is important to note that for certain years, slight discrepancies exist between the HPMS totals and the totals reported in Highway statistics.

4.6.1.3 Distribution of VMT, 1970 to 1979 and 1993

The methodology for allocating VMT totals for 1970 through 1979 was based on state totals which were published in FHWA's Highway Statistics 1985. For each year, state totals were allocated by county, roadway type, and vehicle type using a ration from the 1980 VMT file for each state/county/SCC combination expressed as a percentage of the 1980 state total. Quality assurance was performed by comparing statewide totals for each year's output to the FHWA's state totals.

The input for the 1993 VMT files were rural and urban VMT totals by state which were obtained from FHWA.⁶ The allocation of 1993 VMT by county, roadway category, and vehicle type was accomplished using the 1992 output file. To allocate rural VMT by county, the population file used to allocate rural VMT for the years 1980 to 1992 was used. For urban VMT, the two population files used for earlier years which contained small urban and urban population were combined into one files. After allocating the rural VMT and urban VMT by county, percentages by each of the 12 roadway types were calculated using 1992 output. Lastly, 1993 VMT was divided among the 8 vehicles types using the same vehicles distribution that was used in the allocation of the 1992 VMT.

The resulting annual county-level vehicle and roadway type specific VMT data were temporally allocated to months. Seasonal 1985 NAPAP temporal allocation factors⁷ were used to apportion the VMT to the four seasons. Monthly VMT data were obtained using a ratio between the number of days in a month and the number of days in the corresponding season.

4.6.2 Development of VOC, NO_x, and CO Emission Factors

EPA's MOBILE5a mobile source emission factor model was used to calculate all emission factors.¹⁹ The March 26, 1993, version of MOBILE5a was used for this inventory. The pollutants modeled were exhaust VOC, evaporative VOC (which includes resting loss, running loss, and evaporative emissions), exhaust NO_x, and exhaust CO. VOC emissions include aldehydes and hydrocarbons measured by Flame Ionization Detector (FID) testing.

4.6.2.1 Temperature

The temperature data used for Emission Trends inventory included an average daily maximum and minimum temperature for each state for each month for each year from 1970 to 1993. The data were obtained on diskette from the National Climatic Data Center.⁹ A single city was selected from each state to represent the state's temperature conditions. The cities were selected to be the most representative of the average conditions within the state, generally either centrally located cities or in states with a majority of VMT clustered in one area, the most populous cities. Because of the great variations of temperature and the wide distribution of VMT throughout California, EPA suggested that California should be broken into two geographic regions, with Los Angeles representing the southern and interior portions of the state and San Francisco representing the northern coastal region of the state. It was also suggested that Texas be broken into two regions, with Houston representing the coastal and southern portions of the state and Dallas representing the interior and northern portions of the state. After investigating the differences in the actual temperature data for these two cities, however, it was determined that there was not enough variation in the temperatures for these two cities to warrant dividing the state into two regions. Table 4.6-3 shows the cities that were used to represent each state's temperature conditions. As noted in Table 4.6-3, data were missing for some years for some states. In these cases, 30-year average monthly maximum and minimum temperature values were used from Statistical Abstracts.¹⁰ The allowable temperature range for input to MOBILE5a is 0°F to 100°F for the minimum daily temperatures and 10°F to 110°F for the maximum daily temperatures. In the few cases where the temperatures fell outside of these ranges, the endpoint of the range was substituted for the actual temperatures.

4.6.2.2 RVP

This section describes the methodology used to apportion Reid vapor pressure (RVP) values to each state by month. The steps involved in making these calculations were as follows: (1) assigning a January and July RVP to each state, and (2) estimating the RVP for the other months for each state.

4.6.2.2.1 Apportioning RVP Data to Each State —

The first step in the process of determining monthly RVP values for each state was to assign a weighted January and July RVP for each year to every state. EPA's Office of Mobile Sources (OMS) provided spreadsheets of historic RVP data that included the average January and July RVP values weighted by the market share of each type of gasoline (regular unleaded, intermediate unleaded, premium unleaded, etc.) from each of the 23 cities included in the American Automobile Manufacturer's Association (AAMA) fuel surveys.¹¹ These data were provided for each year from 1970 through 1993. Using these data, January and July RVP values were assigned to each state for each year. This was done using a listing, provided by OMS, matching

each nonattainment area throughout the United States which with the corresponding AAMA survey city whose RVP should be used to represent that nonattainment area. These assignments were based on pipeline distribution maps. The corresponding January and July weighted RVP values were then assigned to each of these nonattainment areas. The January or July RVP values for a given year for all nonattainment areas within a state were then averaged to estimate a single statewide January or July RVP value. Several states had no nonattainment areas and therefore were not included in the OMS cross reference listing. Survey cities were assigned to these states based on a combination of location and pipeline maps. These assignments were as follows:

State	Survey City
Idaho	Billings, MT and Seattle, WA
Iowa	Minneapolis, MN
Nebraska	Kansas City, MO and Minneapolis, MN
North Dakota	Minneapolis, MN
South Dakota	Minneapolis, MN
Wyoming	Billings, MT and Denver, CO

For states where two survey cities are listed, the average of the RVP values for the two survey cities was used. Alaska and Hawaii were not matched with survey cities but were assigned winter and summer RVP values based on guidance from OMS. Alaska was assigned a winter RVP value of 14.5 psi and a summer RVP value of 12.5 psi while Hawaii was assigned a winter RVP value of 10.0 psi and a summer RVP value of 9.5 psi. These assignments applied for each year from 1970 through 1993.

4.6.2.2.2 Estimating Monthly RVP for Each State —

The next step was to estimate statewide RVP values for the remaining months based on the January and July RVP values. The American Society for Testing and Materials (ASTM) schedule of seasonal and geographical volatility classes was used as the basis for the RVP allocation by month.¹² This schedule assigns one or two volatility classes to each state for each month of the year. Volatility classes are designated by a letter (A through E), with A being the least volatile. Several states are divided into two or more regions, with each region having its own set of volatility class guidelines. The *MOBILE4 User's Guide*¹³ provides guidance on which ASTM class to assign to each state for each month when more than one region is included for a state, or when two ASTM classes are listed for a given state in a given month. This guidance was followed here to select a single ASTM class for each state and month. The *MOBILE4 User's Guide* also lists RVP limits that correspond to each ASTM class (EPA, 1989). These RVP limits are as follows:

c	ASTM class A	=	9.0	psi
c	ASTM class B	=	10.0	psi
c	ASTM class C	=	11.5	psi
c	ASTM class D	=	13.5	psi
c	ASTM class E	=	15.0	psi

The January ASTM class designation was assigned to the January RVP value calculated for each state (as determined in step 2 above) and the July ASTM class designation was assigned to the July RVP value calculated for each state. Other months with the same ASTM class designation as either January or July were assigned the January or July RVP value for that state. The RVP values for months with intermediate ASTM class designations were calculated by interpolation using the January and July RVP values and the ASTM class RVP limits. The equation used for this interpolation is shown below.

$$IM = [(IA - SA) \times (WM - SM) / (WA - SA)] \% SM$$

where: IM = Intermediate month's (not January or July) RVP value
 WM = Winter (January) RVP value
 SM = Summer (July) RVP value
 IA = Intermediate month's (non-January or July) ASTM RVP limit
 WA = Winter (January) ASTM RVP limit
 SA = Summer (July) ASTM RVP limit

Calculations were made for each intermediate month for each state. Starting in 1989, summer RVP values were limited by EPA's Phase I RVP limits and in 1992 by the Phase II RVP limits. After the May through September RVP values were calculated for each state using the procedure above, the values were replaced by the state-specific monthly Phase I (for 1989 to 1991) or the Phase II (for 1992 and 1993) limit if the corresponding limit was lower than the calculated monthly RVP value.

4.6.2.3 Speed

Nine speeds were modeled for each state. The nine speeds used in the model were derived from the average overall speed output from the HPMS impact analysis. Average overall speed data were obtained for the years 1987 through 1990.¹ The average overall speed for each vehicle type varied less than one mile per hour (MPH) over the 4-year span. Therefore, the same speeds (from 1990) were used for all years from 1970 to 1993. Table 4.6-4 lists the average overall speed output for 1990 from the HPMS impact analysis. To determine the actual speeds to use in modeling the emission factors, HPMS vehicle types were chosen to represent the speeds for each AMS vehicle type:

- c passenger cars — used for LDVs and motorcycles (speeds for small and large cars were the same)
- c pickup trucks and vans — used for LDTs
- c multi-trailer trucks with five or more axles — used for HDVs

To reduce the number of speeds to be modeled, the HPMS speeds were rounded to the nearest 5 miles per hour. Local speeds, which were not included in the HPMS impact analysis output, were assumed to be the same as minor collector speeds for rural roads and collector speeds for urban roads. Table 4.6-5 lists the average speed used for each road type/vehicle type combination.

4.6.2.4 Operating Mode

All MOBILE5a runs at all speeds were made using the operating mode assumptions of the Federal Test Procedure (FTP). With the FTP, 20.6 percent of all VMT is accumulated in the cold start mode (or Bag 1 of the FTP), 27.3 percent of all VMT is accumulated in the hot start mode (or Bag 3 of the FTP), and 52.1 percent of all VMT is accumulated in the hot stabilized mode (or Bag 2 of the FTP).

4.6.2.5 Altitude

The entire states of Colorado, Nevada, New Mexico, and Utah were modeled as high altitude areas. All other states were modeled as low altitude areas.

4.6.2.6 Registration Distribution/Month

A national registration distribution was included in all of the MOBILE5a input files. These registration distributions varied by calendar year and show the fraction of vehicles registered in the given calendar year by model year. Separate registration distributions are developed for each vehicle type (with a single registration distribution for light duty gasoline and diesel vehicles and a single registration distribution for light duty gasoline trucks I and light duty diesel trucks). Registration distributions developed under earlier Emission Trends work assignments were used for calendar years 1970 through 1990. New registration distributions were developed under this assignment for 1991, 1992, and 1993.

The main difference between the 1991 registration distribution and those of previous years is the expansion from a 20-year distribution to a 25-year distribution. In addition to the development of the 1991 distribution, data used in the development of the 1990 registration distribution were updated with more current vehicle sales figures. All registration distributions for the years 1980 through 1990 were also expanded to a 25-year range.

The specific procedures used in each of the steps outlined above are discussed in detail in the following sections. In some cases, the methods used for this version of Emission Trends inventory correspond to procedures used in previous years, while in other cases, improvements have been made to the estimation procedure. Both old and new methods are documented below.

Vehicle registration distributions for 1991, 1992, and 1993 were developed using a dBase computer program. (This program was developed to perform the computations that had been done for earlier Emission Trends inventory in a spreadsheet model.) This registration distribution program estimates the distribution of vehicles operating by model year in 1991, 1992, and 1993 for each of the eight MOBILE vehicle types. For automobiles, the registration distribution is based on the number of cars in operation by model year as reported in AAMA's *Facts and Figures 1993*¹¹ and sales data from Automotive News' *Market Data Book 1993*¹⁴. For each of the five MOBILE truck classes, the distribution is based on sales figures from AAMA and Automotive News, as well as the number of trucks in operation by model year from AAMA. For motorcycles, the registration distribution for these three years did not change from previous years; this distribution was taken from the default distribution from the previous Emission Trends procedures manual, which covered a 12-

model-year range. The specific procedure used to calculate the registration distribution for automobiles and trucks is discussed below.

4.6.2.6.1 Automobiles —

AAMA's *Facts and Figures 1993* lists the number of cars in operation by model year. The most recent calendar year for which data are available from this source is 1992. The number of cars in operation in 1992 for each model year from 1977 through 1992 was used as a preliminary estimate of the number of cars from these model years operating in 1992 (These will be updated in the next version of Emission Trends inventory by AAMA's actual estimates for the 1993 calendar year).

The earliest model year for which data were given on the number of cars operating in 1992 was the 1977 model year. The figure given for the number of model year 1977 cars operating in 1992 is actually an aggregate figure of the number of cars from 1977 and all earlier model years still operating in 1992. A methodology was developed to distribute the cars operating from model year 1977 and earlier years over the remaining nine years required for developing a 25-year registration distribution. In order to do this, a formula was derived using automobile survival rates to project estimates of operation for these older cars by model year to 1993.¹⁵ Based on AAMA data for previous years, the number of cars from each model year from 1969 through 1977 still in operation in 1993 was estimated using the following formula:

$$\text{Model Year}_N \text{ Cars in Operation in Year}_{1993} = A \times \frac{C}{B}$$

where: A = AAMA number of Model Year_N Cars Operating in Year_Y
 B = Survival rate for age_{Y - N}
 C = Survival rate for age_{1993 - N}
 Year = Last calendar year for which an estimate is available for this particular model year (as of July 1)
 N = Most current model year for which 'Number of Automobiles in Operation' are available

AAMA's estimate of model year 1992 automobiles operating in 1992 appeared to be low in comparison to historical data. Therefore, a rate of change was calculated for automobile sales from the years 1991 to 1992 (*Automotive News*, 1993). The rate was then multiplied by AAMA's estimate of model year 1991 cars in operation in 1992. To develop an estimate of the number of 1993 model year cars operating in 1993, the number of 1992 registrations of model year 1992 automobiles was multiplied by 0.75, since by July 1, three-quarters of the car model year had passed (new model year automobiles are generally released in October).

Using this complete set of automobile registrations by model year for the 25-year period from 1969 to 1993, the registration distribution was calculated by dividing the number of cars in operation by model year by the total number of cars operating over the 25-year period. This process was repeated to develop a registration distribution for 1991 and 1992. The only difference for these years is that the number of cars in

operation in the most recent model year was available from AAMA for these previous years and therefore, no projections of the number of cars in operation were made for the latest model year.

4.6.2.6.2 Trucks —

For each truck type, the 1993 registration distribution was calculated with truck sales figures by type and model year, which were weighted by the distribution of truck registrations (the total over all truck types) from AAMA's *Facts and Figures 1993*. The basic methodology for calculating this distribution is outlined here and closely follows that used in previous years (with a few modifications).

The first step was to determine 1993 truck sales by MOBILE truck category. (Sales figures for years prior to 1992 were not changed from those used in calculating previous years' registration distributions.) AAMA and Automotive News were the sources of sales data.^{11,14} Because AAMA's truck categories do not exactly correspond to the categories used in MOBILE, the previous version of the Emission Trends procedures manual outlined a method for allocating sales from AAMA's weight class categories to the MOBILE truck categories. The formulas used for the 1991, 1992, and 1993 distribution are as follows:

$$LDGT1 = \text{Retail Sales (domestic \% import)}_{(0\&6,000\text{lbs})} \& \text{Diesel Factory Sales}_{(0\&6,000\text{lbs})}$$

$$LDGT2 = \left(\begin{array}{l} \text{Retail} \\ \text{Sales} \end{array} \& \text{VCC} \& \text{M} \& (0.05 \times \text{CP}) \& \begin{array}{l} \text{Diesel} \\ \text{Factory} \\ \text{Sales} \end{array} \right)_{(6,000\&10,000\text{lbs})}$$

where: VCC = Retail sales of van cutaway chassis
M = Retail sales of multi-stops
CP = Retail sales of conventional pickups

$$HDGT = \left(\text{VCC} \% \text{M} \% (0.05 \times \text{CP})_{(6,000\&10,000\text{lbs})} \right) \& \left(\begin{array}{l} \text{Heavy \& Duty} \\ \text{Diesel Trucks} \end{array} \right) \% \left(\begin{array}{l} \text{Retail} \\ \text{Sales} \end{array} \right)_{(>10,000\text{ lbs})}$$

$$LDDT = \text{Diesel Factory Sales}_{(0\&6,000\text{lbs})} \% (0.10 \times \text{Diesel Factory Sales})_{(6,000\&10,000\text{lbs})}$$

$$HDDT = 0.9 \times \left[\text{Diesel Factory Sales}_{(6,000\&10,000\text{ lbs})} \right] \% \left[\text{Diesel Factory Sales}_{(>10\text{Klbs})} \right]$$

Since the most current year for which data were available was 1992, the formulas above were used to determine 1992 truck sales; 1993 sales were then based on 1992 estimates. However, because the 1992 sales calculated with the formulas above seemed unusually low, the ratio of 1991 truck sales to 1992 truck sales¹⁴ was multiplied by AAMA's 1991 sales¹¹ to obtain comparable figures for 1992 sales. Sales for 1993 were then estimated by using 50 percent of the 1992 figures for each of the truck categories. (The truck model year is assumed to start in January, so half of the model year trucks would be sold by July 1.)

Once AAMA sales data for 1992 and 1993 were converted into MOBILE categories, a distribution of truck registrations by model year was needed to determine the percentage of trucks operating for each model year as of July 1, 1993.

The AAMA list of trucks in operation by model year covered a range of 17 model years (the last year representing an aggregate figure of all previous years). The total number of trucks in operation was distributed over the remaining eight years in a method consistent with that described for automobiles. Again, 1993 registrations were estimated based on those in 1992, although in the case of trucks, 1992 registrations were multiplied by 50 percent, rather than 75 percent, since half of the truck model year had passed as of July 1. The total number of trucks operating in 1991 reported by AAMA¹¹ was multiplied by the rate of change in registrations from 1991 to 1992.¹⁴

Because registration data are not available for each of the five MOBILE truck categories, a method was developed and used in past years of the Emission Trends procedures document to estimate the number of trucks operating by MOBILE category. Following this procedure, the 1993 sales figure for each truck type was multiplied by the ratio of the total number of trucks operating from each model year to the total number of truck sales (comparable to AAMA's data on cars in operation from the previous section). For example, the formula used to calculate Model Year_N LDGTs operating in 1993 is as follows:

$$\frac{\text{Model Year}_N \text{LDGTs Operating in 1993}}{\text{Model Year}_N \text{LGTs Sold in 1993}} \times \frac{\text{Total Model Year}_N \text{Trucks Operating in 1993}}{\text{Total Trucks Sold in 1993}}$$

This formula was applied to all five truck types for model years 1969 through 1993. To estimate the registration distribution for each truck type, the number of trucks operating per model year, as estimated above, was divided by the total of all trucks operating for that particular truck category.

The sales and registration data used in the development of registration distribution data for 1991 was updated to be comparable to the 1993 data. To estimate 1991 sales in a manner similar to the estimation procedure used in estimating 1992 sales, AAMA's 1988 sales were multiplied by the ratio of sales of automobiles and trucks for 1990 to 1991.¹⁶ These estimates of 1991 sales were then used to derive 1992 sales by multiplying the 1991 car sales figure by 75 percent and the 1991 truck sales figure by 50 percent. The methodology used in the 1993 distribution is exactly the same procedure used for 1992.

Registration distributions input to MOBILE5a should be expressed as a July 1 registration distribution. Internally, the model can then adjust this registration distribution to represent either a January 1 or a July 1 registration distribution, depending on the user selected setting of the month flag. When modeling months from January through June, the month flag within the MOBILE5a input files was set to "1" to simulate January registration distributions. For months from July through December, the flag was set to "2" to model July registration distribution.

