

**BACKGROUND REPORT**

**AP-42 SECTION 12.7**

**PRIMARY ZINC SMELTING**

**Prepared for**

**U.S. Environmental Protection Agency  
OAQPS/TSD/EIB  
Research Triangle Park, NC 27711**

**II-103**

Pacific Environmental Services, Inc.  
5001 South Miami Boulevard  
P.O. Box 12077  
Research Triangle Park, NC 27709  
919/941-0333

This report has been reviewed by the Technical Support Division of the Office of Air Quality Planning and Standards, EPA. Mention of trade names or commercial products is not intended to constitute endorsement or recommendation for use. Copies of this report are available through the Library Services Office (MD-35), U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

## TABLE OF CONTENTS

1.0	INTRODUCTION .....	1
2.0	INDUSTRY DESCRIPTION .....	2
2.1	General .....	2
2.2	Process Description .....	3
2.3	Emissions and Controls .....	7
2.4	Review of References for Chapter 2.0 .....	8
2.5	References for Chapter 2.0 .....	10
3.0	GENERAL EMISSION DATA REVIEW AND ANALYSIS PROCEDURES .....	11
3.1	Literature Search and Screening .....	11
3.2	Emission Data Quality Rating System .....	12
3.3	Emission Factor Quality Rating System .....	14
3.4	References for Chapter 3.0 .....	15
4.0	POLLUTANT EMISSION FACTOR DEVELOPMENT .....	16
4.1	Criteria Pollutant Emissions Data .....	16
4.2	Noncriteria Pollutant Emissions Data .....	17
4.3	Review of Specific Data Sets .....	18
4.4	Data Gap Analysis .....	21
4.5	References for Chapter 4.0 .....	22

## LIST OF TABLES

TABLE 2.1-1: Primary Zinc Smelters .....	2
TABLE 4.5-1: List of Conversion Factors .....	23

## LIST OF FIGURES

FIGURE 2.2-1: Process Flow for a Typical Primary Zinc Smelter .....	4
---	---

## 1.0 INTRODUCTION

The document "Compilation of Air Pollutant Emission Factors" (AP-42) has been published by the U.S. Environmental Protection Agency (the EPA) since 1972. Supplements to AP-42 have been routinely published to add new emission source categories and to update existing emission factors. The AP-42 document is routinely updated by the EPA to respond to new emission factor needs of the EPA, state and local air pollution control agencies, and industry.

An emission factor relates the quantity (weight) of pollutants emitted to a unit of activity of the source. The uses for the emission factors reported in AP-42 include:

1. Estimates of area-wide emissions;
2. Emission estimates for a specific facility; and
3. Evaluation of emissions relative to ambient air quality.

The purpose of this report is to provide background information for revisions to the emission factors and to descriptions of the industry and its processes for AP-42 Section 12.7, *Primary Zinc Smelting*.

Including the introduction (Chapter 1), this report contains four chapters. Chapter 2 gives a description of the primary zinc smelting industry. It includes a characterization of the industry, an overview of the various industrial processes associated with it, a description of emissions, and a description of the technology and techniques used to control emissions resulting from primary zinc smelting.

Chapter 3 is a review of emissions data collection and analysis procedures. It describes the literature search, the screening of quantitative emissions data reports, and the quality rating system for both emissions data and emission factors. Chapter 4 details criteria and noncriteria pollutant emission factor development. It includes the review of specific data sets and the results of data analysis. Particle size determination and particle size data analysis methodology are described.

## 2.0 INDUSTRY DESCRIPTION

### 2.1 General

Applications for zinc, which is found in the earth's crust primarily as zinc sulfide (ZnS, sphalerite) include the coating of all forms of steel, sheet and otherwise; as a constituent of brass, for electrical and other uses; in primers and paints; and the vulcanization of rubber, as zinc oxide. Most of these applications are highly dependent upon the resistance to corrosion and the light weight characteristic of zinc. In 1991, approximately 260 thousand megagrams of zinc were refined at the four U.S. primary zinc smelters, maintaining a relatively constant level since the 1980's. The location, capacity, operator, and type of each of these facilities are shown in Table 2.1-1 below. This production level approximately represents capacity, despite a mined zinc recovery level of 520 megagrams, a domestic demand of 1190 megagrams, and a secondary smelting production level of only 110 megagrams. As a result, the U.S. is a leading exporter of zinc concentrates as well as the world's largest importer of refined zinc.

**TABLE 2.1-1: PRIMARY ZINC SMELTERS**

Location	Operator	1989 Capacity (megagrams)	Type
Sauget, Illinois	Big River Zinc Corp.	76,000	Electrolytic
Clarksville, Tennessee	Jersey Miniere Zinc Co.	95,000	Electrolytic
Bartlesville, Oklahoma	Zinc Corporation of America	51,000	Electrolytic
Monaca, Pennsylvania	Zinc Corporation of America	103,000	Electrothermic

Zinc ores typically contain three to eleven percent zinc, along with cadmium, copper, lead, silver, and iron. Beneficiation, or the concentration of the zinc in the recovered ore, is accomplished at or near the mine by crushing, grinding, and flotation. Once concentrated, the zinc ore is transferred to smelters for the production of zinc or zinc oxide. The primary product of most zinc companies is slab zinc, which is produced in five grades: special high grade, high grade,

intermediate, brass special, and prime western. All four of the U.S. primary zinc smelters produce sulfuric acid as a byproduct.

