BACKGROUND REPORT

AP-42 SECTION 12.14

SECONDARY ZINC INDUSTRY

Prepared for

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

1-103

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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. AP-42 is routinely updated by the EPA to respond to new emission factor needs of the EPA, state and local air pollution control programs, 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 the revision of AP-42 Section 12.14 *Secondary Zinc*.

Including the introduction (Chapter 1) this report contains four chapters. Chapter 2 gives a description of the secondary zinc industry. It includes a characterization of the industry, an overview of the different process types, a description of emissions, and a description of the technology used to control emissions resulting from processing zinc scrap.

Chapter 3 is a review of emissions data collection and analysis procedures. It describes the literature search, the screening of emission data reports, and the quality rating system for both emission 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.

2.0 INDUSTRY DESCRIPTION

2.1 GENERAL

The secondary zinc industry processes scrap metals for the recovery of zinc in the form of slabs or dust, and zinc oxide. There are currently 10 secondary zinc recovery plants operating in the U. S., with an aggregate capacity of approximately 60 megagrams (60 tons) per year.

2.2 PROCESS DESCRIPTION

Zinc recovery involves three general operations: scrap pretreatment, melting, and refining. Processes typically used in operations are shown in Figure 2.2-1.

Scrap Pretreatment

Scrap metal is delivered to the secondary zinc processor as ingots, rejected castings, flashing and other metal scrap containing zinc. Scrap pretreatment includes sorting, cleaning, crushing and screening (XQ-12), sweating (XQ-09, 10) and leaching (XQ-66).

In sorting, zinc scrap is manually separated according to zinc content and subsequent processing requirements. Cleaning removes foreign materials to improve recovery efficiency. Crushing scrap facilitates separation of zinc from contaminants. Screening and pneumatic classification consolidate zinc metal for further processing.

In sweating, a sweat furnace [rotary (XQ-09), reverberatory (XQ-28), or muffle furnace (XQ-10)] slowly heats the scrap containing zinc and other metals to approximately 364°C (787°F). This temperature is sufficient to melt zinc but is below the melting point of the remaining metals. Molten zinc collects at the bottom of the sweat furnace and is subsequently recovered. The remaining scrap metal is removed to be sold to other secondary processors.

Sodium carbonate leaching (XQ-66) converts dross and skimmings to zinc oxide (ZnO), which can be reduced to zinc metal. The material is crushed and washed with water, separating contaminants from zinc-containing metal. The contaminated aqueous stream is treated with sodium carbonate to convert chlorides (mainly zinc chloride) into sodium chloride (NaCl) and insoluble zinc hydroxide. Most of the NaCl is separated from the insoluble residues by filtration and settling. The precipitate is dried and calcined (oxidized into a powder at high temperature) to convert zinc hydroxide into crude zinc oxide. The ZnO product is usually refined to zinc at primary zinc