4.6.2.7 I/M Programs

For states that had an inspection and maintenance (I/M) program in place in one or more counties in the year being modeled, at least one additional MOBILE5a input file was created that modeled the characteristics of the I/M program in that state. All other inputs (such as temperature, RVP, speeds, etc.) were identical to the no I/M input file modeled for the state in the year being analyzed. The determination of whether or not a county had an I/M program in place in a given year was based on a series of I/M program summaries released by OMS. Emission factors calculated with I/M benefits in a given inventory year were applied only to counties having an I/M program in place in December of the prior year. I/M program characteristics were also included in the I/M program summaries. These program characteristics vary by state and in some cases by nonattainment area or county within a particular state. The effectiveness statistics used as MOBILE5 inputs varied by state based on the characteristics of representative I/M programs in that state. For states where I/M programs varied within a given state, a single set of effectiveness statistics, based on a combination of characteristics of all the I/M programs within the state, was used as an I/M input to the model. In some cases, the characteristics of the different programs within a specific state could not be adequately modeled using some average of the I/M program characteristics. In these cases, multiple I/M programs were modeled for these states, with the appropriate I/M programs applied to the corresponding counties.

4.6.2.8 Oxygenated Fuels

The oxygenated fuel requirements of the 1990 Clean Air Act Amendments (CAAA) took effect beginning in late 1992. Therefore, oxygenated fuel was modeled in the areas indicated by OMS, using the oxygenated fuel flag and the oxygenated fuel market share and oxygen content inputs in MOBILE5a. OMS provided a listing of areas participating in the oxygenated fuel program, the months that each area used oxygenated fuel, and market share data indicating the percentage of ether blends versus alcohol blends in each oxygenated fuel area. The average oxygen content of ether blend fuels for all areas, except California, was assumed to be 2.7 percent while alcohol blend fuels were assumed to have an oxygen content of 3.5 percent. For California, the oxygen content of both ether blends and alcohol blends was modeled as 2 percent, based on documentation from OMS on how to model reformulated and oxygenated fuels in the CALI5 model.

4.6.2.9 California

California's highway vehicle fleet has been subject to different emission standards than the rest of the country. To account for these differences in basic emission rates, an EPA-modified version of MOBILE5a was used for California. This model is referred to as CALI5. Input files used with this model are essentially identical to MOBILE5a input files. The model internally handles the different emission standards.

Temperature, RVP, speed, registration distribution, and operating mode inputs were developed for California in the same manner as they were for the rest of the nation. The primary difference in inputs is the earlier start date (1992) of the reformulated gasoline program in California. Using CALI5, this was modeled in the summer months for 1992 and 1993 by setting the reformulated gasoline flag to "4" and the RVP to 7.8 psi. As mentioned above, California was also divided into two regions to account for the differences in climate throughout the state.

4.6.3 Development of PM-10 and SO₂ Emission Factors

Emission factors for PM-10 and SO₂ can not be calculated with MOBILE5a. The PART5 model can be used to calculate these emission factors, but was not released in time to be used for the 1994 Emission Trends report. Therefore, PM-10 and SO₂ emission factors using data from AP-42 and other applicable EPA documents. Emission factors for both of these pollutants were developed on a national basis by vehicle type for each year. The procedure followed for developing these emission factors is discussed below.

4.6.3.1 PM-10 Emission Factors

Highway vehicle PM-10 emission factors were calculated using the methodology to develop the Regional Particulate Inventory for 1990.¹⁷ National annual 1990 PM-10 emission factors were calculated for this inventory by vehicle type. Gasoline PM-10 exhaust emission factors were based on exhaust particulate emission factors specific to the technology type of the vehicle (i.e., catalyst vs. no catalyst) and model year group.¹⁸ These basic exhaust emission factors were then applied within a spreadsheet to the corresponding portion of the vehicle fleet for each model year from age 1 to 25 comprising the 1990 fleet. Model year specific data indicating the fraction of vehicles with catalysts were obtained from the MOBILE5a source code.¹⁹ After obtaining the model year weighted emission factor for each of the gasoline vehicle types, the model year specific emission factors were then weighted by the model year travel fraction, obtained using the by-model-year option in MOBILE5a that lists VMT fractions for each model year for the calendar year specified. These model year-weighted emission factors were then summed to obtain the fleet average exhaust particulate emission factor for each of the gasoline vehicle types. These particulate emission factors were then multiplied by the PM-10 particle size multiplier from AP-42. The PM-10 emission factors calculated for LDGVs were also applied to motorcycles.

The same procedure was applied to obtain 1970 and 1984 PM-10 exhaust emission factors for gasoline-fueled vehicles. PM-10 exhaust emission factors for the intermediate years and the years out to 1993 were calculated by straight line interpolation. Total PM-10 emission factors were then calculated by adding the brake and tire wear PM-10 emission factors from AP-42 (which do not vary by year).

PM-10 emission factors from diesel vehicles were calculated using a similar methodology, but using data by model year and vehicle type for diesel particulate emission factors and diesel travel fractions.⁸ Again, the particulate emission factors were multiplied by the AP-42 particle size multipliers to obtain PM-10 exhaust emission factors, and PM-10 brake and tire wear emission factors were added to the exhaust emission factors.

The PM-10 emission factors by vehicle type and year used in Emission Trends inventory are shown in Table 4.6-6. These emission factors include the exhaust, brake, and tire wear components of PM-10.

4.6.3.2 SO₂ Emission Factors

The following equation was used to calculate the highway vehicle SO₂ emission factors by vehicle type:

$$SO_2EF_{x,y} = SULFCONT_{y,z} \times 0.98 \times FUELDENS_z \times 453.59 \times \frac{2}{FUELECON_{x,y}}$$

where: $SO_2EF_{x,y}$ = SO₂ emission factor for vehicle type x in year y (grams per mile)
 $SULFCONT_{y,z}$ = Sulfur content in year y for fuel type z (fractional value)
 $FUELDENS_z$ = Fuel density of fuel type z (pounds per gallon)
 $FUELECON_{x,y}$ = Fuel economy for vehicle type x in year y (miles per gallon)

The factor of 0.98 in the above equation represents the fraction of sulfur in the fuel that is converted to SO₂²⁰ while the 2 represents the weight molecular ratio of sulfur to SO₂. The remaining term (453.59) is the conversion from pounds to grams.

The value used for sulfur content of the fuel depends only on whether is gasoline-fueled or diesel-fueled. A fuel sulfur content of 0.000339 was used for gasoline-fueled vehicles based on the fuel sulfur content of EPA baseline fuel while a fuel sulfur content of 0.002²¹ was used for diesel-fueled vehicles through September 1993. Beginning on October 1, 1993, a fuel sulfur content of 0.0005 was used for diesel-fueled vehicles, in accordance with the sulfur content requirements for diesel fuel as specified in the CAAA. Fuel density values of 6.17 pounds per gallon for gasoline and 7.05 pounds per gallon for diesel were used in all years (AP-42).

Fleet average fuel economy varies slightly from year to year for each vehicle type. The values used for fuel economy from 1982 to 1993 were obtained from output from the draft MOBILE4.1 Fuel Consumption Model²² for all vehicle types except motorcycles. 1982 was the earliest model year included in this output. Fuel economy values for 1970 through 1981 were estimated using fuel economy data from Highway Statistics.⁴ Adjustments were made to the Highway Statistics fuel economy data since the vehicle classes included in Highway Statistics differ from the MOBILE vehicle classes and to smooth out the discontinuity in fuel economy estimates between the two sources from 1981 to 1982. This was done using the following general equation:

$$FE_{x,y} = FE(HS)_{x,y} \times \frac{FE(FCM)_{x,1982}}{FE(HS)_{x,1982}}$$

where:	$FE_{x,y}$	=	Fuel economy value for vehicle type x in year y used SO ₂ emission factor calculations (mpg)
	$FE(HS)_{x,y}$	=	Highway Statistics fuel economy for vehicle type x in year y (mpg)
	$FE(FCM)_{x,1982}$	=	MOBILE4.1 Fuel Consumption Model fuel economy for vehicle type x in 1982
	$FE(HS)_{x,1982}$	=	Highway Statistics fuel economy for vehicle type x in 1982

This equation was complicated by the differences in vehicle class definitions used in the MOBILE4.1 Fuel Consumption Model versus those used in Highway Statistics. Therefore, a single light duty vehicle and a single light duty truck fuel economy value were calculated for each year. The weighing of gasoline and diesel vehicles was made using the same OMS apportionment as was used for allocating the HPMS VMT to the diesel and gasoline categories. Motorcycles were not included in the MOBILE4.1 Fuel consumption Model. Therefore, a fuel economy value of 50 mpg was used for motorcycles in all years from 1970 through 1993 based on AAMA motorcycle fuel economy data.¹¹ The fuel economy values used for each vehicle type and year are shown in Table 4.6-7.

The resulting SO₂ emission factors by vehicle type and year are shown in Table 4.6-8. The 1993 diesel emission factors were calculated by weighing emission factors calculated with the two different diesel fuel sulfur content values by weighing the higher fuel sulfur content by 75 percent (for the nine months that the higher sulfur content applies) and the lower fuel sulfur content value by 25 percent (for the three months that the lower sulfur content applies).

4.6.4 Calculation of Emissions

Once the highway vehicle emission factors and VMT were developed, a computer program was used to map the corresponding VMT and emission factors to calculate monthly, county-level emissions estimates for each vehicle type and road type. Although emission factors were developed for VOC, NO_x, and CO at the state level, the factors could vary by county depending on the presence or absence of I/M programs and oxygenated fuel program.

4.6.5 References

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Table 4.6-1. Data Components of HPMS

Universe - All Road Mileage	
Identification	Contains state, county, and rural/small urbanized codes and a unique identification of location reference. Optionally, the latitude and longitude coordinates for the beginning and ending points of universe and sample sections are provided.
System	Provides for coding of functional system and Federal-aid system.
Jurisdiction	Provides for coding of state or local highway system and special funding category.
Operation	Includes type of facility, truck prohibition, and toll.
Other	Contains length of highway section and fields for the coding of AADT and the number of through lanes.
Sample - Statistical Sample of Universe	
Identification	Contains unique identification for the sample section portion of the record.
Computational Elements	Provides data items used to expand sample information to universe values.
Pavement Attributes	Contains data items used to evaluate the physical characteristics of pavement, pavement performance, and the need for pavement overlays.
Improvements	Describes the improvement type for the year of the improvement completion.
Geometrics/ Configuration	Describes the physical attributes used to evaluate the capacity and operating characteristics of the facility.
Traffic/Capacity	Provides operational data items used to calculate the capacity of a section and the need for improvements.
Environment	Contains items that marginally affect the operation of a facility but are important to its structural integrity.
Supplemental Data	Provides linkage to existing structure and railroad crossing information systems.
Areawide - State Summaries	
Mileage	Road mileage
Travel	Vehicle miles traveled, percent travel by vehicle type
Accidents	Number of accidents
Injuries	Number of injuries
Population	Area population

Table 4.6-2. Apportionment Percentages for Conversion of HPMS Vehicle Type Categories to MOBILE5a Categories

HPMS Vehicle Type Category	MOBILE5a Vehicle Type Category and Apportionment Percentages	
Motorcycle	MC	1.0000
Passenger Car	LDGV	0.9864
	LDDV	0.0136
Other 2-Axle, 4-tire	LDGT1	0.6571
	LDGT2	0.3347
	LDDT	0.0082
Buses	HDGV	0.1028
	HDDV	0.8972
Other Single Unit Trucks	HDGV	0.7994
	HDDV	0.2006
Combination Trucks	HDDV	1.0000

Table 4.6-3. Cities Used for Temperature Data Modeling from 1970 through 1993

State	City
Alabama	Birmingham
Alaska	Anchorage
Arizona	Phoenix
Arkansas	Little Rock
California	Los Angeles
California	San Francisco
Colorado	Denver
Connecticut	Hartford
Delaware	Dover
District of Columbia	Washington
Florida	Orlando (1974-1993)
Georgia	Atlanta
Hawaii	Honolulu
Idaho	Boise
Illinois	Springfield
Indiana	Indianapolis
Iowa	Des Moines
Kansas	Topeka
Kentucky	Louisville
Louisiana	Baton Rouge
Maine	Portland
Maryland	Baltimore
Massachusetts	Boston
Michigan	Detroit
Minnesota	Minneapolis
Mississippi	Jackson
Missouri	Springfield
Montana	Billings
Nebraska	Lincoln
Nevada	Las Vegas
New Hampshire	Concord
New Jersey	Newark
New Mexico	Albuquerque
New York	New York City
North Carolina	Greensboro
North Dakota	Bismarck
Ohio	Columbus
Oklahoma	Oklahoma City
Oregon	Eugene
Pennsylvania	Harrisburg (1970-1991), Middletown (1991-1993)
Rhode Island	Providence
South Carolina	Columbia
South Dakota	Pierre
Tennessee	Nashville
Texas	Dallas/Fort Worth (1974-1993)
Utah	Salt Lake City
Vermont	Montpelier
Virginia	Richmond
Washington	Seattle
West Virginia	Charleston
Wisconsin	Milwaukee
Wyoming	Casper

Table 4.6-4. HPMS Average Overall Travel Speeds for 1990 (MPH)

Vehicle Type	Rural					Urban				
	Interstate	Principal Arterial	Minor Arterial	Major Collector	Minor Collector	Interstate	Other Freeways vs Expressways	Principal Arterial	Minor Arterial	Collector
Small Pass. Cars	58.4	46.5	40.1	35.4	30.3	46.3	42.4	18.7	19.3	19.5
Large Pass. Cars	58.4	46.5	40.1	35.4	30.3	46.3	42.4	18.7	19.3	19.5
Pickups & Vans	56.7	45.6	39.7	35.3	30.5	45.4	41.9	19.5	20.1	20.3
Single 2 Axle	55.7	44.5	38.8	32.6	24.1	47.1	42.9	18.1	18.2	18.0
Single 3 + Axle	53.3	43.0	37.6	33.1	29.8	45.4	41.5	18.0	18.1	18.1
Multi 4 + Axle	43.0	34.0	30.7	27.9	25.7	37.2	34.4	14.7	14.6	14.5
Multi 5 + Axle	41.8	33.4	30.2	26.9	22.5	36.4	33.8	14.6	14.5	14.3

Table 4.6-5. Average Speeds by Road Type and Vehicle Type
(MPH)

Rural						
	Interstate	Principal Arterial	Minor Arterial	Major Collector	Minor Collector	Local
LDV	60	45	40	35	30	30
LDT	55	45	40	35	30	30
HDV	40	35	30	25	25	25

Urban						
	Interstate	Other Freeways & Expressways	Principal Arterial	Minor Arterial	Collector	Local
LDV	45	45	20	20	20	20
LDT	45	45	20	20	20	20
HDV	35	35	15	15	15	15

Table 4.6-6. PM-10 Emission Factors used in the Emission Trends Inventory

Year	Emission Factor (grams per mile)							
	LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT	HDDV	MC
1970	0.070	0.069	0.070	0.062	0.615	0.615	2.367	0.070
1971	0.066	0.066	0.067	0.062	0.615	0.615	2.367	0.066
1972	0.063	0.063	0.064	0.062	0.615	0.615	2.367	0.063
1973	0.060	0.060	0.062	0.062	0.615	0.615	2.367	0.060
1974	0.057	0.057	0.059	0.062	0.615	0.615	2.351	0.057
1975	0.054	0.054	0.057	0.062	0.615	0.615	2.335	0.054
1976	0.051	0.051	0.054	0.062	0.615	0.615	2.319	0.051
1977	0.048	0.049	0.052	0.062	0.585	0.583	2.303	0.048
1978	0.045	0.046	0.049	0.062	0.555	0.552	2.287	0.045
1979	0.042	0.043	0.047	0.062	0.525	0.520	2.271	0.042
1980	0.039	0.040	0.044	0.062	0.495	0.489	2.255	0.039
1981	0.036	0.037	0.042	0.062	0.465	0.457	2.239	0.036
1982	0.033	0.034	0.039	0.062	0.435	0.426	2.223	0.033
1983	0.030	0.032	0.037	0.062	0.405	0.395	2.207	0.030
1984	0.026	0.029	0.034	0.062	0.375	0.363	2.191	0.026
1985	0.026	0.028	0.033	0.065	0.368	0.361	2.068	0.026
1986	0.025	0.026	0.031	0.068	0.361	0.360	1.945	0.025
1987	0.024	0.025	0.029	0.071	0.355	0.358	1.822	0.024
1988	0.023	0.024	0.028	0.074	0.348	0.356	1.699	0.023
1989	0.022	0.023	0.026	0.077	0.342	0.354	1.576	0.022
1990	0.021	0.022	0.025	0.080	0.335	0.353	1.453	0.021
1991	0.020	0.021	0.023	0.083	0.329	0.351	1.330	0.020
1992	0.019	0.020	0.022	0.086	0.322	0.349	1.207	0.019
1993	0.018	0.018	0.020	0.089	0.316	0.347	1.084	0.018

Table 4.6-7. Fuel Economy Values Used in Calculation of SO₂ Emission Factors for the Emission Trends Inventory

Year	Fuel Economy (miles/gallon)						MC
	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	
1970	12.68	10.18	6.79	12.68	10.18	5.05	50.00
1971	12.70	10.39	6.85	12.70	10.39	5.17	50.00
1972	12.57	10.51	6.86	12.57	10.51	5.27	50.00
1973	12.48	10.69	6.90	12.48	10.69	5.32	50.00
1974	12.59	11.15	7.11	12.59	11.15	5.47	50.00
1975	12.68	11.40	7.16	12.68	11.40	5.62	50.00
1976	12.69	11.39	7.05	12.69	11.39	5.47	50.00
1977	12.94	11.63	7.05	12.94	11.63	5.47	50.00
1978	13.17	11.81	6.97	13.17	11.81	5.45	50.00
1979	13.52	12.00	6.94	13.52	12.00	5.45	50.00
1980	14.50	12.54	7.13	14.50	12.54	5.64	50.00
1981	14.95	12.72	7.07	14.95	12.72	5.56	50.00
1982	15.49	12.96	7.65	24.90	24.59	5.30	50.00
1983	16.13	13.42	7.96	25.10	24.85	5.44	50.00
1984	16.78	13.90	8.15	25.21	24.96	5.57	50.00
1985	17.46	14.33	8.39	25.31	25.00	5.71	50.00
1986	18.18	14.79	8.49	25.37	25.08	5.82	50.00
1987	18.95	15.24	8.66	25.50	25.15	5.93	50.00
1988	19.63	15.60	8.76	25.55	25.09	6.01	50.00
1989	20.25	15.87	8.90	25.48	24.93	6.11	50.00
1990	20.77	16.06	9.03	25.43	24.65	6.19	50.00
1991	21.23	16.30	9.15	25.41	24.57	6.27	50.00
1992	21.62	16.52	9.27	25.43	24.66	6.34	50.00
1993	21.93	16.70	9.37	25.52	24.77	6.41	50.00

Table 4.6-8. SO₂ Emission Factors used in the Emission Trends Inventory

Year	Emission Factor (grams per mile)							
	LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT	HDDV	MC
1970	0.147	0.183	0.183	0.274	0.989	1.231	2.482	0.037
1971	0.146	0.179	0.179	0.272	0.987	1.207	2.425	0.037
1972	0.148	0.177	0.177	0.271	0.997	1.193	2.379	0.037
1973	0.149	0.174	0.174	0.270	1.004	1.173	2.356	0.037
1974	0.148	0.167	0.167	0.262	0.996	1.124	2.292	0.037
1975	0.147	0.163	0.163	0.260	0.989	1.100	2.231	0.037
1976	0.147	0.163	0.163	0.264	0.988	1.101	2.292	0.037
1977	0.144	0.160	0.160	0.264	0.969	1.078	2.292	0.037
1978	0.141	0.158	0.158	0.267	0.952	1.061	2.300	0.037
1979	0.138	0.155	0.155	0.268	0.927	1.045	2.300	0.037
1980	0.128	0.148	0.148	0.261	0.865	1.000	2.223	0.037
1981	0.124	0.146	0.146	0.263	0.839	0.986	2.255	0.037
1982	0.120	0.144	0.144	0.243	0.503	0.510	2.365	0.037
1983	0.115	0.139	0.139	0.234	0.499	0.504	2.304	0.037
1984	0.111	0.134	0.134	0.228	0.497	0.502	2.251	0.037
1985	0.107	0.130	0.130	0.222	0.495	0.501	2.195	0.037
1986	0.102	0.126	0.126	0.219	0.494	0.500	2.154	0.037
1987	0.098	0.122	0.122	0.215	0.492	0.498	2.114	0.037
1988	0.095	0.119	0.119	0.212	0.491	0.500	2.086	0.037
1989	0.092	0.117	0.117	0.209	0.492	0.503	2.052	0.037
1990	0.090	0.116	0.116	0.206	0.493	0.509	2.025	0.037
1991	0.088	0.114	0.114	0.203	0.493	0.510	1.999	0.037
1992	0.086	0.113	0.113	0.201	0.493	0.508	1.977	0.037
1993	0.085	0.111	0.111	0.199	0.399	0.411	1.589	0.037

4.7 OFF-HIGHWAY

This category includes the estimated emissions from aircraft, commercial marine vessels, railroads, and all other nonroad vehicles and equipment. The methodology used to generate the emissions for these sources is described in this section.

