

1990 EMISSIONS INVENTORY OF SECTION 112(c)(6) POLLUTANTS:

**POLYCYCLIC ORGANIC MATTER (POM),
2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN (TCDD)/
2,3,7,8-TETRACHLORODIBENZOFURAN (TCDF),
POLYCHLORINATED BIPHENYL COMPOUNDS (PCBs),
HEXACHLOROBENZENE, MERCURY, AND
ALKYLATED LEAD**

Final Report

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1.0 INTRODUCTION

1.1 Background and Purpose

Section 112(c)(6) of the Clean Air Act Amendments (CAAA) of 1990 prescribes the following regulatory program for seven specific pollutants:

With respect to alkylated lead compounds, polycyclic organic matter, hexachlorobenzene, mercury, polychlorinated biphenyls, 2,3,7,8-tetrachlorodibenzofurans and 2,3,7,8-tetrachlorodibenzo-p-dioxin, the Administrator shall, not later than 5 years after the date of enactment of the Clean Air Act Amendments of 1990, list categories and subcategories of sources assuring that sources accounting for not less than 90 per centum of the aggregate emissions of each such pollutant are subject to standards under subsection (d)(2) or (d)(4). Such standards shall be promulgated not later than 10 years after such date of enactment. This paragraph shall not be construed to require the Administrator to promulgate standards for such pollutants emitted by electric utility steam generating units."

In order to meet the requirements of Section 112(c)(6), national inventories of sources and emissions of these seven specific pollutants are needed. These inventories will provide the reference basis for the development of a national strategy to control the Section 112(c)(6) pollutants. These same national inventories will prove equally useful as input to the urban area source program pursuant to Section 112(k) of the CAAA, should any of these pollutants also be selected under that program as presenting a threat to public health in urban areas. Because the seven specific pollutants in Section 112(c)(6) are of particular interest to the Great Waters program, these inventories will also prove useful in the context of implementing Section 112(m), dealing with the protection of the Great Lakes and coastal estuaries.

The purpose of this report is to present the results of a national inventory of the seven specific Section 112(c)(6) pollutants: polycyclic organic matter (POM), polychlorinated biphenyls (PCB), 2,3,7,8-tetrachlorodibenzofuran (2,3,7,8-TCDF),

2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD), hexachlorobenzene (HCB), mercury, and alkylated lead.

Readers should be aware that the definition of POM used for the purposes of this Section 112(c)(6) emissions inventory is not the same as the POM definition contained in the Clean Air Act. The POM definition in Section 112(b) of the Act, which is currently under review by EPA, is based on chemical and structural principles of the subject compounds. This type of definition leads to there being possibly thousands of compounds that could qualify as POM. From a practical standpoint, it would not be feasible to inventory all of these potential POM species from all sources. Instead, EPA has opted for a different approach in which specific groups of POM compounds have been listed as surrogates and these groups constitute "POM" for the purposes of this inventory. Two groups have been used, one consisting of 7 POM compounds and one consisting of 16 species. In addition, a third approach is also presented in which POM mixtures have been approximated by using the extractable organic matter (EOM) fraction of particulate matter samples. The use of the EOM approach is limited in that data do not exist for many source categories. A more detailed and thorough discussion of the POM definitions and the methods used for this inventory are presented in Chapter 3.0, Sections 3.1 and 3.2.

The base year for each inventory was selected by EPA to be 1990. A 1990 base year was used because this was the year the most recent Clean Air Act amendments were enacted and the 112(c)(6) requirements came into force. Hence, to the extent practicable, emissions, activity, and control information are presented for 1990 rather than for the present. Any subsequent emission reductions to meet the requirements of Section 112(c)(6) are thus credited with respect to 1990 base year levels. In a limited number of cases, 1990 base year emission estimate data were not available (either emissions or source activity or both) and therefore, a different base year (as close to 1990 as the data would allow) had to be used. These cases can be determined from the inventory documentation.

For several of the source categories presented in this inventory, 112(c)(6) pollutant emissions from 1990 to the present have been significantly reduced due to the development and promulgation of various National Emission Standards for Hazardous Air Pollutants (NESHAPs), which contain Maximum Achievable Control Technology (MACT) requirements. Therefore, for some source categories, the 1990 emission inventory estimates shown in this document are not representative of current emissions due to significant reductions the affected industries have made. For categories where a MACT standard has been put into place and where a more current (e.g., 1996) emission estimate is available (usually through the MACT development effort), these estimates are also provided in the emission estimate tables along with the baseline 1990 value.

The national inventory surveys presented in this report include all known sources of each pollutant, both mobile and stationary. All of these sources and emissions may not be subject to the provisions of Section 112(c)(6) or 112(k) (e.g., mobile sources, forest fires, and pesticide application), and may need to be culled out for strategy development purposes. The provisions of Section 112 focus specifically on stationary sources.

Preparation of these inventories consisted of identifying all sources of emissions of the seven specific pollutants, estimating the national emissions for all source categories in various ways, and distinguishing between emissions from major and area source categories (as defined in Section 112(a) of the CAAA and considering the definition of co-located sources in 57 FR 31576).

Various conventions were adopted for inventorying some of these specific pollutants where no standardized methods currently exist. As discussed previously, this is most notably the case for POM, which is a complex mixture of thousands of polynuclear aromatic hydrocarbons (PAH) and PAH derivatives. For POM, several inventory approaches are presented. One approach assumes that the solvent extractable fraction of particulate matter (hereafter referred to as EOM) is a valid surrogate for POM. Other approaches adopted here assume that specific groupings of individual PAH are representative of total POM. One surrogate grouping includes

16 PAHs and another grouping consists of 7 PAH compounds. Rationale for these choices of surrogates are presented later in this report (Chapter 3.0).

For dioxins and furans, this report inventories the individual dioxin and furan congeners identified in Section 112(c)(6), but also inventories 2,3,7,8-TCDD toxic equivalents (TEQ), which is a single aggregate measure of all dioxin and furan congeners, considering the relative toxicities of each. It should be noted, however, that individual congener data were not readily available for emission estimation purposes for every source category. For this reason, only TEQ emissions are reported for some categories.

1.2 Overview of the Inventory Development Process

The purpose in this discussion is to help the reader better understand the nature of the data presented in this report, and better understand differences in the data (both in form and content). This document essentially contains a summary of several detailed emission inventory development efforts that have been conducted for Section 112(c)(6) pollutants. The intent is to provide the reader with national emission inventory totals by pollutant/source category and concise documentation sufficient to understand the basic concepts behind how the totals were generated. The initial 112(c)(6) inventory development process started in 1994. One group assessed POM, PCB, dioxin, and furan emissions, one group assessed HCB and alkylated lead emissions, and a third group assessed mercury sources and emissions. The data that were available for this document are predominantly summaries generated by these separate groups. While all three efforts had similar scopes and oversight by the same EPA groups, the inventory development efforts were nonetheless separate and not always completely identical in approach. Many of the differences in the type and format of summary data presented in the report for a given pollutant/source category are the result of the differences in how the original development efforts addressed the situation, and the level of effort that was expended to pursue certain data and source categories.

The efforts with the greatest similarity are the POM/PCB/dioxin/furan data and the HCB/alkylated lead data. The available inventory data, how the data were developed, and how emission allocations were done are reasonably similar for these pollutants and their sources. However, the mercury information is somewhat different. The bulk of the mercury data presented in this report are the product of an extensive EPA effort to compile a Report to Congress on mercury in order to meet a mandate in the 1990 CAAA. Significantly more effort and resources went into the compilation of the Mercury Report to Congress than was expended to conduct the research efforts on the other 112(c)(6) pollutants. Many of the mercury data provided in this inventory report are a summary of the information reported in the Report to Congress. Other mercury estimates were obtained from EPA's Toxic Release Inventory (TRI) system, from industry, and from calculations of emission factors and activity data.

For all of these inventory data development efforts, the process has been an ongoing one with updates to estimates occurring routinely. Updates from the originally developed data have come as the result of ongoing programs such as EPA's MACT standards programs, EPA Locating and Estimating (L&E) document projects, EPA's urban area toxics program, the Toxics Release Inventory program, and the Great Waters program. Because there are multiple programs investigating air toxics emissions in the United States, emissions estimates are constantly in flux. For this reason, it is very difficult to always keep all estimates consistent. Applicable emissions data and the associated source activity data are ever changing. The data presented in this document reflect values that have been developed given the assumptions and input data documented in the report. They are applicable for a specific time period. They may not necessarily agree with the national estimates from other sources due to differences in time period, input emission and activity data, and calculation assumptions. It should be recognized that some of the data presented here as 112(c)(6) estimates will likely change as more information and improved estimation approaches are developed.

1.3 Report Organization

Chapter 2.0 contains a description of the general methodologies, approaches, and data sources used to compile the 112(c)(6) pollutant national estimates. Limitations and shortcomings in the available data are also covered. Chapters 3.0 through 8.0 describe the general methodology used to determine source categories, emission estimates, and allocation schemes for POM, dioxin/furan, PCBs, mercury, HCB, and alkylated lead, respectively. Each of these respective sections also presents more detailed summaries of sources and emissions of each pollutant, and data on major versus area source category splits. Data gaps and deficiencies are identified and discussed in Chapter 9.0, along with recommendations for improving the current national estimates.

Appendix A contains specific documentation for the EOM, dioxin/furan, and PCB emission estimates of each source category. The subject pollutants of each category are identified, the input data used to calculate emissions are provided, and the algorithms used to allocate national emissions are presented. Appendix B contains the emission factors, activity data, and emissions calculations, respectively, for the 7-PAH and 16-PAH estimates, which serve as surrogates for POM emissions. The majority of the documentation for the mercury, HCB, and alkylated lead estimates is contained within their respective document sections. Appendix C contains other miscellaneous emissions estimate documentation for source categories of 112(c)(6) pollutants identified through the emission inventory development program for the CAA Section 112(k) requirements. The 112(k) inventory, which included several 112(c)(6) HAPs, was finalized in January 1998. In cases where estimates were taken from the 112(k) inventory report, the 112(k) documentation discussion for those estimates is provided here in Appendix C. The categories and 112(c)(6) pollutants addressed by Appendix C are indexed at the beginning of the appendix.

2.0 INVENTORY DEVELOPMENT METHODOLOGY AND EMISSIONS SUMMARY

2.1 Inventory Methods Summary

The majority of the national emission estimates developed for 112(c)(6) pollutants are “top-down” estimates. This means they were developed using national level activity data and some measure of emissions that could be applied to these data. Few categories had estimates developed from a true “bottom-up” basis (i.e., estimates developed specifically for individual sources and summed to obtain a national total). In cases where individual facility data were available to inventory a category (e.g., municipal waste combustors), sometimes not all sites could be addressed with site-specific data and default factors and/or activities had to be developed to apply in those cases. In such instances the bottom-up estimates are not fully all site-specific, bottom-up data. The 112(c)(6) national estimates were determined using existing data, such that no new source testing or industry surveys to gauge activity levels were conducted for the specific purposes of 112(c)(6).

The bulk of the estimates were completed by applying an emission factor or series of factors (associated with varying source configurations, material/fuel types, and controls) to a set of activity data (e.g., production rate, fuel input rate, waste disposed rate, and vehicle miles traveled rate) that correlates with the surrogate being used to approximate emissions. As stated in Chapter 1.0, the intent was to obtain activity data that represented 1990 base levels as close as possible. The emission factors were obtained by performing an extensive computerized search of existing literature. The identified data were evaluated for age, completeness, and overall quality. Acceptable data were used to develop composite emission factors for use in the national estimates. In some cases, the emission factors came from the most current version of EPA's AP-42 document (U.S. EPA, 1995) or EPA's Factor Information Retrieval (FIRE) database. In most cases, however, factors for the 112(c)(6) hazardous air pollutants (HAPs) were not available in AP-42 or FIRE and other sources had to be sought out. While no source testing was performed specifically and directly for the 112(c)(6) program, some estimates were based on recent test data, since the estimates came from standards programs where EPA, states, and/or

industry had conducted recent testing. Also, some of the AP-42 estimates represented the results of recent testing to develop new data for AP-42. Most of the source activity data were obtained from published sources such as government statistical documents and databases (e.g., Energy Information Administration fuel consumption reports, Forest Service reports on fires and burned acreage, and Agriculture Department publications on pesticide usage), industry trade publications, and commercially published business directories and journals. For some of the MACT standard-derived estimates, activity data were obtained directly from the affected industry.

In addition to use of the factor times activity method, another general approach that was used involved speciating known emissions, production levels, or waste streams for the subject category based on data that indicated the level of the 112(c)(6) HAP pollutant in the stream. For example, national particulate matter (PM) emissions from a category may have been known from other studies, and if available data indicated that 1.2 percent of the PM emissions from this category are POM, a national estimate for POM could be determined. In a similar manner, in some cases the emissions of a related form of a 112(c)(6) pollutant were known from other studies, and the speciation of the larger pollutant group was known for the 112(c)(6) HAP. Emissions for the 112(c)(6) HAP could then be determined based on the speciation ratio. An example of this would be the estimation of 2,3,7,8-TCDD emissions based on its contribution to total chlorinated dioxin emissions from a category, when the total dioxin emissions were known. In other cases, the speciation of a product (e.g., pesticide) may have been known, and due to the nature of the product and its associated operation, an estimate could be made that all or some fraction of the material (and the HAP constituent) was lost to the atmosphere. The same approach was used for some cases where the pollutant was a constituent of a waste stream from a category and the total amount of waste and the HAP composition of the waste stream were known.

A significant number of emission estimates for the 112(c)(6) inventory were also obtained from EPA's Toxics Release Inventory (TRI) System and from data provided by industry sources during the public comment period on the draft 112(c)(6) inventory. Many of the source

categories identified as 112(c)(6) pollutants sources since the draft report was published were identified as a result of data found in the TRI. These data were first determined and reported in the Section 112(k) emissions inventory report (U.S. EPA, 1998). The estimates provided in the Section 112(c)(6) report are the same as those found in the Section 112(k) document. In addition, estimates for several source categories were revised since the draft inventory based on information supplied directly by industrial trade associations and individual companies.

2.2 Major/Area Source Allocations

To better understand the nature and impact of 112(c)(6) pollutant emissions, the national emission estimates were allocated according to whether the emitting source category was classified as “major,” “area,” or could be classified partially as both. As the name implies, major sources are generally larger with greater per source levels of emissions, while area sources have fewer emissions on a per source basis and may be located in a more dispersive manner. According to Title III, Section 112(a) of the CAAA, a "major source" is any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs. An "area source" is any stationary source of HAPs which does not qualify as a major source. The reader should refer to the July 16, 1992 Federal Register notice for a more detailed discussion of the concept of co-location (Federal Register, 1992). The allocation of emissions to a major/area source basis for each source category will be helpful in evaluating the effect of existing and future regulatory programs (e.g., MACT standards) on emissions reductions. For example, existing MACT standards are more geared towards major sources as opposed to area. If it turns out that area sources constitute a large portion of 112(c)(6) emissions, future standards programs may need to consider incorporating more area sources in their applicability determinations.

The major/area allocations that were determined for the purpose of this inventory compilation are presented in Table 2-1. The percentages shown in the table were applied to the total national emissions of each pollutant from each source category to calculate the major and

Table 2-1**Distribution of Major and Area Source Emissions by Source Category^a**

Source Category	% Major	% Area
Abrasive Grain (Media) Manufacturing	5.00	95.00
Adhesives and Sealants Manufacturing	95.00	5.00
Aerospace Industry (Surface Coating)	100.00	0.00
Agricultural Chemicals Manufacturing	92.05	7.95
Asphalt Hot-Mix Production	0.00	100.00
Asphalt Roofing Production	85.38	14.62
Battery Production	75.00	25.00
Blast Furnace and Steel Mills	97.90	2.10
Carbamate Insecticides Production	30.00	70.00
Carbon Black Production	30.00	70.00
Carbon Reactivation Furnaces	25.00	75.00
Chemical Manufacturing: Cyclic Crude and Intermediate Production	96.92	3.08
Chemical Preparations Manufacturing	95.00	5.00
Chloralkali Production	30.00	70.00
Chlorinated Solvents Production	100.00	0.00
Chromium Plating: Chromic Anodizing	5.00	95.00
Cigarette Smoke	0.00	100.00
Clay Refractories Manufacturing	0.00	100.00
Cleaning Products Manufacturing (SICs combined) ^b	95.00	5.00
Coke Ovens: By-Product Recovery Plants	100.00	0.00
Coke Ovens: Charging, Topside & Door Leaks	100.00	0.00
Coke Ovens: Pushing, Quenching & Battery Stacks	100.00	0.00
Commercial Coal Combustion	20.00	80.00
Commercial Natural Gas Combustion	20.00	80.00
Commercial Oil Combustion	20.00	80.00
Commercial Printing, Gravure	99.35	0.65
Commercial Printing, Letterpress and Screen	79.06	20.94
Commercial Wood/Wood Residue Combustion	20.00	80.00
Consumer Products Usage	0.00	100.00
Crematories	0.00	100.00
Custom Compound Purchased Resins Manufacture	83.74	16.26
Dental Preparation and Use	100.00	0.00
Drum and Barrel Reclamation	0.00	100.00
Electronic and Other Electric Equipment Manufacturing (SICs combined) ^c	75.00	25.00
Fabricated Metal Products Manufacturing	75.00	25.00
Fabricated Rubber Products Manufacturing	99.98	0.02
Ferroalloy Manufacture	0.00	100.00
Fiber Cans, Drums, and Similar Products Manufacturing	89.34	10.66

Table 2-1**Distribution of Major and Area Source Emissions by Source Category^a
(Continued)**

Source Category	% Major	% Area
Fluorescent Lamp Recycling	20.00	80.00
Food Products (SICs combined) ^d	5.00	95.00
Gasoline Distribution (Aviation)	10.00	90.00
Gasoline Distribution (Stage I)	10.00	90.00
Gasoline Distribution (Stage II)	10.00	90.00
General Laboratory Activities	20.00	80.00
Geothermal Power	0.00	100.00
Gum and Wood Chemical Manufacturing	98.97	1.03
Hazardous Waste Incineration	100.00	0.00
Industrial Coal Combustion	70.00	30.00
Industrial Gases Manufacturing	98.44	1.56
Industrial Inorganic Chemicals Manufacturing	95.88	4.12
Industrial Machinery and Electrical Equipment Manufacturing (SICs combined) ^e	75.00	25.00
Industrial Natural Gas Combustion	70.00	30.00
Industrial Oil Combustion	70.00	30.00
Industrial Organic Chemicals Manufacturing	98.22	1.78
Industrial Stationary IC Engines - Diesel	70.00	30.00
Industrial Stationary IC Engines - Natural Gas	60.00	40.00
Industrial Turbines - Diesel Fired	70.00	30.00
Industrial Turbines: Natural Gas Fired	60.00	40.00
Industrial Waste Oil Combustion	70.00	30.00
Industrial Wood/Wood Residue Combustion	80.00	20.00
Inorganic Pigments Manufacturing	99.59	0.41
Instrument Manufacturing	0.00	100.00
Iron Foundries	100.00	0.00
Lamp Breakage	20.00	80.00
Landfill (Gas) Flares	0.00	100.00
Lightweight Aggregate Kilns	85.00	15.00
Lime Manufacturing	0.00	100.00
Lubricating Oils and Grease	84.34	15.66
Medical Waste Incineration	15.00	85.00
Metal Household Furniture Manufacturing	92.01	7.99
Miscellaneous Manufacturing	85.00	15.00
Miscellaneous Plastics Products	95.39	4.61
Municipal Waste Combustion	95.00	5.00
Naphthalene - Miscellaneous Uses	30.00	70.00
Naphthalene Production	70.00	30.00

Table 2-1**Distribution of Major and Area Source Emissions by Source Category^a
(Continued)**

Source Category	% Major	% Area
Naphthalene Sulfonates Production	70.00	30.00
Non-Road Vehicles and Equipment (NRVE) - Aircraft	0.00	100.00
Nonmetallic Mineral Products Manufacturing	62.25	37.75
NRVE - Other	0.00	100.00
Office Furniture, Except Wood Manufacturing	96.08	3.92
Onroad Vehicles	0.00	100.00
Open Burning of Scrap Tires	0.00	100.00
Other Biological Incineration	0.00	100.00
Other Miscellaneous Manufacturing (SICs combined) ^f	90.00	10.00
Other Secondary Nonferrous Metals Recovery	45.00	55.00
Other Structural Clay Products Manufacturing	93.83	6.17
Paints and Allied Products Manufacturing	77.03	22.97
Paper Coated and Laminated, Packaging	98.03	1.97
Partitions and Fixtures Manufacturing	0.00	100.00
Pesticides Application	0.00	100.00
Pesticides Manufacture	0.00	100.00
Petroleum Refining: All Processes	97.55	2.45
Pharmaceutical Preparations and Manufacturing (SICs combined) ^g	95.00	5.00
Phthalic Anhydride Production	70.00	30.00
Plastic Foam Products Manufacturing	98.58	1.42
Plastics Material and Resins Manufacturing	97.08	2.92
Porcelain Electrical Supplies	93.53	6.47
Portland Cement Manufacture: Hazardous Waste Kilns	100.00	0.00
Portland Cement Manufacture: Non-Hazardous Waste Kilns	80.00	20.00
Primary Aluminum Production	45.00	55.00
Primary Copper Production	90.88	9.12
Primary Lead Smelting	45.00	55.00
Primary Metal Products Manufacturing (SICs combined) ^h	45.00	55.00
Public Building and Related Furniture	85.22	14.78
Pulp and Paper Manufacturing - Kraft Recovery Furnaces	100.00	0.00
Pulp and Paper Manufacturing - Lime Kilns	100.00	0.00
Pulp and Paper Manufacturing - Sulfite Recovery Furnaces	100.00	0.00
Residential Coal Combustion	0.00	100.00
Residential Natural Gas Combustion	0.00	100.00
Residential Oil Combustion	0.00	100.00
Residential Wood Combustion	0.00	100.00
Scrap or Waste Tire Incineration	100.00	0.00

Table 2-1

**Distribution of Major and Area Source Emissions by Source Category^a
(Continued)**

Source Category	% Major	% Area
Secondary Aluminum Smelting	45.00	55.00
Secondary Copper Smelting	45.00	55.00
Secondary Lead Smelting	52.00	48.00
Secondary Mercury Production	50.00	50.00
Sewage Sludge Incineration	0.00	100.00
Ship Building and Repair (Surface Coating)	94.41	5.59
Surface Active Agents Manufacturing	86.21	13.79
Textiles Manufacturing (SICs Combined) ⁱ	50.00	50.00
Tire Manufacturing	99.00	1.00
Transportation Equipment Manufacturing (SICs combined) ^j	75.00	25.00
Utility Coal Combustion	100.00	0.00
Utility Natural Gas Combustion	0.00	100.00
Utility Oil Combustion	50.00	50.00
Utility Turbines - Diesel Fired	70.00	30.00
Wildfires and Prescribed Burning	0.00	100.00
Wood Household Furniture Manufacturing	97.90	2.10
Wood Treatment/Wood Preserving	0.00	100.00

^a The term major, as defined in this report, refers to any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs. The term area refers to any source of HAPs that is not a major source.

^b SICs used for Cleaning Products: 2840, 2841, 2842, and 2844

^c SICs used for Electronic and Other Electric Equipment: 3612, 3613, 3621, 3622, 3624, 3625, 3629, 3630, 3631, 3632, 3633, 3634, 3635, 3639, 3641, 3643, 3644, 3645, 3646, 3647, 3648, 3651, 3652, 3661, 3663, 3669, 3670, 3671, 3672, 3675, 3676, 3677, 3678, 3679, 3694, 3695, 3699.

^d SICs used in Food Products: 2011, 2015, 2021, 2023, 2033, 2034, 2037, 2041, 2046, 2047, 2048, 2061, 2063, 2075, 2076, 2079, 2082, 2085, 2086, 2087, 2096, and 2099

^e SICs used in Industrial Machinery and Electrical Equipment Manufacturing: 3510, 3511, 3519, 3523, 3524, 3530, 3531, 3532, 3533, 3534, 3535, 3536, 3537, 3540, 3541, 3542, 3543, 3544, 3545, 3546, 3547, 3548, 3549, 3550, 3551, 3552, 3554, 3555, 3556, 3559, 3561, 3562, 3563, 3564, 3565, 3566, 3567, 3568, 3569, 3571, 3572, 3573, 3575, 3577, 3579, 3581, 3582, 3585, 3586, 3589, 3592, 3593, 3594, and 3599

^f SICs used in Other Miscellaneous: 2643, 3142, 3144, 3149, 4213, 4512, 4741, 5012, 5051, 5063, 6321, 7549, 8731, 9661, and 9711

^g SICs used in Pharmaceutical Preparations and Manufacturing: 2830, 2833, 2834, 2835, and 2836

Table 2-1

Distribution of Major and Area Source Emissions by Source Category^a (Continued)

- ^h SICs used in Primary Metal Products Manufacturing: 3300, 3313, 3315, 3316, 3317, 3351, 3353, 3354, 3355, 3356, 3357, 3361, 3362, 3363, 3364, 3365, 3366, 3369, 3398, and 3399
- ⁱ SICs used in Textile Manufacturing: 2211, 2221, 2231, 2251, 2253, 2257, 2258, 2259, 2260, 2261, 2262, 2269, 2272, 2273, 2281, 2282, 2284, 2295, 2296, 2297, 2298, 2299, 2311, 2321, 2325, 2326, 2361, 2381, 2384, 2389, and 2399
- ^j SICs used Transportation Equipment Manufacturing: 3710, 3711, 3713, 3714, 3715, 3716, 3721, 3724, 3728, 3730, 3731, 3732, 3743, 3751, 3761, 3764, 3769, 3790, 3792, 3795, and 3799

area source emissions for the category. These values take into consideration co-location of processes where data are available. The major/area allocation percentages were derived in a variety of ways. The reader should not treat these percentages and the resulting calculated major/area source emissions as absolutes. They are truly estimates at best. The primary goal was to get a sense of whether a category was predominantly in one group or the other. The rationale used to make the major/area determinations varied depending on available information. The EPA report Documentation for the Development of the Initial Source Category List, which was used to identify major source categories for standards development purposes, was a key reference (U.S. EPA, 1992). The U.S. EPA's Emission Standards Division (ESD), which has an extensive knowledge of many source categories due to its Maximum Achievable Control Technology (MACT) work, provided a large number of the allocations. In other cases, the accepted way that a source category is typically inventoried served as a guide for the classification (e.g., residential wood burning is always assessed as an area source). In other cases, technical analyses were conducted using actual and model plant data to determine typical facility sizes and emissions to see what percent of facilities in a category would likely trip the 10/25 ton per year HAP threshold. Lastly, in cases where no applicable data could be found to base an allocation, engineering judgement was used to assign an arbitrary allocation.

