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DEVELOPMENT OF AN APPROACH TO IDENTIFICATION OF EMERGING TECHNOLOGY AND DEMONSTRATION OPPORTUNITIES

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16. ABSTRACT

The report gives results of a study to develop methodology for characterizing major industries from the standpoint of their present environmental impact and for assessing the probable effect of emerging process technology on environmental considerations. It describes a systematic method for separating the industries into process modules. It demonstrates the applicability of this approach, using as examples the petroleum refining and secondary nonferrous metals industries, each with substantially different characteristics. It also reports an approach utilizing expert opinion for rapid identification of emerging technology, and discusses technology being developed in the two industries.

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PROCESS DESCRIPTION OF ZINC SEGMENT OF THE SECONDARY NONFERROUS METALS INDUSTRY

Introduction

The zinc segment of the secondary nonferrous metals industry consists of those plants that process discarded and scrap materials for the purpose of recovering zinc. In 1969,(1) 376,400 tons of zinc were recovered. In the recovery of the zinc, waste products--atmospheric emissions, liquid wastes, and solid wastes--are generated which can cause serious pollution problems.

Raw Materials

The principal sources of zinc scrap as classified by the Bureau of Mines(1) are:

- New clippings
- Old zinc
- Engravers' plates
- Skimmings and ashes
- Sal skimmings
- Die-cast skimmings
- Galvanizers' dross
- Diecastings
- Rod and die scrap
- Flue dust
- Chemical residues.

In addition to containing metallic zinc or compounds and alloys, thereof, the scrap contains a wide variety of organic materials such as oil, grease, lubricants, and electric insulation. Alloying elements commonly found in the scrap are aluminum, copper, and lead.

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(1) Moulds, D. E., Minerals Yearbook, 1969, U. S. Dept. of Interior, Bureau of Mines, p 1148 (1971).

Products

Products from the zinc segment of the secondary nonferrous metals industry are: (1) specification zinc alloys, (2) zinc ingots (slab) containing essentially 100 percent zinc, (3) zinc dust, (4) zinc oxide approaching 100 percent purity, and (5) crude zinc oxide for reduction to zinc metal by the primary smelters.

Process Description

The products from the zinc segment are recovered from the various types of scrap zinc employing two manufacturing operations--scrap pretreatment and refining. These operations and the individual processes in each operation are shown in the attached segment flowsheet.

Scrap Pretreatment Operation

Zinc scrap is pretreated prior to refining to remove a portion of the metallic and nonmetallic impurities and to physically prepare the material for further processing. Three types of preprocessing (hydrometallurgical, pyrometallurgical, and mechanical) are used. The pretreatment varies depending on the type of scrap. The individual pretreatment processes are numbers 1 through 6, as shown in the segment flowsheet.

Crushing/Screening Process (1). The concentration of metallic zinc in skimmings/residues is increased by the crushing/screening process. The process steps involved are: (a) pulverizing or crushing the skimmings/residues to separate the metallic zinc from the flux, and (b) screening or pneumatically treating the crushed material to separate zinc from nonmetallic constituents.

Energy required is that to drive the equipment.

The process generates atmospheric emissions and solid wastes. The atmospheric emissions are composed of dusts from both the pulverizing (crushing) process step and the screening step. These emissions contain, in addition to zinc, those materials--nonmetallic constituents, metallic values such as zinc, aluminum, copper, iron, lead, cadmium, tin, and chromium and fluxes--separated from the scrap zinc during the sweating process. Emissions data are not available; however, based on studies conducted of other industries, the raw emissions factor is estimated to range from 0.9 to 7.5 lb per ton of skimmings/residues processed.

The solid wastes generated by this process are nonmetallic constituents from the screening operation and baghouse dusts, if emissions from crushing and screening process steps are controlled.

This process produces a small quantity of emissions and is, therefore, a minor source of pollution.