4.7.1 1990 Base Year Inventory

The 1990 emissions from aircraft, commercial marine vessels, and railroads have been estimated from the area source portion of the 1985 NAPAP Emission Inventory by the process described in section 4.7.1.2. The basis for the 1990 nonroad emissions was emission inventories¹ prepared by OMS for 27 nonattainment areas (NAAs). These inventories were combined and used to create national county-level emissions. These emissions are detailed in section 4.7.1.1.

4.7.1.1 Nonroad Mobile Source Emissions

Nonroad sources include motorized vehicles and equipment that are not normally operated on public roadways to provide transportation. The nonroad mobile source emissions in the Emission Trends inventory are based on 1990 nonroad emissions² compiled by EPA's Emission Inventory Branch (EIB). The EIB nonroad data contains a total emissions for non-road sources at the county level. These emissions include all nonroad sources except aircraft, commercial marine vessels, and railroads. The EIB nonroad emissions were developed from nonroad emission inventories for 27 ozone NAAs by EPA's Office of Mobile Sources (OMS). The OMS inventories contained 1990 emissions at the SCC-level for each county within 1 of the 27 NAAs. These nonroad data do not include emissions for SO₂. The SO₂ emissions in the 1985 NAPAP Inventory from the nonroad sources was approximately 92,000 short tons.

A two step process was used to convert the OMS NAA emissions to county-SCC-level emissions needed for the Emission Trends inventory. The first step, performed by EIB, used the OMS 1990 nonroad emissions for the 27 ozone NAAs to estimate nonroad emissions for the rest of the country. The second step used the EIB total nonroad emissions for each county to create 1990 county-SCC-level nonroad emissions.

Step 1. Creation of National County-Level 1990 Nonroad Emissions

OMS had 1990 nonroad emission inventories prepared for 27 ozone and 6 CO NAAs. (Data from the CO NAAs was not used because it did not include VOC and NO_x emissions). Table 4.7-1 lists the 27 ozone NAAs for which nonroad inventories were compiled. Each NAA inventory contained county-level emissions for 279 different equipment/engine type combinations for each county in the NAA. For this information to be useful for the Emission Trends inventory, nonroad emissions were needed for the entire country (excluding Alaska and Hawaii). The following methodology was used to create 1990 nonroad emissions for the entire country:

- (a) VOC, NO_x, and CO per capita emission factors were developed for each NAA by summing each pollutant's emissions for all equipment/engine categories for all counties within the NAA and dividing by the NAA population;
- (b) for counties entirely within 1 of the 27 NAAs, the emissions in the OMS inventories was used;
- (c) for counties partially in 1 of the 27 NAAs, emissions were calculated by multiplying the NAA per capita emission factor by the total county population;
- (d) all other counties were assigned a "surrogate NAA" based on geography and climate, emissions were calculated by multiplying the "surrogate NAA" per capita emission factors by the total county population. Figure 4.7-1 shows the "surrogate NAA" each area of the country was assigned.

Step 2. Distribution of Total Nonroad Emissions to SCCs

The resulting emissions from step 1 above, represent total county nonroad emissions. In order to be incorporated into the Emission Trends inventory, these emissions must be distributed to the appropriate SCCs. The following methodology was used to distribute total nonroad emissions to SCCs:

- (a) an SCC was assigned to each of the 279 equipment/engine type combinations in the OMS inventories; the 27 SCCs used are listed in Table 4.7-2;
- (b) for each of the 27 OMS inventories, the percentage of emissions from sources assigned to each of the 27 SCCs was calculated;
- (c) each county's total nonroad emissions were distributed to the 27 sccs using the SCC percentages from its "surrogate NAA".

4.7.1.2 Aircraft, Marine Vessels and Railroads

The **area** source emissions from the 1985 NAPAP Emissions Inventory have been projected to the year 1990 based on BEA historic earnings data or other growth indicators. The specific growth indicator was assigned based on the source category. The BEA earnings data were converted to 1982 dollars as described in section 4.7.1.2.2. All growth factors were calculated as the ratio of the 1990 data to the 1985 data for the appropriate growth indicator.

When creating the 1990 emissions inventory, changes were made to emission factors from the 1985 inventory for some sources. The 1990 emissions for CO, NO_x, SO₂, and VOC were calculated using the following steps: (1) projected 1985 controlled emissions to 1990 using the appropriate growth factors, (2) calculated the uncontrolled emissions using control efficiencies from the 1985 NAPAP Emission Inventory, and (3) calculated the final 1990 controlled emissions using revised emission factors. The 1990 PM-10 emissions were calculated using the TSP emissions from the 1985 NAPAP Emission Inventory. The 1990 uncontrolled TSP emissions were estimated in the same manner as the other pollutants. From these TSP emissions, the

1990 uncontrolled PM-10 estimates were calculated by applying SCC-specific uncontrolled particle size distribution factors.³ The controlled PM-10 emissions were estimated in the same manner as the other pollutants.

4.7.1.2.1 Emission Factor Changes —

Emission factors for several sources were updated to reflect recent technical improvements in AP-42 and other emission inventory guidance documents. Emission factors for all four pollutants were updated for railroads. The SO₂ emission factors for aircraft were also updated.

Railroad emission factors in NAPAP were derived from data in AP-42. Improved emission factors for railroad locomotives have recently been developed in a revision to EPA's mobile source emission inventory guidance.⁴ These updated emission factors were incorporated into the Emission Trends estimates. Railroad emission factors are summarized in Table 4.7-3 for line-haul locomotives and yard (switch) locomotives. Because only one set of emission factors is required for railroads, the separate emission factors for line-haul and yard locomotives were weighted by fuel usage. AAR provided data on fuel consumption by line-haul and yard locomotives for Class I railroads for 1985 through 1990, as shown in Table 4.7-4.

AP-42 SO₂ emission rates were compared with emission rates published in EPA's emission inventory guidance.⁵ SO₂ rates were on average 54 percent lower, due to changes in fuel sulfur content. This change was incorporated into the aircraft emissions for the Emission Trends inventory. (Although new data were available only for civil aircraft, the emission factor change was incorporated for all aircraft). Aircraft emission factors for VOC, NO_x, and CO have not changed. Table 4.7-5 is a comparison of SO₂ emission rates from aircraft.

4.7.1.2.2 1990 Growth Indicators for Aircraft, Marine Vessels, and Railroads —

Emissions from the 1985 NAPAP Inventory were grown to the Emission Trends years based on historical BEA earnings data or other category-specific growth indicators. Table 4.7-6 shows the growth indicators used for each area source by NAPAP category.

Activity levels for aircraft are measured by the number of landing-takeoff operations (LTOs). Annual LTO totals are compiled by the Federal Aviation Administration (FAA) on a regional basis. Commercial aircraft growth is derived from the summation of air carrier and air taxi regional totals of LTOs from FAA-operated control towers and FAA traffic control centers.⁶ These data are compiled on a regional basis, so the regional trends were applied to each State. Civil aircraft growth indicators were also developed from regional LTO totals. Civil aircraft activity levels were determined from terminal area activity for the years 1985 through 1989, and from a 1990 forecast of terminal area activity.⁷ Military aircraft LTO totals were not available; consequently, BEA data were used.

The changes in the military aircraft emissions were equated with the changes in historic earnings by state and industry. Emissions in the 1985 NAPAP Emissions Inventory were projected to the years 1985 through 1991 based on the growth in earnings by industry (2-digit SIC code). Historical earnings data from BEA's Table SA-5⁸ were used to represent growth in earnings from 1985 through 1990. (Earnings data from a

different BEA source, Table SQ-5 discussed below, were used to estimate 1991 emissions.) Table SA-5 historical annual earnings data are by state and industry.

The 1985 through 1990 earnings data in Table SA-5 are in nominal dollars. In order to be used to estimate growth, these values were converted to constant dollars to remove the effects of inflation. Earnings data for each year were converted to 1982 constant dollars using the implicit price deflator for personal consumption expenditures (PCE).⁹ The PCE deflators used to convert each year's earnings data to 1982 dollars are:

<u>Year</u>	<u>1982 PCE Deflator</u>
1985	111.6
1987	114.3
1988	124.2
1989	129.6
1990	136.4

Several BEA categories did not contain a complete time series of data for the years 1985 through 1990. Because the SA-5 data must contain 1985 earnings and earnings for each inventory year (1985 through 1990) to be useful for estimating growth, a log linear regression equation was used to fill in missing data elements where possible. This regression procedure was performed on all categories that were missing at least one data point and which contained at least three data points in the time series.

Each record in the point source inventory was matched to the BEA earnings data based on the state and the 2-digit SIC. Table 4.7-7 shows the BEA earnings category used to project growth for each of the 2-digit SICs found in the 1985 NAPAP Emission Inventory. No growth in emissions was assumed for all point sources for which the matching BEA earnings data were not complete. Table 4.7-7 also shows the national average growth and earnings by industry from Table SA-5.

At the time the Emission Trends inventory was compiled, 1991 BEA earnings data were not available in Table SA-5. Earnings data from BEA Table SQ-5¹⁰ were used to estimate emissions for 1991. Table SQ-5 contains historical quarterly earnings data by state and 1-digit SIC. These data were converted to an annual constant dollars basis.

The 1991 quarterly earnings data were first summed to compute annual totals. Because the PCE deflator used to convert to constant 1982 dollars was not available for 1991, a 1987 PCE deflator¹⁰ was used to convert the 1990 and 1991 earnings data from Table SQ-5 to a 1987 constant dollar basis. The PCE deflators are as follows:

<u>Year</u>	<u>1987 PCE Deflator</u>
1990	114.7
1991	119.3

The 1991 inventory was then developed by growing the 1990 inventory based on the changes in State industry earnings (by 1-digit SIC) from 1990 to 1991. National average growth in earnings by industry is shown below in Table 4.7-8.

Railroad data are provided by the Association of American Railroads (AAR). National totals of revenue-ton-miles for the years 1985 through 1990 are used to estimate changes in activity during this period. The national growth is therefore applied to each State and county.¹¹

Marine vessel activity is recorded annually by the U.S. Army Corp of Engineers. Cargo tonnage national totals are used to determine growth in diesel- and residual-fueled vessel use through the year 1989.¹² Gasoline-powered vessels are used predominantly for recreation, so growth for this category is therefore based on population.

4.7.1.2.3. Emissions Calculations —

A four-step process was used to calculate emissions incorporating rule effectiveness. First, base year controlled emissions are projected to the inventory year using the following formula:

$$CE_i = CE_{BY} \% (CE_{BY} \times EG_i)$$

where: CE_i = Controlled Emissions for inventory year i
 CE_{BY} = Controlled Emissions for base year
 EG_i = Earnings Growth for inventory year i

Earnings growth (EG) is calculated as:

$$EG_i = 1 + \frac{DAT_i}{DAT_{BY}}$$

where: DAT_i = Earnings data for inventory year i
 DAT_{BY} = Earnings data in the base year

Second, uncontrolled emissions in the inventory year are back-calculated from the controlled emissions based on the control efficiency with the following formula

$$UE_i = \frac{CE_i}{\left(1 + \frac{CEFF}{100}\right)}$$

where: UE_i = Uncontrolled Emissions for inventory year i

CE_i = Controlled Emissions for inventory year i
 $CEFF$ = Control Efficiency (%)

For aircraft, marine vessels, and railroads this equations reduces to the equation number 4 since the control efficiency is equal to zero.

$$UE_i = CE_i$$

Third, controlled emissions are recalculated incorporating revised emission factors using the following formula:

$$CER_i = UC_i \times \left(\frac{EF_i}{EF_{BY}} \right)$$

where: CER_i = Controlled Emissions Incorporating Rule Effectiveness
 UC_i = Uncontrolled Emissions
 EF_i = Emission factor for inventory year
 EF_{BY} = Emission factor for Base year

The last step in the creation of the inventory was the matching of NAPAP categories to the new AMS categories. This matching is provided in Table 4.7-9. Note that there is not always a one-to-one correspondence between NAPAP and AMS categories.

4.7.2 Emissions, 1970 through 1989 and 1991

The nonroad emissions for the years 1970 through 1989 and 1991 have been based on the 1990 estimates. Historic E-GAS growth factors¹³ were obtained by representative NAA and rest of state counties and by Bureau of Labor Statistics (BLS) codes and then correlated to the nonroad SCCs and counties.

$$Emissions_{(county, SCC, year)} = Growth_{(county, SCC, year)} \times Emissions_{(county, SCC, 1990)}$$

4.7.3 Emissions, 1992 and 1993

The 1992 and 1993 emissions for all pollutants were estimated by applying growth factors to the 1990 emissions. The growth factors were obtained from the prereleased E-GAS, version 2.0. The E-GAS generates growth factors at the SCC-level for counties representative of all counties within each ozone nonattainment area classified as serious and above and for counties representative of all counties within both the attainment portions and the marginal and moderate nonattainment areas within each state. The appropriate growth factors were applied by county and SCC to the 1990 emissions as shown by equation 6.

There are approximately 150 representative counties in E-GAS and 2000 SCCs present in the base year inventory. This yields a matrix of 300,000 growth factors generated to determine a single year's inventory. To list all combinations would be inappropriate.

4.7.4 References

1. "Documentation for Estimation of Nonroad Emission Estimates for the United States," U.S. Environmental Protection Agency, Research Triangle Park, NC, November 1992.
2. "Nonroad Engine Emission Inventories for CO and Ozone Nonattainment Boundaries," U.S. Environmental Protection Agency, Ann Arbor, MI, October 1992.
3. Barnard, W.R., and P. Carlson, "PM-10 Emission Calculation, Tables 1 and 4" E.H. Pechan & Associates, Inc. Contract No. 68-DO-1020, U.S. Environmental Protection Agency, Emission Factor and Methodologies Section. June 1992.
4. "Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources," Draft revision, Chapter 6, U.S. Environmental Protection Agency, Office of Mobile Sources, Ann Arbor, MI, 1991.
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6. "Air Traffic Activity," U.S. Department of Transportation, Federal Aviation Administration, Washington, D.C., 1991.
7. "Terminal Area Forecasts, FY 1991-2005," FAA-APO-91-5, U.S. Department of Transportation, Federal Aviation Administration, Washington, D.C., July 1991.
8. "Table SA-5 — Total Personal Income by Major Sources 1969-1990," data files, U.S. Department of Commerce, Bureau of Economic Analysis, Washington, DC, September 1991.
9. "Survey of Current Business," U.S. Department of Commerce, Bureau of Economic Analysis, Washington, DC, July 1986, July 1987, July 1988, July 1989, July 1990, July 1991.
10. "Table SQ-5 — Quarterly State Personal Income 1987: I - 1991: IV," data files, U.S. Department of Commerce, Bureau of Economic Analysis, Washington, DC, April 1992.
11. "Railroad Ten-Year Trends 1981-1990," Association of American Railroads, Washington, DC, 1991.
12. "Waterborne Commerce of the United States, Calendar Year 1989," WRSC-WCUS-89, Part 5, U.S. Army Corp of Engineers, New Orleans, LA, June 1991.

13. *E-GAS Growth Factors and BLS to SCC Cross Reference*. Computer PC model and files received by E.H. Pechan & Associates, Inc. from TRC Environmental Corporation, Chapel Hill, NC. June 1994.

Table 4.7-1. Ozone Nonattainment Areas with OMS-Prepared Nonroad Emissions

Atlanta, GA	Hartford, CT	Providence, RI
Baltimore, MD	Houston, TX	San Diego, CA
Baton Rouge, LA	Miami, FL	San Joaquin, CA
Beaumont, TX	Milwaukee, WI	Seattle, WA
Boston, MA	Muskegon, MI	Sheboygan, WI
Chicago, IL	New York, NY	South Coast, CA
Cleveland, OH	Philadelphia, PA	Springfield, MA
Denver, CO	Phoenix, AZ	St. Louis, MO
El Paso, TX	Portsmouth, NH	Washington, DC

Figure 4.7-1. Assignment of Surrogate Nonattainment Areas



Table 4.7-2. Source Categories Used for Nonroad Emissions

AMS SCC	Category Description
2260001000	Recreational Vehicles: Gasoline, 2-Stroke
2260002000	Construction Equipment: Gasoline, 2-Stroke
2260003000	Industrial Equipment: Gasoline, 2-Stroke
2260004000	Lawn & Garden Equipment: Gasoline, 2-Stroke
2260005000	Farm Equipment: Gasoline, 2-Stroke
2260006000	Light Commercial: Gasoline, 2-Stroke
2260007000	Logging Equipment: Gasoline, 2-Stroke
2260008000	Airport Service Equipment: Gasoline, 2-Stroke
2265001000	Recreational Vehicles: Gasoline, 4-Stroke
2265002000	Construction Equipment: Gasoline, 4-Stroke
2265003000	Industrial Equipment: Gasoline, 4-Stroke
2265004000	Lawn & Garden Equipment: Gasoline, 4-Stroke
2265005000	Farm Equipment: Gasoline, 4-Stroke
2265006000	Light Commercial: Gasoline, 4-Stroke
2265007000	Logging Equipment: Gasoline, 4-Stroke
2265008000	Airport Service Equipment: Gasoline, 4-Stroke
2270001000	Recreational Vehicles: Diesel
2270002000	Construction Equipment: Diesel
2270003000	Industrial Equipment: Diesel
2270004000	Lawn & Garden Equipment: Diesel
2270005000	Farm Equipment: Diesel
2270006000	Light Commercial: Diesel
2270007000	Logging Equipment: Diesel
2270008000	Airport Service Equipment: Diesel
2282005000	Recreational Marine Vessels: Gasoline, 2-Stroke
2282010000	Recreational Marine Vessels: Gasoline, 4-Stroke
2282020000	Recreational Marine Vessels: Diesel

Table 4.7-3. Railroad Locomotives Diesel Fuel Consumption, 1985 to 1990
(million gallons)

Year	Line-Haul	Switch
1985	2,889	255
1990	2,876	258

Source: "Railroad Ten-Year Trends 1981-1990," Association of American Railroads, Washington, DC, 1991.

Table 4.7-4. Railroad Emission Factors
(lbs/1,000 gallons)

	Wtg. Factor	NO _x	CO	HC	SO ₂
NAPAP		370	130	90	57
Revised					
Line-haul	2,876	493.1	62.6	20.1	36.0
Yard	258	504.4	89.4	48.2	36.0
New Wtd. Avg.		494	65	22	36

Source: "Procedures for Emission Inventory Preparation, Volume IV: Mobile Sources," Draft revision, Chapter 5, Office of Mobile Sources, U.S. Environmental Protection Agency, Ann Arbor, MI, November 1991.