The percentages shown in Table 2-1 have no bearing or relevance to major source determinations that states may have for individual facilities as a function of any regulatory activity (e.g., New Source Performance Standard, NESHAP, New Source Review, operating permit, etc.). The major/area distributions shown in Table 2-1 are only for the purposes of this 112(c)(6) inventory analysis.

2.3 Limitations and Data Quality

As with any inventory development process, the quality of the final estimate varies considerably across categories. Given the methods used to calculate the estimates, the biggest influence on the quality of the estimate is the validity of the emission factor(s) used, in terms of absolute accuracy as well as representativeness for the processes to which it was applied. The

activity data can also affect the quality of an emissions estimate, but activity data are usually easier to obtain and often have more credibility, especially when trying to determine national scale numbers. Obtaining national scale activity data that are reasonably valid was not that difficult during this inventory development process; however, there were a few categories in which the activity data were highly questionable or practically nonexistent.

Despite the problems with limited data for some source categories, the intent of the 112(c)(6) inventory process was satisfied reasonably well by the data in this report. National scale emission estimates were generated that captured, at a minimum, 90 percent of the aggregate emissions of each listed 112(c)(6) HAP. The quality of the estimates for some of the less important (in terms of emissions potential) categories can clearly be questioned due to limits on available input information; however, taken as a whole, the data presented here provide reasonable inputs, and serve as a first step towards a 112(c)(6) prioritization process.

The most significant issue that should be noted for this inventory is that the available emission factor data were either old (>10 years) and/or very limited in terms of coverage for some source categories. This lack of data may be because the HAPs have not always been viewed as significant; therefore, little testing and emissions characterization work has been performed. This means that a very limited number of data points were available to characterize an entire category, without the benefit of knowing what the variability across the category may be. In some cases, there were no emissions data specific to a category, and surrogate data from a related source category had to be used to estimate emissions. While not optimal, this approach had to be adopted given the time and resource constraints of the 112(c)(6) inventory program. Generally, however, the source categories where this approach was used were not significant emitters of the given HAP.

The estimates that are more than likely the highest quality are those that were obtained from regulatory development programs (e.g., municipal waste combustors, primary aluminum smelters, and Portland cement kilns). These estimates have the benefit of being based on recent test data, up-to-date activity and control information, and input from informed industry experts.

In some instances, these estimates represent a summation of actual source test data for most or all sources in the category. These intensive estimates are of significantly higher quality than those derived through the use of an overall emission factor.

The estimates that have come from special intensive EPA studies such as the Reports to Congress on mercury and electric utilities also represent higher quality information due to the quantity and quality of the new research done to support these programs. Estimates based on factors from recent AP-42 updates (especially those with A or B rated factors) are also relatively high quality, since the applied emission factors are more likely to reflect the increased accuracy of recent test data, as well as better source category representation.

The biggest issue with the development of the inventory estimates for 112(c)(6) categories was the lack of emissions data for categories not constituting the top 60-70 percent of total national emissions. For categories that have already been identified as relatively significant sources (60-70 percent) of a given pollutant, more emphasis has been placed by industry and regulatory agencies on performing testing and deriving good quality emission factors. Less attention and emissions quantification have historically been paid to the remaining categories, which individually may contribute little total emissions but may constitute many individual sources. The emission factor data pool for smaller combustion sources (excluding utilities and large industrial sources), some of the waste disposal sources, non-road mobile sources, secondary industrial sources, and biomass burning sources could definitely benefit from more current and expanded information. To illustrate this point, some of the only POM emissions data that could be identified for small combustion boilers dated back to the late 1970's-early 1980's.

Another issue regarding the estimation process that was clearly undesirable, but also unavoidable in the context of the 112(c)(6) inventory process, was the lack of available emissions data for some pollutant/source category combinations. As discussed further in Chapter 3, EOM data were either not available or only one or two data points were available to derive a factor for a category-wide, national emissions estimate. The overall national estimate quality implications for this type of situation are clear. Similarly, several data limitations also existed for PCB, HCB,

and alkylated lead air emissions. National estimates had to be formulated for several categories from assumptions and factors with only one or two data points.

2.4 Documentation

Documentation for how the emission estimates were prepared is provided in the appendices for POM (7-PAH, 16-PAH, and EOM), dioxins/furans (TCDD, TCDF, and TCDD TEQ), mercury and PCBs. The individual sections on mercury, HCB, and alkylated lead also provide documentation information. The documentation provided in this report is meant to identify the key input data that were used in the calculation of national emissions. The documentation is not meant to provide an exhaustive analysis on the derivation of all the inputs. For example, an emission factor used for a national estimate may be given in an appendix, but the 10 source tests that were evaluated to obtain this factor are not presented and discussed. The goal of the provided documentation is to show the reader in a brief and concise manner where a given number came from. For example, some estimates are based on data obtained directly from work done by EPA for the development of MACT standards. These estimates may have been the product of several years of work, and may have many complex analyses and data sets behind them. In this case, the documentation provided here will attempt to identify the overall methodology and values used to calculate emissions (activity levels, factors, etc.) if available, but it will not provide all of the data that the Agency used to develop these final numbers. Adequate references are provided to allow a reader to further investigate any estimate should they so desire.

Since the publication of the external review draft report for the 112(c)(6) emissions inventory (June 1997), several source categories have been added to the 112(c)(6) inventory as a result of work performed by EPA in its program to meet the CAA requirement put forth in Section 112(k) of the Act. Section 112(k) also required a national inventory of HAP emissions (at least 30 pollutants), of which POM, dioxins/furans, and mercury were included. An interim final 112(k) inventory report was produced by EPA in January 1998. During the course of the 112(k) effort, EPA identified several new source categories of 112(c)(6) pollutants that were not in the June 1997 draft document. These categories and their emissions have been inserted into

this report and the final 112(c)(6) inventory. The documentation of the emission estimates for these categories is primarily contained in Appendix C of this report. Essentially, the documentation materials that were provided in the January 1998 interim final 112(k) report for newly identified 112(c)(6) emission categories were reproduced here as Appendix C.

In evaluating the documentation, readers are cautioned to remember the discussion in Chapter 1.0 on how this inventory and report were compiled. The documentation, like the main report, is a summary of several different data development efforts. Estimates for different pollutants were compiled by different groups at different times and to differing levels of detail. Essentially the data exist in three sets: POM/dioxin-furan/PCBs, HCB/alkylated lead, and mercury. The available documentation maintains greatest consistency within these groupings. Because there were different parties responsible for developing emissions estimates for these three sets, it is possible that a given category was not assessed the same way, and is therefore, not documented here the same way. For example, the same category may have two different activity rates shown between different pollutants because each party obtained their data from a slightly different source or on a differing time period. The time frame and resources available for assembling this document did not allow for additional analyses to eliminate these inconsistencies. Such differences are believed to not significantly affect the estimates given in the document or the conclusions drawn from them.

2.5 Emissions Summary

Table 2-2 contains national level emission estimates for all 112(c)(6) pollutant categories where available data permitted the quantification of emissions. For ease of reporting such a large amount of data, the estimates in Table 2-2 have been rounded to two decimal places.

Table 2-2

Summary of 1990 Emission Inventory Data for Section 112(C)(6) Pollutants (Tons/Yr)

SOURCE CATEGORY	POM			2,3,7,8-TCDD TEQ	MERCURY	PCB	HCB	ALKYLATED LEAD
	7-PAH	16-PAH	EOM					
Abrasive Grain (Media) Manufacturing		2.48e+01						
Adhesives and Sealants (SICs combined)		4.18e+00						
Aerospace Industry (Surface Coating)		1.64e+03			4.00e+00			
Agricultural Chemicals		9.03e+00						
Asphalt Hot-Mix Production	9.40e-02	4.37e+01						
Asphalt Roofing Production	1.68e+00	4.36e+01						
Battery Production					2.00e-02			
Blast Furnace and Steel Mills		4.99e+02			2.50e-01			
Carbamate Insecticides Production		4.08e+00						
Carbon Black Production	4.50e-01	4.33e+00			2.50e-01			
Carbon Reactivation Furnaces				1.25e-07				
Chemical Manufacturing: Cyclic Crude and Intermediate Production		1.04e+02						
Chemical Preparations (SICs combined)		6.79e+00						
Chloralkali Production		4.52e+00			9.80e+00			
Chlorinated Solvents Production							5.81e-01	
Chromium Plating: Chromic Anodizing					2.50e-03			
Cigarette Smoke	5.20e-01	3.45e+00						
Clay Refractories		5.00e-01						
Cleaning Products (SICs combined)		1.38e+00						
Coke Ovens: By-Product Recovery Plants		7.78e+01						
Coke Ovens: Charging, Topside & Door Leaks	7.18e+01	5.39e+02	6.79e+02					
Coke Ovens: Pushing, Quenching & Battery Stacks	3.01e+01	5.17e+02						

Table 2-2

Summary of 1990 Emission Inventory Data for Section 112(C)(6) Pollutants (Tons/Yr) (Continued)

SOURCE CATEGORY	POM			2,3,7,8-TCDD TEQ	MERCURY	PCB	HCB	ALKYLATED LEAD
	7-PAH	16-PAH	EOM					
Commercial Coal Combustion	3.60e+01	1.73e+02	2.74e+03		7.77e-01			
Commercial Natural Gas Combustion		3.00e-02	1.92e+03					
Commercial Oil Combustion	3.16e-02	5.33e+01	1.32e+03		2.00e-01			
Commercial Printing, Gravure		2.89e+01						
Commercial Printing, Letterpress and Screen		1.04e+01						
Commercial Wood/Wood Residue Combustion	1.01e+00	3.58e+01	1.95e+03		8.00e-03			
Consumer Products Usage		5.73e+03						
Crematories	1.42e-08	8.33e-06		9.15e-12	3.77e-04			
Custom Compound Purchased Resins Manufacture					1.28e-01			
Dental Preparation and Use					8.00e-01			
Drum and Barrel Reclamation	1.27e-06	8.19e-05		2.51e-07				
Electronic and Other Electric Equipment Manufacturing (SICs combined)		3.05e+01			8.83e-01			
Fabricated Metal Products		1.43e+02						
Fabricated Rubber Products		1.48e+02						
Ferroalloy Manufacture	2.60e-01	5.60e-01						
Fiber Cans, Drums, and Similar Products		5.06e+00						
Fluorescent Lamp Recycling					6.00e-03			
Food Products (SICs combined)		3.54e+00						
Gasoline Distribution (Aviation)								3.75e-01
Gasoline Distribution (Stage I)		3.55e+02						8.64e-02
Gasoline Distribution (Stage II)		3.74e+02						1.92e-02
General Laboratory Activities					8.00e-01			
Geothermal Power					1.30e+00			
Gum and Wood Chemical		5.00e-01						

Table 2-2

Summary of 1990 Emission Inventory Data for Section 112(C)(6) Pollutants (Tons/Yr) (Continued)

SOURCE CATEGORY	POM			2,3,7,8-TCDD TEQ	MERCURY	PCB	HCB	ALKYLATED LEAD
	7-PAH	16-PAH	EOM					
Hazardous Waste Incineration	2.09e-02	1.75e-01		3.30e-05	3.20e+00	2.78e-02		
Industrial Coal Combustion	3.09e+00	1.57e+02	2.41e+03		2.20e+01			
Industrial Gases Manufacturing		9.43e+00						
Industrial Inorganic Chemicals Manufacturing		1.57e+01			1.00e+00			
Industrial Machinery and Electrical Equipment (SICs combined)		2.77e+00						
Industrial Natural Gas Combustion		2.00e-02	9.28e+02					
Industrial Oil Combustion	3.07e-02	5.09e+01	4.94e+02		5.80e+00	4.97e-05		
Industrial Organic Chemicals Manufacturing		2.27e+02			2.00e-02			
Industrial Stationary IC Engines - Diesel	8.93e-02	5.02e+00	1.93e+03					
Industrial Stationary IC Engines - Natural Gas	1.03e+00	4.76e+01			4.47e+00			
Industrial Turbines - Diesel Fired		1.55e-02	1.73e+03		9.00e-02			
Industrial Turbines: Natural Gas Fired		1.38e+01	7.39e+02		1.61e+00			
Industrial Waste Oil Combustion	1.34e+00	7.82e+00						
Industrial Wood/Wood Residue Combustion	1.21e+00	6.88e+01	4.42e+04	5.07e-05	2.03e-01			
Inorganic Pigments Manufacturing					5.00e-03			
Instrument Manufacturing					5.00e-01			
Iron and Steel Foundries	6.00e-02	1.90e-01		1.15e-05				
Lamp Breakage					1.50e+00			
Landfill (Gas) Flares	1.05e-03	4.45e-01						
Lightweight Aggregate Kilns				3.60e-06	3.10e-01			
Lime Manufacturing					7.00e-01			
Lubricating Oils and Grease		6.00e-02						
Medical Waste Incineration		8.00e-01	1.50e+01	6.60e-04	5.00e+01	4.03e-02		
Metal Household Furniture		2.50e-03						

Table 2-2

Summary of 1990 Emission Inventory Data for Section 112(C)(6) Pollutants (Tons/Yr) (Continued)

SOURCE CATEGORY	POM			2,3,7,8-TCDD TEQ	MERCURY	PCB	HCB	ALKYLATED LEAD
	7-PAH	16-PAH	EOM					
Miscellaneous Manufacturing		6.58e+00						
Miscellaneous Plastics Products		5.76e+00						
Municipal Waste Combustion		9.67e-02	1.82e+02	3.65e-03	5.50e+01	8.01e-02		
Naphthalene - Miscellaneous Uses		1.25e+00						
Naphthalene Production		6.46e+01						
Naphthalene Sulfonates Production		6.53e+00						
Non-Road Vehicles and Equipment (NRVE) - Aircraft	9.00e-02	4.79e+00						
Nonmetallic Mineral Products		2.50e-03			5.00e-03			
NRVE - Other	2.40e+01	4.70e+01	2.51e+04					1.66e-01
Office Furniture, Except Wood Manufacturing		6.45e+00						
On-Road Vehicles	3.44e+01	7.59e+01	5.62e+04	9.50e-05				
Open Burning of Scrap Tires	5.25e+01	2.94e+02						
Other Biological Incineration			1.05e+00	1.60e-04		2.49e-03		
Other Miscellaneous (SICs combined)		1.45e+00			2.50e-01			
Other Secondary Nonferrous Metals Recovery					2.50e-01			
Other Structural Clay Products		5.60e-01			1.10e-01			
Paints and Allied Products		3.07e+01			7.50e-03			
Paper Coated and Laminated, Packaging		5.54e+01						
Partitions and Fixtures		4.35e+00						
Pesticides Application							1.46e-01	
Pesticides Manufacture							4.58e-01	
Petroleum Refining: All Processes	1.64e+01	1.10e+03			4.35e-02			
Pharmaceutical Preparations and Manufacturing (SICs combined)		7.66e-01						
Phthalic Anhydride Production		2.62e+01						

Table 2-2

Summary of 1990 Emission Inventory Data for Section 112(C)(6) Pollutants (Tons/Yr) (Continued)

SOURCE CATEGORY	POM			2,3,7,8-TCDD TEQ	MERCURY	PCB	HCB	ALKYLATED LEAD
	7-PAH	16-PAH	EOM					
Plastic Foam Products Manufacturing		1.10e+02						
Plastics Material and Resins Manufacturing		8.55e+00			4.00e-03			
Porcelain Electrical Supplies		2.08e+00						
Portland Cement Manufacture: Hazardous Waste Kilns	2.08e+00	1.26e+01		4.75e-04	2.75e+00			
Portland Cement Manufacture: Non-Hazardous Waste Kilns	2.60e+00	4.79e+01		4.29e-05	4.13e+00			
Primary Aluminum Production	1.41e+02	6.62e+02	3.88e+03					
Primary Copper Production					7.40e-01			
Primary Lead Smelting					1.30e+00			
Primary Metal Products Manufacturing (SICs combined)		2.69e+01						
Public Building and Related Furniture		1.16e+01						
Pulp and Paper - Kraft Recovery Furnaces	3.74e+00	6.49e+02		3.42e-07	1.90e+00			
Pulp and Paper - Lime Kilns	2.50e-01	1.83e+02						
Pulp and Paper - Sulfite Recovery Furnaces		6.17e+00						
Residential Coal Combustion	3.19e+01	1.03e+02		2.34e-04	6.00e-01			
Residential Natural Gas Combustion	8.02e-02	5.10e+00	4.14e+03					
Residential Oil Combustion	1.70e+00	2.10e+01	1.47e+03	3.78e-06	3.00e+00			
Residential Wood Combustion	5.72e+02	8.86e+03	2.36e+05	3.38e-05				
Scrap or Waste Tire Combustion	2.17e-05	5.18e-03		3.00e-07		1.04e-03		
Secondary Aluminum Smelting				1.90e-04				
Secondary Copper Smelting				6.80e-06				
Secondary Lead Smelting	1.90e-02	6.99e+01		4.25e-06	1.13e-02			
Secondary Mercury Production					7.52e-01			
Sewage Sludge Incineration	8.67e-03	1.64e+00		2.65e-05	1.80e+00	5.12e-03		
Ship Building and Repair (Surface Coating)		1.44e+01						

Table 2-2

Summary of 1990 Emission Inventory Data for Section 112(C)(6) Pollutants (Tons/Yr) (Continued)

SOURCE CATEGORY	POM			2,3,7,8-TCDD TEQ	MERCURY	PCB	HCB	ALKYLATED LEAD
	7-PAH	16-PAH	EOM					
Surface Active Agents Manufacturing		7.41e+00						
Textiles (SICs Combined)		9.68e+00						
Tire Manufacturing		7.00e+00					4.35e-01	
Transportation Equipment Manufacturing (SICs combined)		5.16e+01						
Utility Coal Combustion	2.10e-01	7.55e+00	3.86e+04	1.10e-04	5.10e+01		6.80e-01	
Utility Natural Gas Combustion		6.90e-01	1.00e+03		1.60e-03			
Utility Oil Combustion	5.00e-02	5.70e-01	5.31e+02	7.00e-06	2.50e-01	1.49e-04		
Utility Turbines - Diesel Fired					3.00e-02			
Wildfires and Prescribed Burning	9.64e+02	2.54e+03		9.50e-05				
Wood Household Furniture Manufacturing		1.13e+01						
Wood Treatment/Wood Preserving		9.04e+01		3.80e-05				
Total Emissions (tons/yr)	1995.80	26476.54	428035.05	0.0059	234.59	0.16	2.30	0.65

2.6 References

1. Federal Register. July 16, 1992. "Initial List of Categories of Sources Under Section 112 (c)(1) of the Clean Air Act Amendments of 1990." Volume 57, No. 137. pp. 31576 - 31592.
2. U.S. Environmental Protection Agency. Documentation for Developing the Initial Source Category List. Final Report. EPA-450/3-91-030. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. 1992.
3. U.S. Environmental Protection Agency. Compilation of Air Pollutant Emission Factors, 5th Edition, AP-42, Volume I: Stationary Point and Area Sources. Research Triangle Park, North Carolina. 1995.
4. U.S. Environmental Protection Agency. 1990 Emissions Inventory of Forty Section 112(k) Pollutants, Supporting Data for EPA Proposed Section 112(k) Regulatory Strategy - Interim Final Report. Office of Air Quality Planning and Standards, Emission Factor and Inventory Group and Visibility and Ecosystem Protection Group. Research Triangle Park, North Carolina. January 9, 1998.

3.0 EMISSION ESTIMATES FOR POLYCYCLIC ORGANIC MATTER (POM)

3.1 Alternatives for Inventorying POM

The term "polycyclic organic matter," or "POM," as defined in Section 112(b) of the CAAA, includes organic compounds with more than one benzene ring, and which have a boiling point greater than or equal to 100°C. The EPA is considering a definitional change that would exclude certain compounds (e.g., benzene/styrene polymers and biphenyls) that could technically fall under the existing POM definition, but which are not reflective of the group of compounds that the Agency believes are principally responsible for mutagenicity and carcinogenicity in humans and animals. Currently under review, the EPA may redefine POM as only including polycyclic aromatic hydrocarbons and aromatic heterocyclic compounds, with two or more fused rings, at least one of which is benzenoid in structure, which are generally formed or emitted during thermal processes including: (1) incomplete combustion; (2) pyrolysis; (3) the volatilization, distillation, or processing of fossil fuels or bitumens; or (4) the distillation or thermal processing of non-fossil fuels (Pope, 1996).

The complex mixture of POM consists of literally thousands of organic compounds. Because inventorying all POM compounds individually is impossible, surrogate approaches have been used. Most commonly, a single PAH, such as benzo-a-pyrene [B(a)P], or the sum of representative or particularly toxic PAH species, have been used as surrogates for POM (U.S. EPA, 1990; U.S. EPA, 1989). Alternatively, EPA's Office of Research and Development has been developing an approach using the EOM content of particulate matter as an appropriate measure of complex POM mixtures. EOM is believed to contain the PAH and substituted-PAH compounds that predict cancer risk better than any individual PAH or any sum of PAH species (Lewtas, 1993). However, there is some evidence that the primary health effects associated with particulate POM may be the carbon core of the particles rather than the overall organic fraction (represented as EOM). A draw back to using EOM as a surrogate for POM is the limited amount

of data available to quantify emissions. Few EOM inventories or emission factors exist at this time.

Each of these surrogate approaches for estimating POM emissions contains some inherent advantages and disadvantages. Using B(a)P alone is not thought to represent adequately either the total mass of POM emissions or the related cancer risks (Lewtas, 1993). However, a reasonable data base exists for determining B(a)P emissions from a wide variety of sources. Using a "sum-of-individual PAH species" approach, while perhaps better than using B(a)P alone, may still not represent adequately the cancer-related risks from some sources that emit significant levels of substituted-PAH compounds. However, as with B(a)P, a reasonably extensive data base exists for speciated PAH emissions. Unfortunately, there is little consistency as to what particular PAH compounds have traditionally been measured across studies and source categories. Regarding the use of EOM as a measure of POM, EPA is developing a database of EOM emissions from a variety of sources and has evaluated the toxicity of a limited number of EOM mixtures (Lewtas, 1993). To date, however, many fewer source categories have been tested for EOM than for individual PAH species.

Because there is no currently accepted method for completely characterizing POM emissions from all sources, the EPA is employing several approaches in this report: (1) the EOM approach, (2) a "sum-of-seven" approach which totals the emissions of seven PAH that are probable human carcinogens (U.S. EPA, 1993), and (3) a "sum-of-16" approach which totals the emissions of 16 PAH which are measured in EPA Method 610 (U.S. EPA, 1988). These three approaches are hereafter called the "EOM," "7-PAH," and "16-PAH" approaches, respectively. This inclusion of multiple approaches will have the effect of allowing EPA to evaluate the relative importance of POM emission sources emitters using each of the approaches, and afford EPA some flexibility to use this report if one of the approaches is deemed preferable during strategy development.

3.2 Emission Factors for 7-PAH, 16-PAH, and EOM

Sections 3.2.1 and 3.2.2 provide background information on the development of the 7-PAH/16-PAH and EOM emission factor formats, respectively.

3.2.1 7-PAH and 16-PAH Emission Factor Development

The EPA has identified a subset of 16 PAH compounds that have been targeted as part of a suggested procedure for measuring these type of compounds (U.S. EPA, 1988). The PAHs included in this measurement procedure are:

Naphthalene	Benzo(ghi)perylene
Acenaphthene	Benzo(a)anthracene*
Acenaphthylene	Chrysene*
Fluorene	Benzo(b)fluoranthene*
Phenanthrene	Benzo(k)fluoranthene*
Anthracene	Benzo(a)pyrene*
Fluoranthene	Dibenz(a,h)anthracene*
Pyrene	Indeno(1,2,3-cd)pyrene*

The sum of these 16-PAH constitute the "16-PAH" quantity referred to in this document. The seven compounds with asterisks (*) next to them indicate compounds that the International Agency for Research on Cancer (IARC) has determined to be animal carcinogens. The sum of these seven compounds represents the "7-PAH" emission subset that is used in this inventory.

The 16-PAHs listed above are commonly reported in emissions source testing because they are the targeted compounds in the standard EPA and state analytical methods. These standard analytical methods are the EPA's Modified Method 5, a test procedure to measure semi-volatile organic compounds, and the California Air Resources Board (CARB) Method 429, a sampling and analytical method to determine PAH emissions from stationary sources. Sources that have been tested with these methods include fuel combustion, coke production, motor vehicle emissions, petroleum refining processes, waste incineration, asphalt production, and natural emissions sources such as forest fires.

The majority of the existing research on POM emissions has been compiled for individual PAH compounds listed above or for some grouping of these compounds. This grouping is often referred to in the literature as "total PAH," "total PNA," or inaccurately as "total POM." There is no consistent definition of the term "total PAH" or "total POM" as used in previous inventory efforts. Within one study, the definition will refer to only 4 PAH compounds for one category of sources and 13 PAH compounds for another source. While the testing methods on which the data are based are the same in most cases, different compounds are targeted for reporting purposes.

In compiling the 7-PAH and 16-PAH emission factors used to develop inventory estimates, there was not always a complete set of emission factors for the 7-PAH and 16-PAH subsets. In some cases, certain PAH compounds were not measured in the original emission source tests and therefore are not represented in the emission factor. The reader should refer to Appendix B for a listing of the individual PAH compounds that are included in the 7-PAH and 16-PAH emission factors for each source category.

3.2.2 EOM Emission Factor Development

Extractable organic matter, or EOM, is a gravimetric-based measurement of solvent EOM which includes all of the multi-ring POM compounds. EOM is reported as a total mass with no individual compounds speciated. EOM is generally the organic fraction of particulate and/or semi-volatile matter collected during sampling.

The EOM emission factors used in this inventory were developed from either of two specific sampling methods: the dilution tunnel technique or the Source Assessment Sampling System (SASS). The dilution tunnel method is designed to collect total particulate and particulate bound organic material at conditions which approximate the ambient environment. The SASS is designed to collect particulate and nonparticulate organic and inorganic materials at source conditions.