Kettle Sweating Process (2). The kettle sweating process separates the metallic zinc from metal attachments, having higher melting points, and from nonmetallic residues. This is achieved by the following process steps: (a) charging the scrap into the furnace containing generally a molten heel, (b) melting of zinc fraction of the scrap, (c) working of charge to effect separation of the zinc, (d) fluxing to aid in the separation, and (e) skimming to remove impurities removed by the flux. Afterwards the molten metal may be removed and cast in blocks for further processing, fed to a distillation furnace or alloyed to obtain specification composition and then cast into ingots. Operating temperatures of the kettle-sweating baths range from 800 to 1000 F. Production is batchwise, with one batch requiring 6 to 8 hours to complete one heat.

Energy required is the electricity to drive the equipment and the fuel, generally, natural gas, to melt and keep the zinc molten. Fuel oil is used as fuel in some cases.

The process produces significant quantities of potential environmental pollutants. Atmospheric emissions consist of: (1) combustion gases (which are separate from the emissions from the molten metal), and (2) emissions consisting of gases and particulates from the molten metal. Solid wastes generated are metal attachments and skimmings or slag from the flux present in the scrap or that added to purify the zinc metal and baghouse dusts.

Composition of the particulate atmospheric emissions varies somewhat depending on the charge. However, in most cases, the emissions contain ammonium chloride, zinc, aluminum, tin, nickel, copper, iron, lead, cadmium, magnesium, manganese, and chromium. A typical analysis is shown in Table C-3. The gases are composed of, in addition to the combustion products, carbonaceous materials from the rubber, plastic, and other organic impurities or contaminants in the scrap. Some carbonaceous materials are also mixed with the particulate emissions.

Emissions factors also vary depending on the composition of the charge. When sweating metallic scrap* with zinc chloride as the flux, raw emissions factor was reported to be 10.8 lb/ton of scrap processed. These particulate emissions contained 4, 77, 4, 4, and 10 percent, respectively, of zinc chloride, zinc oxide, water, other metal chlorides and oxides, and carbonaceous materials. In other cases, the raw emissions factor for sweating residual scrap** (the flux was residual zinc chloride) was reported at 24.5 lb/ton of scrap processed. Composition of particulate emissions was similar to that from the sweating of the metallic scrap.

Morphology of the particles is dependent on the type of scrap. For example, the particle size of the emissions from sweating of residual scrap ranged from less than 1 micron to greater than 20 microns, whereas those from sweating of metallic scrap were less than 2 microns. Particle shape is acicular and/or irregular. Those emissions that are predominately zinc oxide are composed of primarily acicular particles which is the

* Metallic scrap consists of metallic items, generally in the same shape as when manufactured or used.

** Residual scrap is composed of residues, skimmings, and other low grade scrap.

TABLE C-3. ANALYSES OF PARTICULATE EMISSIONS FROM ZINC SWEAT PROCESSING(2)

Component	Percent
$ZnCl_2$	14.5 - 15.3
ZnO	46.9 - 50.0
NH_4Cl	1.1 - 1.4
Al_2O_3	1.0 - 2.7
Fe_2O_3	0.3 - 0.6
PbO	0.2
H_2O (in $ZnCl_2 \cdot 4H_2O$)	7.7 - 8.1
Oxides of Mg, Sn, Ni, Si, Ca, Na	2.0
Carbonaceous Material	10.0
Moisture (deliquescent)	5.2 - 10.2

(2) Herring, W. O, Secondary Zinc Industry, Emission Control Problem Definition Study, Part 1, Technical Study, APCO, EPA, Durham, North Carolina.

characteristic shape of zinc oxide. Low zinc emissions have an irregular shape or are composed of a mixture of particle shapes.

Generally, the atmospheric emissions are controlled or collected using baghouses with orlon filter medium. Collection efficiencies of approximately 96 percent are reported.

No liquid wastes are generated by the kettle sweating process unless possibly some cooling water. However, significant quantities of solid wastes are generated. These wastes are: (1) slag (skimmings or drosses), (2) high melting attachments, and (3) baghouse dusts.

Thus, the kettle sweating process is a source of potential pollution problems if the wastes are not collected and disposed of properly.

Reverberatory Sweating Process (3). This process separates or recovers zinc metal from mixed zinc scrap. The recovered impure zinc is processed further to obtain specification alloys or fed to a distillation furnace for refining. The process steps are: (a) charging of furnace, (b) melting of zinc, and (c) removal of unmeltables. In this process the zinc flows from the furnace as it melts and is collected in vessels or allowed to flow to the next process in operation.