## 2.2 Process Description

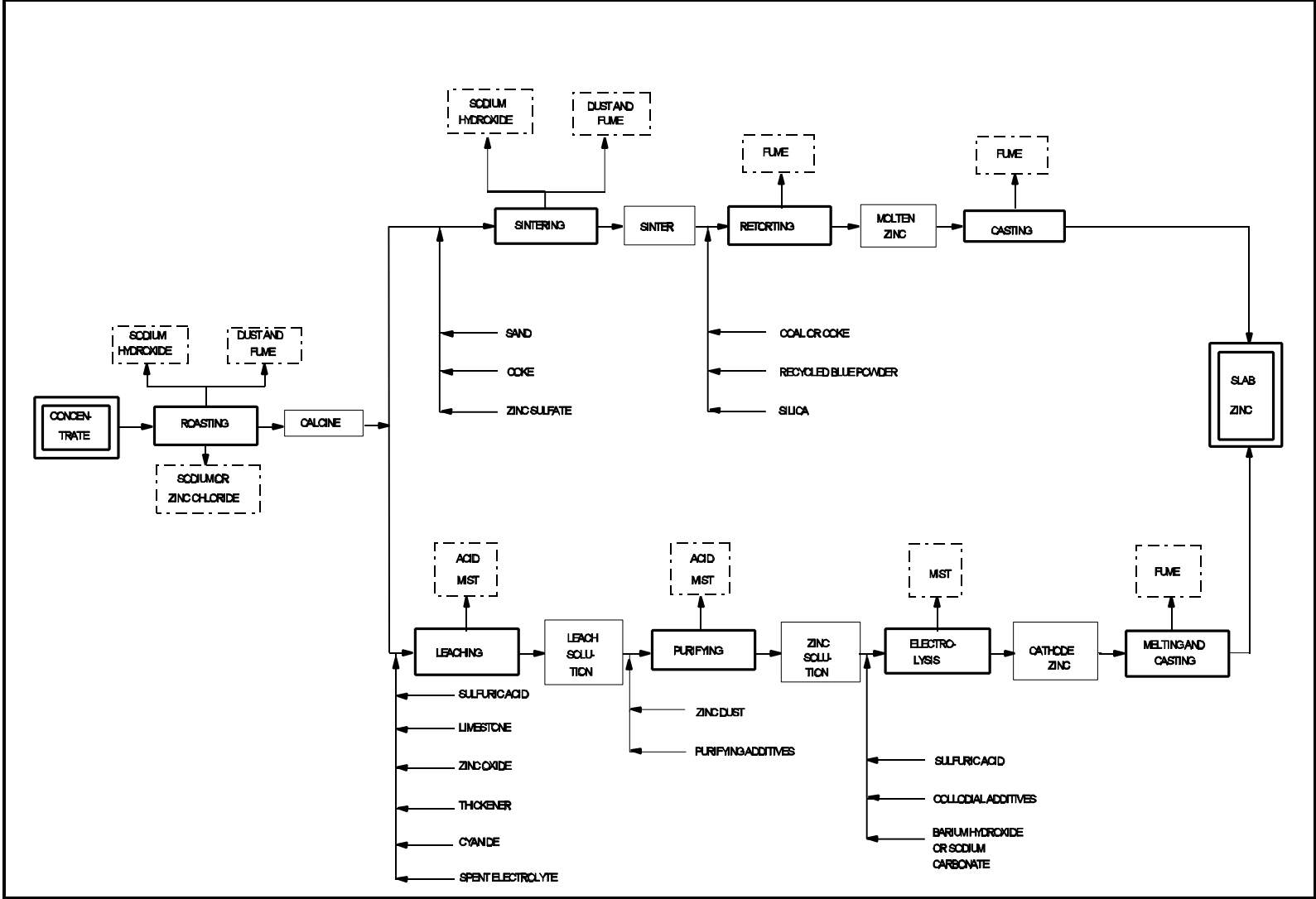
Reduction of zinc sulfide concentrates to metallic zinc is accomplished through either electrolytic deposition from a sulfate solution or by distillation in retorts or furnaces. Both of these methods begin with the elimination of most of the sulfur in the concentrate through a roasting process which is described below. A generalized process flow diagram depicting primary zinc smelting is presented in Figure 2.2-1. *Roasting* is a high-temperature process that converts zinc sulfide concentrate to an impure zinc oxide called calcine. Roaster types include multiple-hearth, suspension or fluidized bed. The following two reactions occur during roasting:



In a multiple-hearth roaster, the concentrate drops through a series of nine or more hearths stacked inside a brick-lined cylindrical column. As the feed concentrate drops through the furnace, it is first dried by the hot gases passing through the hearths and then oxidized to produce calcine. The reactions are slow and can only be sustained by the addition of fuel. Multiple hearth roasters are unpressurized and operate at about 690°C (1,300°F). Operating time depends upon the composition of concentrate and the amount of sulfur removal required. Multiple hearth roasters have the capability of producing a high-purity calcine.