The dilution tunnel technique has been used by the EPA's Air Pollution Prevention and Control Division (APPCD) to measure the EOM emissions from various sources. The known carcinogenic PAH compounds, and the substituted PAHs that constitute POM, are a part of the EOM based estimates, including methylated PAH, nitrated PAH, oxidized PAH, and a variety of other POM compounds that are being studied as potential animal and human carcinogens.

In order to better account for the large number of compounds that may contribute to the overall risk estimate for POM emissions from a source, the current health effects research conducted by the EPA's National Health and Environmental Effects Research Laboratory (NHEERL) has focused on measurements of EOM emissions (Lewtas, 1993). In these studies, the EOM being measured is condensible and usually particle associated. Urban area source data collected for this research is based on EOM from particle source emissions collected by a dilution method in which the condensible organic matter containing POM is absorbed to the particulate matter. Dilution sampling was also used for mobile source emission tests (i.e., diesel and gasoline internal combustion emissions). Source samples have been collected as the condensed fraction from process streams (i.e., coke ovens and roofing tar) or as diluted samples collected on filters and selected sorbents (i.e., wood stoves, residential distillate oil).

The EOM emissions data that has been collected as part of the research described above have been used in the comparative potency method to develop cancer unit risk estimates. It should be noted that comparative potency is not an official EPA unit risk estimate. This approach, and the risk estimates derived from it, have been used by the EPA's Office of Air Quality Planning and Standards (OAQPS) in their current cancer risk assessment reports and are being considered for insertion into the Integrated Risk Information System (IRIS) (Lewtas, 1993). The Office of Mobile Sources has also used comparative potency in the Motor Vehicle-Related Air Toxic Study, but has characterized the estimate as highly uncertain.

The SASS was the sampling technique used to measure gravimetric organics in the EPA's series of environmental assessments performed on various source categories in the late 1970's and early 1980's. Extractable organic material from environmental assessment samples was

quantified in the following way: gravimetric organics, also known as organics >C16, were determined by allowing a measured aliquot of the total organic extract to evaporate to dryness, leaving only the condensible organic material behind. Laboratory studies determined that the range of material in these samples included organic compounds with a boiling point above the normal 16 carbon compound, hexadecane, hence the name >C16. This sample preparation approach was used by the EPA's NHEERL in early studies of animal carcinogenic potency. This approach forms the basis for the mass measurement technique used by NHEERL for EOM from complex environmental samples. Therefore, EOM as defined by NHEERL and as quantified in the SASS analysis are identical. The EOM measurement only differs between these two techniques by the way the materials were obtained from the source.

3.3 Source Category Inclusion

Included in this inventory are most of the known, significant contributors to PAH emissions based on available test data, such as external combustion sources, primary aluminum production, and onroad vehicles. These sources were identified through an extensive literature search, based primarily on identifying sources of any of the compounds in the 7-PAH or 16-PAH subset. However, there are some suspected sources for which there is relatively little or no emissions test data available in order to estimate national emissions. For example, non-road vehicle and equipment sources (NRVE) - other include 74 different equipment types such as agricultural, construction, and industrial equipment and vehicles. All non-road equipment are suspected sources of PAH (including EOM) because they have internal combustion engines, however, adequate test data used to develop emission factors is not available for all 74 equipment types.

Based on available test data, POM emissions can be released from hazardous waste disposal by incineration. POM estimates are quantified in this document for dedicated hazardous waste incinerators and Portland cement kilns burning hazardous waste as a supplemental fuel. Based on the data from these sources, it is suspected that POM emissions would also be released from other hazardous waste disposal processes such as light weight aggregate kilns (LWAKS)

and other boilers and industrial furnaces (BIFs). POM emission estimates could not be determined in this inventory for LWAKs and other BIFs (e.g., large boilers, smelting furnaces) due to either a lack of source-specified emission factors or activity data. EPA's Office of Solid Waste plans to begin studying these types of waste disposal sources in greater depth in the near future, and more data from which to quantify POM emissions may be generated at that time.

The EOM source categories were identified based on an in-depth review of available literature sources and on previous national inventories for POM emissions. Many of the known POM source categories are also EOM source categories; however, there is only a limited number of sources for which EOM emissions data have been collected. National emissions estimates were developed for all source categories where EOM emission factors were available. Table 3-1 identifies the categories for which national emissions were determined.

The following categories were identified as potentially significant sources of EOM emissions (based on known POM emission sources) for which sufficient emission factor data were not available to develop national emissions:

- Iron and Steel Foundries;
- Secondary Lead Smelting;
- Asphalt Roofing Manufacture;
- Asphalt Hot-mix Production;
- Pulp and Paper Production;

Table 3-1

7-PAH, 16-PAH, and EOM 1990 Base Year National Emissions Estimates by Source Category

Source Category ^a	Number of U.S. Facilities	7-PAH Emissions ^b (tons/yr)	16-PAH Emissions ^c (tons/yr)	EOM Emissions (tons/yr)
Abrasive Grain (Media) Manufacturing	1 ^d	ND ^e	24.8	ND
Adhesives and Sealants Manufacturing	1 ^d	ND	4.18	ND
Aerospace Industry (Surface Coating)	2869	ND	1640	ND
Agricultural Chemicals Manufacturing	9 ^d	ND	9.03	ND
Asphalt Hot-Mix Production	3600	0.094	43.7	ND
Asphalt Roofing Production	98	1.68	43.6	ND
Blast Furnace and Steel Mills	58	ND	499	ND
Carbamate Insecticides Production	1	ND	4.08	ND
Carbon Black Production	24	0.45	4.33	ND
Chemical Manufacturing: Cyclic Crude and Intermediate Production	37	ND	104	ND
Chemical Preparations Manufacturing	24 ^d	ND	6.79	ND
Chloralkali Production	7	ND	4.52	ND
Cigarette Smoke	Not applicable	0.52	3.45	ND
Clay Refractories Manufacturing	2	ND	0.5	ND
Cleaning Products Manufacturing (SICs combined)	8 ^d	ND	1.38	ND
Coke Ovens: By-Product Recovery Plants	19	ND	77.8	ND
Coke Ovens: Charging, Topside & Door Leaks	29	71.8	539	679 ^h
Coke Ovens: Pushing, Quenching & Battery Stacks	29	30.1	516.6	ND
Commercial Coal Combustion	Not available	36	172.7	2744
Commercial Natural Gas Combustion	Not available	ND	0.03	1921
Commercial Oil Combustion	111,000	0.03	53.3	1315
Commercial Printing, Gravure	1 ^d	ND	28.9	ND
Commercial Printing, Letterpress and Screen	1 ^d	ND	10.4	ND
Commercial Wood/Wood Residue Combustion	<30,000	1.01	35.8	1946
Consumer Products Usage	Not applicable	ND	5733	ND
Crematories	1015	< 0.01	< 0.01	ND
Drum and Barrel Reclamation	12	< 0.01	< 0.01	ND
Electronic and Other Electric Equipment Manufacturing (SICs combined)	3 ^d	ND	30.5	ND
Fabricated Metal Products Manufacturing	9 ^d	ND	143	ND
Fabricated Rubber Products Manufacturing	1 ^d	ND	148	ND
Ferroalloy Manufacture	17	0.26	0.56	ND
Fiber Cans, Drums, and Similar Products Manufacturing	1 ^d	ND	5.06	ND
Food Products (SICs combined)	4 ^d	ND	3.54	ND
Gasoline Distribution (Stage I)	Not available	ND	355	ND
Gasoline Distribution (Stage II)	210,120	ND	374	ND
Gum and Wood Chemical Manufacturing	1 ^d	ND	0.5	ND
Hazardous Waste Incineration ^f	150	0.02	0.18	ND

Table 3-1

7-PAH, 16-PAH, and EOM 1990 Base Year National Emissions Estimates by Source Category (Continued)

Source Category ^a	Number of U.S. Facilities	7-PAH Emissions ^b (tons/yr)	16-PAH Emissions ^c (tons/yr)	EOM Emissions (tons/yr)
Industrial Coal Combustion	64,000	3.09	157	2412
Industrial Gases Manufacturing	1 ^d	ND	9.43	ND
Industrial Inorganic Chemicals Manufacturing	8 ^d	ND	15.7	ND
Industrial Machinery and Electrical Equipment Manufacturing (SICs combined)	8 ^d	ND	2.77	ND
Industrial Natural Gas Combustion	Not available	ND	0.02	928
Industrial Oil Combustion	6000	0.03	50.85	494
Industrial Organic Chemicals Manufacturing	39 ^d	ND	227	ND
Industrial Stationary IC Engines - Diesel	Not available	0.0893	5.02	1929
Industrial Stationary IC Engines - Natural Gas	Not available	1.03	47.6	ND
Industrial Turbines - Diesel Fired	Not available	ND	0.02	1731
Industrial Turbines: Natural Gas Fired	Not available	ND	13.8	739
Industrial Waste Oil Combustion	Not available	1.34	7.82	ND
Industrial Wood/Wood Residue Combustion	45,150	1.21	68.8	44,200
Iron Foundries	103	0.06	0.19	ND
Landfill (Gas) Flares	Not available	< 0.01	0.445	ND
Lubricating Oils and Grease	3 ^d	ND	0.06	ND
Medical Waste Incineration	3400	ND	0.8	15
Metal Household Furniture Manufacturing	1 ^d	ND	< 0.01	ND
Miscellaneous Manufacturing	5 ^d	ND	6.58	ND
Miscellaneous Plastics Products	2 ^d	ND	5.76	ND
Municipal Waste Combustion	168	ND	0.10	182
Naphthalene - Miscellaneous Uses	Not available	ND	1.25	ND
Naphthalene Production	2	ND	64.6	ND
Naphthalene Sulfonates Production	5	ND	6.53	ND
Non-Road Vehicles and Equipment (NRVE) - Aircraft	Not applicable	0.09	4.79	0
Nonmetallic Mineral Products Manufacturing	1 ^d	ND	< 0.01	ND
NRVE - Other	Not applicable	24	47	25,116
Office Furniture, Except Wood Manufacturing	1 ^d	ND	6.45	ND
Onroad Vehicles	Not applicable	34.4	75.9	56,157
Open Burning of Scrap Tires	Not applicable	52.5	294	ND
Other Biological Incineration	1700	ND	ND	1.05
Other Miscellaneous Manufacturing (SICs combined)	4 ^d	ND	1.45	ND
Other Structural Clay Products Manufacturing	Not available	ND	0.56	ND
Paints and Allied Products Manufacturing	22	ND	30.7	ND
Paper Coated and Laminated, Packaging	1 ^d	ND	55.4	ND
Partitions and Fixtures Manufacturing	1 ^d	ND	4.35	ND
Petroleum Refining: All Processes	190	16.4	1100	ND
Pharmaceutical Preparations and Manufacturing (SICs combined)	3 ^d	ND	0.77	ND

Table 3-1

7-PAH, 16-PAH, and EOM 1990 Base Year National Emissions Estimates by Source Category (Continued)

Source Category ^a	Number of U.S. Facilities	7-PAH Emissions ^b (tons/yr)	16-PAH Emissions ^c (tons/yr)	EOM Emissions (tons/yr)
Phthalic Anhydride Production	1	ND	26.2	ND
Plastic Foam Products Manufacturing	1 ^d	ND	110	ND
Plastics Material and Resins Manufacturing	21	ND	8.55	ND
Porcelain Electrical Supplies	5 ^d	ND	2.08	ND
Portland Cement Manufacture: Hazardous Waste Kilns	20	2.08	12.6	ND
Portland Cement Manufacture: Non-Hazardous Waste Kilns	90	2.6	47.9	ND
Primary Aluminum Production ^e	6	141	662	3876
Primary Metal Products Manufacturing (SICs combined)	10 ^d	ND	26.9	ND
Public Building and Related Furniture Manufacturing	1 ^d	ND	11.6	ND
Pulp and Paper Manufacturing - Kraft Recovery Furnaces	124	3.74	649	ND
Pulp and Paper Manufacturing - Lime Kilns	124	0.25	183	ND
Pulp and Paper Manufacturing - Sulfite Recovery Furnaces	12	ND	6.17	ND
Residential Coal Combustion	Not available	31.85	102.8	ND
Residential Natural Gas Combustion	Not available	0.08	5.1	4142
Residential Oil Combustion	10,000,000	1.7	21	1465
Residential Wood Combustion	25,000,000	572	8855	235,881
Scrap or Waste Tire Incineration	18	< 0.01	0.01	ND
Secondary Lead Smelting	23	0.019	69.9	ND
Sewage Sludge Incineration	174	0.00867	1.64	ND
Ship Building and Repair (Surface Coating)	1 ^d	ND	14.4	ND
Surface Active Agents Manufacturing	3 ^d	ND	7.41	ND
Textiles Manufacturing (SICs Combined)	3 ^d	ND	9.68	ND
Tire Manufacturing	55	ND	7	ND
Transportation Equipment Manufacturing (SICs combined)	12 ^d	ND	51.6	ND
Utility Coal Combustion	426	0.21	7.55	38,627
Utility Natural Gas Combustion	267	ND	0.69	1004
Utility Oil Combustion	137	0.05	0.57	531
Wildfires and Prescribed Burning	Not applicable	964	2540	ND
Wood Household Furniture Manufacturing	2 ^d	ND	11.3	ND
Wood Treatment/Wood Preserving	72 ⁱ	ND	90.4	ND
Total Emissions		1995.80	26476.54	428035.05

^a Source categories listed as “SICs combined” were classified using multiple Standard Industrial Classification (SIC) codes. The EPA TRI database was searched for emissions information based on these codes. The SIC codes used for each identified category are defined in the footnotes to Table 2-1 of this document.

^b 7-PAH subset includes benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(d)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene. All 7-PAH are not included in the 7-PAH emissions for every source category; in some cases, there is not a complete set of emission factors for all 7-PAH

Table 3-1

7-PAH, 16-PAH, and EOM 1990 Base Year National Emissions Estimates by Source Category (Continued)

since the available test data did not report or sample for a specific PAH compound(s). Refer to Appendix B for a listing of specific compounds included in the 7-PAH emission factor for a particular source category.

- ^c 16-PAH subset includes acenaphthene, acenaphthylene, anthracene, benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene. All 16-PAH are not included in the 16-PAH emissions for every source category; in some cases, there is not a complete set of emission factors for all 16-PAH since the available test data did not report or sample for a specific PAH compound(s). Refer to Appendix B for a listing of specific compounds included in the 16-PAH emission factor for a particular source category.
- ^d Indicates a number of facilities value that was obtained from the Toxics Release Inventory (TRI) system. The TRI data do not necessarily contain all facilities in an industry. As such, the values reported here may under-report the correct estimate of U.S. facilities.
- ^e “ND” indicates that there were no emission factor data available, therefore, a national estimate was not calculated in these cases.
- ^f Emissions estimate for this category represent emissions from dedicated waste incinerators. It does not include BIFs. A separate estimate is provided for Portland cement kilns burning hazardous waste. No estimates are available for LWAKs and other BIFs.
- ^g The 1990 emissions will be reduced by an estimated 50 percent after the proposed MACT standard for primary aluminum is implemented.
- ^h EOM emission estimate includes charging operations, leaking doors, charging lids, and oven offtakes.
- ⁱ Number of facilities that treat wood with creosote (57 use creosote exclusively, 15 use both creosote and pentachlorophenol).

- Carbon Black Manufacturing;
- Wood Treatment and Preserving;
- Charcoal Manufacturing;
- Hazardous Waste Incineration;
- Petroleum Refining; and
- Locomotives, Aircraft, and Other Non-road Vehicles (excluding agriculture and construction equipment which are accounted for in this inventory).

Of the above listed categories, iron and steel foundries and petroleum refineries are likely to be significant sources of EOM emissions based on the air emissions for individual POM compounds reported in available source data and references.

3.4 Detailed Emissions Summary

3.4.1 National Emissions

Table 3-1 presents the 1990 base year 7-PAH, 16-PAH, and EOM national emissions by source category. Appendix A summarizes the factors and methodology used for the EOM national emissions calculations. Appendix B documents the national emissions calculations for 7-PAH and 16-PAH. The documentation in Appendices A and B provide information on the data sources on which the emission factors were based for each individual source category.

Current emissions for several of these source categories (e.g., MWC, cement kilns, and MWI) are significantly below the 1990 levels shown here due to the development and application of various MACT standards and industry efforts to reduce emissions. For these source categories, the 1990 estimates are not representative of the reduced contributions these categories are making to current national emission levels.

Due to the lack of adequate emission factor data, there are many source categories listed in Table 3-1 for which EOM national emissions could not be calculated. Section 3.3 provides a listing of suspected EOM sources for which emissions could not be calculated for this inventory due to the lack of emission factor data.

The reader should be aware that the emission sources for each source category, on which the emission factor data are based, are different between the PAH subsets and EOM. The 7-PAH and 16-PAH emission estimates are based on the same emission source test data (i.e, the emission factors were developed from testing done on the same unit at the same time); the EOM emissions, however, are based on test data conducted separately and the emission sources are not always identical (e.g., in terms of unit configuration or control devices in place) to the ones on which the 7-PAH and 16-PAH emissions are based. This inconsistency should be noted in making any comparisons of the relative size of emissions from source categories between the PAH subsets and EOM.

Figure 3-1, 3-2, and 3-3 show the breakdown of 1990 base year national emissions for 7-PAH, 16-PAH, and EOM, respectively. Each figure shows the estimated annual emissions in tons per year and the percentage contribution to national emissions for the most significant source categories. All emission source categories (stationary point, stationary area, mobile, and biogenic) are included in the figures.

For the 7-PAH emissions, total national emissions are dominated by five source categories. Over 90 percent of national 7-PAH emissions come from the categories of wildfires and prescribed burning (48.3%), residential wood combustion (28.7%), primary aluminum production (7.1%), coke oven charging, topside and door leaks (3.6%), and open burning of scrap tires (2.6%). Only 10 of the 41 quantified 7-PAH categories contributed at least 1 percent to total national emissions. Most of the rest contributed less than 0.1 percent.

For 16-PAH emissions, two categories, residential wood combustion (33.4%) and consumer products usage (21.7%), make up over 55 percent of national 16-PAH emissions. The

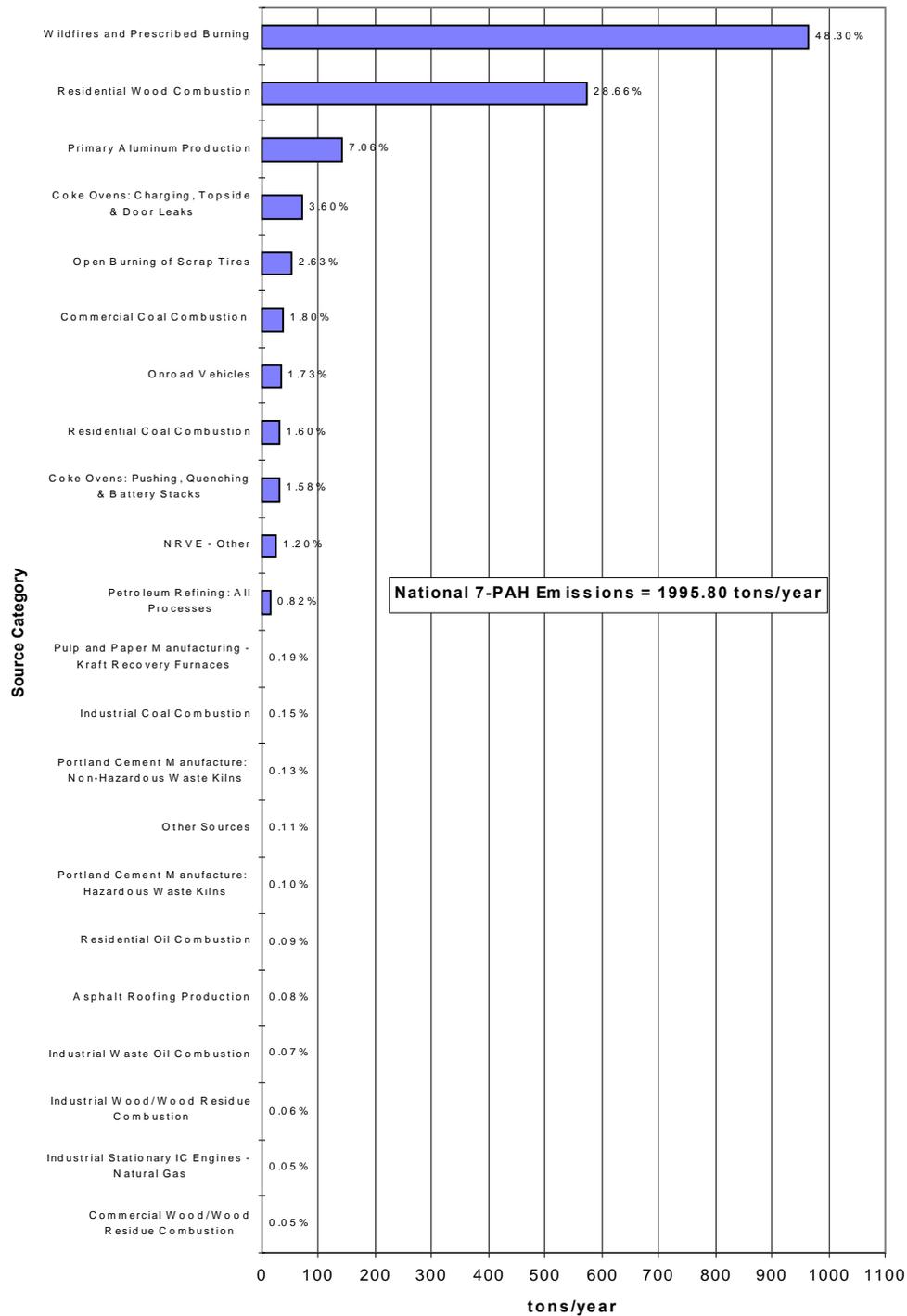


Figure 3-1. Percentage Contribution to 1990 National 7-PAH Emissions by Source Category

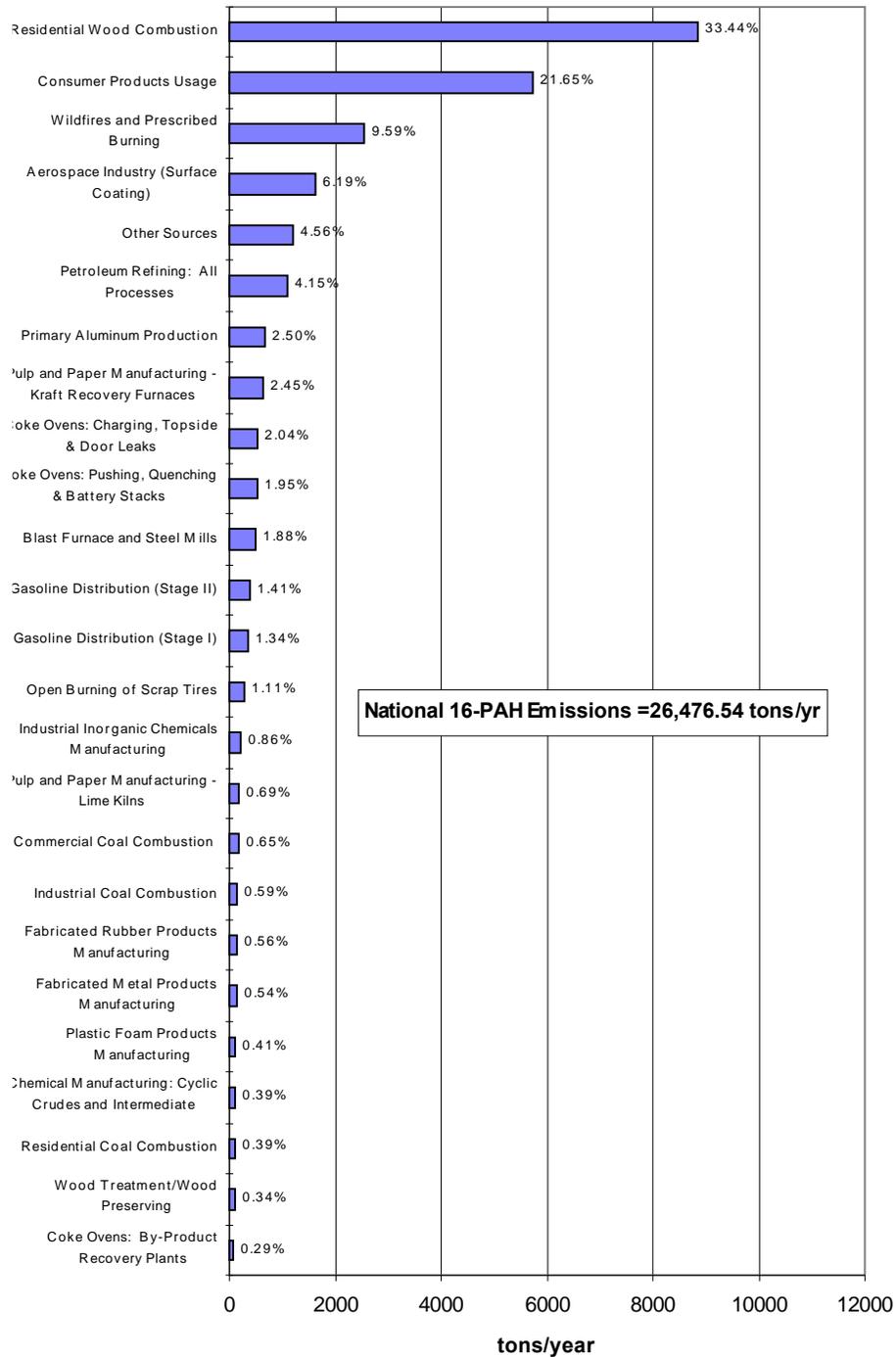


Figure 3-2. Percentage Contribution to 1990 National 16-PAH Emissions by Source Category

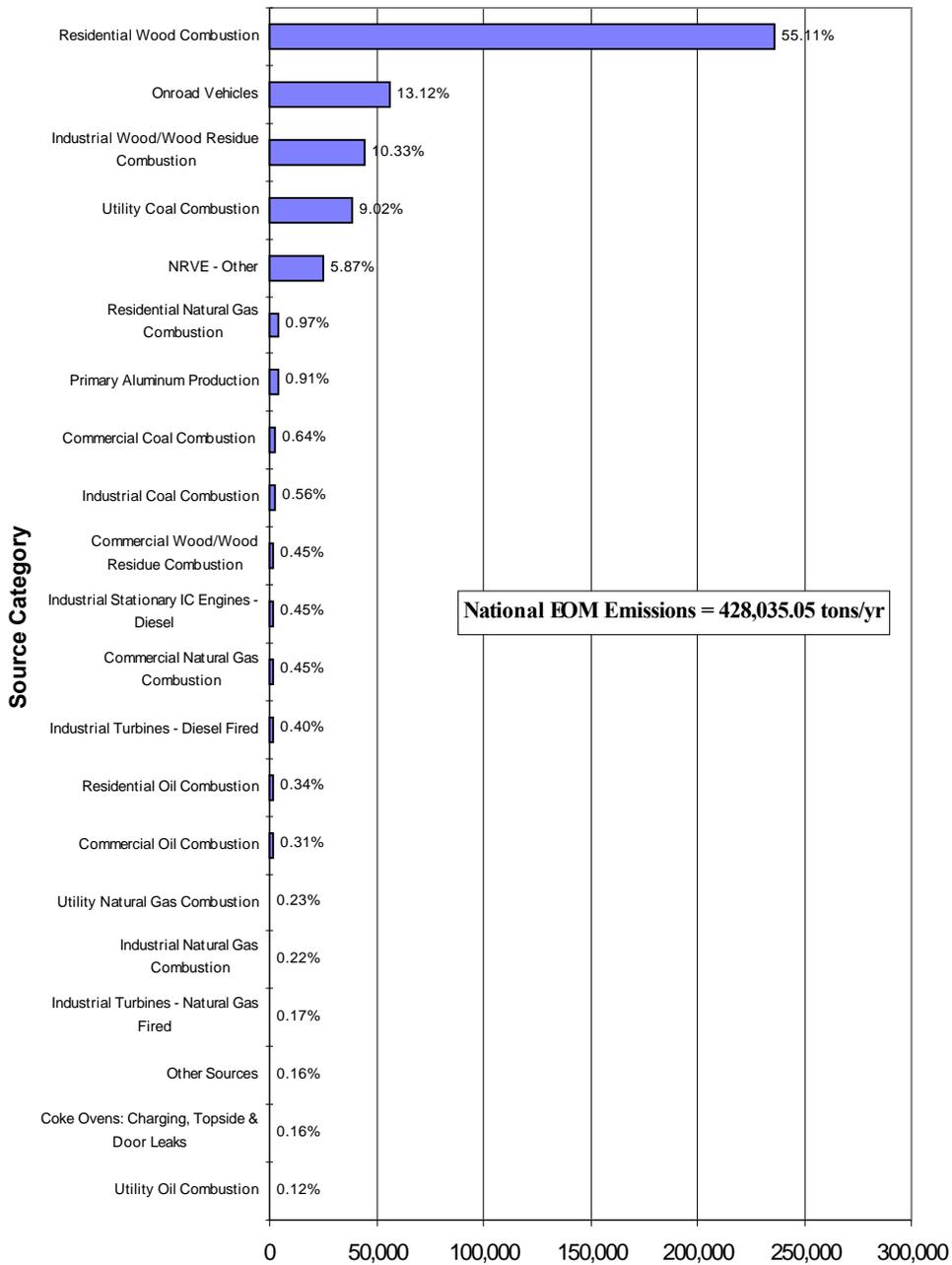


Figure 3-3. Percentage Contribution to 1990 National EOM Emissions by Source Category

next eight categories of 16-PAH emissions add another 30 percent to national emissions indicating that 10 categories (out of 104) constitute over 85 percent of national 16-PAH emissions. The majority of the categories contribute less than 0.1 percent. The major contributors to national EOM emissions (to the extent they have been quantified) are residential wood combustion (55.1%), onroad vehicles (13.1%), industrial wood combustion (10.3%), utility coal combustion (9%), and non-road vehicle engines (5.9%).