Table 4.7-5. Civil Aircraft SO₂ Emission Factors

Engine Type	Fuel Rate (lbs/hr)	AP-42 SO ₂ Emission Factor (lbs/hr)	New SO ₂ Emission Factor (lbs/hr)	Engine Type	Fuel Rate (lbs/hr)	AP-42 SO ₂ Emission Factor (lbs/hr)	New SO ₂ Emission Factor (lbs/hr)
250B17B	63	0.06	0.03	PT6A-41	147	0.15	0.08
	265	0.27	0.14		510	0.51	0.28
	245	0.25	0.13		473	0.47	0.26
	85	0.09	0.05		273	0.27	0.15
501D22A	610	0.61	0.33	Dart RDa7	411	0.41	0.22
	2376	2.38	1.28		1409	1.41	0.76
	2198	2.2	1.19		1248	1.25	0.67
	1140	1.14	0.62		645	0.65	0.35
TPE-331-3	112	0.11	0.06	0-200	8.24	0	0.00
	458	0.46	0.25		45.17	0.01	0.00
	409	0.41	0.22		45.17	0.01	0.00
	250	0.25	0.14		25.5	0.01	0.00
JT3D-7	1013	1.01	0.55	TSIO-360C	11.5	0	0.00
	9956	9.96	5.38		133	0.03	0.01
	8188	8.19	4.39		99.5	0.02	0.01
	3084	3.08	1.67		61	0.01	0.01
JT9D-7	1849	1.85	1.00	O-320	9.48	0	0.00
	16142	16.14	8.72		89.1	0.02	0.01
	13193	13.19	7.12		66.7	0.01	0.01
	4648	4.65	2.51		46.5	0.01	0.01
PT6A-27	115	0.12	0.06				
	425	0.43	0.23				
	400	0.4	0.22				
	215	0.22	0.12				

Source: "Supplement D to Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources," AP-42, U.S. Environmental Protection Agency, Research Triangle Park, NC, September 1991.

Table 4.7-6. Area Source Growth Indicators

NAPAP SCC	Category Description	Data Source	Growth Indicator
45	Railroad Locomotives	AAR	Railroad ton-miles (national)
46	Aircraft LTOs - Military	BEA	Military
47	Aircraft LTOs - Civil	FAA	Aircraft - civil
48	Aircraft LTOs - Commercial	FAA	Aircraft - commercial
49	Vessels - Coal	Corp of Engineers	Cargo tonnage (national)
50	Vessels - Diesel Oil		Cargo tonnage (national)
51	Vessels - Residual Oil		Cargo tonnage (national)

Table 4.7-7. Bureau of Economic Analysis's SA-5 National Changes in Earnings by Industry

Industry	SIC	Percent Growth			
		1985 to 1987	1987 to 1988	1988 to 1989	1989 to 1990
Federal, military	97	1.96	- 1.07	- 1.58	-3.19

Table 4.7-8. BEA National Growth in Earnings by Industry

Industry	Percent Growth from 1990 to 1991
Federal, military	- 1.94

Table 4.7-9. AMS to NAPAP Source Category Correspondence

<u>AMS</u>		<u>NAPAP</u>	
<u>SCC</u>	<u>Category</u>	<u>SCC</u>	<u>Category</u>
Mobile Sources			
2275001001	Aircraft - Military Aircraft (LTOs)	46	Aircraft LTOs - Military
2275020000	Aircraft - Commercial Aircraft (LTOs)	48	Aircraft LTOs - Commercial
2275050000	Aircraft - Civil Aircraft (LTOs)	47	Aircraft LTOs - Civil
2280001000	Marine Vessels - Coal	49	Vessels - Coal
2280002000	Marine Vessels - Diesel	50	Vessels - Diesel Oil
2280003000	Marine Vessels - Residual Oil	51	Vessels - Residual Oil
2285002000	Railroads - Diesel	45	Railroad Locomotives
2260001000	Recreational Vehicles: Gasoline, 2-Stroke	39	Off-Highway Gasoline Vehicles
2260002000	Construction Equipment: Gasoline, 2-Stroke	39	Off-Highway Gasoline Vehicles
2260003000	Industrial Equipment: Gasoline, 2-Stroke	39	Off-Highway Gasoline Vehicles
2260004000	Lawn & Garden Equipment: Gasoline, 2-Stroke	39	Off-Highway Gasoline Vehicles
2260005000	Farm Equipment: Gasoline, 2-Stroke	39	Off-Highway Gasoline Vehicles
2260006000	Light Commercial: Gasoline, 2-Stroke	39	Off-Highway Gasoline Vehicles
2260007000	Logging Equipment: Gasoline, 2-Stroke	39	Off-Highway Gasoline Vehicles
2260008000	Airport Service Equipment: Gasoline, 2-Stroke	39	Off-Highway Gasoline Vehicles
2265001000	Recreational Vehicles: Gasoline, 4-Stroke	39	Off-Highway Gasoline Vehicles
2265002000	Construction Equipment: Gasoline, 4-Stroke	39	Off-Highway Gasoline Vehicles
2265003000	Industrial Equipment: Gasoline, 4-Stroke	39	Off-Highway Gasoline Vehicles
2265004000	Lawn & Garden Equipment: Gasoline, 4-Stroke	39	Off-Highway Gasoline Vehicles
2265005000	Farm Equipment: Gasoline, 4-Stroke	39	Off-Highway Gasoline Vehicles
2265006000	Light Commercial: Gasoline, 4-Stroke	39	Off-Highway Gasoline Vehicles
2265007000	Logging Equipment: Gasoline, 4-Stroke	39	Off-Highway Gasoline Vehicles
2265008000	Airport Service Equipment: Gasoline, 4-Stroke	39	Off-Highway Gasoline Vehicles
2270001000	Recreational Vehicles: Diesel	44	Off-Highway Diesel Vehicles
2270002000	Construction Equipment: Diesel	44	Off-Highway Diesel Vehicles
2270003000	Industrial Equipment: Diesel	44	Off-Highway Diesel Vehicles
2270004000	Lawn & Garden Equipment: Diesel	44	Off-Highway Diesel Vehicles
2270005000	Farm Equipment: Diesel	44	Off-Highway Diesel Vehicles
2270006000	Light Commercial: Diesel	44	Off-Highway Diesel Vehicles
2270007000	Logging Equipment: Diesel	44	Off-Highway Diesel Vehicles
2270008000	Airport Service Equipment: Diesel	44	Off-Highway Diesel Vehicles
2282005000	Recreational Marine Vessels: Gasoline, 2-Stroke	52	Marine Vessels - Gasoline
2282010000	Recreational Marine Vessels: Gasoline, 4-Stroke	52	Marine Vessels - Gasoline
2282020000	Recreational Marine Vessels: Diesel	N/A	

4.8 FUGITIVE DUST

The "Fugitive Dust" grouping includes the estimated emissions for several Tier 2 of two Tier I source categories: Natural Sources and Miscellaneous sources. The emissions for the natural sources category included here are from geogenic sources producing PM-10 from wind erosion. The miscellaneous category including fugitive dust is divided into two subcategories: agriculture and forestry and fugitive dust. This section presents a description of the methodology used to estimate the emissions for the following tier categories:

- Natural Sources
 - Geogenic
 - wind erosion
- Miscellaneous
 - Agriculture and Forestry
 - agricultural crops
 - agricultural livestock
 - Fugitive dust
 - wind erosion
 - unpaved roads
 - paved roads
 - other (construction and mining and quarrying).

For most fugitive dust sources the emissions are estimated every year using the same methodology. Only the point source unpaved road, paved road, and wind erosion and the area source agricultural livestock emissions are grown off a base year inventory.

4.8.1 Natural Sources, Geogenic, Wind Erosion

The wind erosion emissions were estimated for each of the 9 years (1985 -1993) using the following methodology. PM-10 wind erosion emissions estimates for agricultural lands were made using a modification of the methodology used by Gillette and Passi¹ to develop wind erosion emissions for the 1985 National Acid Precipitation Assessment Program (NAPAP). Several simplifying assumptions² were made in order to perform the calculations using a spreadsheet model .

The NAPAP methodology and the method used to develop the wind erosion estimates presented here both develop an expectation of the dust flux based on the probability distribution of wind energy. The methodology uses the mean wind speed coupled with information concerning the threshold friction velocity for the soil and information on precipitation to predict the wind erosion flux potential for soils.

The basic equation used to determine the expected dust flux is given by the following equation:

$$I = k \times C_2 \times C_d^2 \times \left(\frac{u^4}{0.886^4} \right) \times (3,x)$$

where: I = dust flux (gm/cm²/sec)
 k = PM-10 particle size multiplier (0.9)
 C = constant (= 4 x 10⁻¹⁴ gm/cm²/sec)
 C_d = drag coefficient
 u = mean wind speed (cm/sec)
 Γ(3,x) = incomplete gamma function

In order to evaluate Γ(3,x), x must be determined from the following equation:

$$x = \left(u_t \times \left(\frac{0.886}{u} \right) \right)^2$$

The threshold velocity (u_t) can be determined from the threshold friction velocity (u_{*t} - which is a function of soil type and precipitation) from the following equation:

$$u_t = \frac{u_{*t}}{C_d^{0.5}}$$

Values of the threshold friction velocity for different soil types both before and after rain have been reported by Gillette and Passi.¹

4.8.1.1 Determination of Correction Parameters

In order to calculate the flux of emissions from wind erosion using the above equation, information concerning the average monthly wind speed, total monthly precipitation and anemometer height for the wind speed was necessary. Values for monthly wind speed, total monthly precipitation and anemometer height were obtained from the Local Climatological Data³ for several meteorological stations within each state. For most states, several meteorological stations data were obtained and an overall average was determined for the state. The anemometer height was utilized to determine the drag coefficient (C_d) from the following equation:

$$C_d = \left(\frac{0.23}{\ln z_s} \right)^2$$

where: z_s = anemometer height

Information concerning the average soil type for each state was determined from the USDA⁴ surface soil map. A single soil type was assigned to each state in order to determine a single value for the threshold friction velocity (u_{*t}). The threshold friction velocity (u_{*t}) utilized represented either a before or after rain value, depending upon whether or not precipitation exceeded 5.08 cm during a month. If precipitation exceeded this

amount, the after rain u_{*t} value was utilized for all succeeding months until the time of a significant tillage operation or plant emergence. The value of u_t was then calculated using the value of u_{*t} determined and C_d . Once u_t was determined, then x could be calculated and the incomplete gamma function could be evaluated using an asymptotic expansion. Following evaluation of the incomplete gamma function, the flux for each month was determined.

Wind erosion was assumed to be zero from the time of plant emergence until harvest. Separate flux estimates were made for fall planted crops and spring planted crops. This meant that flux estimates were only calculated from July to October for fall planted crops and from September until May for spring planted crops. This approach is consistent with the methodology utilized by Gillette and Passi.¹ However, because they were evaluating the erosion potential over a multi-year time frame, Gillette and Passi utilized previous year precipitation information to assign the threshold friction velocity to an area. In this work, the before rain u_{*t} value was always utilized for January for spring planted crops rather than evaluating whether or not any month between September and December of the previous year had more than 5.08 cm of precipitation.

4.8.3.2 Activity Data

Once the emission flux potential for each month for each crop type (fall or spring planted) for each state was calculated, then the acres of spring or fall planted crops in each state were required (and the number of seconds per month) to determine the emissions. The acres of crops planted in each state was obtained for each of the 9 years from the USDA.⁵ Evaluation of which crops were spring planted or fall planted for each state was made using information available from the USDA.⁶ The emissions calculated were then estimated for each state.

4.8.3.3 County Distribution

State-level PM-10 estimates were distributed to the county-level using estimates of county rural land area from the U.S. Census Bureau.⁷ The following formula was used:

$$\text{County Emissions} = \frac{\text{County Rural Land}}{\text{State Rural Land}} \times \text{State Emissions}$$

4.8.2 Miscellaneous

The methodology used to estimate the emissions from agricultural crops and livestock and fugitive dust are described in this section. The PM-10 fugitive dust emissions arise from construction activities, mining and quarrying, paved road resuspension, and unpaved roads. The general methodology used for these categories estimated the emissions by using an activity indicator, an emission factor, and one or more correction factors. The activity indicator for a given category varied from year to year as may the overall correction factor.

4.8.2.1 Agricultural Crops

The PM-10 emissions for the years 1985 through 1993 were estimated using the AP-42 emission factor equation for agricultural tilling.⁸ The activity data for this calculation were the acres of land planted. The emission factor, expressed in terms of the mass of TSP produced per acre-tilled was corrected by the following constant parameters: the silt of the surface soil, the particle size multiplier, and the number of tillings per year.

The following AP-42 particulate emission factor equation was used to determine regional PM-10 emissions from agricultural tilling for 1985-1993:

$$E = c \times k \times s^{0.6} \times p \times a$$

where: E = PM-10 emissions
 c = constant 4.8 lbs/acre-pass
 k = dimensionless particle size multiplier (PM-10=0.21)
 s = silt content of surface soil, defined as the mass fraction of particles smaller than 75 µm diameter found in soil to a depth of 10 cm (%)
 p = number of passes or tillings in a year (assume to be 3 passes)
 a = acres of land planted

4.8.2.1.1 Determination of Correction Parameters —

4.8.2.1.1.1 Silt content (s). By comparing the USDA⁴ surface soil map with the USDA⁹ county map, soil types were assigned to all counties of the continental U.S. Silt percentages were determined by using a soil texture classification triangle.¹⁰ For those counties with organic material as its soil type, Pechan used the previous silt percentages presented by Cowherd.¹¹ The weighted mean state silt values were determined by weighing the county value by the number of hectares within the county and summing across the entire state. These silt values were assumed constant for the 9 year period examined.

4.8.2.1.1.2 Number of Tillings per year (p). Cowherd *et al.*¹¹ reported that crops are tilled three times each year, on average, and this value was used for p.

4.8.2.1.2 Activity Data —

The acres of crops planted (a) in each state was obtained for each of the 9 years from the USDA.⁵

4.8.2.1.3 County Distribution —

State-level PM-10 estimates were distributed to the county-level using county estimates of cropland harvested from the 1987 Census of Agriculture.¹² The following formula was used:

$$\text{County Emissions} = \left(\frac{\text{County Cropland Harvested}}{\text{State Cropland Harvested}} \right) \times \text{State Emissions}$$

4.8.2.2 Agricultural Livestock

The 1990 emissions from agricultural livestock were determined from activity data, expressed in terms of the number of heads of cattle¹² and a national PM-10 emission factor.¹³ The following formula was used:

$$\text{County Emissions} = \left(\frac{\text{County Head of Cattle}}{1,000} \right) \times 17$$

The emissions for the years 1985 through 1991 were produced using the methodology described in section 4.8.2.6. The emissions for the years 1992 and 1993 were produced using E-GAS growth factors as also described in section 4.8.2.6.

4.8.2.3 Unpaved Roads

The total PM-10 emissions for the years 1985 through 1992 were based on the unpaved roads VMT data, a AP-42 base TSP emission factor, and the following correction factors: particle size multiplier, silt content of road surface material,¹⁴ mean vehicle speed, mean vehicle weight, mean number of wheels,¹⁵ and the number of dry days.³ Mean vehicle speeds were assigned to each unpaved road functional class. The number of dry days is defined in the same manner as for estimating the paved road estimates. The VMT data for unpaved roads were obtained for rural and urban road functional classes excluding local types and for local road types.^{16, 17}

As with the PM-10 emissions from paved roads, the emissions from highway vehicles must be subtracted from the total emissions determined by the method described in section 4.8.2.4 in order to yield the PM-10 fugitive dust emissions from unpaved roads and to prevent the double-counting of vehicle emissions. The highway vehicle emissions were calculated as described in section 4.6 and were distributed to unpaved road using VMT data.

The 1993 PM-10 emissions were produced by multiplying the 1992 VMT by the AP-42 emission factor and 1993 correction factors. The point source emissions are explained in section 4.8.2.6.

The following AP-42 particulate emission factor equation was used to determine regional PM-10 emissions from unpaved roads for 1985-1992:

$$E = VMT \times k \times 5.9 \times \frac{s}{12} \times \frac{S}{30} \times \left(\frac{W}{3} \right)^{0.7} \times \left(\frac{w}{4} \right)^{0.5} \times \left(\frac{x \& p}{x} \right)$$

where: E = PM-10 emissions (lbs/year)
VMT = vehicle miles travelled on unpaved roads
k = dimensionless particle size multiplier (PM-10=0.36)
s = silt content of road surface material (%)
S = mean vehicle speed (mph)

- W = mean vehicle weight (ton)
w = mean number of wheels
p = number of days with at least 0.01 inch of precipitation per year
x = number of days in a year (either 365 or 366).

4.8.2.3.1 Determination of Correction Parameters —

4.8.2.3.1.1 Silt Content (s). Average state silt content values were provided to Pechan by the Illinois State Water Survey.¹¹ These values were developed as part of the 1985 National Acid Precipitation Assessment Program (NAPAP). This database contains the silt content of over 200 unpaved roads from over thirty states. Average silt content of unpaved roads in a state were calculated for each state that had three or more samples for that state. For states that did not have the required number of samples, the average for all samples from all states was substituted.

4.8.2.3.1.2 Vehicle Speeds (S). Mean vehicle speeds were assumed for the various unpaved road functional classes. The assumed speeds are listed below.

<u>Rural Roads</u>	<u>Speeds (mph)</u>
Minor arterial	45
Major collector	40
Minor collector	40
Local	35

<u>Urban Roads</u>	<u>Speeds (mph)</u>
Other principal arterial	50
Minor collector	45
Collector	40
Local	40

4.8.2.3.1.3 Vehicle Weight (W), Wheels (w) and Distribution. Estimates of vehicle weight and the number of wheels per vehicle were made using information provided by the FHWA.¹⁵ This data indicated that the following weighted average values were appropriate for the following vehicle classes:

<u>Vehicle Type</u>	<u>Weight (tons)</u>	<u>Wheels</u>
Single trailer trucks	26.7	18
Multi-trailer trucks	31.5	20
Single unit trucks	9.55	7
Passenger vehicles	2.5	4

National statistics provided by FHWA on travel activity by vehicle type were utilized to allocate the percentage of travel on each road type to each vehicle type.¹⁵

4.8.2.3.1.4 Number of dry days in the year (x-p). By obtaining the number of days with 0.01 inches or more of precipitation in a year from the Local Climatological Data³ for several meteorological stations within each state, the number of dry days per year were calculated.

4.8.2.3.2 Activity Data —

The VMT on unpaved roads was developed from two sources. The first source, annual Highway Statistics¹⁶ provided rural and urban mileage by surface type and functional classification. This source did not include local functional class unpaved road mileage for 1985 to 1990. As a consequence a second source of information was utilized to determine VMT from local functional class unpaved roads. Lotus 1-2-3 spreadsheets were obtained from FHWA¹⁷ for these years. These spreadsheets contained local functional class rural and urban unpaved road mileage by average daily traffic volume (ADTV) ranges. These ADTV ranges were then used to calculate the VMT for both local and non-local functional systems.