In a suspension roaster, the concentrates are blown into a combustion chamber very similar to that of a pulverized coal furnace. The roaster consists of a refractory-lined cylindrical steel shell with a large combustion space at the top and two to four hearths in the lower portion, similar to those of a multiple hearth furnace. Additional grinding, beyond that required for a multiple hearth furnace, is normally required to assure that heat transfer to the material is sufficiently rapid for the desulfurization and oxidation reactions to occur in the

Figure 2.2-1 Generalized Process Flow for Primary Zinc Smelting





furnace chamber. Suspension roasters also are unpressurized and operate at about 980°C (1,800°F).

In a fluidized-bed roaster, finely ground sulfide concentrates are suspended and oxidized in a feedstock bed supported on an air column. As in the suspension roaster, the reaction rates for desulfurization are more rapid than in the older multiple-hearth processes. Fluidized-bed roasters operate under a pressure slightly lower than atmospheric and at temperatures averaging 1,000°C (1,800°F). In the fluidized-bed process, no additional fuel is required after ignition has been achieved. The major advantages of this roaster are greater throughput capacities and greater sulfur removal capabilities.

*Electrolytic* processing of desulfurized calcine consists of three basic steps: leaching, purification, and electrolysis. Leaching occurs in an aqueous solution of sulfuric acid, yielding a zinc sulfate solution as shown in Equation [3] below.



In double leaching, the calcine is first leached in a neutral or slightly alkaline solution, then in an acidic solution, with the liquid passing countercurrent to the flow of calcine. In the neutral leaching solution, sulfates from the calcine dissolve, but only a portion of the zinc oxide enters into solution. The acidic leaching solution dissolves the remainder of the zinc oxide along with metallic impurities such as arsenic, antimony, cobalt, germanium, nickel, and thallium. Insoluble zinc ferrite, formed during concentrate roasting by the reaction of iron with zinc, and lead and silver remain in the leach residue. Lead and silver are typically shipped to a lead smelter for recovery, while the zinc is extracted on-site from the zinc ferrite to increase recovery efficiency.

In the purification process, a variety of reagents are added to the zinc-laden electrolyte in a sequence of steps designed to precipitate the metallic impurities, which otherwise will interfere with

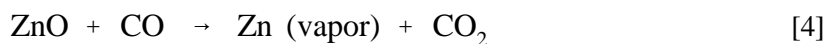
deposition of zinc. After purification, concentrations of these impurities are limited to less than 0.05 milligram per liter ( $4 \times 10^{-7}$  pounds per gallon). Purification is usually conducted in large agitated tanks. The process takes place at temperatures ranging from 40 to 85°C (104 to 185°F), and pressures ranging from atmospheric to 240 kPa (2.4 atmospheres).

In electrolysis, metallic zinc is recovered from the purified solution by passing current through an electrolyte solution, causing zinc to deposit on an aluminum cathode. As the electrolyte is slowly circulated through the cells, water in the electrolyte dissociates, releasing oxygen gas at the anode. Zinc metal is deposited at the cathode and sulfuric acid is regenerated for recycle to the leach process. The sulfuric acid acts as a catalyst in the process as a whole.

Electrolytic zinc smelters contain as many as several hundred cells. A portion of the electrical energy is converted into heat, which increases the temperature of the electrolyte. Electrolytic cells operate at temperature ranges from 30 to 35°C (86 to 95°F) and at atmospheric pressure. A portion of the electrolyte is continuously circulated through the cooling towers to both cool and concentrate the electrolyte through evaporation of water. The cooled and concentrated electrolyte is then repumped to the cells. Every 24 to 48 hours, each cell is shut down and the zinc-coated cathodes are removed, rinsed, and the zinc is mechanically stripped from the aluminum plates.

The *electrothermic distillation retort* process as it exists at one U.S. plant was developed by the St. Joe Minerals Corp. in 1930. The principal advantage of this pyrometallurgical technique over electrolytic processes is its ability to accommodate a wide variety of zinc-bearing materials, including secondary items such as calcine derived from electric arc furnace (EAF) dust. Electrothermic processing of desulfurized calcine begins with a downdraft sintering operation, in which grate pallets are joined to form a continuous conveyor system. The sinter feed is essentially a mixture of roaster calcine and EAF calcine. Combustion air is drawn down through the conveyor, and impurities such as lead, cadmium, and halides in the sinter feed are driven off and collected in a bag filter. The product sinter typically includes 48 percent zinc, 8 percent iron, 5 percent aluminum, 4 percent silicon, 2.5 percent calcium, and smaller quantities of magnesium, lead, and other metals.