Overall, the reader should be aware of the inherent differences between the three POM emission formats when studying the emissions breakdown shown in Figures 3-1, 3-2, and 3-3. While there are similar trends for some source category contributions (e.g., residential wood combustion is clearly a significant category for all three formats), each of the three formats represent uniquely different quantities. The EOM emissions, for example, are much higher for most source categories because the EOM measurement method includes many more PAH compounds than the 7-PAH and 16-PAH subsets. Other differences are related to the characteristics of the emission sources on which the emission calculations were based. For example, the EOM emission factor for onroad vehicles is based on 1970 and early 1980 model year vehicles, whereas the 7-PAH and 16-PAH emission factors represent much more recent data. This may explain, in part, the larger contribution from onroad vehicles for EOM (i.e., older vehicles typically have higher emissions than newer vehicles due to the engine technology, lack of sophisticated control devices, and disrepair). Lastly, the lack of broad source category coverage for EOM emissions hinders any relative comparisons between it and the different PAH formats.

3.4.2 Major/Area Source Emissions

Using the allocation assumptions described in Chapter 2.0, 7-PAH, 16-PAH, and EOM national emissions were grouped, by source category, as to whether they originated from major or area sources. Table 3-2 shows the allocation of 7-PAH national emissions for each source category. The 16-PAH and EOM data on a major/area source basis are given in Tables 3-3 and 3-4, respectively.

Table 3-2

**Allocation of 1990 Base Year 7-PAH National Emissions
By Major/Area Source Classifications**

Source Category	Total National Emissions (tons/yr)	Major Source Emissions^a (tons/yr)	Area Source Emissions^b (tons/yr)
Asphalt Hot-Mix Production	9.40E-02	0.00E+00	9.40E-02
Asphalt Roofing Production	1.68E+00	1.43E+00	2.46E-01
Carbon Black Production	4.50E-01	1.35E-01	3.15E-01
Cigarette Smoke	5.20E-01	0.00E+00	5.20E-01
Coke Ovens: Charging, Topside & Door Leaks	7.18E+01	7.18E+01	0.00E+00
Coke Ovens: Pushing, Quenching & Battery Stacks	3.01E+01	3.01E+01	0.00E+00
Commercial Coal Combustion	3.60E+01	7.20E+00	2.88E+01
Commercial Oil Combustion	3.16E-02	6.31E-03	2.53E-02
Commercial Wood/Wood Residue Combustion	1.01E+00	2.02E-01	8.08E-01
Crematories	1.42E-08	0.00E+00	1.42E-08
Drum and Barrel Reclamation	1.27E-06	0.00E+00	1.27E-06
Ferrous Alloy Manufacture	2.60E-01	0.00E+00	2.60E-01
Hazardous Waste Incineration	2.09E-02	2.09E-02	0.00E+00
Industrial Coal Combustion	3.09E+00	2.16E+00	9.27E-01
Industrial Oil Combustion	3.07E-02	2.15E-02	9.22E-03
Industrial Stationary IC Engines - Diesel	8.93E-02	6.25E-02	2.68E-02
Industrial Stationary IC Engines - Natural Gas	1.03E+00	6.18E-01	4.12E-01
Industrial Waste Oil Combustion	1.34E+00	9.38E-01	4.02E-01
Industrial Wood/Wood Residue Combustion	1.21E+00	9.68E-01	2.42E-01
Iron Foundries	6.00E-02	6.00E-02	0.00E+00
Landfill (Gas) Flares	1.05E-03	0.00E+00	1.05E-03
Non-Road Vehicles and Equipment (NRVE) - Aircraft	9.00E-02	0.00E+00	9.00E-02
NRVE - Other	2.40E+01	0.00E+00	2.40E+01
Onroad Vehicles	3.44E+01	0.00E+00	3.44E+01
Open Burning of Scrap Tires	5.25E+01	0.00E+00	5.25E+01
Petroleum Refining: All Processes	1.64E+01	1.60E+01	4.02E-01
Portland Cement Manufacture: Hazardous Waste Kilns	2.08E+00	2.08E+00	0.00E+00
Portland Cement Manufacture: Non-Hazardous Waste Kilns	2.60E+00	2.08E+00	5.20E-01
Primary Aluminum Production	1.41E+02	6.35E+01	7.76E+01
Pulp and Paper Manufacturing - Kraft Recovery Furnaces	3.74E+00	3.74E+00	0.00E+00
Pulp and Paper Manufacturing - Lime Kilns	2.50E-01	2.50E-01	0.00E+00
Residential Coal Combustion	3.19E+01	0.00E+00	3.19E+01
Residential Natural Gas Combustion	8.02E-02	0.00E+00	8.02E-02
Residential Oil Combustion	1.70E+00	0.00E+00	1.70E+00
Residential Wood Combustion	5.72E+02	0.00E+00	5.72E+02
Scrap or Waste Tire Incineration	2.17E-05	2.17E-05	0.00E+00

Table 3-2

**Allocation of 1990 Base Year 7-PAH National Emissions
By Major/Area Source Classifications (Continued)**

Source Category	Total National Emissions (tons/yr)	Major Source Emissions^a (tons/yr)	Area Source Emissions^b (tons/yr)
Secondary Lead Smelting	1.90E-02	9.88E-03	9.12E-03
Sewage Sludge Incineration	8.67E-03	0.00E+00	8.67E-03
Utility Coal Combustion	2.10E-01	2.10E-01	0.00E+00
Utility Oil Combustion	5.00E-02	2.50E-02	2.50E-02
Wildfires and Prescribed Burning	9.64E+02	0.00E+00	9.64E+02
Total Emissions	1995.80	203.57	1792.22

^a These are the estimated national emissions from “major” sources within the source category. “Major” sources, as defined in this inventory, are defined as any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs.

^b These are the estimated national emissions from “area” sources within the source category. “Area” sources are defined in this inventory as any source of HAPs that is not a major source, as defined in the footnote above.

Table 3-3

**Allocation of 1990 Base Year 16-PAH National Emissions
By Major/Area Source Classifications**

Source Category^a	Total National Emissions (tons/yr)	Major Source Emissions^b (tons/yr)	Area Source Emissions^c (tons/yr)
Abrasive Grain (Media) Manufacturing	2.48E+01	1.24E+00	2.36E+01
Adhesives and Sealants Manufacturing	4.18E+00	3.97E+00	2.09E-01
Aerospace Industry (Surface Coating)	1.64E+03	1.64E+03	0.00E+00
Agricultural Chemicals Manufacturing	9.03E+00	8.31E+00	7.18E-01
Asphalt Hot-Mix Production	4.37E+01	0.00E+00	4.37E+01
Asphalt Roofing Production	4.36E+01	3.72E+01	6.37E+00
Blast Furnace and Steel Mills	4.99E+02	4.89E+02	1.05E+01
Carbamate Insecticides Production	4.08E+00	1.22E+00	2.86E+00
Carbon Black Production	4.33E+00	1.30E+00	3.03E+00
Chemical Manufacturing: Cyclic Crude and Intermediate Production	1.04E+02	1.01E+02	3.20E+00
Chemical Preparations Manufacturing	6.79E+00	6.45E+00	3.40E-01
Chloralkali Production	4.52E+00	1.36E+00	3.16E+00
Cigarette Smoke	3.45E+00	0.00E+00	3.45E+00
Clay Refractories Manufacturing	5.00E-01	0.00E+00	5.00E-01
Cleaning Products Manufacturing (SICs combined)	1.38E+00	1.31E+00	6.90E-02
Coke Ovens: By-Product Recovery Plants	7.78E+01	7.78E+01	0.00E+00
Coke Ovens: Charging, Topside & Door Leaks	5.39E+02	5.39E+02	0.00E+00
Coke Ovens: Pushing, Quenching & Battery Stacks	5.17E+02	5.17E+02	0.00E+00
Commercial Coal Combustion	1.73E+02	3.45E+01	1.38E+02
Commercial Natural Gas Combustion	3.00E-02	6.00E-03	2.40E-02
Commercial Oil Combustion	5.33E+01	1.07E+01	4.26E+01
Commercial Printing, Gravure	2.89E+01	2.87E+01	1.88E-01
Commercial Printing, Letterpress and Screen	1.04E+01	8.22E+00	2.18E+00
Commercial Wood/Wood Residue Combustion	3.58E+01	7.16E+00	2.86E+01
Consumer Products Usage	5.73E+03	0.00E+00	5.73E+03
Crematories	8.33E-06	0.00E+00	8.33E-06
Drum and Barrel Reclamation	8.19E-05	0.00E+00	8.19E-05
Electronic and Other Electric Equipment Manufacturing (SICs combined)	3.05E+01	2.29E+01	7.63E+00
Fabricated Metal Products Manufacturing	1.43E+02	1.07E+02	3.58E+01
Fabricated Rubber Products Manufacturing	1.48E+02	1.48E+02	3.70E-02
Ferrous Alloy Manufacture	5.60E-01	0.00E+00	5.60E-01
Fiber Cans, Drums, and Similar Products Manufacturing	5.06E+00	4.52E+00	5.39E-01
Food Products (SICs combined)	3.54E+00	1.77E-01	3.36E+00
Gasoline Distribution (Stage I)	3.55E+02	3.55E+01	3.20E+02

Table 3-3

**Allocation of 1990 Base Year 16-PAH National Emissions
By Major/Area Source Classifications (Continued)**

Source Category^a	Total National Emissions (tons/yr)	Major Source Emissions^b (tons/yr)	Area Source Emissions^c (tons/yr)
Gasoline Distribution (Stage II)	3.74E+02	3.74E+01	3.37E+02
Gum and Wood Chemical Manufacturing	5.00E-01	4.95E-01	5.14E-03
Hazardous Waste Incineration	1.75E-01	1.75E-01	0.00E+00
Industrial Coal Combustion	1.57E+02	1.10E+02	4.71E+01
Industrial Gases Manufacturing	9.43E+00	9.28E+00	1.47E-01
Industrial Inorganic Chemicals Manufacturing	1.57E+01	1.51E+01	6.46E-01
Industrial Machinery and Electrical Equipment Manufacturing (SICs combined)	2.77E+00	2.08E+00	6.93E-01
Industrial Natural Gas Combustion	2.00E-02	1.40E-02	6.00E-03
Industrial Oil Combustion	5.09E+01	3.56E+01	1.53E+01
Industrial Organic Chemicals Manufacturing	2.27E+02	2.23E+02	4.03E+00
Industrial Stationary IC Engines - Diesel	5.02E+00	3.51E+00	1.51E+00
Industrial Stationary IC Engines - Natural Gas	4.76E+01	2.86E+01	1.90E+01
Industrial Turbines - Diesel Fired	1.55E-02	1.09E-02	4.65E-03
Industrial Turbines: Natural Gas Fired	1.38E+01	8.28E+00	5.52E+00
Industrial Waste Oil Combustion	7.82E+00	5.47E+00	2.35E+00
Industrial Wood/Wood Residue Combustion	6.88E+01	5.50E+01	1.38E+01
Iron Foundries	1.90E-01	1.90E-01	0.00E+00
Landfill (Gas) Flares	4.45E-01	0.00E+00	4.45E-01
Lubricating Oils and Grease	6.00E-02	5.06E-02	9.40E-03
Medical Waste Incineration	8.00E-01	1.20E-01	6.80E-01
Metal Household Furniture Manufacturing	2.50E-03	2.30E-03	2.00E-04
Miscellaneous Manufacturing	6.58E+00	5.59E+00	9.87E-01
Miscellaneous Plastics Products	5.76E+00	5.49E+00	2.66E-01
Municipal Waste Combustion	9.67E-02	9.19E-02	4.84E-03
Naphthalene - Miscellaneous Uses	1.25E+00	3.75E-01	8.75E-01
Naphthalene Production	6.46E+01	4.52E+01	1.94E+01
Naphthalene Sulfonates Production	6.53E+00	4.57E+00	1.96E+00
Non-Road Vehicles and Equipment (NRVE) - Aircraft	4.79E+00	0.00E+00	4.79E+00
Nonmetallic Mineral Products Manufacturing	2.50E-03	1.56E-03	9.44E-04
NRVE - Other	4.70E+01	0.00E+00	4.70E+00
Office Furniture, Except Wood Manufacturing	6.45E+00	6.20E+00	2.53E-01
Onroad Vehicles	7.59E+01	0.00E+00	7.59E+01
Open Burning of Scrap Tires	2.94E+02	0.00E+00	2.94E+02
Other Miscellaneous Manufacturing (SICs combined)	1.45E+00	1.31E+00	1.45E-01
Other Structural Clay Products Manufacturing	5.60E-01	5.25E-01	3.45E-02

Table 3-3

**Allocation of 1990 Base Year 16-PAH National Emissions
By Major/Area Source Classifications (Continued)**

Source Category^a	Total National Emissions (tons/yr)	Major Source Emissions^b (tons/yr)	Area Source Emissions^c (tons/yr)
Paints and Allied Products Manufacturing	3.07E+01	2.36E+01	7.05E+00
Paper Coated and Laminated, Packaging	5.54E+01	5.43E+01	1.09E+00
Partitions and Fixtures Manufacturing	4.35E+00	0.00E+00	4.35E+00
Petroleum Refining: All Processes	1.10E+03	1.07E+03	2.69E+01
Pharmaceutical Preparations and Manufacturing (SICs combined)	7.66E-01	7.28E-01	3.83E-02
Phthalic Anhydride Production	2.62E+01	1.83E+01	7.86E+00
Plastic Foam Products Manufacturing	1.10E+02	1.08E+02	1.56E+00
Plastics Material and Resins Manufacturing	8.55E+00	8.30E+00	2.50E-01
Porcelain Electrical Supplies	2.08E+00	1.95E+00	1.34E-01
Portland Cement Manufacture: Hazardous Waste Kilns	1.26E+01	1.26E+01	0.00E+00
Portland Cement Manufacture: Non-Hazardous Waste Kilns	4.79E+01	3.83E+01	9.58E+00
Primary Aluminum Production	6.62E+02	2.98E+02	3.64E+02
Primary Metal Products Manufacturing (SICs combined)	2.69E+01	1.21E+01	1.48E+01
Public Building and Related Furniture Manufacturing	1.16E+01	9.89E+00	1.71E+00
Pulp and Paper Manufacturing - Kraft Recovery Furnaces	6.49E+02	6.49E+02	0.00E+00
Pulp and Paper Manufacturing - Lime Kilns	1.83E+02	1.83E+02	0.00E+00
Pulp and Paper Manufacturing - Sulfite Recovery Furnaces	6.17E+00	6.17E+00	0.00E+00
Residential Coal Combustion	1.03E+02	0.00E+00	1.03E+02
Residential Natural Gas Combustion	5.10E+00	0.00E+00	5.10E+00
Residential Oil Combustion	2.10E+01	0.00E+00	2.10E+01
Residential Wood Combustion	8.86E+03	0.00E+00	8.86E+03
Scrap or Waste Tire Incineration	5.18E-03	5.18E-03	0.00E+00
Secondary Lead Smelting	6.99E+01	3.63E+01	3.36E+01
Sewage Sludge Incineration	1.64E+00	0.00E+00	1.64E+00
Ship Building and Repair (Surface Coating)	1.44E+01	1.36E+01	8.05E-01
Surface Active Agents Manufacturing	7.41E+00	6.39E+00	1.02E+00
Textiles Manufacturing (SICs Combined)	9.68E+00	4.84E+00	4.84E+00
Tire Manufacturing	7.00E+00	6.93E+00	7.00E-02
Transportation Equipment Manufacturing (SICs combined)	5.16E+01	3.87E+01	1.29E+01
Utility Coal Combustion	7.55E+00	7.55E+00	0.00E+00
Utility Natural Gas Combustion	6.90E-01	0.00E+00	6.90E-01
Utility Oil Combustion	5.70E-01	2.85E-01	2.85E-01
Wildfires and Prescribed Burning	2.54E+03	0.00E+00	2.54E+03
Wood Household Furniture Manufacturing	1.13E+01	1.11E+01	2.38E-01
Wood Treatment/Wood Preserving	9.04E+01	0.00E+00	9.04E+01
Total Emissions	26,476.54	7059.72	19,374.52

Table 3-3

Allocation of 1990 Base Year 16-PAH National Emissions By Major/Area Source Classifications (Continued)

- ^a Source categories listed as “SICs combined” were classified using multiple Standard Industrial Classification (SIC) codes. The EPA TRI database was searched for emissions information based on these codes. The SIC codes used for each identified category are defined in the footnotes to Table 2-1 of this document.
- ^b These are the estimated national emissions from “major” sources within the source category. “Major” sources, as defined in this inventory, are defined as any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs.
- ^c These are the estimated national emissions from “area” sources within the source category. “Area” sources are defined in this inventory as any source of HAPs that is not a major source, as defined in the footnote above.

Table 3-4

**Allocation of 1990 Base Year EOM National Emissions
By Major/Area Source Classifications**

Source Category	Total National Emissions (tons/yr)	Major Source Emissions^a (tons/yr)	Area Source Emissions^b (tons/yr)
Coke Ovens: Charging, Topside & Door Leaks	6.79E+02	6.79E+02	0.00E+00
Commercial Coal Combustion	2.74E+03	5.49E+02	2.20E+03
Commercial Natural Gas Combustion	1.92E+03	3.84E+02	1.54E+03
Commercial Oil Combustion	1.32E+03	2.63E+02	1.05E+03
Commercial Wood/Wood Residue Combustion	1.95E+03	3.89E+02	1.56E+03
Industrial Coal Combustion	2.41E+03	1.69E+03	7.24E+02
Industrial Natural Gas Combustion	9.28E+02	6.50E+02	2.78E+02
Industrial Oil Combustion	4.94E+02	3.46E+02	1.48E+02
Industrial Stationary IC Engines - Diesel	1.93E+03	1.35E+03	5.79E+02
Industrial Turbines - Diesel Fired	1.73E+03	1.21E+03	5.19E+02
Industrial Turbines: Natural Gas Fired	7.39E+02	4.43E+02	2.96E+02
Industrial Wood/Wood Residue Combustion	4.42E+04	3.54E+04	8.84E+03
Medical Waste Incineration	1.50E+01	2.25E+00	1.28E+01
Municipal Waste Combustion	1.82E+02	1.73E+02	9.10E+00
NRVE - Other	2.51E+04	0.00E+00	2.51E+04
Onroad Vehicles	5.62E+04	0.00E+00	5.62E+04
Other Biological Incineration	1.05E+00	0.00E+00	1.05E+00
Primary Aluminum Production	3.88E+03	1.74E+03	2.13E+03
Residential Natural Gas Combustion	4.14E+03	0.00E+00	4.14E+03
Residential Oil Combustion	1.47E+03	0.00E+00	1.47E+03
Residential Wood Combustion	2.36E+05	0.00E+00	2.36E+05
Utility Coal Combustion	3.86E+04	3.86E+04	0.00E+00
Utility Natural Gas Combustion	1.00E+03	0.00E+00	1.00E+03
Utility Oil Combustion	5.31E+02	2.66E+02	2.66E+02
Total Emissions	428,035.05	84,125.25	262,636.80

^a These are the estimated national emissions from “major” sources within the source category. “Major” sources, as defined in this inventory, are defined as any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs.

^b These are the estimated national emissions from “area” sources within the source category. “Area” sources are defined in this inventory as any source of HAPs that is not a major source, as defined in the footnote above.

For the 7-PAH data, area source emissions make up approximately 90 percent of the national total based largely on the contributions from wildfires and prescribed burning, residential wood and coal combustion, mobile sources and open burning of scrap tires. The data for 7-PAHs are difficult to completely interpret; however, since there are several source categories that have no estimates due to a lack of 7-PAH emission factor data. A similar, though not quite as significant, picture exists for the 16-PAH emissions total. Approximately 73 percent of national 16-PAH emissions come from area sources. The leading contributors are residential wood combustion (itself 33 percent of total emissions), consumer products usage, wildfires and prescribed burning, and gasoline distribution (driven by presence of naphthalene emissions component). The more significant major sources for 16-PAH emissions include kraft recovery furnaces, aerospace industry surface coating, primary aluminum production, coke ovens, and petroleum refining.

Area sources, in the aggregate, contribute a greater percentage (80 percent) of nationwide EOM emissions than major sources (20 percent). It is important to keep in mind that this inventory does not include all EOM sources, particularly some potentially large contributors such as kraft recovery furnaces and lime kilns. There are only three categories in the inventory that are assumed to be entirely major sources: coke ovens, primary aluminum production and utility coal combustion. Except for utility coal combustion, these other two categories contribute relatively small amounts to the national EOM emissions but are individually major sources of EOM. Residential woodcombustion, on the other hand, is strictly an area source, with a large contribution to the national EOM emission total that weights the national emission contribution heavily towards area sources.

3.5 References

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4.0 EMISSION ESTIMATES FOR 2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN (TCDD)/2,3,7,8-TETRACHLORODIBENZOFURAN (TCDF)

4.1 Emission Factors for 2,3,7,8-TCDD, 2,3,7,8-TCDF, and 2,3,7,8-TCDD TEQ

Emissions estimates for dioxin and furan species are reported for two specific congeners: 2,3,7,8-TCDD and 2,3,7,8-TCDF. The two 2,3,7,8 congeners of dioxins and furans represent the most toxic compounds of their respective families and have been specifically targeted by Section 112(c)(6) of the CAAA for consideration. Other dioxin and furan congeners have varying levels of toxicity. To aid in ranking the health risk contribution of all dioxin and furan emissions, another reporting scheme is employed, namely that of reporting total dioxin and furan emissions in TEQ to 2,3,7,8-TCDD (U.S. EPA, 1986; U.S. EPA, 1989; Heuvel et al., 1993). The toxicity equivalency factor (TEF) ranking scheme is a method for evaluating the risks inherent with exposure to mixtures of chlorinated dibenzo-p-dioxins (CDDs) and chlorinated dibenzofurans (CDFs). The 2,3,7,8-TCDD and 2,3,7,8-TCDF are only 2 of 210 structurally related CDDs and CDFs, where each CDD/CDF structural variation is called a congener.

The compound 2,3,7,8-TCDD has been identified as the most toxic of all the CDDs and CDFs. For this reason, it has been selected as the reference compound against which the toxicity of all the other CDDs and CDFs can be related. 2,3,7,8-TCDD has been assigned TEF of 1.0, and all the other CDD/CDF congeners have been assigned a TEF of some fraction of 1.0, based on their relative toxicity compared to 2,3,7,8-TCDD.