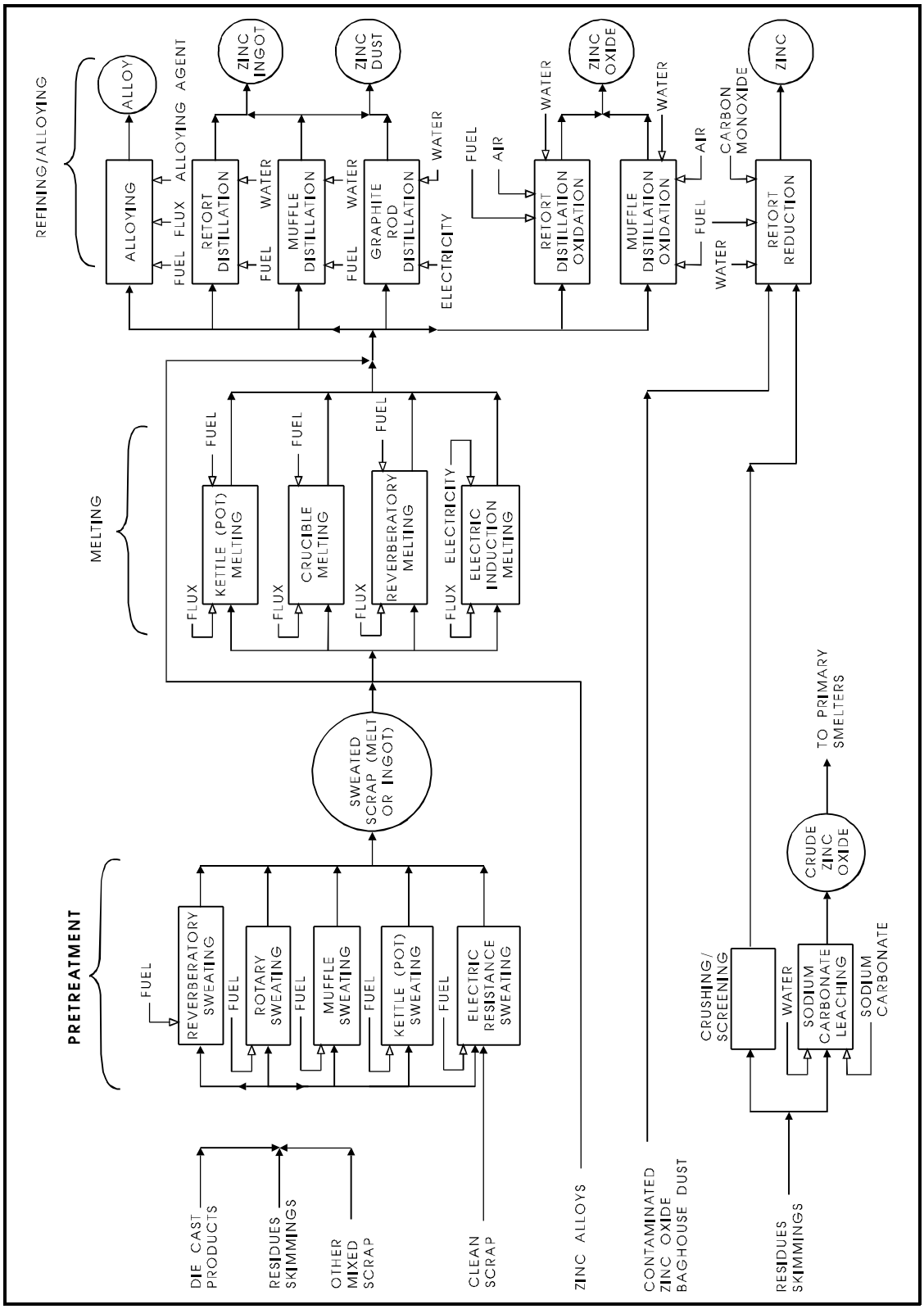

Figure 2.2-1. Secondary zinc recovery processes

smelters. The washed zinc-containing metal portion becomes the raw material for the melting process.

Melting

Zinc is melted in kettle (XQ-67), crucible (XQ-68), reverberatory (XQ-69), and electric induction (XQ-70) furnaces. Once melted, flux is used to remove impurities from the molten zinc. Facilitated by agitation, flux and impurities float to the surface of the melt as dross. The resulting dross is skimmed from the surface. The remaining molten zinc is poured into molds or enters the refining operation in a molten state.

Zinc alloys are produced from pretreated scrap during sweating and melting processes. Zinc alloys may contain small amounts of copper, aluminum, magnesium, iron, lead, cadmium and tin. Alloys of zinc containing 0.65 to 1.25 percent copper are significantly stronger than unalloyed zinc.

Refining

Refining processes remove impurities in clean zinc alloy scrap and in zinc recovered during the melt phase by vaporizing zinc (distilling) in retort furnaces (XQ-50) (shown in Figure 2.2-2). Molten zinc is heated until it vaporizes. Zinc vapor is condensed and recovered in several forms, depending upon temperature, recovery time, absence or presence of oxygen, and equipment used during zinc vapor condensation. Final products from refining processes include zinc ingots, zinc dust, zinc oxide, and zinc alloys.

Distillation retorts and furnaces are used to reclaim zinc from alloys or to refine crude zinc. Bottle retort furnaces consist of a pear-shaped graphite retort (a vessel with a long neck used for distillation). Bottle retorts are filled with zinc alloys and heated for approximately 24 hours, or until most of the zinc is recovered. Distillation involves vaporization of zinc at temperatures from 982 to 1249°C (1800 to 2280°F) and condensation as zinc dust or liquid zinc. Zinc dust is produced by rapid cooling following vaporization. Liquid zinc occurs when the vaporous product is condensed slowly at higher temperatures. This melt can be cast into ingots or slabs.

Muffle furnaces (XQ-76) are continuously charged retort furnaces. They operate for several days at a time. Molten zinc from a sweat furnace or a melting furnace is charged through a feed well that also acts as an airlock. Muffle furnaces generally have a much greater vaporization