Electric retorting has greater thermal efficiency than externally heated furnaces, and is the only pyrometallurgical technique utilized by the U.S. primary zinc industry now and in the foreseeable future. Product sinter and possibly secondary zinc materials are charged with coke to an electric retort furnace. The charge moves downward from a rotary feeder in the furnace top into a refractory-lined vertical cylinder. Paired graphite electrodes protrude from the top and bottom of this cylinder, producing a current flow. The coke serves to provide electrical resistance, producing heat and generating the carbon monoxide required for the reduction process. Temperatures of 1,400°C (2,600°F) are attained, immediately vaporizing zinc oxides according to the following reaction:



The zinc vapor and carbon dioxide pass to a Weaton-Najarjian vacuum condenser, where zinc is recovered by bubbling through a molten zinc bath. Over 95 percent of the zinc vapor leaving the retort is condensed to liquid zinc. The carbon dioxide is regenerated with carbon, and the carbon monoxide is recycled back to the retort furnace.

### **2.3 Emissions and Controls**

Each of the two smelting processes generates emissions along the various process steps. The roasting process in a zinc smelter is typically responsible for more than 90 percent of the potential SO<sub>2</sub> emissions. About 93 to 97 percent of the sulfur in the feed is emitted as sulfur oxides. Concentrations of SO<sub>2</sub> in the offgas vary with the type of roaster operation. Typical SO<sub>2</sub> concentrations for multiple hearth, suspension, and fluidized bed roasters are 4.5 to 6.5 percent, 10 to 13 percent, and 7 to 12 percent, respectively. Sulfur dioxide emissions from the roasting processes at all four U.S. primary zinc processing facilities are recovered at on-site sulfuric acid plants. Much of the particulate matter emitted from primary zinc processing facilities is also attributable to the concentrate roasters. The amount and composition of particulate matter varies according to operating parameters such as air flow rate and equipment configuration. Various combinations of control devices such as cyclones, electrostatic precipitators (ESP's), and baghouses can be used on roasters and on sintering machines, achieving 94 to 99 percent emission reduction.

Controlled and uncontrolled particulate emission factors for point sources and uncontrolled particulate emission factors for fugitive sources within a zinc smelting facility are presented in the revised AP-42 Section 12.7 *Primary Zinc Smelting*. These emission factors should be applied carefully. The factor for sintering operations is derived from data from a single facility no longer operating. Others are estimated based on similar operations in the steel, lead, and copper industries.

#### **2.4 Review of References for Chapter 2.0**

The following entities were contacted during the revision of AP-42 Section 12.7 in order to obtain the most up-to-date information on general industry trends, industrial processes, emission stream characterization, and emission control techniques:

*International Lead/Zinc Research Organization*, Research Triangle Park, NC.

This organization was solicited primarily for process information, and provided a 1990 paper concerning the only electrothermic retort operation in the U.S. (Reference 10: "The Monaca Electrothermic Smelter - The Old Becomes the New"). This paper was used in updating the description of this process presented in the revised AP-42 section.

*Zinc Corporation of America*, Monaca, PA.

Environmental affairs personnel at this facility were solicited by mail and by telephone for emission test results that could be utilized in developing revised AP-42 emission factors for primary zinc smelting by the electrothermic distillation retort process. A report detailing the results of a series of tests conducted in May 1991 was sent in response to these requests. No process rate data were available, precluding the development of emission factors from these results. This report is discussed in more detail in Section 4.3 of this background report.

*Jersey Miniere Zinc Co.*, Clarksville, TN.

Communications with environmental personnel at this facility indicated that regulations for sulfur dioxide and particulate emissions are applicable, but that no quantitative emissions testing has been performed. The facility is subject to periodic opacity testing, and has a continuous SO<sub>2</sub> monitor in place, but was unable to provide any information that would enable development of revised

emission factors. Clarifications to specific process questions were provided by these personnel, and are incorporated into the revised section.

*U.S. Environmental Protection Agency, Region IV, Air, Pesticide and Toxic Management Division, Atlanta, GA.*

No response from this office was received concerning a request for emissions test data and process information that would indicate a need for revisions to AP-42 Section 12.7.

*U.S. Department of the Interior, Bureau of Mines, Washington, DC*

Two documents (Reference 1: "Zinc," Mineral Commodities Summary 1992 and Reference 2: "Zinc," Minerals Yearbook 1992) reviewing the primary zinc smelting industry from a primarily commercial standpoint were received from the Bureau of Mines. These documents are the basis for the industry profile and the general information on zinc and its uses provided in the revised AP-42 Section 12.7. The more detailed *Minerals Yearbook* also provided descriptions of the processes associated with zinc smelting that were utilized in revising the section.