The risk inherent in a CDD/CDF mixture can be determined as follows using the TEF approach (U.S. EPA, 1996c):

- Analytically determine the concentration of all of the CDDs and CDF congeners in a sample;
- Multiply the concentration of each analyzed congener by its assigned TEF to express its concentration in terms of TEQs;

- Sum the concentrations in terms of TEQs for every congener in Step 2; and
- The summed TEQ can then be used to evaluate the health risk of the mixture by comparing it to the risk of an equal concentration of 100 percent 2,3,7,8-TCDD.

To reflect the TEQ emissions of dioxins and furans in this manner, emission estimates of 2,3,7,8-TCDD TEQ are presented in this report. In most cases, emission estimates are reported as an annual value representative of the 1990 base year. As discussed previously, the year 1990 was selected because it is the year the CAAA were enacted.

The emission factors for 2,3,7,8-TCDD, 2,3,7,8-TCDF, and 2,3,7,8-TCDD TEQ used to develop 1990 national emission estimates for this study are presented in Appendix A.

4.2 Source Category Inclusion

The dioxin and furan source categories were identified based on an in-depth review of available literature sources and previously developed national inventories. This review was conducted parallel with a national exposure study of dioxins and furans performed by the EPA's Office of Health and Environmental Assessment (OHEA). National emissions estimates were developed for all source categories with documented emission factors or with credible national estimates. Note that only 2,3,7,8-TCDD TEQ national emission estimates were available from the OHEA study for two source categories: other biological waste incineration and forest fires.

The following categories were identified as potential sources of dioxin and furan emissions for which sufficient data were not available to develop credible national emissions estimates:

- Ethylene Dichloride and Vinyl Chloride Monomer Manufacture;
- Boilers and Industrial Furnaces burning hazardous waste (exclusive of Portland cement kilns and lightweight aggregate kilns);
- Lime Manufacture;

- Petroleum Refining (Catalyst Regeneration);
- Steel Foundries;
- Primary Magnesium Refining;
- Chlorophenol Manufacture; and
- Pulp and Paper Bleached Sludge Burning.

Data for developing emission factors for petroleum refining catalyst regeneration were originally anticipated from the EPA's Petroleum Refinery's NESHAP effort. However, the applicable data obtained through this program were found to contain problems that made them unusable for the purposes of this project. Data for developing emission factors for combustion of landfill gas in flares were also obtained; however, national activity data for landfills were not identified. Thus, national emission estimates for landfills were not determined. In addition, it should be noted that no attempt was made to limit coverage to only those stationary sources that may be subject to requirements of Section 112.

4.3 Detailed Emissions Summary

This section presents the total 1990 base year national emissions estimates for 2,3,7,8-TCDD TEQ, 2, 3, 7, 8-TCDD, and for 2,3,7,8-TCDF. As discussed previously, estimates are not available for all categories for 2,3,7,8-TCDD and 2,3,7,8-TCDF. The 1990 national emissions of each pollutant form have also been allocated as to whether they come from major or area source categories (see Chapter 2.0 for the definition of major and area sources). Appendix A provides documentation on how all emission estimates were calculated; emission factors and activity data are provided. For categories such as municipal waste combustion, medical waste incineration, hazardous waste incineration and Portland cement kilns (non-hazardous and hazardous waste burning), recent regulatory programs provided the bulk of the national emissions data (U.S. EPA 1996a; U.S. EPA, 1996b; Heath, 1996; Rizeq, 1997a; Rizeq, 1997b).

Current emissions for several of these source categories (e.g., MWCs, cement kilns, and MWIs) are significantly below the 1990 levels shown here due to the development and application by EPA of various MACT standards and industry efforts to reduce emissions. For these source categories, the 1990 estimates are not representative of the reduced contributions these categories are making to current national emission levels. For example, 1990 MWI TEQ emissions were 0.00066 tons/yr, while 1996 is estimated at less than 0.00017 tons/yr, and 1990 TEQ emissions from hazardous waste-fired cement kilns were 0.00048 tons/yr contrasted to the 1997 estimate of 1.4E-05 tons/yr (Behan, 1997).

4.3.1 National Emissions

Tables 4-1 through 4-3 present the 1990 national emissions of 2,3,7,8-TCDD, 2,3,7,8-TCDF, and 2,3,7,8-TCDD TEQ for each source category. The tables also present the partitioning of total emissions between major and area sources. All source categories presented in this report are currently listed in the EPA's Section 112 list of major sources (see Section 2.6, Reference No. 1) except for the following:

- Secondary Copper Smelters;
- Residential Coal Combustion;
- Residential Distillate Fuel Combustion;
- Residential Wood Combustion;
- Drum and Barrel Reclamation/Incineration;
- Onroad Mobile Sources;
- Forest Fires; and
- Other Biological Incineration.

Table 4-1

**National 1990 Base Year 2,3,7,8-TCDD Emissions and Emissions
by Major/Area Source Classification**

Source Category	Number of U.S. Facilities	Total National Emissions (lb/yr) ^a	Major Source Emissions (lb/yr) ^b	Area Source Emissions (lb/yr) ^c
Municipal Waste Combustion ^d	168	e	e	e
Medical Waste Incineration	3,400	e	e	e
Residential Wood Combustion	22.5 x 10 ⁶ Households ^f	8.62x10 ⁻⁴	0.00	8.62 x 10 ⁻⁴
Secondary Copper Smelters	4	0.014	0.014	0.00
Industrial Wood Combustion	45,150	0.0067	0.0053	0.0013
Utility Coal Combustion	426	0.028	0.028	0
Residential Coal Combustion	Not available	0.0116	0.00	0.0116
Utility Residual Oil Combustion	137	0.008	0.0072	8.0 x 10 ⁻⁴
Hazardous Waste Incineration	150	2.2 x 10 ⁻⁴	2.2 x 10 ⁻⁴	0.00
Residential Distillate Fuel Combustion	10.1 x 10 ⁶ Households ^f	0.0028	0.00	0.0028
Iron Foundries	103 cypolas	0.0015	0.0015	0.00
Secondary Lead Smelters	23	0.0020	0.016	3.90 x 10 ⁻⁴
Sewage Sludge Incineration ^g	174	9.5 x 10 ⁻⁴	0.00	9.50 x 10 ⁻⁴
Secondary Aluminum Production	23	e	e	e
Onroad Mobile Sources	Not available	0.0077	0.00	0.0077
Drum and Barrel Reclamation/ Incineration	12	2.12 x 10 ⁻⁵	0.00	2.12 x 10 ⁻⁵
Carbon Reactivation Furnaces	Not available	1.51 x 10 ⁻⁵	3.8 x 10 ⁻⁶	1.13 x 10 ⁻⁵
Scrap Tire Incineration	18	1.19 x 10 ⁻⁵	1.19 x 10 ⁻⁵	0.00
Pentachlorophenol Wood Treatment ^h	39	0.00	0.00	0.00
Pulp and Paper/Kraft Recovery Furnaces ⁱ	124	0.00	0.00	0.00
Portland Cement: Non-Hazardous Waste Kilns	90	NA ^j	NA	NA

Table 4-1

**National 1990 Base Year 2,3,7,8-TCDD Emissions and Emissions
by Major/Area Source Classification (Continued)**

Source Category	Number of U.S. Facilities	Total National Emissions (lb/yr) ^a	Major Source Emissions (lb/yr) ^b	Area Source Emissions (lb/yr) ^c
Portland Cement: Hazardous Waste Kilns	20	NA	NA	NA
Other Biological Incineration	1,700	NA	NA	NA
Forest Fires	Not applicable	NA	NA	NA
Crematories	1,015	1.83 x 10 ⁻⁸	0.00	1.83 x 10 ⁻⁸

^a Numbers may not sum across rows due to rounding.

^b These are the estimated national emissions from "major" sources within the source category. "Major" sources are defined in this inventory as any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs.

^c These are the estimated national emissions from "area" sources within the source category. Area sources are defined in this inventory as any source of HAPs that is not a major source, as defined in footnote b above.

^d Dioxin/furan emission estimates from municipal waste combustors are currently under review and evaluation by the EPA. These values are subject to possible change due to these evaluations.

^e Dioxin/furan estimates for these categories were obtained from EPA MACT development programs. Estimates are available at this time only for 2,3,7,8-TCDD TEQ.

^f Households for which the specified fuel is the primary heating source.

^g Dioxin/furan emission estimates from sewage sludge incinerators are currently under review and evaluation by the EPA. These values are subject to possible change due to these evaluations.

^h 2,3,7,8-TCDD emissions were not detected in tests used for emission factor calculation. Number of facilities consists of 24 that use PCP exclusively and 15 that use both PCP and creosote.

ⁱ 2,3,7,8-TCDD emissions were not detected in tests used for emission factor calculation.

^j Not available.

Table 4-2

**National 1990 Base Year 2,3,7,8-TCDF Emissions and Emissions
by Major/Area Source Classification**

Source Category	Number of U.S. Facilities	Total National Emissions (lb/yr) ^a	Major Source Emissions (lb/yr) ^b	Area Source Emissions (lb/yr) ^c
Municipal Waste Combustion ^d	168	e	e	e
Residential Wood Combustion	22.5 x 10 ⁶ households ^f	0.030	0.00	0.030
Secondary Copper Smelters	4	NA ^g	NA	NA
Medical Waste Incineration	3,400	e	e	e
Hazardous Waste Incineration	150	0.025	0.025	0.00
Sewage Sludge Incineration ^h	174	0.342	0.00	0.342
Residential Coal Combustion	Unknown	0.304	0.00	0.304
Industrial Wood Combustion	45,150	0.0095	0.0076	0.0019
Iron Foundries	103 cupolas	0.049	0.049	0.00
Utility Coal Combustion	426	0.068	0.068	0.00
Secondary Lead Smelters	23	0.0120	0.0096	0.0024
Utility Residual Oil Combustion	137	0.0058	0.0052	6.00 x 10 ⁻⁴
Secondary Aluminum Production	23	e	e	e
Residential Distillate Fuel Combustion	10.1 x 10 ⁶ households ^f	0.0027	0.00	0.0027
Onroad Mobile Sources	Not applicable	0.121	0.00	0.121
Drum and Barrel Reclamation/ Incineration	12	3.70 x 10 ⁻⁴	0.00	3.70 x 10 ⁻⁴
Carbon Reactivation Furnaces	Not available	9.77 x 10 ⁻⁵	2.44 x 10 ⁻⁵	7.33 x 10 ⁻⁵
Scrap Tire Incineration	18	2.98 x 10 ⁻⁵	2.98 x 10 ⁻⁵	0.00
Pulp and Paper/Kraft Recovery Furnaces	124	NA	NA	NA
Pentachlorophenol Wood Treatment ⁱ	39	NA	NA	NA
Portland Cement	110	NA	NA	NA

Table 4-2

**National 1990 Base Year 2,3,7,8-TCDF Emissions and Emissions
by Major/Area Source Classification (Continued)**

Source Category	Number of U.S. Facilities	Total National Emissions (lb/yr) ^a	Major Source Emissions (lb/yr) ^b	Area Source Emissions (lb/yr) ^c
Other Biological Incineration	1,700	NA	NA	NA
Forest Fires	Not applicable	NA	NA	NA
Crematories	1,015	1.33 x 10 ⁻⁷	0.00	1.33 x 10 ⁻⁷

^a Numbers may not sum across rows due to rounding.

^b These are the estimated national emissions from "major" sources within the source category. "Major" sources are defined in this inventory as any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs.

^c These are the estimated national emissions from "area" sources within the source category. Area sources are defined in this inventory as any source of HAPs that is not a major source, as defined in footnote b above.

^d Dioxin/furan emission estimates from municipal waste combustors are currently under review and evaluation by the EPA. These values are subject to possible change due to these evaluations.

^e Dioxin/furan estimates for these categories were obtained from EPA MACT development programs. Estimates are available at this time only for 2,3,7,8-TCDD TEQ.

^f Households for which the specified fuel is the primary heating source.

^g Not available.

^h Dioxin/furan emission estimates from sewage sludge incinerators are currently under review and evaluation by the EPA. These values are subject to possible change due to these evaluations.

ⁱ Number of facilities consists of 24 that use PCP exclusively and 15 that use both PCP and creosote.

Table 4-3

**National 1990 Base Year 2,3,7,8-TCDD TEQ Emissions and Emissions
by Major/Area Source Classification**

Source Category	Number of U.S. Facilities	Total National Emissions (tons/yr)	Major Source Emissions ^a (tons/yr)	Area Source Emissions ^b (tons/yr)
Carbon Reactivation Furnaces	Not available	1.25E-07	3.11E-08	9.34E-08
Crematories	1015	9.15E-12	0.00E+00	9.15E-12
Drum and Barrel Reclamation	12	2.51E-07	0.00E+00	2.51E-07
Hazardous Waste Incineration ^c	150	3.30E-05	3.30E-05	0.00E+00
Industrial Wood/Wood Residue Combustion	45,150	5.07E-05	4.06E-05	1.01E-05
Iron Foundries	103	1.15E-05	1.15E-05	0.00E+00
Lightweight Aggregate Kilns ^d	5	3.60E-06	3.06E-06	5.40E-07
Medical Waste Incineration ^e	3400	6.60E-04	9.90E-05	5.61E-04
Municipal Waste Combustion ^f	168	3.65E-03	3.47E-03	1.83E-04
Onroad Vehicles	Not applicable	9.50E-05	0.00E+00	9.50E-05
Other Biological Incineration	1700	1.60E-04	0.00E+00	1.60E-04
Portland Cement Manufacture: Hazardous Waste Kilns ^g	20	4.75E-04	4.75E-04	0.00E+00
Portland Cement Manufacture: Non-Hazardous Waste Kilns	90	4.29E-05	3.43E-05	8.58E-06
Pulp and Paper Manufacturing - Kraft Recovery Furnaces	124	3.42E-07	3.42E-07	0.00E+00
Residential Coal Combustion	Not available	2.34E-04	0.00E+00	2.34E-04
Residential Oil Combustion	10 million	3.78E-06	0.00E+00	3.78E-06
Residential Wood Combustion	25 million	3.38E-05	0.00E+00	3.38E-05
Scrap or Waste Tire Incineration	18	3.00E-07	3.00E-07	0.00E+00
Secondary Aluminum Smelting	23	1.90E-04	8.55E-05	1.05E-04
Secondary Copper Smelting	4	6.80E-06	3.06E-06	3.74E-06
Secondary Lead Smelting	23	4.25E-06	2.21E-06	2.04E-06
Sewage Sludge Incineration ^h	174	2.65E-05	0.00E+00	2.65E-05
Utility Coal Combustion	426	1.10E-04	1.10E-04	0.00E+00
Utility Oil Combustion	137	7.00E-06	3.50E-06	3.50E-06
Wildfires and Prescribed Burning	Not applicable	9.50E-05	0.00E+00	9.50E-05
Wood Treatment/Wood Preserving	39 ⁱ	3.80E-05	0.00E+00	3.80E-05
Total Emissions		5.93E-03	4.37E-03	1.56E-03

^a These are the estimated national emissions from “major” sources within the source category. “Major” sources, as defined in this inventory, are defined as any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs.

Table 4-3

National 1990 Base Year 2,3,7,8-TCDD TEQ Emissions and Emissions by Major/Area Source Classification (Continued)

- ^b These are the estimated national emissions from “area” sources within the source category. “Area” sources are defined in this inventory as any source of HAPs that is not a major source, as defined in the footnote above.
- ^c 1997 2,3,7,8-TCDD TEQ emissions are estimated to be 0.054 lb. Reference: Behan, 1997.
- ^d 1997 2,3,7,8-TCDD TEQ emissions are estimated to be 0.053 lb. Reference: Behan, 1997.
- ^e 1995 2,3,7,8-TCDD TEQ emissions are estimated to be 0.33 lb. Reference: U.S. EPA, 1996b.
- ^f Dioxin/furan emission estimates from municipal waste combustors are currently under review and evaluation by the EPA. These values are subject to possible change due to these evaluation. Emissions for 1995 are estimated to be 1.6 lb. Reference: U.S. EPA, 1996a.
- ^g 1997 2,3,7,8-TCDD TEQ emissions are estimated to be 0.029 lb. Reference: Behan, 1997.
- ^h Number of facilities consists of 24 that use pentachlorophenol exclusively, and 15 that use both creosote and pentachlorophenol.
- ⁱ Dioxin/furan emission estimates from sewage sludge incinerators are currently under review and evaluation by the EPA. These values are subject to possible change due these evaluations.

Since complete emissions estimates are only available for the 2,3,7,8-TCDD TEQ basis, summary statistics are only discussed for this pollutant form. Both the 2,3,7,8-TCDD and 2,3,7,8-TCDF data have source categories for which estimates are missing; therefore, discussions of dominant emitting categories could be misleading. Total national 2,3,7,8-TCDD TEQ emissions are estimated to be 11.86 lbs/yr, with 8.74 lbs/yr attributable to major sources and 3.12 lbs/yr to area sources. The leading individual sources categories emissions are:

- Municipal Waste Combustion - 62 percent
- Medical Waste Combustion - 11 percent
- Portland Cement Kilns: Hazardous Waste Fuels - 8 percent
- Residential Coal Combustion - 4.0 percent
- Secondary Aluminum Production - 3.2 percent
- Other Biological Incineration - 2.7 percent
- Utility Coal Combustion - 1.9 percent
- Onroad Vehicles - 1.6 percent
- Wildfires and Prescribed Burning - 1.6 percent

This list of sources comprises over 95 percent of the national emissions total. In terms of the categories whose emissions are quantified in this study, 17 source categories are responsible for the remaining 5 percent of total national 2,3,7,8-TCDD TEQ emissions.

It should be noted that the estimate for municipal waste combustors (MWC) reflects the data point estimated by EPA for the 1993 time period. This value was selected for this report because based on the available data it is the closest in time to the desired baseline date of 1990. The 1993 data do not, however, reflect the significant control and dioxin emission reductions expected to occur as a result of the MWC MACT standards (U.S. EPA, 1996b).

Figure 4-1 graphically presents the relative contributions of the source categories to 1990 national 2,3,7,8-TCDD TEQ emissions.

4.3.2 Major/Area Source Emissions

Allocation of the national emissions to major and area sources was determined for each source category as shown in Tables 4-1, 4-2, and 4-3. The dominant major source categories are MWCs (79 percent of major source emissions), Portland cement kilns burning hazardous waste (11 percent), utility coal combustion (2.5 percent), medical waste incinerators (2.3 percent), and secondary aluminum production (2 percent). The leading contributors to area source emissions are medical waste incinerators (36 percent of area source emissions), residential coal combustion (15 percent), municipal waste combustion (12 percent), other biological incineration (10 percent), secondary aluminum production (6.7 percent), and forest fires (6.1 percent).

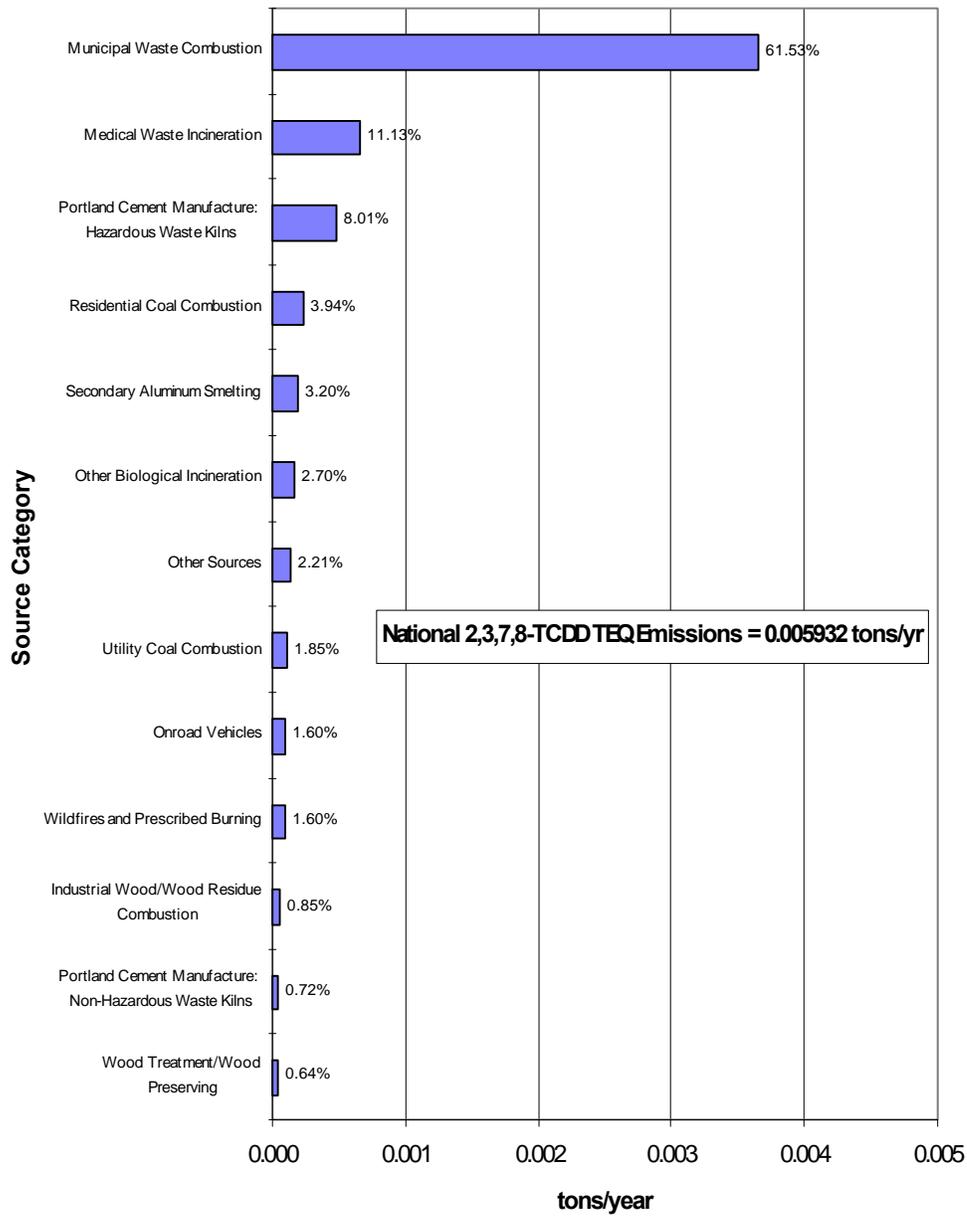


Figure 4-1. Relative Source Category Contribution to 1990 National 2,3,7,8-TCDD TEQ Emissions

4.4 References

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5.0 EMISSION ESTIMATES FOR POLYCHLORINATED BIPHENYL COMPOUNDS (PCBs)

5.1 General Methodology and Assumptions

This section briefly describes the methodologies associated with developing the national inventory of PCB emissions. More detailed descriptions of inventory development procedures are available in Appendix A and in the following documents: "Memorandum for Inventory Plan for Section 112(c)(6) Pollutants" (Mangino et al., 1993) "Memorandum for Status of PCB Data Search and Analysis," (Elmore et al., 1993), and the OHEA Report Estimating Exposures to Dioxin-Like Compounds, Volume II: Properties, Sources, and Occurrence and Background Exposures (U.S. EPA, 1994). Table 5-1 summarizes the methodology and assumptions used to estimate emissions for each source category. The table contains a listing of the national activity data, emission factors, major source/area source distributions, and urban/rural allocation methods used for each PCB category.

There are 209 possible PCB congeners that can be created (U.S. EPA, 1987). The toxicity of a particular PCB is affected by the number and position of the chlorine molecules attached to the biphenyl. Some PCB species (i.e., some coplanar and monortho coplanar PCBs) have recently been identified as "dioxin-like" that have relative toxicities 100-1000 times higher than those associated with other PCB congeners (U.S. EPA, 1993). Because of the range in toxicities between the different PCB congeners, an attempt was made to identify emissions and activity data for individual PCB species that could be used to develop national PCB emissions. Unfortunately, very little information is available on emissions of the individual PCB congeners. Therefore, emission estimates for PCBs are reported here as "total PCBs," and individual congener emissions are not presented. All emission estimates are reported as annual values representative of the 1990 base year, unless noted otherwise.

Table 5-1

National Activity, Emission Factors, and Allocation Assumptions for PCB Source Categories^a

Source Category	1990 National Annual Activity Level	Emission Factor	Major/Area Assumptions (%) of Source ^b
INCINERATION SOURCES			
Municipal Waste Combustion	32.0 million tons of municipal waste incinerated	5.5×10^{-6} lb/ton waste incinerated	95/5
Medical Waste Incineration	1.73 million tons of medical waste incinerated	4.65×10^{-5} lb/ton waste incinerated	15/85
Other Biological Incineration	117,900 tons biological waste per year incinerated	4.65×10^{-5} lb/ton waste incinerated	0/100
Sewage Sludge Incineration	953,200 tons dry sludge incinerated	1.08×10^{-5} lb/ton dry sludge incinerated	0/100
Hazardous Waste Incineration	2.78×10^4 tons of PCBs incinerated	2.0×10^{-3} lb/ton PCB incinerated	100/0
Scrap Tire Incineration	551,000 tons tires incinerated	3.78×10^{-6} lbs/ton tire incinerated	100/0
STATIONARY EXTERNAL FUEL COMBUSTION			
Utility Residual Fuel Oil Combustion	181 million barrels residual fuel consumed (3.04×10^5 lbs of PCBs burned)	1 lb/ 10^6 lb PCB burned	50/50
Industrial Residual Fuel Oil Combustion	66 million barrels residual fuel consumed (1.1×10^5 lbs of PCBs burned)	1 lb/ 10^6 lb PCB burned	70/30

^a The derivation of the emissions data and assumptions presented in this table are explained in detail in Mangino et al., 1993.

^b The term "major," as defined for this report, refers to any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs. The term "area" refers to any source of HAPs that is not a major source. This column provides an estimate of the percentage of emissions from each source category that are major and area sources.

A toxic equivalent approach for PCBs has been used in a way similar to that used for chlorinated dioxins and furans, but only for those PCBs having "dioxin-like" toxicological properties (Safe, 1992). Because information was not available to inventory PCB congeners individually, and because "dioxin-like" PCBs are only a fraction of all PCBs, this toxic equivalency approach was not used in this report.

5.2 Source Category Inclusion

The PCB-emitting source categories were identified based on an in-depth review of available literature sources and on previously developed national inventories. National emissions estimates were developed for all source categories with documented emission factors or credible national emissions estimates. Table 5-1 identifies the categories for which national emissions estimates were developed.