Energy required for this process is the electricity to drive the equipment and the gas or fuel oil to fire the furnace. The reverberatory furnace is direct-fired whereas the kettle furnace is heated indirectly.

Both atmospheric emissions and solid wastes are generated. The atmospheric emissions are composed of the combustion gases, gases or vapors from burning of the organic content of the scrap, and volatile metallic materials. The particulate emission is the fume volatilized from the furnace and dust carried from the furnace by the entrainment of particles in the furnace exit gases.

Composition of the atmospheric emissions varies depending on the source and type of scrap. However, in general, the particulate emission will contain such metals as zinc, aluminum, copper, iron, lead, cadmium, manganese, and chromium, in addition to carbonaceous materials and components from the residual fluxes. The gases contain primarily carbon dioxide, nitrogen, oxygen, and water, and possible sulfur oxides, chlorides, and fluorides.

Particulate emission factors vary depending on the type of scrap. For metallic scrap, raw emissions factor was reported to be approximately 13 lb of particulate matter per ton of charge processed, whereas raw emissions factor for residual scrap was reported to be approximately 32 lb per ton of feed process.[3] Baghouses with orlon filter media are used to control these emissions.[4]

Particle morphology of atmospheric emissions is the same or comparable to the morphology of emissions from the kettle furnace.

No liquid wastes are generated. Solid wastes from this process are: (1) baghouse dusts; (2) skimmings, drosses or slag; and (3) unmeltable attachments.

The process does produce significant quantities o. atmospheric emissions and solid wastes which could cause pollution problems.

Rotary Sweating Process (4). Zinc metal is separated from zinc scrap such as die-castings by the rotary sweating process. During the sweating, the furnace is rotated on its axis. The zinc metal is collected in a kettle (outside the furnace) and the residue is skimmed off the molten metal.* The process steps are: (a) charging of furnace, (b) melting of zinc values, (c) removing (skimming) of residue, and (d) removing the unmeltables from the furnace. Afterwards, the impure zinc melt is transferred to a distillation furnace or alloyed and cast into ingots.

Energy required is the electrical energy to rotate the furnace and fuel (gas or oil) to heat the furance which is direct fired.

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(3) Herring, W. O., "Secondary Zinc Industry, Emissions Control Problem Definition Study, Part 1-Technical Study", NASMI, APCO, EPA, Durham, North Carolina.

(4) Air Pollution Engineering Manual, U. S. Dept. HEW NAPCA, p 307 (1967).

* No fluxes are added.

Potential environmental pollutants generated by this process are: (1) atmospheric emissions, and (2) solid wastes. The atmospheric emissions include both gases and particulate emissions. The gases are composed of those produced by combustion of the fuel and burning of organic matter contained in the scrap. The particulate emissions generally are composed of such metal values as are found in the emissions from the reverberatory sweating process. Included in this list are zinc, aluminum, copper, iron, lead, cadmium, manganese, and chromium.

Particulate emission factor data are not available. However, based on reported values from other sweating processes, it is estimated the raw emission factors will range from 11 to 25 lb of particulate matter per ton of feed.

Particulate morphology of the particles should be similar to the morphology of the particles from other sweating processes.

The solids generated by this process are skimmings, unmeltable attachments, and baghouse dusts.

The process produces significant quantities of atmospheric emissions and solid wastes and, therefore, is a potential source of atmospheric and water pollution problems.

Electric-Resistance Sweating (5). This process is employed in small plants to recover zinc from clean scrap. The process steps are: (a) charging of furnace, (b) sweating of zinc, (c) pouring of zinc melt for subsequent processing, and (d) removing residue from furnace.

Energy required is the electricity to sweat the zinc.

Potential environmental pollutants are: atmospheric emissions and solid wastes. Atmospheric emissions are composed of primarily fume and dust since only clean scrap is used as the source of zinc and no combustion products are formed. The fume and dust contain primarily zinc oxide from the oxidation of zinc vapor along with trace quantities of other heavy metals and possibly a small quantity of chloride and fluxing materials. The gaseous portion of the emissions is primarily nitrogen. Emissions are controlled with baghouses, if pollution controls are used.