4.8.2.3.3 County Distribution —

State-level PM-10 estimates were distributed to the county-level using estimates of county rural and urban land area from the U.S. Census Bureau.⁷ The following formula was used:

$$\text{County Emissions} = \frac{\text{County Urban Land}}{\text{State Urban Land}} \times \frac{\text{State Urban Emissions}}{\%} + \frac{\text{County Rural Land}}{\text{State Rural Land}} \times \frac{\text{State Rural Emissions}}{\%}$$

4.8.2.4 Paved Road Resuspension

The calculation of total PM-10 emissions for the years 1985 through 1993 were based on the paved road VMT, a AP-42 base emission factor, and two correction factors: road surface silt loading and the number of dry days.³ A dry day is defined as any day with less than 0.1 inches of precipitation. This term attempts to account for the effect of precipitation. Surface silt loading values by paved road functional classes and state were determined using an empirical model based on traffic volume.¹⁸

Total VMT data for the years 1985 through 1992 were obtained by state and road functional class.¹⁶ The total preliminary 1993 VMT data were obtained by state and two road types (urban and rural). The rural and urban VMT data were apportioned to the road functional classes using the distribution of the 1992 VMT data. The VMT from paved roads for each year was calculated by subtracting the unpaved road VMT (see section 4.8.2.3) from the total VMT for each year.

The base emission factor used in the calculation of total PM-10 emissions from paved roads accounts for the emissions from the vehicle (tailpipe, brake wear, and tire wear) as well as from the interaction between the vehicle and the road surface. The fugitive dust category includes only those emissions from the road surface and not the vehicle. For this reason, the PM-10 emissions for highway vehicles calculated as described in section 4.6 and distributed to paved roads using VMT data were subtracted from the total PM-10 emissions for paved roads. The results were the PM-10 fugitive dust emissions for paved roads. The point source emissions are explained in section 4.8.2.6.

The following AP-42 particulate emission factor equation for paved urban roads was used to determine regional PM-10 emissions from paved road resuspension for 1985-1993. This methodology was modified

slightly by adding a "dry days" term similar to that used in the unpaved road emission factor in an effort to account for meteorological influences on emissions.

$$E = VMT \times k \times \left(\frac{sL}{0.7} \right)^q \times \left(\frac{x \& p}{x} \right)$$

where: E = PM-10 emissions from paved road resuspension (lbs/yr)
 VMT = VMT from paved roads (vehicle miles traveled per yr)
 k = base emission factor (0.0081 lb/VMT for PM-10)
 sL = road surface silt loading (grains/sq.ft)
 q = exponent (0.8 dimensionless)
 p = number of days with at least 0.01 inch of precipitation per year
 x = number of days in a year (either 365 or 366)

4.8.2.4.1 Determination of Correction Parameters —

4.8.2.4.1.1 Road Surface Silt Loading (sL). The empirical model presented by Cowherd and Englehart¹⁹ to express the relationship between traffic volume and surface silt loading is shown below.

$$sL = \left(\frac{21.3}{V^{0.41}} \right) \times c$$

where: V = average daily traffic volume (vehicles/d)
 c = conversion factor (1.4337 sq meters-grains/gram-sq ft)

The surface silt loading values were determined for various paved road functional classes by state. The average daily traffic volume was calculated by dividing the total VMT for a particular functional class by the total mileage of roads within that functional class and then dividing that quantity by the number of days in the year.

4.8.2.4.1.2 Number of dry days in the year (x-p). By obtaining the number of days with 0.01 inches or more of precipitation in a year from the Local Climatological Data³ for several meteorological stations within each state, the number of dry days per year were calculated.

4.8.2.4.2 Activity Data —

For the years 1985 to 1992 the total VMT (by state and functional class) was obtained from the annual Highway Statistics report¹⁶ for the previous years statistics. VMT from paved roads was calculated by subtracting the unpaved VMT (see unpaved roads section 4.8.2.3) from the total VMT.

4.8.2.4.3 1993 Emissions Methodology —

The method for estimating 1993 PM-10 emissions from paved roads is similar to the above paved road methodology with the exception that VMT distributed by functional class was unavailable. The silt loading values calculated for 1992 were used for 1993. Since the state VMT for total rural and total urban roads²⁰ was available, it was distributed to functional classes using the previous year's distribution.

4.8.2.4.3 County Distribution —

State-level PM-10 estimates were distributed to the county-level using estimates of county rural and urban land area from the U.S. Census Bureau.⁷ The following formula was used:

$$\text{County Emissions} = \frac{\text{County Urban Land}}{\text{State Urban Land}} \times \frac{\text{State Urban Emissions}}{\%} + \frac{\text{County Rural Land}}{\text{State Rural Land}} \times \frac{\text{State Rural Emissions}}{\%}$$

4.8.2.5 Other Fugitive Dust Sources

The other fugitive dust sources are from construction and mining and quarrying activities. Construction sources are explained in section 4.8.2.5.1 and mining and quarrying methodology is detailed in section 4.8.2.5.2.

4.8.2.5.1 Construction Activities —

The PM-10 emissions for the years 1985 through 1992 were calculated from an emission factor, an estimate of the acres of land under construction, and the average duration of construction activity.²¹ The acres of land under construction were estimated from the dollars spent on construction.²² The PM-10 emission factor was calculated from the TSP emission factor for construction obtained from AP-42 and the PM-10/TSP ratio.¹³

The 1993 emissions were extrapolated from the 1992 emissions using the ratio between the numbers of residential and nonresidential construction permits issued in 1993 and the numbers issued in 1992.

The following AP-42 particulate emission factor equation for heavy construction was used to determine regional PM-10 emissions from construction activities for 1985-1992:

$$E = T \times \$ \times f \times m \times P$$

- where:
- E = PM-10 emissions
 - T = TSP emission factor (1.2 ton/acre of construction/month of activity)
 - \$ = dollars spent on construction (\$ million)
 - f = factor for converting dollars spent on construction to acres of construction (varies by type of construction, acres/\$ million)
 - m = months of activity (varies by type of construction)

P = dimensionless PM-10/TSP ratio (0.22).

4.8.2.5.1.1 Dollars spent on construction (\$). Estimates of the dollars spent on the various types of construction by EPA region for 1987 were obtained from the Census Bureau.²³ The fraction of total U.S. dollars spent in 1987 for each region for each construction type was calculated. Since values from the Census Bureau are only available every five years, the Census dollars spent for the United States for construction were normalized using estimates of the dollars spent on construction for the U.S. as estimated by the F.W. Dodge²² corporation for the other years. This normalized Census value was distributed by region and construction type using the above calculated fractions. An example of how this procedure was applied for SIC 1521 (general contractor, residential building: single family) follows:

$$\$_{1988,Region I,SIC 1521} \cdot \frac{\$_{1987,Nation,Census}}{\$_{1987,Nation,Dodge}} \times \$_{1988,Nation,Dodge} \times \frac{\$_{1987,Region 1,Census,SIC 1521}}{\$_{1987,Nation,Census,SIC 1521}}$$

where: \$ = dollar amount of construction spent
 1988 = year 1988
 1987 = year 1987
 Region I = U.S. EPA Region I
 SIC 1521 = Standard Industrial Code for general contractor, residential building; single family
 Nation = United States
 Census = Census Bureau
 Dodge = F.W. Dodge

4.8.2.5.1.2 Determination of construction acres (f). Information developed by Cowherd *et al.*²¹ determined that for different types of construction, the number of acres was proportional to dollars spent on that type construction. This information (proportioned to constant dollars using the method developed by Heisler²⁴) was utilized along with total construction receipts to determine the total number of acres of each construction type.

4.8.2.5.1.3 Months of construction (m). Estimates of the duration (in months) for each type construction were derived from Cowherd *et al.*²¹

4.8.2.5.1.4 PM-10/TSP Ratio (P). The PM-10/TSP ratio for construction activities was derived from Midwest Research Institute [MRI].¹³ In MRI's report, the data in Table 9, "Net Particulate Concentrations and Ratios" is cited from Kinsey *et al.*²⁵ That table included the ratios of PM-10/TSP for 19 test sites for three different construction activities. MRI suggests averaging the ratios for the construction activity of interest. Since Pechan was looking at total construction emissions from all sources, Pechan averaged the PM-10/TSP ratios for all test sites and construction activities.

4.8.2.5.1.5 County Distribution. Regional-level PM-10 estimates were distributed to the county-level using county estimates of payroll for construction (SICs 15, 16, 17) from County Business Patterns.²⁶ The following formula was used:

$$County\ Emissions \cdot \frac{County\ Construction\ Payroll}{Regional\ Construction\ Payroll} \times Regional\ Emissions$$

4.8.2.5.2 Mining and Quarrying —

The PM-10 emissions for the years 1985 through 1992 were the sum of the emissions from metallic ore, nonmetallic ore, and coal mining operations. The 1993 PM-10 emissions were produced through a linear projection of the emissions for the years 1985 through 1992.

PM-10 emissions estimates from mining and quarrying operations include only the following sources of emissions: 1) overburden removal, 2) drilling and blasting, 3) loading and unloading and 4) overburden replacement. Transfer and conveyance operations, crushing and screening operations and storage were not included. Travel on haul roads was also omitted. These operations were not included in order to be consistent with previous TSP emissions estimates from these sources (i.e., Evans and Cooper²⁷), because they represent activities necessary for ore processing, but not necessary for actual extraction of ore from the earth, and because these activities are the most likely to have some type of control implemented.

Pechan's emissions of mining and quarrying operations is a summation of three types of mining (metallic, non-metallic and coal) which are expressed in the following equation.

$$E = E_m \% E_n \% E_c$$

where: E = PM-10 emissions from mining and quarrying operations
 E_m = PM-10 emissions from metallic mining operations
 E_n = PM-10 emissions from non-metallic mining operations
 E_c = PM-10 emissions from coal mining operations

4.8.2.5.2.1 Determination of Correction Parameters. It was assumed that, for the four operations listed above, the TSP emission factors utilized in developing copper ore processing Emission Trends estimates applied to all metallic minerals. PM-10 emission factors were determined for each of the four operations listed above by making the following assumptions. Table 11.2.3-2 of AP-42⁸ was used to determine that 35% of overburden removal TSP emissions were PM-10. For drilling and blasting and truck dumping, 81% of the TSP emissions were assumed to be PM-10.²⁸ For loading operations, 43% of TSP emissions were assumed to be PM-10.²⁸

Non-metallic mineral emissions were calculated by assuming that the PM-10 emission factors for western surface coal mining²⁹ applied to all non-metallic minerals.

Coal mining includes two additional sources of PM-10 emissions compared to the sources considered for metallic and non-metallic minerals. The two additional sources are overburden replacement and truck loading and unloading of that overburden. Pechan assumed that tons of overburden was equal to ten times the tons of coal mined.²⁷

4.8.2.5.2.2 Activity Data. The regional metallic and non-metallic crude ore handled at surface mines for 1985 through 1992 were obtained from the U.S. Bureau of Mines.³⁰

The regional production figures for surface coal mining operations were obtained from the Coal Production Annual³¹ for 1985 through 1992.

4.8.2.5.2.2.1 Metallic Mining Operations. The following PM-10 emissions estimate equation calculates the emissions from overburden removal, drilling and blasting, and loading and unloading during metallic mining operations.

$$E_m = A_m \times EF_o \% B \times EF_b \% EF_l \% EF_d$$

where: A_m = metallic crude ore handled at surface mines (1000 short tons)
 EF_o = PM-10 open pit overburden removal emission factor for copper ore processing (lbs/ton)
 B = fraction of total ore production that is obtained by blasting at metallic mines
 EF_b = PM-10 drilling/blasting emission factor for copper ore processing (lbs/ton)
 EF_l = PM-10 loading emission factor for copper ore processing (lbs/ton)
 EF_d = PM-10 truck dumping emission factor for copper ore processing (lbs/ton)

4.8.2.5.2.2.2 Non-metallic Mining Operations. The following PM-10 emissions estimate equation calculates the emissions from overburden removal, drilling and blasting, and loading and unloading during non-metallic mining operations.

$$E_n = A_n \times EF_v \% D \times EF_r \% EF_a \% \frac{1}{2} \times EF_e \% EF_t$$

where: A_n = non-metallic crude ore handled at surface mines (1000 short tons)
 EF_v = PM-10 open pit overburden removal emission factor at western surface coal mining operations (lbs/ton)
 D = fraction of total ore production that is obtained by blasting at non-metallic mines
 EF_r = PM-10 drilling/blasting emission factor at western surface coal mining operations (lbs/ton)
 EF_a = PM-10 loading emission factor at western surface coal mining operations (lbs/ton)
 EF_e = PM-10 truck unloading: end dump-coal emission factor at western surface coal mining operations (lbs/ton)
 EF_t = PM-10 truck unloading: bottom dump-coal emission factor at western surface coal mining operations (lbs/ton)

4.8.2.5.2.2.3 Coal Mining. The following PM-10 emissions estimate equation calculates the emissions from overburden removal, drilling and blasting, loading and unloading and overburden replacement during coal mining operations.

$$E_c = A_c \times 10 \times EF_{to} \% EF_{or} \% EF_{dt} \% EF_v \% EF_r \% EF_a \% \frac{1}{2} \times EF_e \% EF_t$$

- where:
- A_c = coal production at surface mines (1000 short tons)
 - EF_{to} = PM-10 emission factor for truck loading overburden at western surface coal mining operations (lbs/ton of overburden)
 - EF_{or} = PM-10 emission factor for overburden replacement at western surface coal mining operations (lbs/ton of overburden)
 - EF_{dt} = PM-10 emission factors for truck unloading: bottom dump-overburden at western surface coal mining operations (lbs/ton of overburden)
 - EF_v = PM-10 open pit overburden removal emission factor at western surface coal mining operations (lbs/ton)
 - EF_r = PM-10 drilling/blasting emission factor at western surface coal mining operations (lbs/ton)
 - EF_a = PM-10 loading emission factor at western surface coal mining operations (lbs/ton)
 - EF_e = PM-10 truck unloading: end dump-coal emission factor at western surface coal mining operations (lbs/ton)
 - EF_t = PM-10 truck unloading: bottom dump-coal emission factor at western surface coal mining operations (lbs/ton)

4.8.2.5.2.3 1993 Emissions Methodology. For the year 1993 PM-10 emissions from mining and quarrying operations were projected based on linear regression of the previous 8 years. Pechan was unable to obtain regional metallic and non-metallic crude ore handled at surface mines for 1993. The Bureau of Mines publishes summary statistics on mining and quarrying with a one year delay.

4.8.2.5.2.4 County Distribution. Regional-level emissions were distributed equally among counties within each region.

$$\text{County Emissions} = \frac{1}{\text{Number of Counties in Region}} \times \text{Regional Emissions}$$

4.8.2.6 Grown Emissions

Point source fugitive dust sources in the 1985 NAPAP Emissions Inventory were wind erosion, unpaved roads, and paved roads. Emissions from these sources were grown from the 1985 NAPAP Emissions Inventory based on BEA earnings listed in tables 4.8-1. The cattle feedlot emissions estimated above were also grown from year to year but with a base year of 1990.

4.8.2.6.1 Emissions Calculations —

Base year controlled emissions are projected to the inventory year using the following formula:

$$CE_i = CE_{BY} \times (EG_i)$$

where: CE_i = Controlled Emissions for inventory year i
 CE_{BY} = Controlled Emissions for base year
 EG_i = Earnings Growth for inventory year i

Earnings growth (EG) is calculated as:

$$EG_i = 1 + \frac{DAT_i}{DAT_{BY}}$$

where: DAT_i = Earnings data for inventory year i
 DAT_{BY} = Earnings data in the base year

4.8.2.6.2. Growth Indicators, 1985-1989 and 1991 —

The changes in the point and area source emissions were equated with the changes in historic earnings by state and industry. Emissions from each point source in the 1985 NAPAP Emissions Inventory were projected to the years 1985 through 1991 based on the growth in earnings by industry (2-digit SIC code). Historical earnings data from BEA's Table SA-5³² were used to represent growth in earnings from 1985 through 1990. (Earnings data from a different BEA source, Table SQ-5 discussed below, were used to estimate 1991 emissions.) Table SA-5 historical annual earnings data are by state and industry.

The 1985 through 1990 earnings data in Table SA-5 are in nominal dollars. In order to be used to estimate growth, these values were converted to constant dollars to remove the effects of inflation. Earnings data for each year were converted to 1982 constant dollars using the implicit price deflator for personal consumption expenditures (PCE).³³ The PCE deflators used to convert each year's earnings data to 1982 dollars are:

<u>Year</u>	<u>1982 PCE Deflator</u>
1985	111.6
1987	114.8
1988	124.2
1989	129.6
1990	136.4

Several BEA categories did not contain a complete time series of data for the years 1985 through 1990. Because the SA-5 data must contain 1985 earnings and earnings for each inventory year (1985 through 1990) to be useful for estimating growth, a log linear regression equation was used to fill in missing data elements where possible. This regression procedure was performed on all categories that were missing at least one data point and which contained at least three data points in the time series.

Each record in the inventory was matched to the BEA earnings data based on the state and the 2-digit SIC. Table 4.8-1 shows the BEA earnings category used to project growth for each of the 2-digit SICs found in the 1985 NAPAP Emission Inventory. No growth in emissions was assumed for all point sources for which

the matching BEA earnings data were not complete. Table 4.8-1 also shows the national average growth and earnings by industry from Table SA-5.

At the time the Emission Trends inventory was compiled, 1991 BEA earnings data were not available in Table SA-5. Earnings data from BEA Table SQ-5³⁴ were used to estimate emissions for 1991. Table SQ-5 contains historical quarterly earnings data by state and 1-digit SIC. These data were converted to an annual constant dollars basis.

The 1991 quarterly earnings data were first summed to compute annual totals. Because the PCE deflator used to convert to constant 1982 dollars was not available for 1991, a 1987 PCE deflator³⁴ was used to convert the 1990 and 1991 earnings data from Table SQ-5 to a 1987 constant dollar basis. The PCE deflators are as follows:

<u>Year</u>	<u>1987 PCE Deflator</u>
1990	114.7
1991	119.3

The 1991 inventory was then developed by growing the 1990 inventory based on the changes in State industry earnings (by 1-digit SIC) from 1990 to 1991. National average growth in earnings by industry is shown below in Table 4.8-2.

4.8.2.6.3. Growth Indicators, 1992 and 1993 —

The 1992 and 1993 emissions for all pollutants were estimated by applying growth factors to the 1990 emissions using a modified version of equation 22. The growth factors were obtained from the prereleased E-GAS, version 2.0.³⁵ The E-GAS generates growth factors at the SCC-level for counties representative of all counties within each ozone nonattainment area classified as serious and above and for counties representative of all counties within both the attainment portions and the marginal and moderate nonattainment areas within each state. The appropriate growth factors were applied by county and SCC to the 1990 emissions as shown by equation 24.

$$Emissions_{(county, SCC, year)} = Growth_{(county, SCC, year)} \times Emissions_{(county, SCC, 1990)}$$

There are approximately 150 representative counties in E-GAS and 2000 SCCs present in the base year inventory. This yields a matrix of 300,000 growth factors generated to determine a single year's inventory. To list all combinations would be inappropriate.