*Oklahoma State Department of Health, Air Quality Service, Oklahoma City, OK.*

Personnel at this agency examined the files of the one Oklahoma zinc smelter, which were found to contain the results of one emissions test conducted in August 1990. This test report was not suitable for use in emission factor development, because it concerned a process not specific to zinc smelting and because it contained no raw test data. Specifically, the test summary in the files was in the form of a memo summarizing the results with respect to permitted emission limitations, and the process tested involved the recovery of lead sulfate, metallic cadmium, and zinc carbonate from fumes and dusts exiting other operations at this and other facilities.

## 2.5           **References for Chapter 2.0**

1. J.H. Jolly, "Zinc," Mineral Commodity Summaries 1992, U.S. Department of the Interior, Bureau of Mines, Washington, DC, 1992.
2. J.H. Jolly, "Zinc," Minerals Yearbook 1989, U.S. Department of the Interior, Bureau of Mines, Washington, DC, 1990.
3. R.L. Williams, "The Monaca Electrothermic Smelter - The Old Becomes the New," Lead-Zinc '90, T.S. Mackey and R.D. Prengaman, eds., The Minerals, Metals & Materials Society, Philadelphia, PA, 1990.
4. Environmental Assessment of the Domestic Primary Copper, Lead and Zinc Industries, EPA-600/2-82-066, U.S. Environmental Protection Agency, Cincinnati, OH, October 1978.

### 3.0 GENERAL EMISSION DATA REVIEW AND ANALYSIS PROCEDURES

#### 3.1 Literature Search and Screening

The first step of this investigation involved a search of available literature relating to the industrial processes and emissions of criteria and noncriteria pollutants associated with primary zinc smelting and refining. This search included, but was not limited to, the following references:

- 1) *AP-42 background files maintained by the Emission Factor and Methodologies Section*. The references from which all of the emission factors presented in both the previous and revised versions of AP-42 Section 12.7 are derived were obtained from these files, and are summarized in Chapter 4.0 of this background report.
- 2) *"Locating and Estimating" reports* published by the Emission Factor and Methodologies Section. None of the pollutants for which these reports have been compiled is emitted from primary zinc smelting facilities, and thus no useful information was contained in these reports.
- 3) PM<sub>10</sub> "gap filling" documents as listed below; none of these documents contained data of a quality suitable for development of emission factors.
  - 3a) "PM<sub>10</sub> Emission Factor Listing Developed by Technology Transfer" (EPA-450/4-89-022).
  - 3b) "Gap Filling PM<sub>10</sub> Emission Factors for Selected Open Area Dust Sources" (EPA-450/88-003).
  - 3c) "Generalized Particle Size Distributions for Use in Preparing Size Specific Particulate Emission Inventories" (EPA-450/4-86-013).
- 4) *Handbook of Emission Factors*, Parts I and II, Ministry of Health and Environmental Protection, The Netherlands, 1980/1983. No information concerning the primary zinc smelting industry is contained in this handbook.
- 7) The EPA databases, including but not limited to the *VOC/Particulate Matter (PM) Speciation Database Management System (SPECIATE)*, the *Crosswalk/Air Toxic Emission Factor Data Base Management System (XATEF)*, and the *Test Methods Storage and Retrieval System* maintained by the Emission Measurement Technical

Information Center (EMTIC/TSAR). No emissions test data for the primary zinc smelting industry are contained in these databases.

- 6) The EPA *Clearinghouse for Inventories and Emission Factors* (CHIEF) and *National Air Toxics Information Clearinghouse* (NATICH). No emissions test data for the primary zinc smelting industry are contained in these databases.

To reduce the amount of literature collected to a final group of references pertinent to this report, the following general criteria were used:

1. Emissions data must be from a primary reference; i.e., the document must constitute the original source of test data. For example, a technical paper was not included if the original study was contained in the previous document.
2. The referenced study must contain test results based on more than one test run.
3. The report must contain sufficient data to evaluate the testing procedures and source operating conditions (e.g., one-page reports were generally rejected).

In cases such as that for the primary zinc processing industry where no primary emissions data were found for a particular process and the emission factors in the current AP-42 section are derived from secondary emissions data, these factors were still used. The expected representativeness of these emission factors was reevaluated according to the criteria set forth below, and ratings were assigned to reflect this evaluation. The final set of reference materials is reviewed in detail in Chapter 4.0 of this background report.

### **3.2 Emission Data Quality Rating System**

As part of the emissions data analysis, the quantity and quality of the information contained in the final set of reference documents were evaluated. The following data were always excluded from consideration.

1. Test series averages reported in units that cannot be converted to the selected reporting units;
2. Test series representing incompatible test methods (e.g., comparison of the EPA Method 5 front-half with the EPA Method 5 front- and back-half);
3. Test series of controlled emissions for which the control device is not specified;
4. Test series in which the source process is not clearly identified and described; and



5. Test series in which it is not clear whether the emissions were measured before or after the control device.

Data sets that were not excluded were assigned a quality rating. The rating system used was that specified by the OAQPS for the preparation of AP-42 sections. The data were rated as follows:

**A**

Multiple tests performed on the same source using sound methodology and reported in enough detail for adequate validation. These tests do not necessarily conform to the methodology specified in the EPA reference test methods, although these methods were certainly used as a guide for the methodology actually used.