Particle morphology is the same as that of emissions from other processes.

Emissions factor is probably low, <10 lb of fume and dust per ton of feed processed.

Solid wastes from this process are drosses, if fluxes are used, unmeltable components of the scrap, and baghouse dusts.

Although this process produces small quantities of atmospheric emission, there is potential atmospheric and water pollution problems associated with disposal of these materials and with the process.

Muffle Sweating Process (6). Zinc metal is recovered from zinc scrap materials by the muffle sweating process. The process steps are: (a) charging of furnace, (b) sweating of zinc values, (c) tapping of furnace to remove molten zinc for subsequent refining or alloying, and (d) removing residue with a shaker screen to separate the dross from the unmeltable attachments.

Energy required is the fuel--gas or oil--to heat the muffle furnace which is indirectly fired.

Potential pollutants from this process are: (1) atmospheric emissions composed of gases from the combustion of the fuel and from the sweating chamber and particulate emissions from the sweating chamber, and (2) solid wastes--drosses and unmeltable attachments. The gaseous emissions include those from the combustion chamber which are emitted separately to the atmosphere and those from the sweating chamber. The combustion gases contain primarily carbon dioxide, nitrogen, unburned fuel, and possibly trace quantities of heavy metals and sulfur oxides if oil is used as the source of fuel. Those from the sweating chamber are composed of a small quantity of gases from air leaking into the chamber and from combustion or decomposition of organic compounds added with the scrap.

Composition of the particulate emissions from the sweating chamber will vary depending on the type of scrap but, in general, contains the metals found in particulate emissions from other sweating processes, with the major component being zinc.

Particle morphology of the particulates is the same as that of emissions from other processes.

Emission factors for the muffle furnace process are not available. However, they are estimated to range from approximately 10.8 to 32 lb per ton of feed processed. Baghouses are used to control the emissions. A cyclone may be used in series with the baghouse.

The solid wastes generated are drosses, baghouse dusts, and unmeltable attachments.

The process generates a considerable quantity of atmospheric emissions and solid wastes, and thus is a source of pollution problems.

Sodium Carbonate Leaching Process (7). The sodium carbonate leaching process removes the nonmetallic contaminants from skimmings and residues and converts the zinc values to zinc oxide which can be reduced to zinc metal. The process steps are: (a) crushing to make the scrap more amenable to leaching, (b) washing with water to separate nonmetallic contaminants and recover metallic zinc, (c) treating the aqueous stream with sodium carbonate to precipitate the zinc values, (d) drying the precipitate to remove the water, and (e) calcining to convert zinc hydroxide to zinc oxide. The product (zinc oxide) is shipped to a primary smelter for reduction to zinc metal.

Energy required for this process is electrical energy to drive the equipment and fuel, either gas or oil, to dry and calcine the zinc hydroxide.

The process produces waste products--atmospheric emissions, liquid wastes and solid wastes--in modest quantities. The atmospheric emissions consisting of both gases and particulate matter are produced during the crushing, drying, and calcining process steps. The gases are from the crushing step and present no problem since they primarily consist of air. Those from the drying and calcining steps contain primarily the combustion gases and water vapor. Since any residual zinc chloride is vaporized during the calcination, the gases may also contain hydrogen chloride and zinc chloride. The particulate matter consists primarily of zinc oxide fume contaminated with other metal values either vaporized with the zinc oxide or entrained in the gaseous stream. The atmospheric emissions are controlled with baghouses.

Liquid wastes are generated in steps (b) and (c). These wastes contain sodium chloride, sodium carbonate, and other water-soluble compounds not precipitated by the sodium carbonate.

Because of the corrosive nature of the atmospheric emissions, allowing them to escape to the environment could cause pollution problems. Liquid wastes may cause water pollution problems if not treated before discharge.

Refining Operation

The pretreated zinc scrap still contains a wide variety of metallic and nonmetallic contaminants which are removed in the refining operation to produce pure zinc ingots, zinc dust, zinc oxide, and specification zinc alloys. These products are produced by the processes 8 through 12 as shown in the attached flowsheet entitled "Zinc Segment of the Secondary Nonferrous Metals Industry".