4.8.3 References

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Table 4.8-1. Bureau of Economic Analysis's SA-5 National Changes in Earnings by Industry

Industry	SIC	Percent Growth from:			
		1985 to 1987	1987 to 1988	1988 to 1989	1989 to 1990
Farm	01, 02	14.67	-2.73	14.58	-3.11
Agricultural services, forestry, fisheries, and other	07, 08, 09	23.58	5.43	1.01	2.48
Coal mining	11, 12	-17.46	-6.37	-4.16	4.73
Metal mining	10	-3.03	18.01	8.94	4.56
Nonmetallic minerals, except fuels	14	2.33	3.74	-2.79	-0.45
Construction	15, 16, 17	7.27	4.81	-1.36	-3.80

Table 4.8-2. BEA SQ-5 National Growth In Earnings By Industry

Industry	Percent Growth from 1990 to 1991
Farm	-18.38
Agricultural services, forestry, fisheries, and other	-5.06
Coal mining	-0.75
Construction	-10.37

SECTION 5.0

LEAD EMISSIONS METHODOLOGY

5.1 INTRODUCTION

The methodology used to estimate the lead emissions presented in the *Trends* reports for the years 1940, 1950, 1960, and 1970 to 1993 was based on the 1940-1984 Methodology. This section describes, in detail, the procedures used to create these estimates.

5.1.1 Background

The lead emissions methodology was based on a "top-down" approach where national information was used to create a national inventory of lead emissions. The emissions were estimated based on the source of the emissions and, in the case of combustion sources, the fuel type. The national activity of a process producing lead emissions was measured by the consumption of fuel, the throughput of raw materials, or an alternative production indicator. An emission factor was then applied to activity data to determine the amount of lead emitted from a specific process. For some categories, the lead content of the fuel was incorporated into the estimating procedure as part of the emission factor. The final element used to estimate emissions was the control efficiency, which quantifies the amount of lead not emitted due to the presence of control devices.

The lead emissions were presented in the 1994 *Trends* report by Tier categories, but in the lead emissions methodology, emissions were estimated by a different set of source categories. The source categories or subcategories contributing to lead emissions were regrouped into the Tier categories. The estimation procedures are presented in this section by Tier 2 category. The correspondence between the Tier 2 categories and the lead emissions methodology source categories is presented in Table 5.1-1. Within the description of the procedures for each Tier 2 category, the correlation between the categories is reiterated.

5.1.2 General Procedure

Lead emissions were calculated according to the following general equation:

$$\text{Lead Emissions}_{i,j} = A_{i,j} \times EF_{i,j} \times [1 - CE_{i,j}]$$

where: A = activity
EF = emission factor
CE = control efficiency
i = year
j = source category

As an aid in the calculation of emissions by the lead methodology, two Excel spreadsheets were created for each year and are collectively referred to as the *Trends* spreadsheets. The spreadsheets were entitled TRENDSxx.XLS and MGTMPxx.XLS, where xx represents the year. The required data were entered into the TRENDSxx.XLS spreadsheet, after which the MGTMPxx.XLS spreadsheet was opened and the necessary calculations were made to estimate the national emissions. This procedure was designed to simplify the process of estimating emissions for a new year. By using the TRENDSxx.XLS spreadsheets from the previous year as templates, the spreadsheets for the new year were created by editing only the data requiring updating.

The calculations utilized within the TRENDSxx.XLS spreadsheets required specific units for the activity indicators and the emission factors. The required units are specified within the procedures for each Tier 2 category. In general, the units for activity indicators were short tons for solids, gallons for liquids, and cubic feet for gases. Emission factors were expressed in units of metric pounds of pollutant per unit consumption or throughput. Control efficiencies were expressed as a dimensionless decimal fraction. By using these units, the emissions calculated within the spreadsheets were expressed in metric tons. Raw data used as the basis for activity indicators or emission factors were often expressed in units which required conversion to the appropriate units. The following conversion factors were used in many cases.

1 ton (metric)	=	1.1016 tons (short)
1 ton (long)	=	1.12 tons (short)
1 ton (short)	=	0.9072 tons (metric)
1 lb (metric)	=	1.1016 lb
1 bbl	=	42 gal

The emission factors used to estimate lead emissions were based on the most recent information available. For many categories, the most recent emission factor was used to estimate the emissions for all years.

When the emissions were estimated for 1993, not all of the activity information was available. In order to make a preliminary emissions estimate, activity data from preceding years were used to estimate the activity data for 1993. This was done using several different methods. The first method used a quadratic equation and the past 20 years of activity data. The second method used a linear regression and the past 7 years of activity data. The third method, used in cases where the first method resulted in a negative activity value, calculated the average of the activity data over the past 5 years. Table 5.1-2 presents by general source category the method used to estimate activity data for generating 1993 emissions. For general source categories not listed, activity data for the current year were available at the time the emissions were estimated.

5.1.3 Organization of Procedures

The methodology used to estimate lead emissions is described by Tier 2 category except for the Highway Vehicles category which is described at the Tier 1 level. For each category, the procedure is divided into four sections, reflecting the data required to generate the estimates: (1) technical approach, (2) activity indicator, (3)

emission factor, and (4) control efficiency. The procedures for obtaining activity indicators, emission factors or control efficiencies are arranged in a variety of ways, depending on the specific requirements of the category. The procedures could be arranged by process, fuel type, or other subcategory.

References are provided at the end of the description of the procedure for each Tier 2 category. Many of the references are published annually as part of a series. In some cases, several references are provided for the same information, reflecting a change or discontinuation of one source and its replacement by another. The specific source used would depend on the specific year for which information is needed. All tables and supporting data immediately follow the description of the procedure for each Tier 2 category.

Table 5.1-1. Correspondence Between Tier 2 Categories and Lead Emissions Methodology Categories

Tier 1 Category	Tier 2 Category	Tier 1/Tier 2 Code	Lead Emissions Methodology Category	Lead Emissions Methodology Subcategory
Fuel Combustion - Electric Utilities	Coal	01-01	Bituminous Coal and Lignite	Electric Utilities
			Anthracite Coal	Electric Utilities
	Oil	01-02	Residual Oil	Electric Utilities
			Distillate Oil	Electric Utilities
Fuel Combustion - Industrial	Coal	02-01	Bituminous Coal and Lignite	Industrial
			Anthracite Coal	Industrial
	Oil	02-02	Residual Oil	Industrial
			Distillate Oil	Industrial
Fuel Combustion - Other	Commercial and Institutional Coal	03-01	Bituminous Coal and Lignite	Commercial and Institutional
			Anthracite Coal	Commercial and Institutional
	Commercial and Institutional Oil	03-02	Residual Oil	Commercial and Institutional
			Distillate Oil	Commercial and Institutional
	Miscellaneous Fuel Combustion (except residential)	03-04	Residual Oil	Waste Oil
Fuel Combustion - Other, cont.	Residential Other	03-06	Bituminous Coal and Lignite	Residential
			Anthracite Coal	Residential
			Residual Oil	Residential
			Distillate Oil	Residential
Chemical and Allied Product Manufacture	Inorganic Chemical Manufacturing	04-02	Industrial Processes	Secondary Metals (lead oxide/pigment)

Table 5.1-1. Correspondence Between Tier 2 Categories and Lead Emissions Methodology Categories

Tier 1 Category	Tier 2 Category	Tier 1/Tier 2 Code	Lead Emissions Methodology Category	Lead Emissions Methodology Subcategory
Metals Processing	Nonferrous	05-01	Industrial Processes	Nonferrous Metals (copper, zinc, and lead production) Secondary Metals (lead, copper, and battery production) Miscellaneous Process Sources [miscellaneous products (can soldering and cable covering)]
	Ferrous	05-02	Industrial Processes	Iron and Steel Industry Nonferrous Metals (ferroalloy production) Secondary Metals Industry (grey iron foundries)
	Not Elsewhere Classified	05-03	Industrial Processes	Mineral Products (ore crushing) Miscellaneous Process Sources [miscellaneous products (type metal production)]
Other Industrial Processes	Mineral Products	07-05	Industrial Processes	Mineral Products (cement manufacturing and glass production, lead-glass)
	Miscellaneous Industrial Processes	07-10	Industrial Processes	Miscellaneous Process Sources (lead alkyl production - electrolytic process, sodium lead alloy, and miscellaneous products (ammunition))
Waste Disposal and Recycling	Incineration	10-01	Solid Waste Disposal	Incineration
Highway Vehicles	All Categories (Light-Duty Gas Vehicles and Motorcycles, Light-Duty Gas Trucks, and Heavy-Duty Gas Vehicles)	11	Highway Vehicles	Gasoline (leaded and unleaded)
Off-Highway Vehicles	Nonroad Gasoline	12-01	Other Off-Highway	Gasoline
			Vessels	Gasoline

Table 5.1-2. Method Used for Estimating 1993 Activity Data

General Source Category	Activity Data Estimation Method
Off-Highway Vehicles	Quadratic equation method, except for motorcycles for which the 5-year average method is used
All Anthracite Coal Categories	Linear regression method
Fuel Combustion, excluding Electric Utilities	
Bituminous Coal	Linear regression method
Residual Oil	Quadratic equation method
Distillate Oil	Linear regression method, except for industrial sources for which the 5-year average method is used
Solid Waste	Quadratic equation method
Industrial Process Sources	Linear regression method

5.2 FUEL COMBUSTION ELECTRIC UTILITIES - COAL: 01-01

The emissions for this Tier 2 category were determined by the Lead Emissions Methodology for the following source categories:

Category:	Subcategory:
Bituminous Coal and Lignite	Electric Utilities
Anthracite Coal	Electric Utilities

5.2.1 Technical Approach

The lead emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator and an emissions factor. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million short tons for bituminous coal, and in thousand short tons for anthracite coal. Emission factors were expressed in metric pounds/thousand short tons.

The following procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1993.

5.2.2 Activity Indicator

The activity indicator for the combustion of coal at electric utilities was the anthracite coal receipts at electric utilities obtained from Reference 1a.

The activity indicator for the combustion of bituminous coal and lignite was calculated as the difference between the total national consumption of coal by electric utilities and the anthracite coal consumption at electric utilities as determined above. The total national consumption of coal was obtained from Reference 2 or Reference 3.

5.2.3 Emission Factor

The emission factors for the combustion of anthracite coal and of bituminous coal and lignite were obtained from Reference 4a.

5.2.4 Control Efficiency

No control efficiencies were applied to activity data to estimate emissions from the sources included in this Tier 2 category.

5.2.5 References

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 - a. Appendix E

5.3 FUEL COMBUSTION ELECTRIC UTILITIES - OIL: 01-02

The emissions for this Tier 2 category were determined by the Lead Emissions Methodology for the following source categories:

Category:	Subcategory:
Residual Oil	Electric Utilities
Distillate Oil	Electric Utilities

5.3.1 Technical Approach

The lead emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator and an emissions factor. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million gallons and emission factors were expressed in metric pounds/million gallons.

The following procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1993.

5.3.2 Activity Indicators

The activity indicators for the combustion of residual and distillate oils were the consumption of these fuel types by electric utilities. The distillate oil consumption was assumed to be equal to the "adjusted" distillate fuel oil sales to electric utilities obtained from Reference 1 or Reference 2. The residual fuel oil consumption was obtained from "adjusted" residual fuel sales in Reference 1. When this reference was unavailable, the residual oil consumption was calculated as the difference between the total oil consumption and the distillate oil consumption. The total annual oil consumption was obtained from Reference 3.

5.3.3 Emission Factors

The emission factors for the combustion of residual oil and of distillate oil by electric utilities were obtained from Reference 4a.

5.3.4 Control Efficiency

No control efficiencies were applied to activity data to estimate emissions from the sources included in this Tier 2 category.

5.3.5 References

1. *Fuel Oil and Kerosene Sales 19xx*. DOE/EIA-0535(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
2. *Petroleum Marketing Annual*. DOE/EIA-0389(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
3. *Electric Power Annual*. DOE/EOA-0348(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
4. *Compilation of Air Pollutant Emission Factors, Third Edition, Supplements 1 through 14, AP-42*. NTIS PB-275525. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1977.
 - (a) Appendix E

5.4 FUEL COMBUSTION INDUSTRIAL - COAL: 02-01

The emissions for this Tier 2 category were determined by the Lead Emissions Methodology for the following source categories:

Category:	Subcategory:
Anthracite Coal	Industrial
Bituminous Coal and Lignite	Industrial

5.4.1 Technical Approach

The lead emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator and an emissions factor. In order to utilize these values in the *Trends* spreadsheets, the activity indicators were expressed in million short tons for bituminous coal, and in thousand short tons for anthracite coal. The emission factors were expressed in metric pounds/thousand short tons.

The following procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1993.

5.4.2 Activity Indicator

The activity indicator for the industrial combustion of anthracite coal was the distribution of anthracite coal from Pennsylvania (i.e. District 24) obtained from Reference 1a under the category "Industrial Plants (except coke)."

The activity indicator for the combustion of bituminous coal and lignite was based on total national coal consumption obtained from Reference 2 under the category "Industrial Plants (except coke)." The sum of coal consumption by cement plants and lime plants was subtracted from the total coal consumption. The coal consumption by cement plants was obtained from Reference 3. The coal consumption by lime plants was estimated by multiplying the lime production value obtained from Reference 4 by the conversion factor, 0.1 tons coal/ton lime produced.

5.4.3 Emission Factors

The emission factors for the industrial combustion of anthracite coal and of bituminous coal and lignite were obtained from Reference 5a.

5.4.4 Control Efficiency

No control efficiencies were applied to activity data to estimate emissions from the sources included in this Tier 2 category.

5.4.5 References

1. *Coal Distribution January-December 19xx*. DOE/EIA-0125(xx/4Q). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
 - (a) table entitled "Domestic Distribution of U.S. Coal by Origin, Destination, and Consumer: January-December 19xx."
2. *Quarterly Coal Report: January - March*. DOE/EIA-0121(xx/1Q). Energy Information Administration, U.S. Department of Energy, Washington, DC. Quarterly.
3. *Minerals Industry Surveys, Cement*. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Monthly.
4. *Chemical and Engineering News, Facts and Figures Issue*. American Chemical Society, Washington, DC. Annual.
5. *Compilation of Air Pollutant Emission Factors, Third Edition, Supplements 1 through 14, AP-42*. NTIS PB-275525. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1977.
 - (a) Appendix E

5.5 FUEL COMBUSTION INDUSTRIAL - OIL: 02-02

The emissions for this Tier 2 category were determined by the Lead Emissions Methodology for the following source categories:

Category:	Subcategory:
Residual Oil	Industrial
Distillate Oil	Industrial

5.5.1 Technical Approach

The lead emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator and an emissions factor. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million gallons and emission factors were expressed in metric pounds/million gallons.

The following procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1993.

5.5.2 Activity Indicator

The activity indicator for industrial combustion of residual oil was based on the adjusted quantity of residual oil sales for industrial and oil company use obtained from Reference 1 or 2. The total of three statistics was subtracted from this value to obtain the activity indicator. The first statistic was two-thirds of the quantity of oil consumed by cement plants reported in Reference 3. The second statistic was the quantity of residual oil consumed by petroleum refineries reported in Reference 4a. The third statistic was the quantity of residual oil consumed by steel mills; this value was calculated by multiplying the quantity of raw steel production obtained from Reference 5, by $0.00738 * 10^6$ gal/ 10^3 ton steel. The conversion factor between the gallons of oil and the tons of steel was updated in 1982 based on Reference 6.

The activity indicator for industrial combustion of distillate oil was based on the adjusted quantity of distillate oil sales to industrial and oil companies obtained from Reference 1 or 2. The total of two statistics was subtracted from this value to obtain the activity indicator for distillate oil. The first statistic was one-third of the quantity of oil consumed by cement plants, expressed in gallons, reported in Reference 3. The second statistic was the quantity of distillate oil consumed by petroleum refineries, expressed in gallons, reported in Reference 4a.

5.5.3 Emission Factor

The lead emission factor for the industrial combustion of residual oil and of distillate oil were obtained from Reference 7a.

5.5.4 Control Efficiency

No control efficiencies were applied to activity data to estimate emissions from the sources included in this Tier 2 category.

5.5.5 References

1. *Petroleum Marketing Monthly*. DOE/EIA-0380(xx/01). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
2. *Fuel Oil and Kerosene Sales 19xx*. DOE/EIA-0535(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
3. *Minerals Industry Surveys, Cement*. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Monthly.
4. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
 - a. table entitled "Fuel Consumed at Refineries by PAD District."
5. *Survey of Current Business*. Bureau of Economic Analysis, U.S. Department of Commerce, Washington, DC.
 - a. table containing information on Metals and Manufactures
6. *Census of Manufactures (Fuels and Electric Energy Consumed)*. Bureau of the Census, U.S. Department of Commerce, Washington, DC. 1982.
7. *Compilation of Air Pollutant Emission Factors, Third Edition, Supplements 1 through 14, AP-42*. NTIS PB-275525. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1977.
 - (a) Appendix E

5.6 FUEL COMBUSTION OTHER - COMMERCIAL/INSTITUTIONAL COAL: 03-01

The emissions for this Tier 2 category were determined by the Lead Emissions Methodology for the following source categories:

Category:	Subcategory:
Anthracite Coal	Commercial / Institutional
Bituminous Coal and Lignite	Commercial / Institutional

5.6.1 Technical Approach

The lead emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator and an emissions factor. In order to utilize these values in the *Trends* spreadsheets, the activity indicators were expressed in million short tons for bituminous coal, and in thousand short tons for anthracite coal. The emission factors were expressed in metric pounds/thousand short tons.

The following procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1993.

5.6.2 Activity Indicator

The activity indicators for the combustion of anthracite and bituminous coal and lignite were the consumption of each coal type by commercial and institutional users. Determination of these activity indicators required activity data for both anthracite and bituminous residential coal combustion.

The commercial/institutional consumption of anthracite coal was obtained by subtracting the residential anthracite consumption from residential and commercial/institutional anthracite consumption. Residential and commercial/institutional consumption of anthracite coal was obtained from Reference 1a for District 24 only.

$$\text{Anthracite Coal}_{C/I} = \text{Anthracite Coal}_{R \text{ and } C/I} - \text{Anthracite Coal}_R$$

where: R = residential consumption
C / I = commercial/institutional consumption

Residential consumption of anthracite coal was determined by extrapolating the consumption of the previous year based on the change in the number of dwelling units in the Northeastern United States having coal as the

main fuel for space heating. Data concerning the number of dwelling units were obtained from Reference 2. The calculation of the residential anthracite coal consumption is summarized in the equation below.

$$\text{Anthracite Coal}_{R, i} = \text{Anthracite Coal}_{R, i\&1} \times \frac{\text{Dwelling Units}_i}{\text{Dwelling Units}_{i\&1}}$$

where: R = residential consumption
i = year under study

Commercial/institutional consumption of bituminous coal was obtained by subtracting the residential bituminous consumption from the residential and commercial/institutional bituminous consumption. Residential and commercial/institutional consumption of bituminous coal was calculated by subtracting residential and commercial/institutional consumption of anthracite coal from residential and commercial/institutional consumption of all types of coal. These two consumption values were obtained from Reference 1a and excluded coal from District 24 which represents anthracite coal consumption. This calculation is summarized in the equation below.

$$\text{Bituminous Coal}_{C/I} = (\text{All Coal}_{R \text{ and } C/I} \& \text{Anthracite Coal}_{R \text{ and } C/I}) \& \text{Bituminous Coal}_R$$

where: R = residential consumption
C / I = commercial/institutional consumption

The residential consumption of bituminous coal was determined by estimating the quantity of all coal consumed by all dwelling units using coal as the main fuel and subtracting from this value the residential consumption of anthracite coal calculated above. The quantity of all coal consumed was calculated using the number of dwelling units using coal as the main fuel for space heating obtained from Reference 3 and a factor estimating the average annual consumption of coal per dwelling unit. This calculation is summarized in the equation below.

$$\text{Bituminous Coal}_R = (\text{Dwelling Units} \times 6.73 \text{ tons burned /dwelling /year}) \& \text{Anthracite Coal}_R$$

where: R = residential consumption

5.6.3 Emission Factors

The emission factors for the commercial/institutional combustion of anthracite coal and of bituminous coal and lignite were obtained from Reference 3a.