**B**

Tests that were performed by a generally sound methodology but lack enough detail for adequate validation.

**C**

Tests that were based on an untested or new methodology or that lacked a significant amount of background data.

**D**

Tests that were based on a generally unacceptable method but may provide an order-of-magnitude value for the source.

The following criteria were used to evaluate source test reports for sound methodology and adequate detail:

1. Source operation. The manner in which the source was operated is well documented in the report. The source was operating within typical parameters during the test.
2. Sampling procedures. The sampling procedures conformed to a generally acceptable methodology. If actual procedures deviated from accepted methods, the deviations are well documented. When this occurred, an evaluation was made of the extent such alternative procedures could influence the test results.
3. Sampling and process data. Adequate sampling and process data are documented in the report. Many variations can occur unnoticed and without warning during testing.

Such variations can induce wide deviations in sampling results. If a large spread between test results cannot be explained by information contained in the test report, the data are suspect and are assigned a lower rating.

4. Analysis and calculations. The test reports contain original raw data sheets. The nomenclature and equations used were compared to those (if any) specified by the EPA to establish equivalency. The depth of review of the calculations was dictated by the reviewer's confidence in the ability and conscientiousness of the tester, which in turn was based on factors such as consistency of results and completeness of other areas of the test report.

### **3.3 Emission Factor Quality Rating System**

The quality of the emission factors developed from analysis of the test data was rated utilizing the following general criteria:

#### **A (Excellent)**

Developed only from A-rated test data taken from many randomly chosen facilities in the industry population. The source category is specific enough so that variability within the source category population may be minimized.

#### **B (Above average)**

Developed only from A-rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industries. As in the A-rating, the source category is specific enough so that variability within the source category population may be minimized.

#### **C (Average)**

Developed only from A- and B-rated test data from a reasonable number of facilities. Although no specific bias is evident, it is not clear if the facilities tested represent a random sample of the industry. As in the A-rating, the source category is specific enough so that variability within the source category population may be minimized.

#### **D (Below average)**

The emission factor was developed only from A- and B-rated test data from a small number of facilities, and there is reason to suspect that these facilities do not represent a random sample of the industry. There also may be evidence of variability within the source category

population. Limitations on the use of the emission factor are noted in the emission factor table.

#### **E (Poor)**

The emission factor was developed from C- and D-rated test data, and there is reason to suspect that the facilities tested do not represent a random sample of the industry. There also may be evidence of variability within the source category population. Limitations on the use of these factors are always noted.

The use of these criteria is somewhat subjective and depends to an extent on the individual reviewer.

### **3.4 References for Chapter 3.0**

1. Technical Procedures for Developing AP-42 Emission Factors and Preparing AP-42 Sections. U.S. Environmental Protection Agency, Emissions Inventory Branch, Office of Air Quality Planning and Standards, Research Triangle Park, NC 27711, April 1992. [Note: this document is currently being revised at the time of this printing.]
2. Compilation of Air Pollutant Emission Factors, Volume I: Stationary Sources. Supplement A, Appendix C.2, "Generalized Particle Size Distributions." U.S. Environmental Protection Agency, October 1986.

## **4.0 POLLUTANT EMISSION FACTOR DEVELOPMENT**

### **4.1 Criteria Pollutant Emissions Data**

#### Particulate Matter.

Due to a lack of usable data, no new emission factors for particulate matter from processes associated with the primary zinc processing industry were developed during this update. The sources from which the emission factors presented in the previous AP-42 section are derived were reviewed, and the factors appear to have been compiled correctly. As is discussed in detail in Section 4.3 of this background report, no raw emission test data is contained in the cited references, and the methodology by which the emission factor data was originally acquired could not be evaluated. Many of the factors are undocumented engineering estimates, and others are based on studies performed with respect to other metallurgical industries. As a result, these factors have been assigned ratings of "E" due to uncertainty as to their representativeness of current industry operations.

#### Sulfur Dioxide.

Due to a lack of data quantifying sulfur dioxide emissions from processes associated with the primary zinc processing industry, no emission factors for this pollutant are presented in either the previous or revised versions of AP-42 Section 12.7. Significant quantities of SO<sub>2</sub> are emitted from these processes, particularly concentrate roasting, and are recovered in on-site sulfuric acid plants.

#### Nonmethane Organic Compounds.

Due to a lack of data quantifying emissions of organic compounds from processes associated with the primary zinc processing industry, no emission factors for these pollutants are presented in either the previous or revised versions of AP-42 Section 12.7.

#### Nitrogen Oxides.

No data on emissions of oxides of nitrogen were found directly from processes associated with the primary zinc processing industry. It can be assumed that these compounds are emitted from in-process heating units such as concentrate roasters, but no quantitative data are available.