Retort Distillation Process (8). This process produces pure zinc ingots and pure zinc dust from pretreated zinc scrap--molten zinc-rich metal from the sweat furnace or cast zinc-rich metal ingots from a sweating process--and/or zinc dross. The process steps are: (a) charging the furnace with the pretreated zinc scrap or dross, (b) melting the charge, (c) distilling the zinc, (d) condensing the zinc vapor rapidly to produce zinc dust or slowly to produce pure liquid zinc. Afterwards, the zinc metal is removed and cast into ingots (slabs). Zinc dust, if the final product, is removed and packaged.

The energy required for this process is the fuel--gas or oil--to heat the furnace which is indirectly fired.

This process produces significant quantities of atmospheric emissions and solid wastes. Sources of atmospheric emissions are the retort opening, combustion chamber, the condenser, and casting of ingots. Emissions as zinc oxide fumes are evolved from the retort opening (charging port) during removal of the hot residue from the retort after a distillation heat and recharging of the retort for the next distillation. These emissions contain primarily zinc oxide along with aluminum, copper, and other metal values found in the residues. Raw emissions factor from this source and the condenser as discussed below are estimated to be 45 lb of particulates per ton of zinc distilled.(5) Emissions factor may be much higher due to leaks in the grout seal around the condenser neck.

Particle size of the fumes is estimated to range from approximately 0.05 to 1.0 micron. Since the fumes are primarily zinc oxide resulting from air oxidation of zinc metal, particle shape is acicular, the characteristic shape of zinc oxide.

Combustion gases which are emitted separately from the other emissions contain carbon dioxide, unburned fuel and nitrogen, and possibly trace quantities of heavy metals if oil is used as the fuel.

During distillation of zinc, the condenser must be kept positive pressure to prevent air from entering the condenser and contaminating the zinc metal with oxygen. To ensure that there is a positive pressure, a small hole, called a "speise" hole, is provided through which a small amount of zinc vapor is allowed to escape continuously into the atmosphere where it reacts with oxygen. These emissions (fumes) are essentially 100 percent zinc oxide. The particles, acicular in shape, are extremely fine, i.e., approximately 0.05 to 1 micron.

Only a small amount of atmospheric emissions is formed during the pouring and casting processing steps. Emission factors are estimated to range from 0.4 to 0.8 and 0.2 and 0.4 lb of particulates, respectively, per ton of zinc produced. These data are based on similar operations in other industries. These emissions are emitted as fine particulates with the same particle size and shape as those from the condenser.

Solid wastes generated by the retort distillation process are the distillation residues and the particulate matter, if collected, in the atmospheric emissions. The atmospheric emissions are primarily zinc

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(5) Vandegriff, A. E., et al., Particulate Pollutant System Study, Volume 1-Mass Emissions, Midwest Research Institute, Kansas City, Missouri, p 179 (May 1, 1971).

oxide, whereas the distillation residues are composed of heavy metals such as residual zinc (10 to 50 percent) not removed by the distillation process and contaminants such as aluminum, copper, lead, and fluxes not removed during the pretreatment process.

In view of the quantity of atmospheric emissions and solid wastes generated by the retort distillation process, serious pollution problems may arise if the atmospheric emissions are not collected and the wastes are not disposed of by a nonpolluting method.

Muffle Distillation Process (9). This process produces pure zinc ingots, generally from pretreated zinc scrap. However, in some cases, untreated scrap such as zinc die-castings may be substituted for pretreated scrap. This process may be operated continuously whereas the retort distillation process is batch. The process steps involve: (a) continuously adding molten zinc from a melting pot or a sweating furnace to the muffle section, (b) continuously distilling and condensing the pure zinc, (c) periodically tapping the zinc from the condenser into the molds, (d) casting the zinc ingots, and (e) periodically removal of residue from muffle.

Energy utilized by this process is fuel oil or gas to supply the heat for vaporization of the zinc.