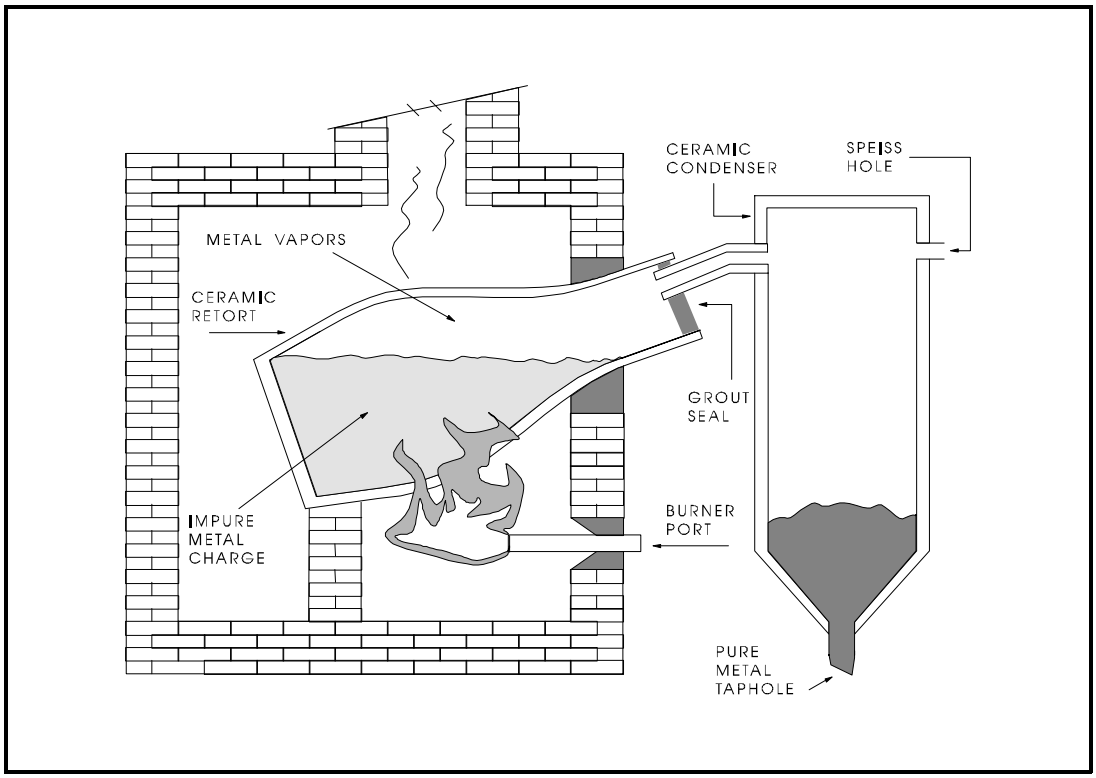

Figure 2.2-2. Zinc retort distillation furnace

capacity than bottle retort furnaces. (See Figure 2.2-3.) They produce zinc ingots of 99.8 percent purity and zinc oxide of 99.8 percent purity.

Retort and muffle furnace distillation with oxidation processes also produce zinc oxide dust. These processes are similar to distillation without the condenser. Instead of entering a condenser, the zinc vapor discharges directly into an air stream leading to a refractory-lined combustion chamber. Excess air completes the oxidation and cools the zinc oxide dust before it is collected in a fabric filter.

Zinc oxide is transformed into zinc metal using retort reduction process. Zinc metal is produced by the reaction of carbon monoxide (supplied by the partial oxidation of the coke) and zinc oxide to yield zinc and carbon dioxide. The zinc vapor is recovered by condensation.

Pot melting, unlike bottle retort and muffle furnaces, does not incorporate distillation as a part of the refinement process. This method merely monitors the composition of the intake to control the composition of the product. Specified die-cast scraps containing zinc are melted in a steel pot. Pot melting is a simple indirect heat melting operation where the final alloy cast into zinc alloy slabs is controlled by the scrap input into the pot.

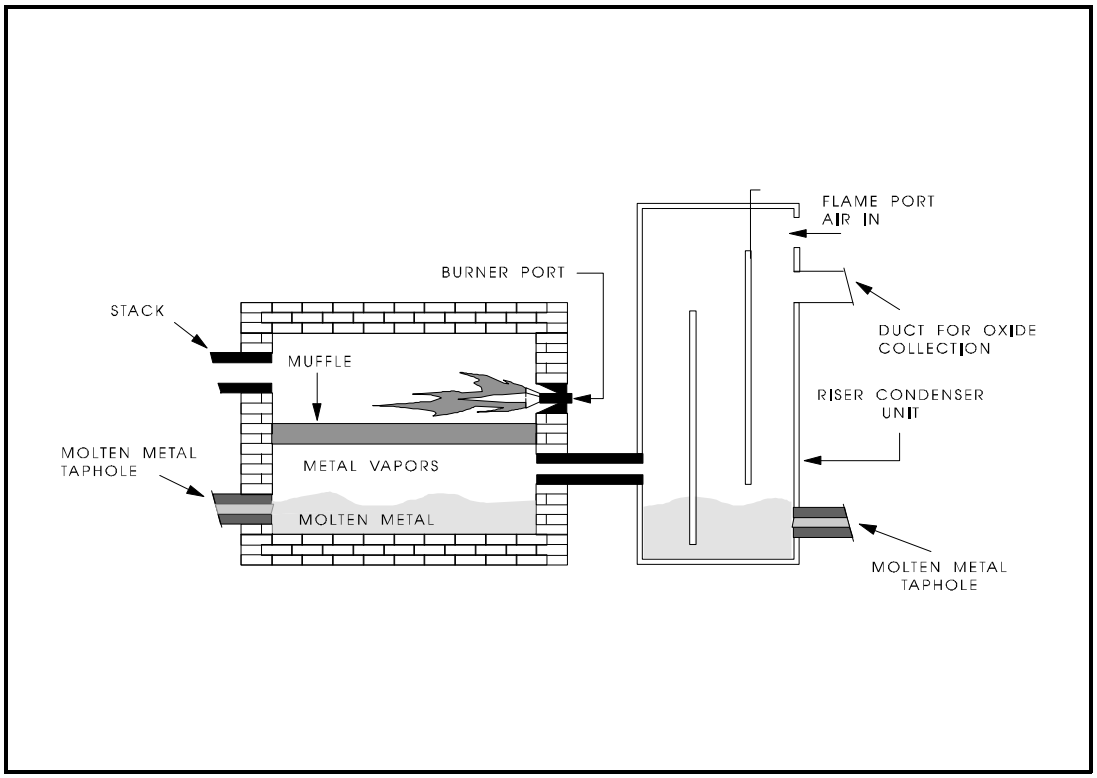

Figure 2.2-3 Muffle furnace and condenser

2.3 EMISSIONS AND CONTROLS[2-4]

Emissions from sweating and melting operations consist of particulate, zinc fumes, other volatile metals, flux fumes, and smoke generated by the incomplete combustion of grease, rubber and plastics in zinc scrap. Zinc fumes are negligible at low furnace temperatures. Flux emissions may be minimized by using a nonfuming flux. In production requiring special fluxes (i.e. ammonium chloride) that do generate fumes, fabric filters may be used to collect emissions. Substantial emissions may arise from incomplete combustion of carbonaceous material in the zinc scrap. These contaminants are usually controlled by afterburners.