### Carbon Monoxide.

No data on emissions of carbon monoxide were found directly from processes associated with the primary zinc processing industry. It can be assumed that this compound is emitted from in-process heating units such as concentrate roasters and from electric retort furnaces, but no quantitative data are available.

## **4.2 Noncriteria Pollutant Emissions Data**

### Hazardous Air Pollutants.

Hazardous Air Pollutants (HAP's) are defined in the 1990 Clean Air Act Amendments. Included in this list are lead, cadmium, and other heavy metals entrained in the zinc concentrates that are the primary raw materials for the primary zinc smelting industry. No quantitative emissions data suitable for use in emission factor development are available for any HAP's. However, one report detailing the results of a series of emission tests (Reference 9, Emission Study) performed on the only U.S. electrothermic primary zinc smelter was received, and this report quantifies emissions of five heavy metals. These results are discussed in Section 4.3 of this background report.

### Global Warming Gases.

Pollutants such as methane (CH<sub>4</sub>), carbon dioxide (CO<sub>2</sub>), and nitrous oxide (N<sub>2</sub>O) have been found to contribute to overall global warming. No data on emissions of any of these pollutants were found for processes associated with the primary zinc smelting industry.

### Stratospheric Ozone-Depleting Gases.

Chlorofluorocarbons, hydrochlorofluorocarbons, carbon tetrachloride, methyl chloroform, and halons have been found to contribute to stratospheric ozone depletion. Because none of these compounds are used in any of the processes associated with primary zinc smelting, no data on emissions of these pollutants were found nor expected.

### 4.3 Review of Specific Data Sets

The emission factors presented in the revised AP-42 Section 12.7 *Primary Zinc Smelting* are derived from seven published and unpublished documents dating from the 1970's. None of these cited references contain raw emission test data. One report containing raw emission test data was received, but was not suitable for use in emission factor development.

Reference 1: *Environmental Assessment of the Domestic Primary Copper, Lead, and Zinc Industries*

This document is primarily qualitative, containing detailed descriptions of the various processes associated with primary zinc industry. These descriptions were utilized in the process narrative presented in the AP-42 section. A description of the waste streams associated with the electric retorting process includes an unqualified and undocumented statement that these furnaces emit an average of ten kilograms of particulate matter per metric ton (megagram). It is not known whether this figure is in terms of input or output, whether it refers to a controlled or uncontrolled operation, or if it is based upon the results of emissions testing. Because no better data is available to allow the development of revised emission factors for this process, this factor is presented as uncontrolled in the updated AP-42 section as it was in the previous section.

Reference 2: *Particulate Pollutant Systems Study*

This document presents uncontrolled emission factors for multiple hearth, suspension, and fluidized bed concentrate roasters, and for a sinter plant. No raw emissions test data is contained in this document, but for lack of superior data, these factors are presented in the revised AP-42 section as in the previous section.

Reference 3: *G. Sallee, Personal Communication*

This reference consists of a single page with unqualified, undocumented handwritten emission factors for material handling, fluid-bed and multiple hearth concentrate roasters, and sinter machines which, for lack of superior data, are presented in the revised AP-42 section as in the previous section. Emission factors for horizontal and vertical retort furnaces are found on this page, but have been omitted from the revised AP-42 section because these technologies are no longer utilized in the U.S., along with an emission factor for ore crushing which has been omitted because the process is not specific to primary zinc smelting.

Reference 4: *Systems Study for Control of Emissions in the Primary Nonferrous Smelting Industry*

This document presents emission factors different from those found in the previous AP-42 section, and cites an older (1972) version of AP-42 as its source. None of these emission factors are utilized in the section revision.

Reference 5: *Trace Metal Emission Test Results*

This reference documents the results of a Purdue University study of the flow of cadmium and other trace metals in high-temperature industrial processes, including a cyclone-controlled sintering operation in a primary zinc processing facility. This study utilized a modification of EPA Reference Method 5 (with 5 percent nitric acid solution in the first two impingers) that appears similar to Method 12. No raw test data is presented, and no mention is made of the number of test runs performed. No evaluation of the methodology utilized can be made. The results of this study include a calculated particulate matter emission factor of 24.1 kilograms per megagram (kg/Mg), which is presented in both the previous and revised versions of AP-42 section 12.7. An atomic absorption spectroscopy analysis of the particulate being emitted from this process yielded results of 4.8 kg/Mg zinc, 3.16 kg/Mg cadmium, 2.18 kg/Mg lead, and 0.0101 kg/mg copper. These values are not presented in the AP-42 section.

Reference 6: *Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions*

This document presents uncontrolled emission factor ranges for fugitive particulate matter from the sinter plant, retort building, and casting areas of a primary zinc processing facility. These factors are based not on testing performed at a primary zinc facility, but on operations in the steel, lead, and copper industries. For lack of superior data, these factors are presented in the revised AP-42 section as in the previous section.