The following source categories were identified as potential sources of PCB emissions for which sufficient data could not be determined to develop credible national emissions estimates:

- Treatment, Storage, and Disposal Facilities (TSDFs);
- Landfills;
- Superfund Sites;
- Steel and Iron Reclamation (Auto Scrap Burning);
- Accidental Releases (PCB spills and leaks and transformer fires); and
- Environmental Sinks of Past PCB Contamination.

Emissions of PCBs were not determined from TSDFs and landfills due to a lack of PCB emission factors. Secondary steel and iron reclamation may be a limited PCB emission source. National PCB air emissions were not determined from this source because a large portion of automobile scrap is not incinerated, and emission factors were not available. Activity data for

accidental PCB spills and transformer fires are not currently available. It was determined that the spill database maintained by the National Response Center did not provide reasonable activity data. Environmental media contaminated with past PCB releases is also a source of PCB emissions. National PCB emissions from contaminated lakes and sediments were not estimated due to the large number of water bodies in the United States, and the probable variation in both PCB contamination levels and emission rates that would lead to very low confidence in any national or regional scale emission estimates.

5.3 Detailed Emissions Summary

This section presents detailed PCB emissions estimate information on a total national and major/area source basis for the 1990 base year.

5.3.1 National Emissions

National emission estimates 1990 for each source category and subcategory were developed using one of two basic approaches. The first, and preferred, approach was to utilize emissions estimates developed by the EPA's OAQPS project teams in charge of developing MACT standards, or other EPA projects where in-depth evaluation and characterization of the source categories was conducted. National PCB emissions estimates have not been developed previously by the EPA for any particular source category. The second or alternative approach was to combine category-specific national activity data (i.e., throughput, production, and fuel use) with emission factors and available information on industry characteristics and control levels to develop national emissions estimates. The availability and overall quality of national activity data vary by category. Preferred sources of national activity data are trade associations and statistics compiled by government agencies such as the EPA and the Department of Energy. Emission factors derived from source tests were used wherever possible. An attempt was made to utilize emission factors that reflect the standard emission control methods used by each source category in 1990.

Table 5-2 presents the estimated 1990 base year national emissions of PCB for each source category. The source categories are presented in the order of their contribution to total emissions. All of the PCB source categories are currently listed in the EPA's Section 112 list of major sources (Federal Register, 1992). The total national emissions are presented as well apportioned to source definitions as "major" or "area." Also presented in Table 5-2 are the estimated number of facilities or units (e.g., number of incinerators) within each source category. The numbers of facilities and units are, for the most part, crude estimates that provide some indication of the population within each category and therefore provide some insight into the size of the population that may need to be regulated.

Figure 5-1 identifies the contribution of specific source categories to total 1990 national emissions. Municipal waste combustion, hazardous waste incineration, and medical waste incineration contribute over 95 percent of national PCB emissions. Municipal waste combustion contributes the largest percentage (51 percent), followed by medical waste incineration (26 percent), and hazardous waste incineration (18 percent). All other categories combined contribute less than 6 percent of national PCB emissions.

5.3.2 Major/Area Source Emissions

Of the national total, 71 percent is attributed to major sources. Municipal waste combustion is the dominant major source contributor (69 percent of major source emissions). Hazardous waste incineration and medical waste incineration contribute 25 and 5.4 percent, respectively, to the major source total. The category with the greatest quantity of area source emissions is medical waste incineration (68.4 lbs/year). It constitutes 75 percent of the area source total. The bulk of the remaining area source emissions are attributable to sewage sludge incineration (11 percent) and municipal waste combustion.

Table 5-2

**National 1990 Base Year PCB Emissions and Distribution
on a Major/Area Source Basis^a**

Source Category	Number of Facilities	Total National Emissions (lb/year)	Percent Contribution (%)	Major Source Emissions (lb/year) ^b	Area Source Emissions (lb/year) ^c
Municipal Waste Combustion	168	161	51	153	8
Medical Waste Incineration	3,400	80.5	26	12.1	68.4
Hazardous Waste Incineration	150	55.5	18	55.5	0
Sewage Sludge Incineration	174	10.3	3.3	0	10.3
Other Biological Incineration	1,700	5.0	1.6	0	5.0
Scrap Tire Incineration	18	2.1	0.7	2.1	0
Utility Boilers - Residual Oil Combustion	137	0.3	0.1	0.15	0.15
Industrial Boilers - Residual Oil Combustion	Not available	0.1	<0.01	0.08	0.02
TOTAL		314.8	100	223.0	91.8

^a Appendix A contains documentation on the derivation of all emission estimates.

^b These are the estimated national emissions from "major" sources within the source category. "Major" sources are defined in this inventory as any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs.

^c These are the estimated national emissions from "area" sources within the source category. Area sources are defined in this inventory as any source of HAPs that is not a major source, as defined in footnote b above.

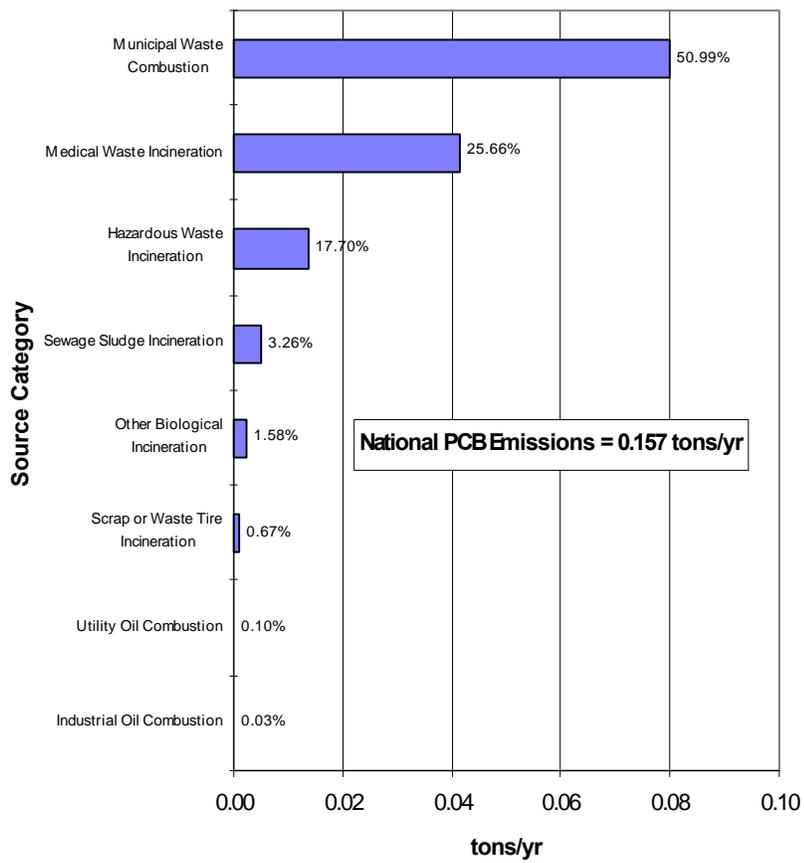


Figure 5-1. Percentage Contribution to 1990 National PCB Emissions by Source Category

This inventory indicates that area sources contribute less than 30 percent of national PCB emissions. Area source emissions, however, may not be well represented in this inventory. In general, activity data are much less available for PCB emissions sources which are primarily composed of area sources rather than major sources (for example, PCB fires and accidental releases).

5.4 References

1. Federal Register. July 16, 1992. "Initial List of Categories of Sources Under Section 112 (c)(1) of the Clean Air Act Amendments of 1990." Volume 57, No. 137. pp. 31576-31592.
2. Memorandum from Joe Mangino, Lauren Elmore, Peter Keller, Kevin Hastings, and Glenn Rives, Radian Corporation, to Anne Pope, OAQPS/EIB/EPA. "Inventory Plan for Section 112(c)(6) Pollutants." September 30, 1993.
3. Memorandum from Lauren Elmore, Radian Corporation, to Anne Pope, EIB/EPA, and Tom Lahre, PAB/EPA. "Status of PCB Data Search and Analysis." June 10, 1993.
4. Safe, Stephen. "Toxicology, Structure-Function Relationship, and Human and Environmental Health Impacts of Polychlorinated Biphenyls: Progress and Problems." In: Environmental Health Perspectives, Volume 100, pp. 259-268. 1992.
5. U.S. Environmental Protection Agency. Locating and Estimating Air Emissions from Sources of Polychlorinated Biphenyls (PCB). Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. EPA-450/4-84-007. May 1987.
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7. U.S. Environmental Protection Agency. Estimating Exposures to Dioxin-Like Compounds, Volume II: Properties, Sources, and Occurrence and Background Exposures. External Review Draft. Office of Health and Environmental Assessment, Washington, DC. EPA-600/6-88-55b. June 1994.

6.0 EMISSION ESTIMATES FOR MERCURY

6.1 General Methodology and Assumptions

This section briefly describes the methodologies associated with the development of a national inventory of mercury emissions. The bulk of the emission estimates and information on mercury sources were obtained directly from the document Mercury Study Report to Congress. Volume II: An Inventory of Anthropogenic Mercury Emissions in the United States, (U.S. EPA, 1996a), and other EPA sources such as MACT standard development studies and the Toxic Release Inventory (TRI) system. The bulk of the mercury estimates obtained from the final EPA Section 112(k) Inventory Report (U.S. EPA, 1998) originated from either MACT standards work or the TRI database (Rizeq, 1997a; Rizeq, 1997b). The Mercury Study Report to Congress document was prepared by the EPA's Office of Air Quality Planning and Standards (OAQPS) and Office of Research and Development (ORD) in order to fulfill 1990 CAAA requirements to produce a Report to Congress (RTC) on mercury emissions (U.S. EPA, 1996a). The reader is strongly encouraged to consult the RTC document to obtain more in-depth knowledge of mercury sources and emissions.

The methodologies and assumptions used to determine emissions for each mercury source category are presented in Table 6-1. The table contains a listing of the number of facilities, national activity data, basis for the emissions estimates, and the major source/area source distribution used for each source category. It should be noted that for most source categories, the numbers of facilities are rough approximations, but they are useful in providing some indication of the population within each category, and therefore, some insight into the size of the population that may need to be evaluated for possible regulation.

The base years for the national mercury emissions estimates presented in the RTC are 1990-1993, with the exception of the estimate provided for hazardous waste combustors. There were insufficient data to estimate 1990 emissions for this category, but an estimate for 1995 was

Table 6-1

Number of Facilities, National Activity, Basis for Emissions Estimates and Major/Area Distributions for Mercury Emissions Source Categories^a

Source Category	Number of Facilities	1990 National Annual Activity Level	Basis for Emissions Estimate	Major/Area Assumptions (%) of Source ^b
Medical Waste Incinerators	3,400	1.73 x 10 ⁶ tons of medical waste incinerated ^c	All estimates are from the EPA NESHAP program. Model plants representing the different incinerator configurations in use were used to derive national estimate. ^c	15/85
Municipal Waste Combustors	168	32.7 x 10 ⁶ tons, assuming all plants operate at 85% design capacity	Emission factor * activity level method	95/5
Utility Boilers - Coal Combustion	426	1.6 x 10 ¹⁶ Btu heat input	Mercury concentration in fuel * emission modification factors based on boiler/control configurations * national activity levels for each boiler/control configuration	100/0
Utility Boilers - Oil Combustion	137	1.2 x 10 ¹⁵ Btu heat input	Mercury concentration in fuel * emission modification factors based on boiler/control configurations * national activity levels for each boiler/control configuration	50/50
Utility Boilers - Natural Gas Combustion	267	2.8 x 10 ¹⁵ Btu heat input	Mercury concentration in fuel * emission modification factors based on boiler/control configurations * national activity levels for each boiler/control configuration	0/100

Table 6-1

Number of Facilities, National Activity, Basis for Emissions Estimates and Major/Area Distributions for Mercury Emissions Source Categories^a (Continued)

Source Category	Number of Facilities	1990 National Annual Activity Level	Basis for Emissions Estimate	Major/Area Assumptions (%) of Source ^b
Commercial/industrial Boilers - Coal Combustion	42,000	Bituminous/lignite- 2.82×10^{15} Btu heat input; anthracite- 2.18×10^{13} Btu heat input	Emission factor * activity level method; uncontrolled emission factors- 16 lb/10 ¹² Btu for bituminous/lignite, 18 lb/10 ¹² Btu for anthracite	70/30
Commercial/Industrial Boilers - Oil Combustion	494,000	1.67×10^{15} Btu heat input, distillate and residual	Emission factor * activity level method; Uncontrolled emission factors- 6.8 lb/10 ¹² Btu for residual, 7.2 lb/10 ¹² Btu for distillate	70/30
Residential Boilers - Coal Combustion	Not available	Bituminous/lignite- 4.34×10^{13} Btu heat input; Anthracite- 1.83×10^{13} Btu heat input	Emission factor * activity level method; Uncontrolled emission factors- 16 lb/10 ¹² Btu for bituminous/lignite, 18 lb/10 ¹² Btu for anthracite	0/100
Residential Boilers - Oil	10,000,000	Distillate and residual- 8.38×10^{14} Btu heat input	Emission factor * activity level method; uncontrolled emission factors- 6.8 lb/10 ¹² Btu for residual, 7.2 lb/10 ¹² Btu for distillate	0/100
Sewage Sludge Incinerators	174	1.65×10^6 tons	Emission factors for each control type * percent of population for each control type * activity level; emission factors- 3.5×10^{-5} lb/ton for venturi and impingement scrubbers, 3.25×10^{-3} lb/ton for other controls; percent of population- 32.6% for venturi and impingement scrubbers, 67.4% for other controls	0/100

Table 6-1

Number of Facilities, National Activity, Basis for Emissions Estimates and Major/Area Distributions for Mercury Emissions Source Categories^a (Continued)

Source Category	Number of Facilities	1990 National Annual Activity Level	Basis for Emissions Estimate	Major/Area Assumptions (%) of Source ^b
Crematories	1,015	366,000 cremations	Emission factor * activity level method; emission factor- 2.06×10^{-6} lb/cremation ^d	0/100
Wood-fired Boilers (Non-residential)	45,150	7.87×10^7 tons wood burned	Activity level * emission factor: emission factor = 5.15×10^{-6}	80/20
Hazardous Waste Incinerators ^c	150	1.43×10^6 tons of waste burned	Estimate provided by EPA/Office of Solid Waste (OSW), based on measured data and extrapolations of the measured data to similar facilities in the source category.	100/0
Lightweight Aggregate Kilns	5	Not available	Estimate provided by EPA/OSW, based on measured data and extrapolations of the measured data to similar facilities in the source category.	85/15
Primary Lead Smelters	3	Activity data not used to estimate emissions	Information received from facilities and input from EPA's metals group	45/55
Secondary Mercury Production	4	371 tons produced	Emissions were based on data found in 1990 TRI database for the category. Data available for 2 plants was extrapolated to the other 2 plants.	50/50
Chlor-alkali Production	20	Activity data not used to estimate emissions	Section 114 responses	30/70

Table 6-1

Number of Facilities, National Activity, Basis for Emissions Estimates and Major/Area Distributions for Mercury Emissions Source Categories^a (Continued)

Source Category	Number of Facilities	1990 National Annual Activity Level	Basis for Emissions Estimate	Major/Area Assumptions (%) of Source ^b
Portland Cement Kilns: Non-Hazardous Waste	90	63.3 million tons clinker produced ^f	Emission factor activity level method; emissions represent the average of estimates derived from two factor bases. One factor basis was 24 mg/dscm, while the other basis was 1.29E-04 lb/ton clinker. ^f	80/20
Portland Cement Kilns: Hazardous Waste	20	16.5 million tons clinker produced ^g	Estimate provided by cement kiln industry associations, based on measured data and extrapolations of the measured data to similar facilities in the source category. ^h EPA/OSW has reviewed and concurred with the estimate.	100/0
Primary Copper Production	8	Not available	Emissions determined from test data for all 8 plants. Data were developed by EPA Metals Group as a part primary copper NESHAP development program. Base year of the test data was 1992.	90.88/9.12
Lime Manufacturing	10	Not available	Emission factor * activity level method; emission factor- 1.22 x 10 ⁻⁴ lb/ton lime produced	0/100
Electrical Apparatus Manufacturing	Not available	116 tons mercury used	Emission factor * activity level method; emission factor- 8 lb/ton mercury used	75/25
Instrument Manufacturing	Not available	57 tons mercury used	Emission factor * activity level method; emission factor- 18 lb/ton mercury used	0/100

Table 6-1

Number of Facilities, National Activity, Basis for Emissions Estimates and Major/Area Distributions for Mercury Emissions Source Categories^a (Continued)

Source Category	Number of Facilities	1990 National Annual Activity Level	Basis for Emissions Estimate	Major/Area Assumptions (%) of Source ^b
Carbon Black Production	24	1.7 x 10 ⁶ tons capacity	Emission factor x activity level method; emission factor- 3 x 10 ⁻⁴ lb/ton carbon black produced	30/70
Fluorescent Lamp Recycling	Not available	Not available	Emission factor * activity level method; emission factor-1 lb/100 lbs mercury recycled	0/100
Battery Production	16	18 tons mercury used in battery production	Emission factor * activity level method; emission factor- 2 lb/ton mercury used	75/25
Geothermal Power	18	2,628.4 megawatts of capacity	Emission factor * activity level method; emission factors: off-gas ejectors- 0.00002 lb/MWe/hr, cooling tower exhaust- 0.0001 lb/MWe/hr	0/100
Lamp Breakage	Not available	Not available	Mass balance and engineering judgement	0/100
General Laboratory Activities	Not available	20 tons mercury used	Emission factor * activity level method; emission factor- 80 lb/ton mercury used	0/100
Dental Preparation and Use	Not available	41 tons mercury used	Emission factor * activity level method; emission factor- 2 lb/100 lb mercury used	0/100
Aerospace Industry (Surface Coating) ¹	2,869	Not available	The emissions estimate was obtained from estimates produced as a part of the EPA MACT development program for this source category.	100/0

Table 6-1

Number of Facilities, National Activity, Basis for Emissions Estimates and Major/Area Distributions for Mercury Emissions Source Categories^a (Continued)

Source Category	Number of Facilities	1990 National Annual Activity Level	Basis for Emissions Estimate	Major/Area Assumptions (%) of Source ^b
Blast Furnaces and Steel Mills ⁱ	1	Not applicable	The emission estimate was obtained directly from data reported for the category in the 1990 TRI database maintained by EPA.	97.9/2.1
Chromium Plating: Chromic Anodizing ⁱ	1	Not applicable	The emission estimate was obtained directly from data reported for the category in the 1990 TRI database maintained by EPA.	5/95
Custom Compound Purchased Resin Manufacturing ⁱ	1	Not applicable	The emission estimate was obtained directly from data reported for the category in the 1990 TRI database maintained by EPA.	83.74/16.26
Industrial Inorganic Chemicals Manufacturing ⁱ	3	Not applicable	The emission estimate was obtained directly from data reported for the category in the 1990 TRI database maintained by EPA.	95.88/4.12
Industrial Organic Chemicals Manufacturing ⁱ	2	Not applicable	The emission estimate was obtained directly from data reported for the category in the 1990 TRI database maintained by EPA.	98.22/1.78
Inorganic Pigments Manufacturing ⁱ	1	Not applicable	The emission estimate was obtained directly from data reported for the category in the 1990 TRI database maintained by EPA.	99.59/0.41

Table 6-1

Number of Facilities, National Activity, Basis for Emissions Estimates and Major/Area Distributions for Mercury Emissions Source Categories^a (Continued)

Source Category	Number of Facilities	1990 National Annual Activity Level	Basis for Emissions Estimate	Major/Area Assumptions (%) of Source ^b
Nonmetallic Mineral Products Manufacturing ⁱ	1	Not applicable	The emission estimate was obtained directly from data reported for the category in the 1990 TRI database maintained by EPA.	62.25/37.75
Secondary Nonferrous Metals Recovery ⁱ	1	Not applicable	The emission estimate was obtained directly from data reported for the category in the 1990 TRI database maintained by EPA.	45/55
Other Structural Clay Products Manufacturing ⁱ	Not available	Gas-fired Kilns: 9,612,433 tons/yr brick production Coal-fired Kilns: 1,435,623 tons/yr brick production Saw dust-fired Kilns: 1,435,623 tons/yr brick production	Emissions are based on activity data * emission factors; emission factors = 7.5×10^{-6} lb/ton for gas-fired kilns, 9.6×10^{-5} lb/ton for coal-fired kilns, and 7.5×10^{-6} for saw dust-fired kilns. Emission factors were taken from AP-42.	93.83/6.17
Plastics Material and Resins Manufacturing ⁱ	5	Not applicable	The emission estimate was obtained directly from data reported for the category in the 1990 TRI database maintained by EPA.	97.08/2.92
Other Miscellaneous Manufacturing (SICs Combined) ⁱ	1	Not applicable	The emission estimate was obtained directly from data reported for the category in the 1990 TRI database maintained by EPA.	90/10

Table 6-1

Number of Facilities, National Activity, Basis for Emissions Estimates and Major/Area Distributions for Mercury Emissions Source Categories^a (Continued)

Source Category	Number of Facilities	1990 National Annual Activity Level	Basis for Emissions Estimate	Major/Area Assumptions (%) of Source ^b
Utility Turbines - Diesel Fired ⁱ	Not available	73,355,000 million Btu heat input	Emissions are based on activity data * emission factor; emission factor = 9.10×10^{-7} lb/MM Btu heat input. Emission factor is from EPA's FIRE database.	70/30
Paints and Allied Products ⁱ	4	Not applicable	The emission estimate was obtained directly from data reported for the category in the 1990 TRI database maintained by EPA.	77.03/22.97
Petroleum Refining: All Processes ⁱ	3	Not applicable	The emission estimate was obtained directly from data reported for the category in the 1990 TRI database maintained by EPA.	97.55/2.45
Pulp and Paper: Kraft Recovery Furnaces ⁱ	124	Not available	The emissions estimate was obtained from estimates produced as a part of the EPA MACT development program for this source category.	100/0
Secondary Lead Smelting ⁱ	23	Not available	The emissions estimate was obtained from estimates produced as a part of the EPA MACT development program for this source category	52/48
Industrial Stationary IC Engines - Natural Gas ⁱ	Not available	787,500,000 million Btu of heat input based on natural gas usage of 7.50×10^{11} cubic ft. and factor of 1050 Btu/cubic foot of gas	Emissions are based on activity data * emission factors; emission factor = 1.14×10^{-5} lb/MM Btu of heat input. Emission factor was obtained form AP-42.	60/40

Table 6-1

Number of Facilities, National Activity, Basis for Emissions Estimates and Major/Area Distributions for Mercury Emissions Source Categories^a (Continued)

Source Category	Number of Facilities	1990 National Annual Activity Level	Basis for Emissions Estimate	Major/Area Assumptions (%) of Source ^b
Industrial Turbines - Diesel Fired ⁱ	Not available	35,197,267 barrels distillate oil	Emission factor x activity level method; emission factor = 9.04×10^{-7} lb/MMBtu and 5.825 MMBtu/barrel	70/30
Industrial Turbines - Natural Gas Fired ⁱ	Not available	4.72×10^{11} cubic feet of gas burned	Emission factor x activity level method; emission factor = 6.63×10^{-6} lb/MMBtu and 1,030 Btu/cubic ft of gas	60/40

^a Activity and emission factor data are from U.S. EPA, 1996a, unless indicated otherwise, and were used to estimate annual emissions for 1990-1993.

^b The term "major," as defined for this report, refers to any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs. The term "area" refers to any source of HAPs that is not a major source. This column provides an estimate of the percentage of emissions from each source category that are major and area sources.

^c Copeland, 1996.

^d Camellia Cemetary, 1992.

^e Emission estimate for this category represents emissions from dedicated hazardous waste incinerators. It does not include emissions from BIFs. Separate estimates are provided for Portland cement kilns and light weight aggregate kilns burning hazardous waste. No estimates were available for other BIFs (e.g., boilers or smelting furnaces).

^f Heath, 1996.

^g CKRC, 1996.

^h Campbell, 1997.

Table 6-1

Number of Facilities, National Activity, Basis for Emissions Estimates and Major/Area Distributions for Mercury Emissions Source Categories^a (Continued)

ⁱ The emission estimate for this category was developed as a part of EPA's Urban Air Toxics Program under Clean Air Act Section 112(k). The full documentation for the estimate and major/area assumptions can be found in U.S. EPA, 1998.

available and it is presented in the RTC. For convenience, throughout this chapter, emissions for the 1990-1993 period are referred to as 1990 base year emissions.

The EPA used an emission factor-based approach to estimate national mercury emissions for most source categories in the RTC. This approach requires a source-specific emission factor and an estimate of the annual nationwide source activity to estimate emissions. There are uncertainties inherent in the emission factor-based approach that affect the accuracy of national emissions estimates. Quantitative estimates of the uncertainty in the emission factor-based approach are not available, although they can be discussed qualitatively. Ideally, emission factors are based on a substantial quantity of data from sources that represent the entire source category population. For trace pollutants like mercury, however, emission factors are frequently based on limited data that may not have been collected from sources that are representative of the entire source category. In addition, changes over time in processes, pollution control systems, measurement techniques, and analytical methods may result in biased emission factors. Finally, the sources of data used to develop activity levels vary in reliability, adding further uncertainty to the emissions estimates. (U.S. EPA, 1996a).

Other approaches used by the EPA to develop the emissions estimates presented in the RTC include engineering judgment, mass balance, and data obtained directly from industries. As with the emission factor-based approach, the accuracy and representativeness of the data used will affect the uncertainties of emissions estimates.

Since the publication of the draft 112(c)(6) emissions inventory, several additional mercury source categories and emission estimates have also been added to the 112(c)(6) inventory study as a result of the inventory developed by EPA for CAA section 112(k) purposes (U.S. EPA, 1998). During the 112(k) study, the EPA identified several additional mercury-emitting categories by assessing the data in the Agency's TRI database system for 1990 (U.S. EPA, 1996c). Over a dozen new mercury source categories were added to the 112(c)(6) inventory as a result of the 1990 TRI information. The TRI system had previously not been used as a source of emissions estimates for the draft 1990 112(c)(6) inventory.

6.2 Source Category Inclusion

The mercury RTC discussed above was the primary reference used to identify the source categories of mercury emissions that are presented in this document. The RTC was prepared in response to the mandate listed in the CAAA that requires EPA to submit a study on atmospheric mercury emissions to Congress. The RTC consists of a seven-volume study. Volume II of the RTC presents source categories of mercury emissions and provides annual mercury emissions estimates, abbreviated process descriptions, control technique options, emission factors, and activity levels for these sources. The EPA relied on various emission studies that they have conducted to identify the source categories of mercury emissions presented in the RTC.