The process produces significant quantities of atmospheric emissions and solid wastes. Sources of atmospheric emissions are the combustion gases, distillation residues, pouring and casting of the ingots, and the orifice in the condenser. Emission factors, composition of emissions, and morphology of particulates are the same for both distillation processes. Atmospheric emissions may be controlled with baghouses alone or in series with cyclones.

Solid wastes generated are distillation residues and baghouse dusts which are essentially of the same composition as the solid wastes from the retort distillation process.

Thus, the process is a source of pollution problems.

Retort Distillation/Oxidation Process (10). Zinc oxide produced by the retort distillation/oxidation process involves vapor oxidation of zinc metal. The process steps in this process are the same as for the retort distillation process except zinc vapor from the retort is discharged through an orifice into a stream of air where zinc oxide is formed inside a refractory-lined chamber. The combustion gases from oxidation of the metallic zinc vapors and excess air carry the zinc oxide to a baghouse collector where the zinc oxide is collected. The combustion gases and excess air pass through the baghouse into the surrounding atmosphere.

Energy required for this process is the fuel--gas or oil--to vaporize the zinc metal.

Waste products from this process are atmospheric emissions and solid wastes. The atmospheric emissions, which consist of gases and fumes, are emitted to the atmosphere from the retort opening (charging port), baghouse, and combustion (furnace) chamber. Those from the retort opening result from oxidation of the hot residue removed after a distillation heat and upon charging of the retort with molten zinc for the next distillation heat. See the discussion on the retort distillation process for pertinent data on composition of emission, emission factors, and morphology of the particles.

Combustion gases from the retort furnace consist of primarily carbon dioxide, nitrogen, and unburned fuel. If oil is used as the fuel, the gases may also contain sulfur oxides, chlorides, and trace amounts of heavy metals.

Atmospheric emissions from the baghouse contain pure zinc oxide fume and the gases from burning of the zinc with air. The zinc oxide may contain trace quantities of heavy metals such as cadmium, depending on the purity of the feed. The particles of zinc oxide are very small, ranging in size from approximately 0.05 to about 1.0 micron. The particle shape is predominantly acicular, i.e., needle-like.

Emission factors for the baghouse are estimated at 20 to 40 lb of zinc oxide per ton of oxide produced. These data are calculated based on a collection efficiency of 98 to 99 percent.

Solid waste generated is the distillation residue remaining in the retort after removal of the zinc. This residue contains 10 to 50 percent zinc and contaminants--aluminum, copper, lead, and residual flux--not removed from the zinc scrap during the pretreatment operation.

Thus, the retort distillation/oxidation process is a source of potential environmental pollutants which can cause problems.

Muffle Distillation/Oxidation Process (11). This process produces zinc oxide from pretreated zinc scrap. The process steps are the same as for the muffle distillation process except that in the production of zinc oxide, zinc vapors are allowed to escape through an orifice at the top of the first chamber of the condenser and are burned or oxidized in the air. The resulting zinc oxide is transported by the combustion gases and excess air through conduits and collected in a baghouse.

Energy required for this process is gas or oil to heat the muffle furnace.

The potential environmental pollutants are: (1) atmospheric emissions, and (2) solid wastes. Sources of atmospheric emissions are: (1) the furnace combustion chamber which is separate from the other sources as the furnace is indirectly fired, (2) muffle opening (charging port), and (3) baghouse. See discussion on the muffle distillation process for details concerning composition of emissions, emission factors and morphology on particulates from sources (1) and (2), and the above discussion on the retort distillation/oxidation process for pertinent data on composition of emissions, emission factors, and morphology of particles for conversion of zinc to zinc oxide and subsequent collection of the zinc oxide.

Solid waste generated by the muffle distillation/oxidation process is the distillation residue from the muffle. This residue has the same composition as the residue from the retort distillation/oxidation process.

Based on these data, this process is a source of pollution problems.

Alloying Process (12). The alloying process produces zinc alloys from pretreated scrap. The process steps are: (a) melting the pretreated scrap, (b) adding the alloying agent to molten metal, (c) homogenizing the mixture, (d) pouring the melt into ingot molds, and (e) casting the ingot. In many cases, the alloying process is combined with the sweating process, whereby the molten pretreated scrap is used directly to produce the alloy.