Reference 7: *Background Information for New Source Performance Standards: Primary Copper, Lead and Zinc Smelters*

This document presents an uncontrolled particulate matter emission factor for the electrolytic smelting process. No raw emission test data is presented, and the methodologies by which the data from which this factor was calculated can not be evaluated. For lack of superior data, this factor is presented in the revised AP-42 section as in the previous section.

References 8 & 9: *Written Communication from J.D. Reese and enclosed Emission Study performed for Zinc Corporation of America*

The Director of Environmental Affairs at the only U.S. electrothermic primary zinc smelter forwarded a copy of a report detailing the results of a series of emission tests performed on various control devices at this facility. According to the letter accompanying the report, the five sources tested were:

- 1) #1 Bag House - Controls particulate emissions from the sinter plant material transfer points, crusher, etc.;
- 2) #4 Bag House - Controls particulate emissions from the process gases off the sinter machine;
- 3) Pre-Mix Scrubber - Controls emissions from the wet exhaust gases from the sinter machine feed pre-mix drum;
- 4) West End Collector - Controls particulate emissions from some of the electrothermic furnaces; and
- 5) PW Dracco - Controls particulate emissions from some of the electrothermic furnaces and the coke and residue system.

Testing was performed at these sites for filterable particulate matter, sulfur dioxide, nitrogen oxides, carbon monoxide, total gaseous nonmethane organic compounds, and PM<sub>10</sub> by EPA Reference Methods 5, 6C, 7E, 10, 25, 201a, respectively. In addition, particulate matter samples collected on filters and in impingers containing potassium permanganate and nitric acid were analyzed for cadmium, chromium, lead, mercury, and nickel, all of which are classified under Title III of the 1990 Clean Air Act Amendments as Hazardous Air Pollutants (HAP's), as well as zinc. Zinc was the predominant metal in all samples, with average contents ranging from 2.3 percent at the PW Dracco to 30 percent at the outlet from the West End Collector. Testing for all pollutants appears to have been performed in accordance with applicable EPA Reference Methods, and all



quality assurance procedures are well documented. All field and laboratory data are included in the report. However, no process data are available to allow development of emission factors from these otherwise sound test results.

#### **4.4 Data Gap Analysis**

A significant data gap exists for emissions of all pollutants from the primary zinc smelting industry, insofar as current data were unavailable for the development of emission factors. Given that this industry is comprised of only four facilities, it is reasonable to assert that quantification of emissions from this industry is justifiable.

#### 4.5 References for Chapter 4.0

1. Environmental Assessment of the Domestic Primary Copper, Lead and Zinc Industries, EPA-600/2-82-066, U.S. Environmental Protection Agency, Cincinnati, OH, October 1978.
2. Particulate Pollutant System Study, Volume I: Mass Emissions, APTD-0743, U.S. Environmental Protection Agency, Research Triangle park, NC, May 1971.
3. G. Sallee, Personal Communication, Midwest Research Institute, Kansas City, MO, June 1970
4. System Study Control of Emissions in the Primary Nonferrous Smelting Industry, Volume I, APTD-1280, U.S. Environmental Protection Agency, Research Triangle Park, NC, June 1969.
5. Robert B. Jacko and David W. Nevendorf, "Trace Metal Emission Test Results from a Number of Industrial and Municipal Point Sources," Journal of the Air Pollution Control Association, 27(10): 989-994, October 1977.
6. Technical Guidance for Control of Industrial Process Fugitive particulate emissions, EPA-450/3-77-010, U.S. Environmental Protection Agency, Research Triangle Park, NC, March 1977.
7. Background Information for New Source Performance Standards: Primary Copper, Zinc and Lead Smelters Volume I: Proposed Standards, EPA-450/2-74-002a, U.S. Environmental Protection Agency, Research Triangle park, NC, October 1974.
8. Written communication from J.D. Reese, Zinc Corporation of America, Monaca, PA, to C.M. Campbell, Pacific Environmental Services, Inc., Research Triangle Park, NC, 18 November 1992.
9. Emission Study Performed for Zinc Corporation of America at the Monaca Facilities, 14-30 May 1991, EMC Analytical, Inc., Gilberts, IL, 27 April 1992.

**TABLE 4.5-1**

**LIST OF CONVERSION FACTORS**

<b>Multiply:</b>	<b>by:</b>	<b>To obtain:</b>
mg/dscm	$4.37 \times 10^{-4}$	gr/dscf
m <sup>2</sup>	10.764	ft <sup>2</sup>
m <sup>3</sup>	35.31	ft <sup>3</sup>
m	3.281	ft
kg	2.205	lb
kPa	$1.45 \times 10^{-1}$	psia
kg/Mg	2.0	lb/ton
Mg	1.1023	ton

**Temperature conversion equations:**

Fahrenheit to Celsius:

$$^{\circ}\text{C} = \frac{(^{\circ}\text{F} - 32)}{1.8}$$

Celsius to Fahrenheit:

$$^{\circ}\text{F} = 1.8(^{\circ}\text{C}) + 32$$