The RTC identifies several potential source categories of mercury emissions for which data were not sufficient to develop national emissions estimates. For example, mercury has been identified as a constituent of landfill gas emissions, but emission factors have not yet been developed that can be used to estimate national emissions. The categories identified in the RTC and elsewhere as probable or known mercury emissions sources but for which estimates could not be formulated are:

- Mobile Sources;
- Agricultural Burning;
- Boilers and Industrial Furnaces burning hazardous waste (excluding Portland cement kilns and light weight aggregate kilns burning hazardous waste);
- Landfills;
- Primary Mercury Production;
- Mercury Compounds Production;
- Byproduct Coke Oven Batteries; and
- Natural Sources (oceanic, terrestrial, vegetative).

6.3 Detailed Emissions Summary

This section presents detailed 1990 base year mercury emissions information on a total national and major/area basis.

6.3.1 National Emissions

Table 6-2 presents the 1990 base year national emissions estimates of mercury for each source category. Municipal waste combustion (23.5%), coal-fired utility boilers (21.8%), and medical waste incinerators (21.3%), industrial coal combustion (9.4%), and chloralkali production (4.2%) account for over 80 percent of the total emissions. Of the 53 categories of mercury emissions that were quantified, 77 percent contribute less than 1 percent to the national emissions total.

Figure 6-1 identifies the contribution of specific source categories to total national 1990 base year emissions.

Current emissions for several of these source categories (e.g., MWCs, cement kilns, and MWIs) are significantly below the 1990 levels shown here due to the development and application by EPA of various MACT standards. For these source categories, the 1990 estimates are not representative of the reduced contributions these categories are making to current national emission levels.

6.3.2 Major/Area Source Emissions

Using the allocation assumptions described in 2.0, mercury emissions were grouped, by source category, as to whether they originated from major or area sources. As shown in Table 6-2, 67.5 percent of the total mercury emissions are attributable to major sources, with the remaining 32.5 percent coming from area sources. Mercury emissions from municipal waste combustors account for 33 percent of the major source emissions. Coal-fired utility boilers

Table 6-2

National 1990 Base Year Mercury Emissions Estimates and Major/Area Source Distributions^a

Source Category ^b	Number of U.S. Facilities	Total National Emissions (tons/yr)	Major Source Emissions ^c (tons/yr)	Area Source Emissions ^d (tons/yr)
Aerospace Industry (Surface Coating) ^f	2869	4.00E+00	4.00E+00	0.00E+00
Battery Production	16	2.00E-02	1.50E-02	5.00E-03
Blast Furnace and Steel Mills ^f	1	2.50E-01	2.45E-01	5.25E-03
Carbon Black Production	24	2.50E-01	7.50E-02	1.75E-01
Chloralkali Production	20	9.80E+00 ^e	2.94E+00	6.86E+00
Chromium Plating: Chromic Anodizing ^f	1	2.50E-03	1.25E-04	2.38E-03
Commercial Coal Combustion	42,000	7.77E-01	1.55E-01	6.22E-01
Commercial Oil Combustion	494,000	2.00E-01	4.00E-02	1.60E-01
Commercial Wood/Wood Residue Combustion	<30,000	8.00E-03	1.60E-03	6.40E-03
Crematories	1015	3.77E-04	0.00E+00	3.77E-04
Custom Compound Purchased Resins Manufacture ^f	1	1.28E-01	1.07E-01	2.08E-02
Dental Preparation and Use	Not available	8.00E-01	8.00E-01	0.00E+00
Electronic and Other Electric Equipment Manufacturing (SICs combined)	4	8.83E-01	6.62E-01	2.21E-01
Fluorescent Lamp Recycling	Not available	6.00E-03	1.20E-03	4.80E-03
General Laboratory Activities	Not available	8.00E-01	1.60E-01	6.40E-01
Geothermal Power	18	1.30E+00	0.00E+00	1.30E+00
Hazardous Waste Incineration ^g	150	3.20E+00	3.20E+00	0.00E+00
Industrial Coal Combustion	64,000	2.20E+01	1.54E+01	6.61E+00
Industrial Inorganic Chemicals Manufacturing ^f	3	1.00E+00	9.59E-01	4.12E-02
Industrial Oil Combustion	Not available	5.80E+00	4.06E+00	1.74E+00
Industrial Organic Chemicals Manufacturing ^f	2	2.00E-02	1.96E-02	3.56E-04
Industrial Stationary IC Engines - Natural Gas	Not available	4.47E+00	2.68E+00	1.79E+00
Industrial Turbines - Diesel Fired	Not available	9.00E-02	6.30E-02	2.70E-02
Industrial Turbines: Natural Gas Fired	Not available	1.61E+00	9.66E-01	6.44E-01
Industrial Wood/Wood Residue Combustion	45,150	2.03E-01	1.62E-01	4.06E-02
Inorganic Pigments Manufacturing ^f	1	5.00E-03	4.98E-03	2.05E-05
Instrument Manufacturing	Not available	5.00E-01	0.00E+00	5.00E-01
Lamp Breakage	Not available	1.50E+00	3.00E-01	1.20E+00
Lightweight Aggregate Kilns ^h	5	3.10E-01	2.64E-01	4.65E-02
Lime Manufacturing	10	7.00E-01	0.00E+00	7.00E-01
Medical Waste Incineration	3400	5.00E+01 ⁱ	7.50E+00	4.25E+01
Municipal Waste Combustion	168	5.50E+01 ^j	5.23E+01	2.75E+00
Nonmetallic Mineral Products Manufacturing ^f	1	5.00E-03	3.11E-03	1.89E-03
Other Miscellaneous Manufacturing (SICs combined) ^f	1	2.5E-01	2.25E-01	2.5E-02
Other Structural Clay Products Manufacturing ^f	Not available	1.10E-01	1.03E-01	6.78E-03

Table 6-2

National 1990 Base Year Mercury Emissions Estimates and Major/Area Source Distributions^a (Continued)

Source Category^b	Number of U.S. Facilities	Total National Emissions (tons/yr)	Major Source Emissions^c (tons/yr)	Area Source Emissions^d (tons/yr)
Paints and Allied Products Manufacturing ^f	4	7.50E-03	5.78E-03	1.72E-03
Petroleum Refining: All Processes ^f	3	4.35E-02	4.24E-02	1.07E-03
Plastics Material and Resins Manufacturing ^f	5	4.00E-03	3.88E-03	1.17E-04
Portland Cement Manufacture: Hazardous Waste Kilns ^k	20	2.75E+00 ^m	2.75E+00	0.00E+00
Portland Cement Manufacture: Non-Hazardous Waste Kilns	20	4.13E+00	3.30E+00	8.26E-01
Primary Copper Production	8	7.40E-01	6.72E-01	6.75E-02
Primary Lead Smelting ^l	3	1.30E+00	5.85E-01	7.15E-01
Pulp and Paper Manufacturing - Kraft Recovery Furnaces ^f	124	1.90E+00	1.90E+00	0.00E+00
Residential Coal Combustion	Not available	6.00E-01	0.00E+00	6.00E-01
Residential Oil Combustion	10 million	3.00E+00	0.00E+00	3.00E+00
Secondary Lead Smelting	23	1.13E-02	5.88E-03	5.42E-03
Secondary Mercury Production	4	7.52E-01	3.76E-01	3.76E-01
Secondary Nonferrous Metals Recovery ^f	1	2.50E-01	1.13E-01	1.38E-01
Sewage Sludge Incineration	174	1.80E+00	0.00E+00	1.80E+00
Utility Coal Combustion	426	5.10E+01	5.10E+01	0.00E+00
Utility Natural Gas Combustion	267	1.60E-03	0.00E+00	1.60E-03
Utility Oil Combustion	137	2.50E-01	1.25E-01	1.25E-01
Utility Turbines - Diesel Fired ^f	Not available	3.00E-02	2.10E-02	9.00E-03
Total Emissions		2.34E+02	1.58E+02	7.63E+01

^a All emission estimates were obtained from U.S. EPA, 1996a and are 1990-93 estimates, unless indicated otherwise.

^b Source categories listed as “SICs combined” were classified using multiple Standard Industrial Classification (SIC) codes. The EPA TRI database was searched for emissions information based on these codes. The SIC codes used for each identified category are defined in the footnotes to Table 2-1 of this document.

^c These are the estimated national emissions from “major” sources within the source category. “Major” sources, as defined in this inventory, are defined as any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs.

^d These are the estimated national emissions from “area” sources within the source category. “Area” sources are defined in this inventory as any source of HAPs that is not a major source, as defined in the footnote above.

^e EC/R, Inc., 1996.

Table 6-2

National 1990 Base Year Mercury Emissions Estimates and Major/Area Source Distributions^a (Continued)

^f Emissions for this category were determined as a part of EPA's Section 112(k) national inventory development program (U.S. EPA, 1998). Documentation for the estimate from the 112(k) inventory report is provided in Appendix C of this document.

^g 1997 emissions are estimated to be 4.85 tons. Reference: Behan, 1997.

^h 1997 emissions are estimated to be 0.059 tons. Reference: Behan, 1997.

ⁱ Copeland, 1996.

^j Emissions for 1995 are estimated to be 29 tons. Reference: U.S. EPA, 1996b.

^k 1997 emissions are estimated to be 1.66 tons. Reference: Behan, 1997.

^l Cavendar, 1996.

^m Campbell, 1997

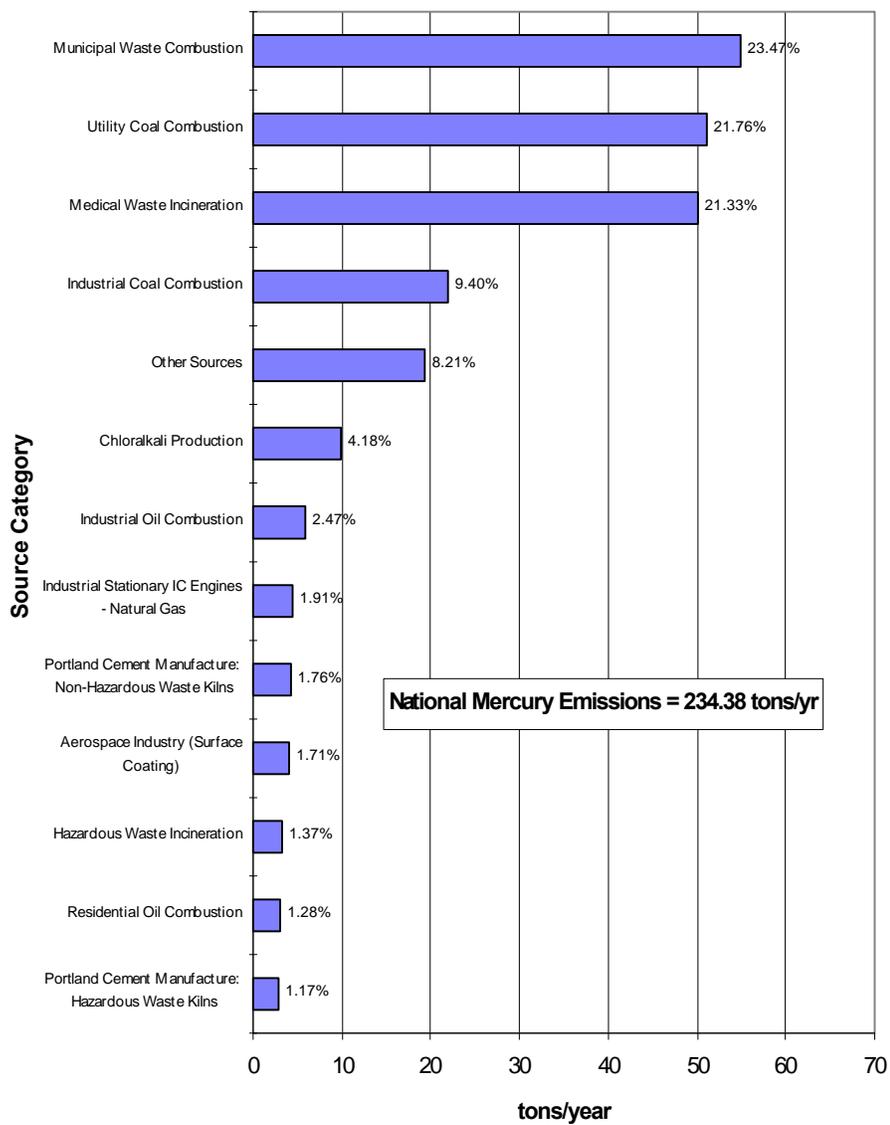


Figure 6-1. Percentage Contribution to 1990 National Mercury Emissions by Source Category

contribute the next largest amount of major source emissions with 32 percent, followed by coal-fired industrial boilers with 9.7 percent. Medical waste incinerators are the largest source of area emissions, accounting for 55 percent of the total area emissions. The next largest sources of area emissions are chlor-alkali production with 9 percent, coal-fired industrial boilers with 8.7 percent, residential oil combustion at 3.9 percent, municipal waste combustion at 3.6 percent, and sewage sludge incineration with 2.4 percent.

6.4 References

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7.0 EMISSION ESTIMATES FOR HEXACHLOROBENZENE

7.1 General Methodology and Assumptions

This section briefly describes the methodologies associated with the development of a national inventory of hexachlorobenzene (HCB) emissions. All of the emission estimates and information on HCB sources, with the exception of pesticides application, tire manufacturing, and utility coal combustion, were obtained directly from the document Estimation of National Hexachlorobenzene Emissions for 1990, Final Report prepared in 1993 by TRC Environmental Corporation for the U.S. EPA's Office of Air Quality Planning and Standards (OAQPS). This document was prepared by OAQPS to fulfill 1990 CAAA requirements to identify source categories emitting 90 percent of the total national HCB emissions (TRC, 1993). Estimates for pesticides application were generated from industry sources, published production statistics, and published data for the agricultural industry. Estimates for tire manufacturing were obtained from the EPA's MACT standards development project for this source category. HCB emissions for utility coal combustion were taken from an EPA report on hazardous air pollutant emissions from utilities (U.S. EPA, 1996).

The source categories of HCB emissions that are identified in the TRC, 1993 document are chlorinated solvents production and pesticides manufacture. HCB is generated as an impurity during the manufacture of chlorinated solvents and pesticides, and is found in the air emissions from these processes. Also, because HCB is a pesticide contaminant, HCB is emitted when pesticides are applied to crops.

The methodologies and assumptions used to determine emissions for each source category of HCB emissions are presented in Table 7-1. The table contains a listing of the number of facilities, national activity data, basis for emissions estimates, and the major source/area source distribution used for each source category. It should be noted that for most source categories the numbers of facilities are rough approximations, but they are useful for providing

Table 7-1

Number of Facilities, National Activity, Basis for Emissions Estimates and Major/Area Distributions for Hexachlorobenzene Emissions Source Categories^a

Source Category	Number of Facilities	1990 National Annual Activity Level	Basis for Emission Estimate	Major/Area Assumptions (%) of Source ^b
Chlorinated Solvents Production ^c	21	16,347 million pounds of chlorinated solvents produced	Extracted 1990 emissions data from TRI for facilities reporting to TRI, extrapolated data to facilities not reporting to TRI.	100/0
Pesticides Production ^d	10	Not available	TRI data	0/100
Pesticides Application ^{d,e}	Not available	Total pesticide use= 90,129,653 lbs; available HCB=2,880 lbs	Speciation approach- Amounts of pesticide active ingredients used nationally X HCB% for each pesticide active ingredient (assume 8.4% of available HCB is volatilized as air emissions)	0/100
Tire Manufacturing ^f	55	264,262,000 tires produced	Estimate taken from MACT standard program. Emission factors were obtained from Rubber Manufacturers Association study. HCB emission factors used were: Mixing = 6.90E-08 lb/lb-rubber Milling = 2.49E-08 lb/lb-rubber Extrusion = 4.37E-08 lb/lb-rubber Calendaring= 2.78E-09 lb/lb-rubber The aggregate factor used for national emissions calc was 3.29E-06 lb/lb-rubber.	99/1

Table 7-1

Number of Facilities, National Activity, Basis for Emissions Estimates and Major/Area Distributions for Hexachlorobenzene Emissions Source Categories^a (Continued)

Source Category	Number of Facilities	1990 National Annual Activity Level	Basis for Emission Estimate	Major/Area Assumptions (%) of Source ^b
Utility Coal Combustion ^g	426	Not available	Estimate taken from U.S. EPA Study for Congress on HAP emissions from coal-fired utilities. Estimate based on source test data from 52 units obtained by EPA, U.S. Department of Energy Electric Power Research Institute, and Northern States Power Company. Emission factor developed from testing was applied to utility coal consumption data.	100/0

^a All data are from TRC, 1993, unless indicated otherwise.

^b The term "major," as defined for this report, refers to any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs. The term "area" refers to any source of HAPs that is not a major source. This column provides an estimate of the percentage of emissions from each source category that are major and area sources.

^c Includes the production of carbon tetrachloride, perchloroethylene, trichloroethylene, ethylene dichloride and 1,1,1-trichloroethane.

^d Includes the pesticides atrazine, dimethyl tetrachloroterephthalate (DCPA), chlorothalonil, picloram, simazine, lindane, and pentachloronitrobenzene (PCNB).

^e Gilding, 1996; Bailey, 1996; Parshley, 1996; Noble, 1996; McMaster, 1996; McMaster, 1997.

^f U.S. EPA, 1998.

^g U.S. EPA, 1996.

some indication of the population within each category, and therefore, some insight into the size of the population that may need to be evaluated for possible regulation.

The TRC study used two methods to develop the emissions estimates presented in the OAQPS document. One approach consisted of examining the TRI system to identify facilities that emit HCB, and extracting the HCB emissions data for those facilities. The SRI Directory of Chemical Producers (SRI, 1990) then used to categorize the TRI facilities and to identify other facilities (non-TRI) that should be included in the source category. The TRI data were then extrapolated to the non-TRI facilities. This approach was used to estimate emissions from chlorinated solvents production.

The emissions estimate for pesticides manufacture was also developed from TRI data, but data were not available to extrapolate the emissions for TRI facilities to non-TRI facilities. Thus, the emissions estimate presented in the EPA HCB document for pesticides manufacture was developed from emissions data for TRI facilities only, and does not include emissions from facilities that do not report to TRI.

The emissions estimate for pesticides application was developed using a speciation approach. Emissions from pesticides application are the result of the volatilization of the active ingredients (AI), organic solvents, emulsifiers, and other organic compounds that may be used in formulation. Annual usage estimates of the leading AIs in pesticides were obtained and an estimate of the percentage of HCB of each AI was developed from data obtained from published literature and the industry. These data were combined to obtain an estimate of the amount of HCB contained in each pesticide. These data were then adjusted by the percent of HCB that has been shown in studies to be volatilized as air emissions. The volatilization rate is 8.4 percent. The data used to derive the pesticide application estimate are shown in Table 7-2.

There are some uncertainties in the approaches used by the EPA to estimate HCB emissions. As discussed above, the emissions estimate for pesticides manufacture was developed

Table 7-2

Data Used to Derive 1990 HCB Emission Estimate for Pesticides Application^a

Pesticide	Usage (lb/yr)	HCB Content (%)	HCB Available for Release (lb/yr)	% Volatilized	1990 HCB Emissions (lb/yr)
DACTHAL (DCPA)	1,340,000	0.10	1,340.00	8.4	112.56
Chlorothalonil	11,566,093	0.005	578.30	8.4	48.58
Picloram	1,000,000	0.005	50.00	8.4	4.20
Atrazine	70,500,000	0.0001	70.50	8.4	5.92
Simazine	4,000,000	0.0001	4.00	8.4	0.34
Lindane	61,189	0.01	6.12	8.4	0.51
PCNB	1,662,371	0.05	831.19	8.4	69.82
TOTAL	90,129,653		2,880.11		241.93

^a Gilding, 1996; Bailey, 1996; Parshley, 1996; Noble, 1996; McMaster, 1996; McMaster, 1997.

from TRI data only and does not include emissions from facilities not reporting to TRI. It is not known what effect these uncertainties have on the national HCB emissions estimate, but it is probable that they result in an underestimate of emissions.

The HCB emission estimate for tire manufacturing was developed from information that EPA has collected for the tire manufacturing MACT standards development program. A significant amount of the emission factor and activity data for this category have come from the industry through the MACT process. The national emissions estimate was developed by first developing a model tire manufacturing facility and determining emissions for various operations on a lb/lb production basis. The results of the model facility analysis were then extrapolated to the national tire production of the whole category.

The HCB estimate for coal-fired power plants was obtained directly from the EPA's CAA-mandated study of HAP emissions from coal-fired utilities. The emission estimates from this study were generated using extensive source testing information from tests conducted by both EPA and the industry. Composite emission factors were developed and applied to high quality coal combustion activity data provided by industry and the U.S. Department of Energy (DOE). Both the utility coal combustion and the tire manufacturing HCB estimates were originally assembled for the purposes of EPA's CAA section 112(k) emission inventory. More detailed information on the estimates for these two categories can be obtained from the Section 112(k) inventory report (U.S. EPA, 1998).

7.2 Source Category Inclusion

The EPA relied on the TRI database and emission studies that they have conducted to identify the source categories of HCB emissions presented in the 1993 document. All known or probable sources of HCB emissions are included in the document and national emissions estimates were developed for all source categories. Table 7-1 identifies the source categories of HCB emissions.

7.3 Detailed Emissions Summary

This section presents detailed HCB emissions information on a total national and major/area basis for a 1990 base year.

7.3.1 National Emissions

Table 7-3 presents the 1990 national emissions of HCB for each source category. As shown in the table, utility coal combustion (29.6%) and chlorinated solvents production (25.3%) constitute the greatest portion of total emissions. Tire manufacturing and pesticide manufacturing add approximately another 40 percent to the national total. Pesticides application is responsible for only 6.4 percent of total emissions. Recent data from manufacturers indicate that current (1995-96) HCB emissions from pesticides application are less than 1990 levels or about 232 lb/yr (Gilding, 1996; Noble, 1996; McMaster, 1996; Parshley, 1996; Bailey, 1996).

Figure 7-1 illustrates graphically the contribution of specific source categories to total national emissions in 1990.

Table 7-3

National 1990 Base Year Hexachlorobenzene Emissions Estimates and Major/Area Source Distributions

Source Category	Total National Emissions (lb/year)	Major Source Emissions (lb/year) ^a	Area Source Emissions (lb/year) ^b
Pesticides Application ^c	292 ^{d,e}	0	292
Chlorinated Solvents Production	1,161 ^f	1,161	0
Pesticides Manufacturing ^g	915 ^f	0	915
Tire Manufacturing	869 ^h	860.3	8.7
Utility Coal Combustion	1,360 ⁱ	1,360	0
TOTAL	4,597	3,381.3	1,215.7

^a These are estimated national emissions from "major" sources within the source category. "Major" sources are defined in this inventory as any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs.

^b These are estimated national emissions from "area" sources within the source category. "Area" sources are defined in this inventory as any source of HAPs that is not a major source.

^c Emissions estimate is for the application of atrazine, simazine, picloram and dimethyl tetrachloroterephthalate.

^d Gilding, 1996; Bailey, 1996; Parshley, 1996; Noble, 1996; McMaster, 1996.

^e 1995-96 period emissions are estimated to be 232 lb/yr.

^f TRC, 1993.

^g Emissions estimate is only for facilities reporting to TRI, lindane, chlorothalonil, and pentachloronitrobenzene (PCNB).

^h U.S. EPA, 1998.

ⁱ U.S. EPA, 1996.

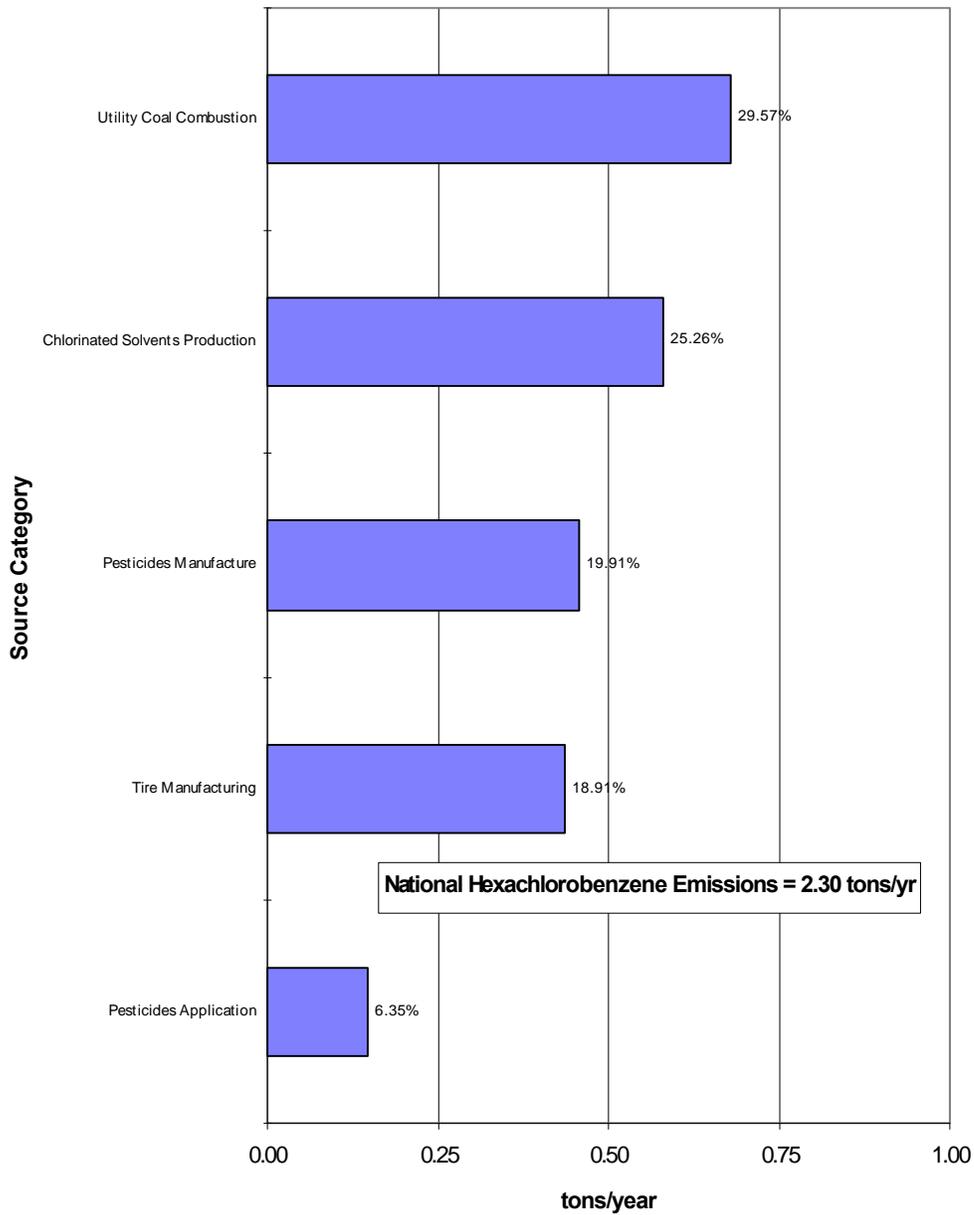


Figure 7-1. Percentage Contribution to 1990 National Hexachlorobenzene Emissions by Source Category

7.3.2 Major /Area Source Emissions

As shown in Table 7-3, HCB emissions from probable major sources account for about 74 percent (3,3381 pounds) of the total emissions, with the remaining 26 percent (1,216 pounds) coming from area sources. Contributors to major source emissions are utility coal combustion (40.2 %), chlorinated solvents production (34.3%), and tire manufacturing (25.4%). Area source HCB emissions are dominated by pesticides manufacturing, comprising over 75 percent of the area source total. Pesticides application is responsible for 24 percent and tire manufacturing area sources make up less than 1 percent of the area source total.