TABLE 2.3-1. (METRIC UNITS)
UNCONTROLLED PARTICULATE EMISSION FACTORS FOR SECONDARY ZINC SMELTING[a]

All Emission Factors are in kg/Mg of Product
Ratings (A-E) Follow Each Factor
Galvanizing factor expressed in kilograms per megagram of zinc used.

Operation	Emissions	
Reverberatory sweating[b](in mg/Mg feed material) (SCC No)		
Clean metallic scrap (3-04-008-18)	Negligible	
General metallic scrap (3-04-008-28)	6.5	C
Residual scrap (3-04-008-38)	16	C
Rotary sweating[c] (3-04-008-09)	5.5-12.5	C
Muffle sweating[c] (3-04-008-10)	5.4-16	C
Kettle sweating[b]		
Clean metallic scrap (3-04-008-14)	Negligible	
General metallic scrap (3-04-008-24)	5.5	C
Residual scrap (3-04-008-34)	12.5	C
Electric resistance sweating[c] (3-04-008-11)	< 5	C
Crushing/screening[c] (3-04-008-12 (in kg/Mg residues processed)	0.5-3.8	C
Sodium carbonate leaching (3-04-008-66)		C
crushing/screening	0.5-3.8	C
calcining[d]	44.5	
Kettle (pot) melting[d] (3-04-008-67 (in mg/Mg metal product)	0.05	C
Crucible melting (3-04-008-68)		
Reverberatory melting (3-04-008-69)		
Electric induction melting (3-04-008-70)		
Alloying (3-04-008-70)		
Retort and muffle distillation (in kg/Mg metal product)		C
pouring[c] (3-04-008-51)	0.2-0.4	C
casting[c] (3-04-008-52)	0.1-0.2	C
muffle distillation[d] (3-04-008-55)	22.5	
Graphite rod distillation[c,e] (3-04-008-74)	Negligible	C
Retort distillation/oxidation[f] (3-04-008-75)	10-20	C
Muffle distillation/oxidation[f] (3-04-008-76)	10-20	C
Retort reduction (3-04-008-77)	23.5	C
Galvanizing[d] (3-04-008-05)	2.5	C

TABLE 2.3-1. (ENGLISH UNITS)
UNCONTROLLED PARTICULATE EMISSION FACTORS FOR SECONDARY ZINC SMELTING[a]

All Emission Factors are in lb/ton of Product
Ratings (A-E) Follow Each Factor

Operation	Emission Factor	Rating
Reverberatory sweating[b] (in lb/ton feed material)		
Clean metallic scrap	Negligible	
General metallic scrap	13	E
Residual scrap	32	E
Rotary sweating[c]	11-25	E
Muffle sweating[c]	10.8-32	E
Kettle sweating[b]		
Clean metallic scrap	Negligible	
General metallic scrap	11	E
Residual scrap	25	E
Electric resistance sweating[c]	< 10	E
Crushing/screening[c] (in lb/ton residues processed)	1.0-7.5	E
Sodium carbonate leaching		
crushing/screening	1.0-7.5	E
calcining[d]	89	E
Kettle (pot) melting[d] (in mg/Mg metal product)	0.1	E
Retort and muffle distillation (in lb/ton metal product) po		
uri	0.4-0.8	E
ng[c]	0.2-0.4	E
casting[c]	45	E
muffle distillation[d]		
Graphite rod distillation[c,e]	Negligible	E
Retort distillation/oxidation[f]	20-40	E
Muffle distillation/oxidation[f]	20-40	E
Retort reduction	47	E
Galvanizing[d]	5	E

[a] Galvanizing factor expressed in pounds per ton of zinc used.
[b] Reference 3.
[c] Reference 4.
[d] Reference 5-7.
[e] Reference 1.
[f] Reference 4. Factor units per unit weight of ZnO produced. The product zinc oxide dust is totally carried over in the exhaust gas from the furnace and is recovered with 98-99% efficiency.