5.6.4 Control Efficiency

No control efficiencies were applied to activity data to estimate emissions from the sources included in this Tier 2 category.

5.6.5 References

1. *Coal Distribution January-December 19xx*. DOE/EIA-0125(xx/4Q). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
 - (a) Table entitled "Domestic Distribution of U.S. Coal to the Residential and Commercial Sector by Origin."
2. *American Housing Survey, Current Housing Reports, Series H-150-83*. Bureau of the Census, U.S. Department of Commerce, Washington DC. Biennial.
3. *Compilation of Air Pollutant Emission Factors, Third Edition, Supplements 1 through 14, AP-42*. NTIS PB-275525. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1977.
 - (a) Appendix E

5.7 FUEL COMBUSTION OTHER - COMMERCIAL/INSTITUTIONAL OIL: 03-02

The emissions for this Tier 2 category were determined by the Lead Emissions Methodology for the following source categories:

Category:	Subcategory:
Residual Oil	Commercial / Institutional
Distillate Oil	Commercial / Institutional

5.7.1 Technical Approach

The lead emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator and an emissions factor. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million gallons and emission factors were expressed in metric pounds/million gallons.

The following procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1993.

5.7.2 Activity Indicator

The activity indicator for the commercial/institutional combustion of residual oil was the "adjusted" total quantity of residual oil sales for commercial and military use obtained from Reference 1 or Reference 2.

The activity indicator for the combustion of distillate oil was the "adjusted" total quantity of distillate oil sales for commercial and military use (not including military diesel fuel) obtained from Reference 1 or Reference 2.

5.7.3 Emission Factor

The emission factors for the commercial/institutional combustion of residual oil and of distillate oil were obtained from Reference 3a.

5.7.4 Control Efficiency

No control efficiencies were applied to activity data to estimate emissions from the sources included in this Tier 2 category.

5.7.5 References

1. *Petroleum Marketing Monthly*. DOE/EIA-0380(xx/01). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
2. *Fuel Oil and Kerosene Sales 19xx*. DOE/EIA-0535(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
3. *Compilation of Air Pollutant Emission Factors, Third Edition, Supplements 1 through 14, AP-42*. NTIS PB-275525. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1977.
 - (a) Appendix E

5.8 FUEL COMBUSTION OTHER - MISCELLANEOUS FUEL COMBUSTION (EXCEPT RESIDENTIAL): 03-04

The emissions for this Tier 2 category were determined by the Lead Emissions Methodology for the following source categories:

Category:	Subcategory:
Residual Oil	Waste Oil

5.8.1 Technical Approach

The lead emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator and an emissions factor. In order to utilize these values in the *Trends* spreadsheets, the activity indicator was expressed in million gallons and the emission factor was expressed in metric pounds/million gallons.

The following procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1993.

5.8.2 Activity Indicator

The activity indicator for the combustion of residual waste oil was assumed to be a constant annual consumption of 500×10^6 gallons of waste oil.

5.8.3 Emission Factor

The emission factor for the combustion of residual waste oil was calculated as 75 lb/1,000 gal multiplied by the average percentage of lead. It was assumed that the percentage of lead had a constant value of 0.5333 up to the year 1975; after which, it was assumed that the lead percentage steadily decreased. After 1984, the value has remained constant at 0.0213. The average lead percentage values are presented in Table 5.8-1.

5.8.4 Control Efficiency

No control efficiency was applied to activity data to estimate lead emissions from the combustion of waste oil.

5.8.5 References

None.

Table 5.8-1. Annual Percentage Lead Content

Year	Percent Lead
1975	0.5333
1976	0.4702
1977	0.407
1978	0.3439
1979	0.2807
1980	0.2176
1981	0.1545
1982	0.0913
1983	0.0282
1984	0.0213

5.9 FUEL COMBUSTION OTHER - RESIDENTIAL OTHER: 03-06

The emissions for this Tier 2 category were determined by the Lead Emissions Methodology for the following source categories:

Category:	Subcategory:
Anthracite Coal	Residential
Bituminous Coal and Lignite	Residential
Residual Oil	Residential
Distillate Oil	Residential

5.9.1 Technical Approach

The lead emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator and an emissions factor. In order to utilize these values in the *Trends* spreadsheets, the activity indicators were expressed in million tons for bituminous coal and in thousand tons for anthracite coal. The emission factors for these categories were expressed in metric pounds/thousand tons. Activity indicators for residual and distillate oils were expressed in million gallons and emission factors were expressed in metric pounds/million gallons.

The following procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1993.

5.9.2 Activity Indicator

The activity indicator for the residential combustion of anthracite coal was the residential consumption of anthracite coal. This value was determined by extrapolating the residential consumption of anthracite coal during the previous year based on the change in the number of dwelling units in the Northeastern United States having coal as the main fuel for space heating. Data concerning the number of dwelling units were obtained from Reference 1. The calculation of the residential anthracite coal consumption is summarized in the equation below.

$$Anthracite\ Coal_{R, i} = Anthracite\ Coal_{R, i\&1} \times \frac{Dwelling\ Units_i}{Dwelling\ Units_{i\&1}}$$

where: R = residential consumption
i = year under study

The activity indicator for the combustion of bituminous coal and lignite was the residential consumption of bituminous coal and lignite. This value was determined by estimating the quantity of all coal consumed by all dwelling units using coal as the main fuel and subtracting from this value the residential consumption of anthracite coal calculated above. The quantity of all coal consumed was calculated using the number of dwelling units using coal as the main fuel for space heating obtained from Reference 1 and a factor estimating the average annual consumption of coal per dwelling unit. This calculation is summarized in the equation below.

$$\text{Bituminous Coal}_R = (\text{Dwelling Units} \times 6.73 \text{ tons burned /dwelling/year}) - \text{Anthracite Coal}_R$$

where: R = residential consumption

The activity indicator for the residential combustion of residual oil was assumed to be zero. The activity indicator for the combustion of distillate oil was the sum of the "adjusted" sales (or deliveries) for residential use of distillate oil and for farm use of other distillates as reported in Reference 2 or Reference 3.

5.9.3 Emission Factors

The emission factor for the residential combustion of anthracite coal was obtained from Reference 4.

The emission factor for the combustion of bituminous coal and lignite and for distillate oil was obtained from Reference 5a.

No emission factor was required for the combustion of residual oil because the activity was assumed to be zero.

5.9.4 Control Efficiency

No control efficiencies were applied to activity data to estimate emissions from the sources included in this Tier 2 category.

5.9.5 References

1. *American Housing Survey, Current Housing Reports, Series H-150-83*. Bureau of the Census, U.S. Department of Commerce, Washington DC. Biennial.
2. *Petroleum Marketing Monthly*. DOE/EIA-0380(xx/01). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
3. *Fuel Oil and Kerosene Sales 19xx*. DOE/EIA-0535(xx). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
4. *Development of HATREMS Data Base and Emission Inventory Evaluation*. EPA-450/3-77-011. U.S. Environmental Protection Agency, Research Triangle Park, NC. April 1977.

5. *Compilation of Air Pollutant Emission Factors, Third Edition, Supplements 1 through 14, AP-42.* NTIS PB-275525. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1977.
 - a. Appendix E

5.10 CHEMICAL AND ALLIED PRODUCT MANUFACTURE - INORGANIC CHEMICAL MANUFACTURE: 04-02

The emissions for this Tier 2 category were determined by the Lead Emissions Methodology for the following source categories:

Category:

Industrial Processes - Pb Emissions

Subcategory:

Secondary Metals (lead oxide/pigment)

5.10.1 Technical Approach

The lead emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator and an emissions factor. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand tons and emission factors were expressed in metric pounds/tons.

The following procedures for determining activity indicators and emission factors were used for the years 1940, 1950, 1960, and 1970 through 1993.

5.10.2 Activity Indicator

Activity indicators for the of barton pot (litharge and leady oxide), red lead, and white lead were the respective quantities of each produced as reported in Reference 1.

5.10.3 Emission Factor

The lead emission factors for barton pot, red lead, and white lead were obtained from Reference 2a.

5.10.4 Control Efficiency

No control efficiencies were applied to activity data to estimate lead emissions from the sources included in this Tier 2 category.

5.10.5 References

1. *Minerals Yearbook*, Lead. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.
 - a. Table entitled "Production & Shipments of Lead Pigments and Oxides in the U.S."
2. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - a. Table 7.16-1

5.11 METALS PROCESSING - NONFERROUS: 05-01

The emissions for this Tier 2 category were determined by the Lead Emissions Methodology for the following source categories:

Category:	Subcategory:
Industrial Processes - Pb Emissions	Nonferrous Metals (copper, zinc, and lead production)
Industrial Processes - Pb Emissions	Secondary Metals (lead, copper, and battery production)
Industrial Processes - Pb Emissions	Miscellaneous Process Sources [miscellaneous products (can soldering and cable covering)]

5.11.1 Technical Approach

The lead emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emissions factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand tons and emission factors were expressed in metric pounds/tons. All control efficiencies were expressed as dimensionless fractions.

The following procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1993.

5.11.2 Activity Indicator

5.11.2.1 Nonferrous Metals

The activity indicator for copper roasting was based on the primary copper smelter production from domestic and foreign ores from Reference 1a. Copper smelter production was expressed in units of blister copper produced. It was assumed that of the 4 tons of copper concentrate/ton of blister, only half was roasted. Therefore, the amount of blister copper produced multiplied by 2 resulted in the activity indicator for the roasting process.

Activity indicators for copper smelting and converting were assumed to be equivalent. Activity data were calculated in the same manner as for the roasting process, except it was assumed that all of the blister copper produced was smelted and converted. Therefore, units of blister copper produced multiplied by 4 resulted in the activity indicators for the smelting and converting process.

Activity data for zinc sintering was based on the redistilled slab zinc production obtained from Reference 2a. The activity indicator for the horizontal retort process was assumed to be zero. The activity indicator for the vertical retort process was assigned the same value as used for zinc sintering.

The activity indicators for lead sintering, blast furnaces, and reverberatory furnaces were assumed to be equal to the primary refined lead production from domestic and foreign ores as listed in Reference 3.

5.11.2.2 Secondary Metals

Activity data for three copper-producing processes were obtained from Reference 1b. The production level of high-leaded tin bronze was used as the basis for high Pb (58%) activity. The production level of yellow brass was used as the basis for red-yellow brass (15%) activity. Other alloys (7%) activity was based on the production level of leaded red brass and semi-red brass.

Activity indicators for three lead-producing furnace types and fugitive lead processes were obtained from Reference 3. The pot furnace activity was estimated as 90 percent of the total consumption of lead scrap by all consumers obtained from Reference 3. The activity indicator for reverberatory furnaces was estimated by multiplying the total consumption of lead scrap by the ratio between the quantity of lead recovered as soft lead and the total lead recovered from scrap. The activity indicator for blast furnaces was estimated by multiplying the total consumption of lead scrap by the ratio between lead recovered as antimonial lead and the total lead recovered from scrap. Fugitive lead activity was assumed to be equal to the total quantity of lead recovered.

Battery production consists of five processes: (1) grid casting, (2) paste mixing, (3) lead oxide mill, (4) three process operations, and (5) lead reclamation furnace. The number of batteries produced was used as the activity indicator for each process. The total weight of lead used to produce storage batteries was obtained from Reference 3. This value was converted from metric tons to English units and was used to calculate the number of batteries produced, expressed in thousands of batteries, as shown in the equation below.

$$\text{Number of Batteries} = \frac{\text{Weight}_{Pb} \times 1.10231 \times 2,000 \text{ lb/ton}}{1,000 \times 26 \text{ lb/battery}}$$

The activity indicator for lead reclamation furnaces was 1 percent of the number of batteries produced as calculated above.

5.11.2.3 Miscellaneous Process Sources

The activity indicator for can soldering was the can soldering consumption as listed in Reference 3. The activity indicator for cable covering was based on the value for cable covering consumption, also obtained from Reference 3, which was multiplied by 10 to account for recycling.

5.11.3 Emission Factor

5.11.3.1 Nonferrous Metals

The emission factors for primary copper and lead smelting processes were obtained from References 4a and 4b, respectively. The emission factors for processes associated with primary zinc smelting were obtained from Reference 5a. Values for these emission factors were established as the midpoint of the emission factor ranges reported in the references cited.

5.11.3.2 Secondary Metals

The emission factors for secondary lead processing were obtained from Reference 5a. The emission factors for secondary copper processing were obtained from Reference 4c. Battery production emission factors were reported in Reference 4d.

5.11.3.3 Miscellaneous Process Sources

The emission factors for can soldering and can covering were obtained from Reference 4e.

5.11.4 Control Efficiency

5.11.4.1 Nonferrous Metals

The control efficiencies for all copper, zinc, and lead production processes for the years 1970 through 1993 were equivalent to the TSP control efficiencies for the same processes. The TSP control efficiencies were derived from Reference 6 or Reference 7 using the equation below.

$$CE = \frac{(UE \& AE)}{UE}$$

where: CE = control efficiency
UE = emissions before control
AE = emissions after control

For the years 1940, 1950, and 1960, the origin of the control efficiencies applied to the activity for these processes is currently unknown.

5.11.4.2 Secondary Metals

The control efficiencies for the secondary lead production processes were obtained from Reference 8.

5.11.4.3 Miscellaneous Process Sources

The control efficiencies for can soldering and cable covering were obtained from Reference 8.

5.11.5 References

1. *Minerals Yearbook*, Copper. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.
 - (a) Table entitled "Copper: World Smelter Production, by Country."
 - (b) Table entitled "Production of Secondary Copper & Copper Alloy Products in the U.S.," by item produced from scrap.
2. *Minerals Yearbook*, Zinc. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.
 - (a) Table entitled "Salient Zinc Statistics" (production of slab zinc from scrap).
3. *Minerals Yearbook*, Lead. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.
 - (a) Table entitled "U.S. Consumption of Lead, by Product".
4. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - (a) Table 7.3-10
 - (b) Table 7.6-1
 - (c) Table 7.9-1
 - (d) Table 7.15-1
 - (e) Table 7.17-1
5. *Compilation of Air Pollutant Emission Factors, Third Edition, Supplements 1 through 14, AP-42*. NTIS PB-275525. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1977.
 - (a) Appendix E
6. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
7. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
8. *Control Techniques for Lead Air Emissions, Volumes 1 and 2*. U.S. Environmental Protection Agency, Research Triangle Park, NC. December 1977.

5.12 METALS PROCESSING - FERROUS: 05-02

The emissions for this Tier 2 category were determined by the Lead Emissions Methodology for the following source categories:

Category:	Subcategory:
Industrial Processes - Pb Emissions	Iron and Steel Industry (coke, blast furnace, sintering, open hearth, BOF, and electric arc furnace)
Industrial Processes - Pb Emissions	Nonferrous Metals (ferroalloy production)
Industrial Processes - Pb Emissions	Secondary Metals Industry (grey iron foundries)

5.12.1 Technical Approach

The lead emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emissions factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators for all source categories, except those in the iron and steel industry, were expressed in thousand tons. For the iron and steel industry source categories, activity indicators were expressed in million tons. All emission factors were expressed in metric pounds/tons. All control efficiencies were expressed as dimensionless fractions.

The following procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1993.

5.12.2 Activity Indicator

5.12.2.1 Iron and Steel

The activity indicator for coke production was the oven production figure obtained from Reference 1a. The activity indicator for blast furnaces was the total pig iron production as reported in Reference 1b. This value included exports. The activity indicator for the windbox sintering process was the total production of pig iron obtained from Reference 2 or Reference 1.

The activity indicators for open hearth, basic oxygen, and electric arc furnaces were based on the total scrap and pig iron consumption. Reference 3 contained the total scrap and pig iron consumed by each furnace type by manufacturers of pig iron and raw steel and castings. The fraction of the combined quantity of scrap and pig iron consumed by each of the three furnace types was calculated. Total raw steel production reported in Reference 1b was multiplied by each fraction to obtain the raw steel production for each furnace type.

5.12.2.2 Nonferrous Metals

The activity indicator for ferrosilicon production was the net gross weight production obtained from Reference 4a. Silicon manganese activity was assumed to be 42.1 percent of the net production of ferrosilicon. Production of ferromanganese by electric furnaces was assumed to be 57.9 percent of the net production of ferrosilicon. Production of silicon metal was obtained from Reference 5a. For ferromanganese from blast furnaces and for Ferro-Mang (std), the activity indicators were assumed to be zero.

Ferrochrome-silicon activity was obtained from Reference 4a or 6, and activity data for High Carbon Ferro production was obtained from Reference 4a or 7. If these data were not available, values for the previous year were used.

5.12.2.3 Secondary Metals

The activity indicator for cupola furnaces in grey iron foundries was based on the combined quantity of scrap and pig iron consumed by cupola furnaces. This value was obtained from Reference 3a under the category of iron foundries and miscellaneous users. The final activity was determined by adjusting this production value to account for this category's respective emission factor, which was expressed in terms of the charged quantity, and not the fresh feed quantity. This adjustment required dividing the production value by 0.78.

The activity indicator for electric induction was based on the combined quantity of iron and steel scrap and pig iron consumed in electric furnaces. This value was obtained from Reference 3a under the category of iron foundries and miscellaneous users. The amount consumed was adjusted to account for recycling by dividing the consumption value by 0.78.

5.12.3 Emission Factor

5.12.3.1 Iron and Steel

The emission factors for all processes were obtained from Reference 8a. The emission factor used for by-product coke was the same as that established for metallurgical coke manufacturing.

5.12.3.2 Nonferrous Metals

The emission factors for all processes were set equal to the midpoint of the emission factor ranges reported in Reference 9a.

5.12.3.3 Secondary Metals - Grey Iron Foundries

The emission factors for all processes were reported in Reference 9b.

5.12.4 Control Efficiency

The control efficiencies for all processes included in this Tier 2 category for the years 1970 through 1993 were equivalent to the TSP control efficiencies for the same processes. The TSP control efficiencies were derived from Reference 10 or Reference 11 using the equation below.

$$CE = \frac{(UE \& AE)}{UE}$$

where: CE = control efficiency
UE = emissions before control
AE = emissions after control

For the years 1940, 1950, and 1960 the origin of the control efficiencies applied to the activity for these processes are unknown.

5.12.5 References

1. *Survey of Current Business*. Bureau of Economic Analysis, U.S. Department of Commerce, Washington, DC.
 - (a) Table containing information on "Petroleum, Coal, and Products." SCC = 3-03-003
 - (b) Table containing information on "Metals and Manufactures."
2. *Minerals Industry Surveys, Iron Ores*. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Monthly.
3. *Minerals Industry Surveys, Iron and Steel Scrap*. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Monthly.
 - (a) Table on consumption of iron and steel scrap and pig iron in the United States by type of furnace or other use.
4. *Minerals Yearbook, Ferroalloys*. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.
 - (a) Table entitled "Table 2. Ferroalloys Produced and Shipped from Furnaces in the U.S."
5. *Minerals Yearbook, Silicon*. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.
 - (a) "Table 1. Production, Shipments, and Stocks of ... and Silicon Metal in the U.S. in 19xx"
6. *Minerals Yearbook, Chromium*. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.