7.4 References

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8.0 EMISSION ESTIMATES FOR ALKYLATED LEAD

Currently the only use for alkylated lead is as a fuel additive for piston engine combustion. Alkylated lead has been used in motor gasoline since the 1920s to boost octane and to provide lubrication for intake and exhaust valves. Alkylated lead antiknock compounds function by decomposing in the combustion cycle to form metal oxide particles. The particles interrupt the hydrocarbon chain branching reactions that cause rapid combustion, known as "knock." Alkylated lead antiknock compounds interfered with 1970 catalytic converter technologies developed to reduce hydrocarbon, carbon monoxide, and nitrogen oxides emissions. This led to the development of lead-free fuel in the early 1970s.

The lead levels in alkylated leaded gasoline have been gradually reduced from the industrial average of 5.5×10^{-3} lbs as lead per gallon of leaded gasoline in the 1970's to 4.4×10^{-7} lbs as lead per gallon of unleaded gasoline in 1991. Since 1982, the majority of gasoline fuel sold for motor vehicles has been lead free. Diesel fuel is assumed to contain quantities of alkylated lead that are insignificant compared to gasoline fuel. The fuel which currently has the greatest lead content is aviation gasoline (4.4×10^{-3} to 8.8×10^{-3} lbs as lead/gal). This fuel is not regulated under the 1990 CAAA.

The two most common lead antiknock additives are tetraethyl lead (TEL) and tetramethyl lead (TML). TEL and TML, both high in octane, lubricate intake and exhaust valves and help to reduce engine knock. In 1990, 93 percent of highway fuel lead additive was TEL, and the remaining 7 percent was TML.

Of the different aviation fuels currently in use, only aviation gasoline contains lead as an antiknock compound. There are two grades of aviation gasoline: low-lead, which has a lead concentration of 4.4×10^{-3} lbs lead per gallon of aviation gasoline, and high-lead, which has a lead concentration of 8.8×10^{-3} lbs lead per gallon of aviation gasoline. Only TEL is used in leaded aircraft fuel.

8.1 General Methodology and Assumptions

This section briefly describes the methodologies associated with developing the national inventory of alkylated lead emissions. More detailed descriptions of inventory development procedures are available in Estimation of Alkylated Lead Emissions, Final Report prepared in 1993 by TRC for the EPA's OAQPS. This document was commissioned by OAQPS to fulfill 1990 CAAA requirements to identify source categories emitting 90 percent of the total national alkylated lead emissions (TRC, 1993).

The TRC report focuses on alkylated lead emissions from evaporative losses from marketing and distribution of leaded vehicle and aviation gasoline. The TRC study determined that it was impractical to calculate new evaporative loss emission factors using AP-42 equations because these equations require so much detailed data and assumptions about the individual source types, controls, fuel characteristics, and ambient conditions. These data were not readily available.

This problem was remedied by using emission factors from existing studies. The national gasoline marketing and distribution system has been studied previously in other EPA reports such as Gasoline Distribution Industry - Background Information for Proposed Standards Draft Report (U.S. EPA, 1992), Evaluation of Air Pollution Regulatory Strategies for Gasoline Marketing Industry (U.S. EPA, 1984); and Draft Regulatory Impact Analysis: Proposed Refueling emission Regulations for Gasoline-Fuel Motor Vehicles - Volume I; Analysis of Gasoline Marketing Regulatory Strategies (U.S. EPA, 1987).

TRC obtained VOC emission factors from these reports for each of the source categories studied. The TEL and TML fractions of the VOC emissions were estimated using temperature-dependent weight fractions. These temperature-dependent weight fractions were based on the physical properties of the pure compounds (TEL, TML, and gasoline), the average lead content by weight of motor vehicle gasoline fuel in 1990 (1.87×10^{-4} lbs lead per gallon), and Antoine coefficients. The actual TEL/TML emission factors were estimated by applying the alkylated

lead vapor phase weight fraction to the gasoline VOC emission factor. The complete equations and calculations may be found in the TRC report (TRC, 1993).

State-level leaded gasoline sales data for 1990 which were provided by the Department of Energy were employed to calculate State-level emissions from gasoline distribution. In a few cases, where state-level gasoline sales were unavailable (e.g., pipelines), emissions were estimated based on the configuration (i.e., number of tanks, valves and seals) of a typical plant provided in the Gasoline Distribution Industry (Stage I) - Background Information for Proposed Standards document. These emissions were allocated to States based on the number of facilities reported in each state for the appropriate SIC code.

Aviation gasoline is transported directly from refineries to the airport terminal, which are assumed to represent the bulk plant. The aviation gasoline is then transported to the aircraft via small tank trucks. No emission factors specific to aircraft refueling were identified, so motor vehicle refueling emission factors were used because the operations are similar. Emissions from aviation gasoline distribution are likely to be uncontrolled due to the relatively low volatility of aviation gasoline. No factors were identified in the TRC report to estimate evaporative emissions from the plane's fuel tank after refueling.

One underlying assumption in the TRC report is that VOC emissions from unleaded and leaded fuels would be of the same general magnitude. This assumption is of concern as lead additives in gasoline were replaced by high octane hydrocarbon fractions. For example, aromatics, isoparaffins, and olefins produced from catalytic cracking and reforming processes can be blended with unleaded low octane straight-run refinery products to elevate the octane numbers of the unleaded fuel. As the concentration of aromatics are increased in unleaded gasoline, the VOC content of the fuel increases.

Table 8-1 summarizes the methodology and assumptions used to determine emission estimates for each source category identified as an emitter of alkylated lead. The table contains a listing of the number of facilities, national activity data, basis for emissions estimates, and the

Table 8-1

**Number of Facilities, National Activity, and Major/Area Distribution
for Alkylated Lead Source Categories^a**

Source Category	Number of Facilities	1990 National Annual Activity Level (Gallons)	Basis for Emission Estimate	Major/Area Assumptions (%) of Source ^b
Bulk Plants - Aviation Gasoline	c	322,629,000 ^d	VOC emission factors were used for motor vehicle fuel bulk plants. Temperature-dependent TEL weight fraction of VOC emission factors were developed assuming a lead content of 4 grams/gallon. The TEL emission factors were applied to 1990 State aviation gasoline data.	10/90
Non-road Vehicles Evaporative	e	e	TEL and TML emission factors based on population of equipment type and usage for 4 and 2 stroke gasoline engines. Emissions were not allocated to state-level.	0/100 ^f
Service Stations	387,750	1,363,508,750 ^d	TEL and TML emission factors derived from temperature-dependent weight fraction of VOC emission factors. The TEL and TML emission factors were applied to 1990 leaded gasoline sales.	0/100
Bulk Plants - Motor Vehicle Gasoline	12,600	1,363,508,750 ^d		10/90
Bulk terminals	748	e		10/90
Pipelines	79,624 miles	e	Based on emissions from national plant inventory as quantified in other EPA studies, disaggregated to states by SIC.	0/100

^a All data are taken from TRC, 1993. The derivation of the emission data and assumptions presented in this table are explained in detail in that report.

Table 8-1

Number of Facilities, National Activity, and Major/Area Distribution for Alkylated Lead Source Categories^a (Continued)

- ^b The term "major," as defined for this report, refers to any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs. The term "area" refers to any source of HAPs that is not a major source. This column provides an estimate of the percentage of emissions from each source category that are major and area sources.
- ^c As aviation fuel is delivered directly from refineries to airports, the airports are considered to be bulk plants.
- ^d See Appendix J of TRC, 1993.
- ^e The data used to estimate emissions could not be summarized in this table. Refer to TRC, 1993.
- ^f Mobile area sources.

major source/area source distribution used for each category. It should be noted that estimates for the number of facilities and units are, for the most part, rough estimates but they are useful for providing some indication of the population within each category and therefore some insight into the size of the population that may need to be evaluated for possible regulation.

8.2 Source Category Inclusion

Alkylated lead source categories were identified based on an in-depth review of available literature sources and previously developed national emissions inventories. National emissions estimates were developed for all source categories with documented emission factors or with credible emission inventories. Table 8-1 identifies the categories for which national emissions estimates were determined.

The following categories were identified as potential sources of alkylated lead emissions for which sufficient data were not available to develop credible national emissions estimates:

- Evaporative Emissions from Operations of Aircraft;
- Evaporative Emissions from Operations of Onroad Vehicles; and
- Alkylated Lead Production.

At this time it is not possible to discern quantitatively how significant the above sources are, but considering the amount of alkylated lead in aviation fuel, evaporative and combustion emissions from aircraft may be the most significant alkylated lead source.

8.3 Detailed Emissions Summary

This section presents detailed alkylated lead emissions information on a total national and major/area basis for a 1990 base year.

8.3.1 National Emissions

Total national 1990 base year emissions of TEL and TML are 810.6 lb of TEL per year and 481.23 lb of TML per year as shown in Table 8-2. The source categories are presented in the order of their contribution to total emissions. Aviation gasoline bulk plants (airport terminals) proportionally dominated the TEL evaporative emission inventory representing 92 percent of national TEL emissions. Non-road engines and vehicles proportionably dominate the TML evaporative emission inventory representing 61 percent of national TML emissions.

8.3.2 Major/Area Source Emissions

As shown in Table 8-2, greater than 94 percent of total estimated TEL and TML emissions are considered area source emissions. The most significant major source contributor is aviation gasoline bulk plants, representing about 5.8 percent of total national emissions. Figure 8-1 identifies the contribution of specific source categories to total national emissions. Together, aviation bulk plants (58%), non-road vehicles (26%), and service stations (9%) comprise roughly 93 percent of total alkylated lead emissions.

Table 8-2

**National 1990 Base Year Alkylated Lead Emissions Estimates
and Major/Area Source Distributions**

Source Category	Total National Emissions (lb/year)		Major Source Emissions (lb/yr) ^a		Area Source Emissions (lb/yr) ^b	
	TEL	TML	TEL	TML	TEL	TML
Bulk Plants - Aviation Gasoline	749.57	NA	75	NA	674.6	NA
Non-road Vehicles Evaporative	37.92	293.21	0	0	37.92	293.21
Service Stations	12.72	102.29	0	0	12.72	102.29
Bulk Plants - Motor Vehicle Gasoline	4.81	39.68	0.48	3.97	4.33	35.7
Bulk Terminals	3.62	29.98	0.36	3.0	3.26	26.98
Pipelines	1.96	16.07	0	0	1.96	16.07
TOTAL	810.6	481.23	76.8	6.97	734.8	474.3

^a These are estimated national emissions from "major" sources within the source category. "Major" sources are defined in this inventory as any stationary source (including all emission points and units located within a contiguous area and under common control) of air pollution that has the potential to emit, considering controls, 10 tons or more per year of any HAP or 25 tons or more per year of any combination of HAPs.

^b These are estimated national emissions from "area" sources within the source category. "Area" sources are defined in this inventory as any source of HAPs that is not a major source as defined in footnote b above.

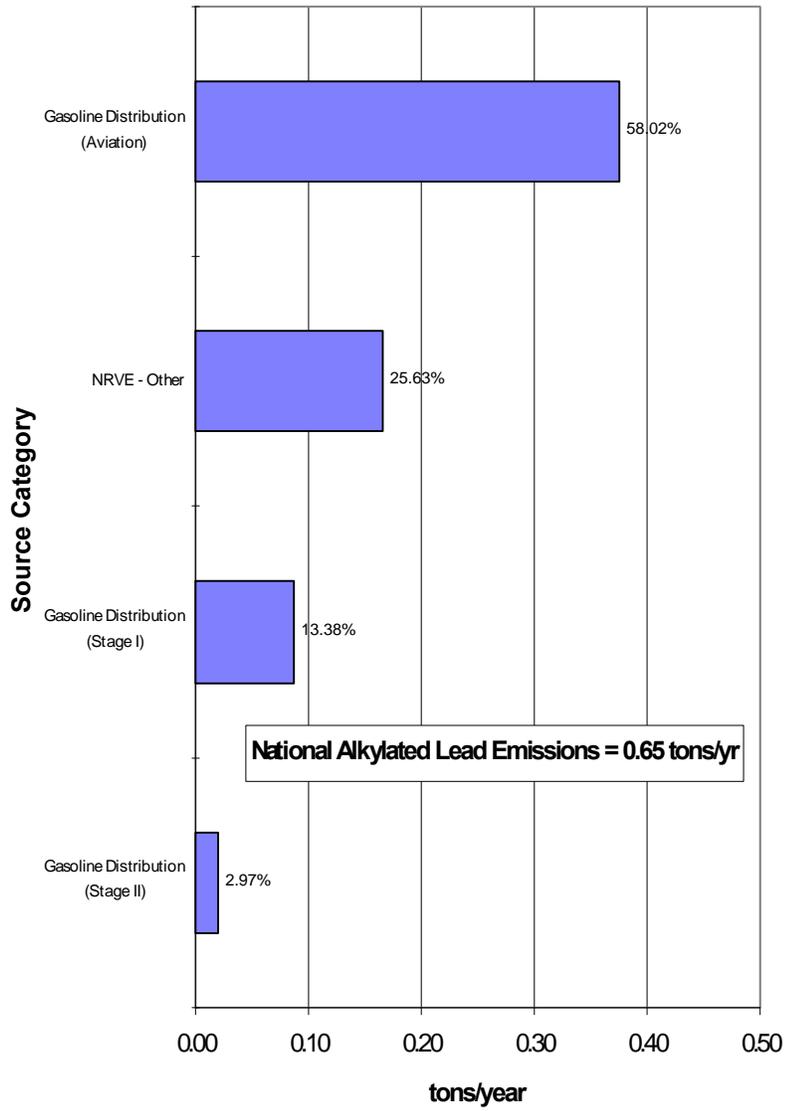


Figure 8-1. Percentage Contribution to 1990 National Alkylated Lead Emissions by Source Category

8.4 References

1. TRC Environmental Corporation. Estimation of Alkylated Lead Emissions, Final Report, prepared under contract 68-D9-0173 for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina. September, 1993.
2. U.S. Environmental Protection Agency. Evaluation of Air Pollution Regulatory Strategies for Gasoline Marketing Industry. EPA Report No. EPA-450/3-84-012a. Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina. July, 1984.
3. U.S. Environmental Protection Agency. Draft Regulatory Impact Analysis: Proposed Refueling Emission Regulations for Gasoline-Fueled Motor Vehicles-Volume 1 Analysis of Gasoline Marketing Regulatory Strategies. Office of Air and Radiation. Washington, DC. EPA-450/3-87-001a. July, 1987.
4. U.S. Environmental Protection Agency. Gasoline Distribution Industry (Stage I) - Background Information for Proposed Standards, Draft Report. Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina. September, 1992.

9.0 INVENTORY DATA GAPS

This chapter identifies data gaps for 112(c)(6) pollutants and source categories in terms of problems that prohibit the determination of reasonable national emissions estimates. Categories that are suspected or known to be emitters of 112(c)(6) pollutants but for which estimates cannot be prepared are identified. The expected relative magnitude of these sources as 112(c)(6) emitters is discussed. The types of data that are needed to produce more complete national 112(c)(6) estimates and the necessary means to obtain these data are also described. This information is presented below on a pollutant basis.

9.1 POM Sources

One of the most significant issues that still remains to be resolved for POM is how to define the pollutant of study. As discussed in Chapter 3.0, there are several ways in which POM has been defined. Standardizing and making emissions source test data consistent will continue to be difficult without a commonly understood and accepted POM definition. The available POM data presented in this document reflect this same dilemma, as evidenced by the documentation in Appendix A and B. Because of this lack of consistent pollutant definition, comparison of existing emission estimates is somewhat imprecise and difficult.

Like several other 112(c)(6) pollutants, POM suffers from a lack of high quality, representative emissions/emission factor data from which to calculate national emission estimates. For many of the combustion source categories, particularly below the utility level, existing data are very limited and of questionable quality. Several of these estimates have been based on emission factors developed from 15-year-old test data collected by differing methods. Additional testing for these source types to produce more category-representative data would improve the national estimates greatly.

Another category that needs additional examination and emissions testing for POM is mobile sources (both onroad and non-road). Some data were available for mobile sources, but

for many of the non-road sources, no estimates could be prepared because of a lack of emissions data or emissions stream speciation data. However, additional POM testing of mobile sources may not be a priority, given recent information provided in ORD's health assessment for diesel emissions that suggests that the primary health risk from particulate POM may be from the inert carbon core of particles rather than the associated organic compounds.

Several other combustion-related categories should also be examined in greater detail for POM purposes. Included here would be metals industry sources (both primary and secondary), steel production, coke ovens, and waste incineration.

In addition to the lack of emissions data in general, the POM situation also suffers from a difficulty to assess the representativeness of the available data to all sources within a category. The very nature of most POM emissions, especially those associated with combustion processes, makes assigning representative factors very difficult. More work is needed to determine the variability of POM emissions from various source types and the reasons for that variability.

9.2 Dioxin/Furan Sources

Like most of the other pollutants, dioxin/furan emission estimates in the national inventory suffer from a lack of extensive emissions data on which to base category-wide estimates. Like POM, data representativeness and variability are key issues. Dioxin/furan emissions for many sources are related to a number of process factors such as temperature, moisture content, chlorine content, etc., that vary from source to source and from time to time within the same source. Obtaining data to better understand and predict these emissions in light of such process conditions will facilitate the development of better emissions estimates. Such understandings will also improve the quality of the source tests that are conducted.

For the purposes of 112(c)(6), there is a lack of emissions data specific to the dioxin and furan species delineated in the Act (2,3,7,8-TCDD and 2,3,7,8-TCDF). This document and most of the other EPA activities related to dioxin/furan have focused on expressing emissions on the

TEQ basis. Emissions data on the basis of 2,3,7,8-TCDD and 2,3,7,8-TCDF were not available for all identified source categories. If these individual species will be the focus of 112(c)(6) regulatory activities rather than TEQ estimates, then additional testing will be needed.

The 112(c)(6) national inventory data presented in this document identified most of the categories of dioxins/furans generally thought to be important. Of the identified categories, emissions estimates not quantifiable for ethylene dichloride manufacture, vinyl chloride monomer manufacture, and catalyst regeneration (in petroleum refining). National estimates for landfill gas flares were also not prepared due to a difficulty in obtaining accurate activity level data for the category.

9.3 PCB Sources

The available PCB emissions data from which to prepare the national PCB 112(c)(6) inventory were very limited. All estimates prepared should be viewed as having a high degree of uncertainty. National estimates could not be developed for all categories identified as potential emission sources. Credible estimates were not feasible for the following sources:

- TSDFs;
- Landfills;
- Superfund Sites;
- Steel and Iron Reclamation (auto scrap burning);
- Accidental Releases such as PCB Spills and Transformer Fires; and
- Environmental Sinks of Past PCB Contamination.

Emission factors were not available for most of these categories. For some categories, such as accidental releases, reliable activity data were not available.

In general, estimating emissions of PCBs was the most difficult of all the 112(c)(6) pollutants due to the lack of emissions characterization data. Estimation of air emissions of

PCBs from most of these source types has not been a particular research focus, and therefore, data relevant to the objectives of 112(c)(6) are scarce. It is recommended that future testing include PCB as a subject analyte, especially where there are 112(c)(6) source categories overlapping with other pollutants (boilers, incinerators, landfills, etc.). In particular, incinerators and landfills that have been specifically permitted under the Toxic Substances Control Act (TSCA) to handle PCBs at regulated levels (i.e., 50 ppm or greater) should be evaluated.

9.4 Mercury Sources

The draft mercury RTC contained a thorough identification of mercury air emission sources. It is felt that few if any potential air emission source categories remain unidentified. Several of the identified categories, however, do not have emissions estimates, primarily due to insufficient or nonexistent emissions data. The categories that were identified as mercury air sources but for which emissions were not estimated were:

- Mobile Sources;
- Agricultural Burning;
- Landfills;
- Sludge Application;
- Residential Woodstoves;
- Primary Mercury Production;
- Mercury Compounds Production;
- By-product Coke Production;
- Zinc Mining;
- Explosives Manufacturing;
- Mercury Catalysts; and
- Natural Sources.

The bulk of the national emissions estimates contained in the RTC document were based on an emission factors and activity levels. The draft report, however, indicates that there are

concerns with the emissions/emission factor database available for mercury sources. For a trace pollutant like mercury, only limited data are available, such that it is very difficult to obtain information that is representative for an entire source category. In addition, it was felt that the available data are imprecise and highly uncertain due to problems in measurement techniques and data bias. For most of the source categories addressed, the report listed the “degree of uncertainty” as high. It was also noted that for some of the categories the accuracy and validity of the activity level data is also a concern.

None of these problems are unique to mercury. Emission estimates for several of the other 112(c)(6) pollutants share the same problems. In order to improve the state of the mercury inventory estimates, the draft RTC made the following recommendations:

- Improve the state of available source test data; sources recommended for additional testing include mobile sources, landfills, agricultural burning, sludge application, coke ovens, petroleum refining, residential woodstoves, mercury compounds production, and zinc mining;
- Improve existing emissions information for the categories of secondary mercury production (i.e., recycling), commercial and industrial boilers, electric lamp breakage, iron and steel manufacturing, and primary lead smelting;
- Develop and validate a stack test protocol for speciated mercury emissions;
- Improve the state of knowledge on coal cleaning and mercury removal, and the potential for slurries from the process to be a mercury source;
- Improve the state of knowledge on the levels of mercury found in coals and petroleum used in the United States;
- Conduct more research to address the potential for methylmercury to be emitted or formed in the flue gas of combustion sources; and
- Investigate the importance to air concentrations of mercury re-emitted from deposited anthropogenic emissions and mining wastes.

9.5 HCB Sources

One of the major contributors to HCB emissions was chlorinated solvent production, which encompasses several individual chemical products. The national inventory estimates for these products came from data reported in the TRI database. HCB air emissions estimates were developed based on total environment HCB releases reported in the database. The most significant problem with this method was that not all applicable chemical facilities had data reported in TRI. This required that emissions extrapolations be made to those facilities based on the ones that were in the database. This extrapolation process introduces additional sources of possible error into the national HCB estimates. The chemicals that were studied as a part of the TRI approach were carbon tetrachloride, perchloroethylene, trichloroethylene, ethylene dichloride, and 1,1,1-trichloroethane.

An additional 29 chemical products/processes were also suspected of being sources that contained HCB as a contaminant/by-product; however, no information could be identified to verify the levels of contamination or estimate potential HCB releases for these facility types. The 29 chemicals/products identified were:

- aluminum
- azo dyes
- benzyl chloride
- chlorinated biphenyls
- chlorinated naphthalene
- chlorinated paraffins
- chlorine
- chloroprene
- chloropropane, 3-
- cyanuric chloride
- dichloropropenes
- electrode manufacture
- ethyl chloride
- fluorocarbon 113
- maleic hydrazine
- pentachlorobenzene
- pentachlorophenol
- phosgene
- phthalic anhydride
- phthalocyanine dyes/pigments
- polyethylene
- polypropylene
- sodium chlorate
- synthetic rubber production
- tetrachlorophthalic anhydride
- titanium dioxide
- toluene diisocyanate
- ordnance and pyrotechnics

One problem with the development of HCB emission estimates involved a lack of data on HCB contamination levels in various chemical products, and a lack of chemical specific production/activity data from which to estimate national emissions due to proprietary data concerns. One of the other quantifiable categories of HCB air releases was determined to be pesticides production and use. Seven pesticides were identified as being the chief ones containing HCB as an impurity. These seven include Dacthal (DCPA), pentachloronitrobenzene (PCNB), propazine, simazine, chlorothalonil (daconil), picloram, and atrazine. Pesticide application information was not available for daconil, and only limited data were available for PCNB and propazine. Production data for all pesticides manufacture (which could have been useful in estimating application rates) were not available due to the proprietary nature of the commercial chemical information.

9.6 Alkylated Lead Sources

The most significant inventory data gap for the alkylated lead sources is that three source categories could not be inventoried due to a lack of credible information. These three are aircraft emissions, alkylated lead production emissions, and onroad motor vehicle emissions. Given the alkylated lead content of aviation fuel, evaporative and combustion emissions associated with aircraft could be a relatively significant emissions source not included in the 112(c)(6) inventory. Emissions from aircraft refueling were evaluated; however, no process-specific emission factor could be determined and a surrogate based on motor vehicles had to be used. The effect of this data deficiency on the emissions estimate cannot be determined without more in-depth research.

In general, the methods used to estimate 112(c)(6) alkylated lead emissions were based on the use of gasoline distribution industry emission factors and gasoline throughput activity data. The estimates derived from this method are susceptible to the same problems as any others based on this technique, including validity and representativeness of the emission factors and accuracy of the activity data. Further study should probably be focused on assessing the factors used, since gasoline production and use data are collected and tracked for several purposes and by several agencies such that the activity data are reasonably reliable.