TABLE 2.3-2. (METRIC UNITS)
FUGITIVE PARTICULATE UNCONTROLLED EMISSION FACTORS
FOR SECONDARY ZINC SMELTING
All Emission Factors are in kg/Mg of Product
Ratings (A-E) Follow Each Factor

Operation	Emission Factor	Rating
Reverberatory sweating[b] (in kg/Mg end product)	0.63	E
Rotary sweating[b] (in kg/Mg end product)	0.45	E
Muffle sweating[b] (in kg/Mg end product)	0.54	E
Kettle (pot) sweating[b] (in kg/Mg end product)	0.28	E
Electric resistance sweating[b] (in kg/Mg scrap processed)	0.25	E
Crushing/screening[c] (in kg/Mg scrap processed)	2.13	E
Kettle (pot) melting furnace[b]	0.0025	E
Crucible melting furnace[d]	0.0025	E
Reverberatory melting furnace[b]	0.0025	E
Electric induction melting[b]	0.0025	E
Retort and muffle distillation	1.18	E
Casting[b]	0.0075	E

[a] Reference 8. Expressed as kilograms per megagram of end product, except factors for crushing/screening

[b] Estimate based on stack emission factor given in Reference 1, assuming fugitive emissions to be equal to five percent of stack emissions.

[c] Reference 1. Average of reported emission factors.

[d] Engineering judgment, assuming fugitive emissions from crucible melting furnace to be equal to fugitive emissions from kettle (pot) melting furnace.

TABLE 2.3-2. (ENGLISH UNITS)
FUGITIVE PARTICULATE UNCONTROLLED EMISSION FACTORS FOR SECONDARY ZINC SMELTING

All Emission Factors are in lb/ton of Product
Ratings (A-E) Follow Each Factor

Operation	Emission Factor	Rating
Reverberatory sweating[b] (in lb/ton end product)	1.30	E
Rotary sweating[b] (in lb/ton end product)	0.90	E
Muffle sweating[b] (in lb/ton end product)	1.07	E
Kettle (pot) sweating[b] (in lb/ton end product)	0.56	E
Electric resistance sweating[b] (in lb/ton scrap processed)	0.50	E
Crushing/screening[c] (in lb/ton scrap processed)	4.25	E
Kettle (pot) melting furnace[b]	0.005	E
Crucible melting furnace[d]	0.005	E
Reverberatory melting furnace[b]	0.005	E
Electric induction melting[b]	0.005	E
Retort and muffle distillation	2.36	E
Casting[b]	0.015	E

[a] Reference 8. Expressed as pounds per ton of end product, except factors for crushing/screening.
[b] Estimate based on stack emission factor given in Reference 1, assuming fugitive emissions to be equal to five percent of stack emissions.
[c] Reference 1. Average of reported emission factors.
[d] Engineering judgment, assuming fugitive emissions from crucible melting furnace to be equal to fugitive emissions from kettle (pot) melting furnace.

Fabric filters are the most common used control devices used to recover particulate emissions from sweating and melting. In one application on a muffle sweating furnace, a cyclone and fabric filter achieved particulate recovery efficiencies in excess of 99.7 percent. In another application on a reverberatory sweating furnace, a fabric filter removed 96.3 percent of the particulate. Fabric filters show similar efficiencies in removing particulate from exhaust gases of melting furnaces.[3]

Crushing and screening operations are significant sources of particulate emissions. These particulates are composed of zinc, aluminum, copper, iron, lead, cadmium, tin, and chromium. Control is provided by using hooded exhausts as capture devices and particulate removal by using fabric filters.

The sodium carbonate leaching process produces particulate emissions of zinc oxide dust during the calcining (oxidizing precipitate into powder at high temperature) operation. This dust can be recovered in fabric filters, although zinc chloride in the dust may cause plugging problems.

Emissions from refining operations are zinc and zinc oxide. Distillation/oxidation operations discharge zinc oxide product in the exhaust gas. Zinc oxide is recovered using fabric filters with collection efficiencies given of 98 to 99 percent.

Hazardous air pollutants (HAPs) identified by the VOC/PM (the SPECIATE Database) as being present in secondary zinc processes are lead, cadmium, aniline and 4,4-methylenedianiline. No reliable emission factors are available for these four hazardous air pollutants.

The AIRS database lists PM_{10}, lead, cadmium, SO_2, and NO_x air pollutants in the emissions from secondary zinc and gives an "E" rating for the emission factor.

2.4 REVIEW OF SPECIFIC DATA SETS

Pacific Environmental Services (PES) contacted the following sources to obtain the most up-to-date information on process descriptions and emissions for this industry.

1) American Zinc Association, Washington, DC
2) ARCO Alloys Corporation, Detroit, MI
3) Charles Licht Engineering Association
4) Huron Valley Steel Company, Huron City, Mi
5) Independent Alloyers Association, Washington, DC
6) Non-Ferrous Metal Producers, Washington, DC
7) Roth Brothers Smelting Corporation, East Syracuse, NY
8) S-G Metals Industry, Kansas City, KS
9) Air Pollution Engineering Manual—AP-40.

Reference 9 was used to develop the industry and process descriptions. It was not used in emission factor development.

No responses were received from any of the sources contacted. PES was unable to locate any source test information for the secondary zinc industry. Therefore, the references for this revision were obtained from the EPA background file for the previous revision of Section 12.14 (October 1981).

2.5 REFERENCES FOR CHAPTER 2

1. William M. Coltharp, et al., Multimedia Environmental Assessment of the Secondary Nonferrous Metal Industry, Draft Final Report, EPA Contract No. 68-02-1319, Radian Corporation, Austin, TX, June 1976.

2. John A. Danielson, Air Pollution Engineering Manual, 2nd Edition, AP-40, U.S. Environmental Protection Agency, Research Triangle Park, NC 1973. Out of Print.