7. *Minerals Yearbook, Iron and Steel*. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.
8. *Compilation of Air Pollutant Emission Factors, Third Edition, Supplements 1 through 14, AP-42*. NTIS PB-275525. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1977.
 - (a) Appendix E
9. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - (a) Table 7.4-5
 - (b) Table 7.10-3
10. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
11. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

5.13 METALS PROCESSING - NOT ELSEWHERE CLASSIFIED: 05-03

The emissions for this Tier 2 category were determined by the Lead Emissions Methodology for the following source categories:

Category:	Subcategory:
Industrial Processes - Pb Emissions	Mineral Products (ore crushing)
Industrial Processes - Pb Emissions	Miscellaneous Process Sources [miscellaneous products (type metal production)]

5.13.1 Technical Approach

The lead emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emissions factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand tons and emission factors were expressed in metric pounds/tons. All control efficiencies were expressed as dimensionless fractions.

The following procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1993.

5.13.2 Activity Indicator

The activity indicator for lead ore production was the gross weight of lead ore produced on a dry weight basis as reported in Reference 1. The activity indicator for Zn, Cu, Cu-Zn ores was estimated as the sum of the "ore produced" listed in Reference 2a, and "all other sources" listed in Reference 1a. The activity data for Pb-Zn, Cu-Pb, Cu-Pb-Zn ores was assumed to be zero.

The activity indicator for type metal production was based on the consumption of lead for type metal production obtained from Reference 1. In accordance with procedures provided in Reference 3, this value was multiplied by 330 to account for recycling.

5.13.3 Emission Factor

The emission factors for ore crushing and grinding processes were obtained from Reference 4a. The emission factors for type metal production were obtained from Reference 4b.

5.13.4 Control Efficiency

The control efficiencies for ore crushing and grinding processes and type metal production were obtained from Reference 3. No control efficiencies were applied to the activity data to estimate emissions from type metal production.

5.13.5 References

1. *Minerals Yearbook*, Lead. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.
 - (a) Table entitled "Production of Lead and Zinc in Terms of Recoverable Metals, in U.S. in 19xx, by State."
2. *Minerals Yearbook*, Copper. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.
 - (a) Table entitled "Salient Copper Statistics."
3. *Control Techniques for Lead Air Emissions, Volumes 1 and 2*. U.S. Environmental Protection Agency, Research Triangle Park, NC. December 1977.
4. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - (a) Table 7.6-1
 - (b) Table 7.17-1

5.14 OTHER INDUSTRIAL PROCESSES - MINERAL PRODUCTS: 07-05

The emissions for this Tier 2 category were determined by the Lead Emissions Methodology for the following source categories:

Category:

Industrial Processes - Pb Emissions

Subcategory:

Mineral Products [Cement Manufacturing (wet kiln/cooler, wet dryer/grinder, dry kiln/cooler and dry dryer/grinder) and Glass Production (lead-glass)]

5.14.1 Technical Approach

The lead emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emissions factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand tons and emission factors were expressed in metric pounds/tons. All control efficiencies were expressed as dimensionless fractions.

The following procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1993.

5.14.2 Activity Indicator

The activity indicators for wet kiln/cooler and wet dryer/grinder used in cement manufacturing were assumed to be equal. The value used was the sum of two categories: "wet" clinker produced and "both" clinker produced, reported in Reference 1a. The activity indicators for dry kiln/cooler and dry dryer/grinder were both estimated to be the sum of "dry" clinker produced and "both" clinker produced, as reported in Reference 1a. The activity indicator for lead-glass production was assumed to be zero.

5.14.3 Emission Factor

The emission factors for cement manufacturing processes were obtained from Reference 2a. The emission factor for glass production was obtained from Reference 2b.

5.14.4 Control Efficiency

The control efficiencies for the wet and dry kiln/cooler used in cement manufacturing for the years 1970 through 1993 were equivalent to the TSP control efficiencies for kilns. The control efficiencies for the wet and dry dryer/grinders for the years 1970 through 1993 were equivalent to the TSP control efficiencies for grinders. These TSP control efficiencies were derived from Reference 3 or Reference 4 using the equation below.

$$CE = \frac{(UE \& AE)}{UE}$$

where: CE = control efficiency
 UE = emissions before control
 AE = emissions after control

For the years 1940, 1950, and 1960 the origin of the control efficiencies applied to the activity for these processes is currently unknown.

No control efficiencies were applied to activity data to estimate emissions from lead-glass production.

5.14.5 References

1. *Minerals Industry Surveys, Cement*. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Monthly.
 - (a) Table entitled "Clinker Produced and Fuel Consumed by the Portland Cement Industry."
2. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - (a) Table 8.6-1
 - (b) Table 8.13-1
3. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
4. *Standard Computer Retrievals, NE257 report, from the National Emissions Data System (NEDS)*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.

5.15 OTHER INDUSTRIAL PROCESSES - MISCELLANEOUS INDUSTRIAL PRODUCTS: 07-10

The emissions for this Tier 2 category were determined by the Lead Emissions Methodology for the following source categories:

Category:

Industrial Processes - Pb Emissions

Subcategory:

Miscellaneous Process Sources [Lead Alkyl Production (electrolytic process), Sodium Lead Alloy (recovery furnace, TEL process vents, TML process vents, and sludge pits), and Miscellaneous Products (ammunition)]

5.15.1 Technical Approach

The lead emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator, emissions factor, and control efficiency, where applicable. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in thousand tons and emission factors were expressed in metric pounds/tons. All control efficiencies were expressed as dimensionless fractions.

The following procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1993.

5.15.2 Activity Indicator

The activity indicator for lead alkyl production by the electrolytic process was based on the quantity of lead consumed in anti-knock manufacturing obtained from Reference 1a. This quantity of lead was converted to a quantity of additive by multiplying by 1.76. The activity indicator for this category was assumed to be 10 percent of the quantity of additive consumed based on Reference 2.

The activity indicator for sodium lead alloy production processes was based on the remaining 90 percent of the quantity of additive consumed as determined above for lead alkyl production. The activity for recovery furnaces and sludge pits was assumed to be equal to the remaining quantity of additive. The activity of TEL process vents and TML process vents was 63 percent and 37 percent, respectively, of the remaining quantity of additive. These apportionments were based on Reference 2.

The activity indicator for ammunition production was the sum of lead consumption for the following uses: (1) caulking lead (building construction), (2) total pipes, traps, and other extruded products, (3) total sheet lead, and (4) other metal products. The consumption information was obtained from Reference 1.

5.15.3 Emission Factor

The emission factors for lead alkyl and sodium lead alloy production processes were obtained from Reference 3a. The emission factors for ammunition production were obtained from Reference 3b.

5.15.4 Control Efficiency

The control efficiencies for ammunition production were obtained from Reference 2. No control efficiencies were applied to estimate emissions from the other sources included in this Tier 2 category.

5.15.5 References

1. *Minerals Yearbook, Lead*. Bureau of Mines, U.S. Department of the Interior, Washington, DC. Annual.
 - (a) Table entitled "U.S. Consumption of Lead, by Product."
2. *Control Techniques for Lead Air Emissions, Volumes 1 and 2*. U.S. Environmental Protection Agency, Research Triangle Park, NC. December 1977.
3. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - (a) Table 5.22-1
 - (b) Table 7.17-1

5.16 WASTE DISPOSAL AND RECYCLING - INCINERATION: 10-01

The emissions for this Tier 2 category were determined by the Lead Emissions Methodology for the following source categories:

Category:	Subcategory:
Solid Waste Disposal	Incineration (Municipal, Residential, Commercial/Institutional, and Conical Woodwaste)

5.16.1 Technical Approach

The lead emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator and an emissions factor. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million tons and emission factors were expressed in metric pounds/thousand tons.

The following procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1993.

5.16.2 Activity Indicator

The activity indicator for municipal incineration was the sum of the operating rates for the SCCs 5-01-001-01 and 5-01-001-02 obtained from Reference 1 or 2.

The activity indicator for residential incineration was the operating rate for residential on-site incineration obtained from Reference 3.

Commercial/industrial incineration was based on the sum of the operating rates provided in Reference 1 or 2 for the following SCCs: 5-02-001-01, 5-02-001-02, 5-03-001-01, and 5-03-001-02. The previous year's activity data reported in the *Trends* spreadsheet was scaled based on the ratio of the total operating rate for the current year to the total for the previous year.

$$A_i = A_{i&1} \times \left(\frac{\sum_{SCCs} OR_i}{\sum_{SCCs} OR_{i&1}} \right)$$

where: A = activity indicator
 i = year
 OR = operating rates for SCCs 5-02-001-01, 5-02-001-02, 5-03-001-01, and 5-03-001-02

The activity indicator for conical woodwaste incineration was the sum of the operating rates for the SCCs 5-02-001-05 and 5-03-001-05 obtained from Reference 1 or 2.

5.16.3 Emission Factor

The emission factors for municipal, residential, and commercial/institutional incineration were obtained from Reference 4a or Reference 5a.

The emission factor for conical woodwaste incineration (SCC 5-02-001-05) was assumed to be zero.

5.16.4 Control Efficiency

The control efficiency associated with municipal incineration was obtained from Reference 1 or 2 for SCC 5-01-001.

No control efficiencies were applied to the activity data to estimate emissions from the remaining types of incineration (i.e., residential, commercial/institutional, and conical woodwaste).

5.16.5 References

1. *Standard Computer Retrievals, AFP650 report, from the AIRS Facility Subsystem*. Unpublished computer reports. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. Annual.
2. *Computer Retrieval, NE257 report, by Source Classification Code (SCC) from the National Emission Data System (NEDS)*. Unpublished computer report. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. February 9, 1980.
3. *Computer Retrieval, NE260 report, by Source Classification Code (SCC) from the National Emission Data System (NEDS)*. Unpublished computer report. National Air Data Branch, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC. February 9, 1980.
4. *Compilation of Air Pollutant Emission Factors, Fourth Edition, Supplements A through D, AP-42*. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1991.
 - (a) Table 2.1-1.
5. *Compilation of Air Pollutant Emission Factors, Third Edition, Supplements 1 through 14, AP-42*. NTIS PB-275525. U.S. Environmental Protection Agency, Research Triangle Park, NC. September 1977.
 - (a) Appendix E

5.17 HIGHWAY VEHICLES: 11

The emissions for all Tier 2 categories under this Tier 1 category were determined by the Lead Emissions Methodology for the following source categories:

Category:	Subcategory:
Highway Vehicles	Gasoline (leaded, unleaded)

5.17.1 Technical Approach

The lead emissions included in these Tier 2 categories were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator and an emissions factor. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million gallons and emission factors were expressed in metric pounds/gallons. The total lead emissions for the Tier 1 category were allocated to the Tier 2 categories by the relative fraction of vehicle miles traveled (VMT) for the appropriate vehicle types.

The following procedures for determining activity indicators, emission factors, and allocation to the Tier 2 categories were used for the years 1940 through 1993.

5.17.2 Activity Indicator

The activity indicator for highway vehicles was the gasoline consumption by all highway vehicles as reported in Reference 1. If this consumption value was not available, the previous year's consumption was adjusted based on the vehicle miles travelled (VMT) using the following equation:

$$GC_i = GC_{i-1} \times \frac{VMT_i}{VMT_{i-1}}$$

where: GC = total gasoline consumption by all highway vehicles
i = year of interest
VMT = vehicle miles traveled

The percentage of total unleaded gasoline was obtained from Reference 2a, and this value was applied to the total consumption of gasoline, resulting in unleaded gasoline use. This procedure was repeated to obtain leaded gasoline activity.

5.17.3 Emission Factor

The lead emission factors for highway vehicles were reported in Reference 3 to be 1.65(Y) lb/ton, where Y is the number of grams of lead/gasoline. The value of Y was obtained from Reference 4.

5.17.4 Control Efficiency

No control efficiencies were applied to activity data to estimate emissions from highway vehicles.

5.17.5 Allocation of Emissions to the Tier 2 Categories

The total lead emissions were the sum of the emissions from leaded gasoline and from unleaded gasoline. Lead emissions from these two types of gasolines were calculated by multiplying the activity indicator by the emission factor. In order to allocate the total lead emissions to the Tier 2 categories, the relative fraction of the VMT for each of the three vehicle classifications was determined. The VMT data for this purpose were obtained from a variety of sources. Relative VMT fractions used for the years 1940 through 1993 for each of the vehicle classifications are given in Table 5.17-1.

5.17.6 References

1. *Highway Statistics*. Federal Highway Administration, U.S. Department of Transportation. Washington, DC. Annual.
2. *Petroleum Supply Annual*. DOE/EIA-0340(xx/07). Energy Information Administration, U.S. Department of Energy, Washington, DC. Annual.
 - a. Table entitled "Finished Motor Gasoline Supply and Disposition."
3. *Control Techniques for Lead Air Emissions, Volumes 1 and 2*. U.S. Environmental Protection Agency, Research Triangle Park, NC. December 1977.
4. Gray, C.L. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency. "Transmittal of Revised Lead Mobile Source Emission Factors." Internal Memorandum to D. Tyler.

Table 5.17-1. Relative VMT Fractions for Each Tier 2 Category

Year	Light-Duty Gas Vehicles and Motorcycles	Light-Duty Gas Trucks	Heavy-Duty Gas Trucks
1940	0.83	0.11	0.07
1950	0.80	0.12	0.08
1960	0.83	0.10	0.06
1970	0.83	0.13	0.04
1971	0.83	0.13	0.03
1972	0.82	0.14	0.03
1973	0.82	0.14	0.03
1974	0.82	0.15	0.03
1975	0.82	0.15	0.03
1976	0.81	0.16	0.03
1977	0.80	0.17	0.03
1978	0.80	0.17	0.03
1979	0.79	0.18	0.03
1980	0.78	0.19	0.03
1981	0.76	0.21	0.03
1982	0.79	0.19	0.02
1983	0.78	0.20	0.02
1984	0.77	0.21	0.02
1985	0.76	0.22	0.02
1986	0.75	0.23	0.02
1987	0.74	0.24	0.02
1988	0.75	0.24	0.02
1989	0.75	0.24	0.02
1990	0.75	0.24	0.02
1991	0.75	0.24	0.01
1992	0.75	0.24	0.01
1993	0.75	0.24	0.01

5.18 OFF-HIGHWAY - NONROAD GASOLINE: 12-01

The emissions for this Tier 2 category were determined by the Lead Emissions Methodology for the following source categories:

Category:	Subcategory:
Other Off-Highway	Gasoline (Farm Tractors, Other Farm Equipment, construction, Snowmobiles, Small Utility Engines, Heavy Duty General Utility Engines, Motorcycles)
Vessels	Gasoline

5.18.1 Technical Approach

The lead emissions included in this Tier category were the sum of the emissions from the source categories listed above. Emissions were estimated from an activity indicator and an emissions factor. In order to utilize these values in the *Trends* spreadsheets, activity indicators were expressed in million gallons and emission factors were expressed in metric pounds/thousand gallons.

The following procedures for determining activity indicators, emission factors, and applicable control efficiencies were used for the years 1940, 1950, 1960, and 1970 through 1993.

5.18.2 Activity Indicator

The activity indicator for gasoline-powered farm tractors was based on the 1973 gasoline consumption by farm tractors reported in Reference 1. The adjustment factor applied to the 1973 data was the ratio of the quantity of gasoline consumed by all agricultural equipment in 1973 and in the year under study as reported in Reference 2a. It is assumed that this procedure was used for the years both before 1973 and after 1973. The following formula summarizes this procedure.

$$GC_{Tractor, i} = GC_{Tractor, 1973} \times \frac{GC_{Agriculture, i}}{GC_{Agriculture, 1973}}$$

where: GC = gasoline consumption
 i = year under study

The activity indicator for other gasoline-powered farm equipment was also based on gasoline consumption. It was assumed that the gasoline consumption by other farm equipment was equivalent to 8.52 percent of the quantity of gasoline consumed by farm tractors as determined by the preceding procedure.

The activity indicator for gasoline-powered construction equipment was the total gasoline consumption by construction equipment as reported in Reference 2.

Activity data for snowmobiles were based on the 1973 gasoline consumption by snowmobiles, as reported in Reference 1. An adjustment factor was applied to the 1973 value to account for the ratio of the number of snowmobile registrations in 1973 and in the year under study as reported in Reference 3. It is assumed that this procedure was used for the years both before 1973 and after 1973. The following formula summarizes this procedure.

$$GC_{Snowmobiles, i} = GC_{Snowmobiles, 1973} \times \frac{N_{Snowmobiles, i}}{N_{Snowmobiles, 1973}}$$

where: GC = gasoline consumption
 i = year under study
 N = number of registered vehicles

Activity data for small utility gasoline engines was based on the 1980 value for gasoline consumption by small engines (533 x 10⁶ gallons). An adjustment factor was applied to the 1980 data to account for the ratio of the number of single unit dwellings in 1980 and in the year under study. The number of single unit dwellings in 1980 was obtained from Reference 4. For the year under study, the number of single unit dwellings was estimated by adding or subtracting the number of new one-family structures started each year between 1980 and the year under study to the number of single unit dwellings in 1980. The number of new one-family structures started was obtained from Reference 5 for each year. It is assumed that this procedure was used for the years both before 1973 and after 1973. The following formula summarizes this procedure.

$$GC_{Small\ Engines, i} = 533 \times 10^6 \text{ gal} \times \frac{Single\ Unit\ Dwellings_i}{Single\ Unit\ Dwellings_{1980}}$$

where: GC = gasoline consumption
 i = year under study

The activity indicator for heavy duty general gasoline utility engines was the total gasoline consumed by the industrial/commercial category obtained from Reference 2.

The activity indicator for motorcycles was calculated from the number of motorcycles, the average annual off-highway mileage traveled, and the median estimated average miles per gallon. The motorcycle population

and the off-highway mileage were obtained from Reference 6. The average miles per gallon (MPG) was assumed to be 44.0 miles/gallon. The following equation summarizes this calculation.

$$GC_{Motorcycles} = N_{Motorcycles} \times \frac{M_{Motorcycles, Off\&highway}}{MPG}$$

where: GC = gasoline consumption
 N = number of motorcycles
 M = mileage
 MPG = miles/gallon

The activity indicator for gasoline-powered vessels was the total quantity of gasoline consumed by the marine sector (private and commercial) from Reference 2.

5.18.3 Emission Factor

The lead emission factor for the combustion of gasoline in off-highway vehicles was reported in Reference 7 to be 1.65(Y) lb/ton, where Y is the number of grams of lead/gasoline. It was assumed that all gasoline used for these engines was leaded. The value of Y was obtained from Reference 8.

5.18.4 Control Efficiency

No control efficiencies were applied to activity data to estimate emissions from off-highway vehicles.

5.18.5 References

1. *Exhaust Emissions from Uncontrolled Vehicles and Related Equipment Using Internal Combustion Engines*. U.S. Environmental Protection Agency. Prepared by Southwest Research Institute, San Antonio, TX, under Contract No. EHS-70-108. October 1973.
2. *Highway Statistics*. Federal Highway Administration, U.S. Department of Transportation, Washington, DC. Annual.
 (a) Table MF-24
3. International Snowmobile Industry Association, 7535 Little River Turnpike, Suite 330, Annandale, VA.
4. *American Housing Survey, Current Housing Reports, Series H-150-83*. Bureau of the Census, U.S. Department of Commerce, Washington DC. Biennial.
5. *Survey of Current Business*. Bureau of Economic Analysis, U.S. Department of Commerce, Washington, DC.
6. *19xx Motorcycle Statistical Annual*. Motorcycle Industry Council, Inc., Costa Mesa, CA. Annual.

7. *Control Techniques for Lead Air Emissions, Volumes 1 and 2.* U.S. Environmental Protection Agency, Research Triangle Park, NC. December 1977.
8. Gray, C.L. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency. "Transmittal of Revised Lead Mobile Source Emission Factors." Internal Memorandum to D. Tyler.