3. W. Herring, Secondary Zinc Industry Emission Control Problem Definition Study (Part I), APTD-0706, U.S. Environmental Protection Agency, Research Triangle Park, NC, May 1971.

4. H. Nack, et al., Development of an Approach to Identification of Emerging Technology and Demonstration Opportunities, EPA-650/2-74-048, U.S. Environmental Protection Agency, Research Triangle Park, NC, May 1974.

5. G.L. Allen, et al., Control of Metallurgical and Mineral Dusts and Fumes in Los Angeles County, Number 7627, U.S. Department of the Interior, Washington, DC, April 1952.

6. Restricting Dust and Sulfur Dioxide Emissions from Lead Smelters, translated from German, VDI Number 2285, U.S. Department of Health, Education and Welfare, Washington, DC, September 1961.

7. W.F. Hammond, Data on Nonferrous Metallurgical Operations, Los Angeles County Air Pollution Control District, Los Angeles, CA, November 1966.

8. Assessment of Fugitive Particulate Emission Factors for Industrial Processes, EPA-450/3-78-107, U.S. Environmental Protection Agency, Research Triangle Park, NC, September 1978.

9. Source Category Survey: Secondary Zinc Smelting and Refining Industry, EPA-450/3-80-012, Office of Air Quality, Planning and Standards, Research Triangle Park, NC, May 1980.

10. AIRS Facility Subsystem Source Classification, EPA 450/4-90-003. Office Of Air Quality, Planning and Standards, Technical Support Division, Research Triangle Park, NC, March 1990.

3.0 GENERAL EMISSION DATA REVIEW AND ANALYSIS PROCEDURES

3.1 LITERATURE SEARCH AND SCREENING

The first step of the investigation of the emissions from the secondary zinc industry involved a search of available literature relating to criteria and noncriteria pollutant emissions. This search included the following references:

1) AP-42 background files maintained by the Emission Factor and Methodologies Section.
2) Files maintained by the Emission Standards Division.
3) "Locating and Estimating" reports published by the Emission Factor and Methodologies Section.
4) "PM_{10} Emission Factor Listing Developed by Technology Transfer" (EPA-450/4-89-022).
5) "Gap Filling PM_{10} Emission Factors for Selected Open Area Dust Sources" (EPA-450/88-003).
6) "Generalized Particle Size Distributions for Use in Preparing Size Specific Particulate Emission Inventories" (EPA-450/4-86-013).
7) Information in the *Air Facility Subsystems* (AFS) of the EPA *Aerometric Information Retrieval System* (AIRS).
8) References in the National Technical Information Service (NTIS).
9) Handbook of Emission Factors, Parts I and II, Ministry of Health and Environmental Protection, The Netherlands, 1980/1983.
10) The EPA *Clearinghouse for Inventories and Emission Factors* (CHIEF) and *National Air Toxics Information Clearinghouse* (NATICH).
11) The EPA databases, including the *VOC/Particulate Matter* (PM) *Speciation Database Management System* (SPECIATE), the *Crosswalk/Air Toxic Emission Factor Data Base Management System* (XATEF), and the Emission Measurement Technical Information Center's *Test Methods Storage and Retrieval System* (TSAR).

The following general criteria were used to select pertinent references:

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.

No primary data was found and the previous update of this section was entirely from secondary data, this secondary data was used for emission factor development, but the Emission Factor Ratings were lowered. The final set of reference materials are discussed in Chapter 4.0.

3.2 EMISSION DATA QUALITY RATING SYSTEM

As part of Pacific Environmental Services' analysis of the emission data, 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 (i.e., 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.

Since no original test data were found, no test rating system was used. The rating system used by the OAQPS for the preparation of AP-42 sections is given below:

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 either the inhalable particulate (IP) protocol documents or the EPA reference test methods, although these documents and 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 is 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 were given 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

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. AP-42, Supplement A, Appendix C.2, "Generalized Particle Size Distributions." U.S. Environmental Protection Agency, October, 1986.

4.0 POLLUTANT EMISSION FACTOR DEVELOPMENT[1,3,4,7,8,9,10]

4.1 CRITERIA POLLUTANT EMISSIONS DATA

Except for particulates, no source test data on emissions of criteria pollutants were found for the secondary zinc process. However, lead, SO_2, and NO_x have been identified in secondary zinc emissions in the AIRS database, but the data is insufficient to develop emission factors.

Total Suspended Particulate & PM_{10}.

The emission factors in the previous revision of Section 12.14 (Section 7.14 revised October 1981) were for uncontrolled particulate and fugitive particulate emissions. A closer examination of the references used to develop emission factors indicated that they originate from the same reference; *Development of an Approach to Identification of Emerging Technology and Demonstration Opportunities* (Reference 4). This reference is discussed in detail in Section 4.3, Review of Specific Data Sets. The emission factors in this reference are based on engineering estimates or are emission factors transferred from similar type processes in other industries. None are derived from source test data from the secondary zinc industry. In the last revision the emission factors were downgraded from "C" ratings to "E." Since no new data were found, the emission factors were unchanged from the previous revision and are presented in Table 4.1-1.

TABLE 4.4-1 (METRIC UNITS)
TOTAL SUSPENDED PARTICULATE
Units in kg/Mg of Product

Source Test #	Data Rating	Test Method	Run #	Production Rate	Emission Rate	Emission Factor
Source: Crushing/screening (uncontrolled)						
	E	Transferred	**Average**	N/A	N/A	0.5 - 3.8
Source: Kettle sweating process (uncontrolled)						
Clean scrap	E	Transferred	**Average**	N/A	N/A	5.5
General scrap	E	Transferred	**Average**	N/A	N/A	Negligible
Residue	E	Transferred	**Average**	N/A	N/A	12.5
			Average	N/A	N/A	9.0
Source: Reverberatory sweat furnace (uncontrolled)						
Clean metallic	E	Transferred	**Average**	N/A	N/A	Negligible
General metallic	E	Transferred	**Average**	N/A	N/A	6.5
Residual scrap	E	Transferred	**Average**	N/A	N/A	16.0
	E	Estimated	**Average**	N/A	N/A	6.5 - 16
Source: Rotary sweat furnace (uncontrolled)						
	E	Transferred	**Average**	N/A	N/A	5.5 - 17.5
Source: Electric resistance sweat furnace (uncontrolled)						
	E	Estimated	**Average**	N/A	N/A	> 5
Source: Muffle distillation (uncontrolled)						
	E	Transferred	**Average**	N/A	N/A	10 - 28
Source: Casting (uncontrolled)						
	E	Transferred	**Average**	N/A	N/A	0.2 - 0.4
Source: Pouring (uncontrolled)						
	E	Transferred	**Average**	N/A	N/A	0.1 - 0.2
Source: Muffle sweat furnace						
	E	Transferred	**Average**	N/A	N/A	5.4 - 16.0
Source: Retort reduction						
	E	Transferred	**Average**	N/A	N/A	23.5
Source: Galvanizing						
	E	Transferred	**Average**	N/A	N/A	2.5

TABLE 4.1-1 (ENGLISH UNITS)
TOTAL SUSPENDED PARTICULATE
(Units in lb/ton Product)

Source Test #	Data Rating	Test Method	Run #	Production Rate	Emission Rate	Emission Factor
Source: Crushing/screening (uncontrolled)						
	E	Transferred	**Average**	N/A	N/A	1.0 - 7.5
Source: Kettle sweating process (uncontrolled)						
Clean scrap	E	Transferred		N/A	N/A	11
General scrap	E	Transferred		N/A	N/A	Negligible
Residue	E	Transferred		N/A	N/A	25
			Average	N/A	N/A	18
Source: Reverberatory sweat furnace (uncontrolled)						
Clean metallic	E	Transferred	**Average**	N/A	N/A	Negligible
General metallic	E	Transferred	**Average**	N/A	N/A	13
Residual scrap	E	Transferred	**Average**	N/A	N/A	32
	E	Estimated	**Average**	N/A	N/A	13 - 32
Source: Rotary sweat furnace (uncontrolled)						
	E	Transferred	**Average**	N/A	N/A	11 - 25
Source: Electric resistance sweat furnace (uncontrolled)						
	E	Estimated	**Average**	N/A	N/A	> 10
Source: Muffle distillation (uncontrolled)						
	E	Transferred	**Average**	N/A	N/A	10 - 28
Source: Casting (uncontrolled)						
	E	Transferred	**Average**	N/A	N/A	0.2 - 0.4
Source: Pouring (uncontrolled)						
	E	Transferred	**Average**	N/A	N/A	0.1 - 0.2
Source: Muffle sweat furnace						
	E	Transferred	**Average**	N/A	N/A	10.8 - 32.0
Source: Retort reduction						
	E	Transferred	**Average**	N/A	N/A	47.0
Source: Galvanizing						
	E	Transferred	**Average**	N/A	N/A	5.0

4.2 NONCRITERIA POLLUTION EMISSION DATA[1-4]

Hazardous Air Pollutants.

Hazardous Air Pollutants (HAPs) are defined in the 1990 Clean Air Act Amendments. The SPECIATE database indicated the existence of two HAPs (aniline and 4,4-dianiline) in the emissions, in addition to lead and cadmium identified in AIRS. The source of the information contained in the SPECIATE database is not sufficiently documented to generate emission factors. The origin of these HAPs is probably introduced from material included in the scrap zinc feed to the process.

Global Warming Gases.

Pollutants such as methane, CO_2, and N_2O have been found to contribute to overall global warming. No data on emissions of these pollutants were found for the secondary zinc process. Since most of the processes rely on fossil fuels for combustion, CO_2 is undoubtedly present, but is not documented.

Ozone-Depleting Gases.

No data were found on ozone-depleting gases. These compounds would not be expected in secondary zinc processing emissions.

4.3 REVIEW OF SPECIFIC DATA SETS

Reference 1: *Multimedia Environmental Assessment of the Secondary Non-ferrous Metal Industry*.

This reference was used to provide the fugitive emissions from the crushing and screening operations. This report estimated 0.5 and 3.8 kg of particulate per megagram of residue processed. The report does not offer any information as to the basis of the estimate and is therefore given an "E" rating.

All of the other fugitive emission factors provided from this reference are based on stack emission factors assuming fugitive emissions to be 5 percent of stack emissions. No basis for this relationship is given.

Reference 3: Secondary Zinc Industry Emission Control Problem Definition Study (Part 1).

This reference was used for emission factor development for the reverberatory and kettle sweat furnaces. The factors given are the exact values as given for these processes in Reference 4. The source of these factors was the 1968 revision of the AP-42.

Reference 4: *Development of an Approach to Identification of Emerging Technology and Demonstration Opportunities*.

This reference was cited as the source for process emission factors for crushing/screening process, the rotary sweat furnace, muffle sweat furnace, electric resistance furnace, retort and muffle distillation processes, and pouring/casting operations.

The following comments are from the reference describing the source of the emission factors used:

Crushing and screening. The emission factor was transferred to secondary zinc based on experiences of other industries.

Rotary sweat furnaces. The reference states that emission factor data were not available. The factors used were based on reported values from other sweat processes.

Reverberatory sweat furnace. The emission factor was reported to be between 6.5 to 16 kg/Mg (13 to 32 lb/ton), based on the type of scrap used. This data were referred to Reference 3 above, which credited the source of their data to be the 1968 AP-42.

Electric resistance sweat furnace. The reference stated that the emission factor was probably low, less than 10 pounds of particulate per ton of feed. No comment or reference was given to support this estimate.

Muffle sweat furnace. The reference stated that emission factors were not available, and is estimated to range from approximately 5.4 to 16 kg/Mg (10.8 to 32 lb/ton) of feed. It did not give the source of this estimate.

Muffle furnace distillation. The emission factor was estimated to be 45 lb/ton of zinc produced. This was referenced to a study done by MRI, *Particulate Pollutant System Study* (page 179, May 1971).

Pouring and casting. Emission factors were estimated based on similar operations in other industries. No reference was given.

Apparently, none of the emission factors used were based on source tests of the secondary zinc industry. Therefore, all of the emission factors are rated "E." Since no new data on this industry were available, the emission factors obtained from Reference 4 were presented in this revision as well.

4.4 DATA GAP ANALYSIS

None of the emission factors presented for processes associated with the secondary zinc industry are based upon emission tests performed on secondary zinc processing facilities. This is primarily due to the fact that for this revision, as well as past revisions, no such emission test data has been made available. Therefore, it is suggested that emission testing be performed on secondary zinc processing facilities for the purpose of emission factor development. This testing should address gaseous products of combustion, such as sulfur dioxide and carbon monoxide, toxic heavy metals such as cadmium and nickel, in addition to particulate matter. The existing emission factors, which address only particulate matter, have been assigned a quality rating of "E" to reflect their subject representativeness of current industry operations.

4.5 REFERENCES FOR CHAPTER 4

1. William M. Coltharp, et al., Multimedia Environmental Assessment of the Secondary Nonferrous Metal Industry, Draft Final Report, EPA Contract No. 68-02-1319, Radian Corporation, Austin, TX, June 1976.

2. John A. Danielson, Air Pollution Engineering Manual, 2nd Edition, AP-42, U.S. Environmental Protection Agency, Research Triangle Park, NC 1973. Out of Print.

3. W. Herring, Secondary Zinc Industry Emission Control Problem Definition Study (Part I), APTD-0706, U.S. Environmental Protection Agency, Research Triangle Park, NC, May 1971.

4. H. Nack, et al., Development of an Approach to Identification of Emerging Technology and Demonstration Opportunities, EPA-650/2-74-048, U.S. Environmental Protection Agency, Research Triangle Park, NC, May 1974.

5. G.L. Allen, et al., Control of Metallurgical and Mineral Dusts and Fumes in Los Angeles County, Number 7627, U.S. Department of the Interior, Washington, DC, April 1952.

6. Restricting Dust and Sulfur Dioxide Emissions from Lead Smelters, translated from German, VDI Number 2285, U.S. Department of Health, Education and Welfare, Washington, DC, September 1961.

7. W.F. Hammond, Data on Nonferrous Metallurgical Operations, Los Angeles County Air Pollution Control District, Los Angeles, CA, November 1966.

8. Assessment of Fugitive Particulate Emission Factors for Industrial Processes, EPA-450/3-78-107, U.S. Environmental Protection Agency, Research Triangle Park, NC, September 1978.

9. Source Category Survey: Secondary Zinc Smelting and Refining Industry, EPA-450/3-80-012, Office of Air Quality, Planning and Standards, Research Triangle Park, NC, May 1980.

10. AIRS Facility Subsystem Source Classification, EPA 450/4-90-003. Office Of Air Quality, Planning and Standards, Technical Support Division, Research Triangle Park, NC, March 1990.

TABLE 4.5-1

LIST OF CONVERSION FACTORS

Multiply:	**by:**	**To obtain:**
mg/dscm	4.37×10^{-4}	gr/dscf
m^2	10.764	ft^2
m^3	35.31	ft^3
m	3.281	ft
kg	2.205	lb
kPa	0.145	psia
kg/Mg	2.0	lb/ton
Mg	1.1023	ton

Temperature conversion equations:

Fahrenheit to Celsius:

$$°C = \frac{(°F - 32)}{1.8}$$

Celsius to Fahrenheit:

$$°F = 1.8(°C) + 32$$