Energy requirement for the Alloying Process is fuel--oil or gas to keep the melt molten or to melt pretreated scrap ingots.

The process produces atmospheric emissions and solid wastes. If alloying is carried out using molten zinc from a sweating furnace, the atmospheric emissions contain zinc oxide, small amounts of the alloying agent, and the flux cover. If pretreated scrap ingots are used as the source of zinc, the atmospheric emissions will contain, in addition to the particulate matter, gaseous emissions from combustion of the fuel. Particulate matter may be controlled using a baghouse; however, in many cases, no pollution control is employed.

Solid waste is the flux cover used to protect the melt. Flux covers commonly used are carbon or zinc chloride.

The process produces minor quantities of emissions and solid wastes and, therefore, is not a major source of pollution.

Graphite Rod Resistor Distillation Process (13). This process produces zinc dust from pretreated scrap ingots. The process steps are: (1) charge the ingot or melt to furnace, (2) heat with electric power, and (3) collect zinc dust as distillate using closed-loop water cooling system.

Electric energy is used in significant quantities to vaporize the zinc.

The process generates vapors containing traces of zinc, zinc oxide, lead, and lead oxide.

The pollution potential of these vapors is not significant because the metal content is recovered in baghouses and returned to the process.

The process has no pollution potential.

Population of Secondary Zinc Processors

(1) Apex Smelting Company
Division of AMAX Aluminum Company
2515 West Taylor Street
Chicago, Illinois
Telephone: (312) 332-2214

(2) Belmont Smelting and Refining Works, Inc.
320 Belmont Avenue
Brooklyn, N.Y. 11207

(3) Colonial Metals Company
Columbia, Pennsylvania
Telephone: (717) 684-2311

(4) Empire Metal Company
820 E. Water Street
Syracuse, New York 13210
Telephone: (315) 47[illegible]-6950

(5) Florida Smelting Company
2640 Capitola Street
Jacksonville, Florida
Telephone: (904) 353-4317

(6) Freedman Metal Company
310 McGinnis Boulevard
Brooklyn, N.Y. 11222
Telephone: EV9-4131

(7) General Copper and Brass Company
Post Office Box 5353-D
Philadelphia, Pennsylvania
Telephone: (215) SA6-7111

(8) General Smelting Company
Division of Wabash Smelting, Inc.
2901 EW Moreland Street
Philadelphia, Pennsylvania
Telephone: GA3-3200

(9) Gettysburg Foundry Specialties Company
Post Office Box 421
Gettysburg, Pennsylvania 17325
Telephone: 335-5616

(10) Gulf Reduction Corporation
6030 Esperson Street
Houston, Texas

(11) Holtzman Metal Company
5223 McKissock Avenue
St. Louis, Missouri 63147
Telephone: (314) CI1-3280

(12) Inland Metals Refining Co.
651 E. 119th Street
Chicago, Illinois 60628

(13) Jordan Company
Salvage Reclamation Division
5000 S. Merrimac Avenue
Chicago, Illinois 60638
Telephone: (312) PO7-6570

(14) Metchem Research, Inc.
Radcliff and Monroe Streets
Bristol, Pennsylvania
Telephone: (215) 848-0820

(15) National Metal and Smelting Company
210 NW Fourth Street
Fort Worth, Texas

(16) North American Smelting Company
Marine Terminal
Post Office Box 1952
Wilmington, Delaware
Telephone: OL4-9901

(17) Pacific Smelting Company
22219 Southwestern Avenue
Torrance, California
Telephone: SP5-3421

(18) Paragon Smelting Corporation
36-08 Review Avenue
Long Island City, N.Y. 11101
Telephone: (212) RA9-3481

(19) Roth S
Thomp
Syrac

(20) Georg
2255
Phila
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(21) Sand
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(19) Roth Smelting Company
Thompson Road
Syracuse, New York

(20) George Sall Metals Company, Inc.
2255 East Butler Street
Philadelphia, Pennsylvania 19137
Telephone: (215) PI3-3900

(21) Sandoval Zinc Company
3649 South Albany Avenue
Chicago, Illinois 60632
Telephone: FR6-1900

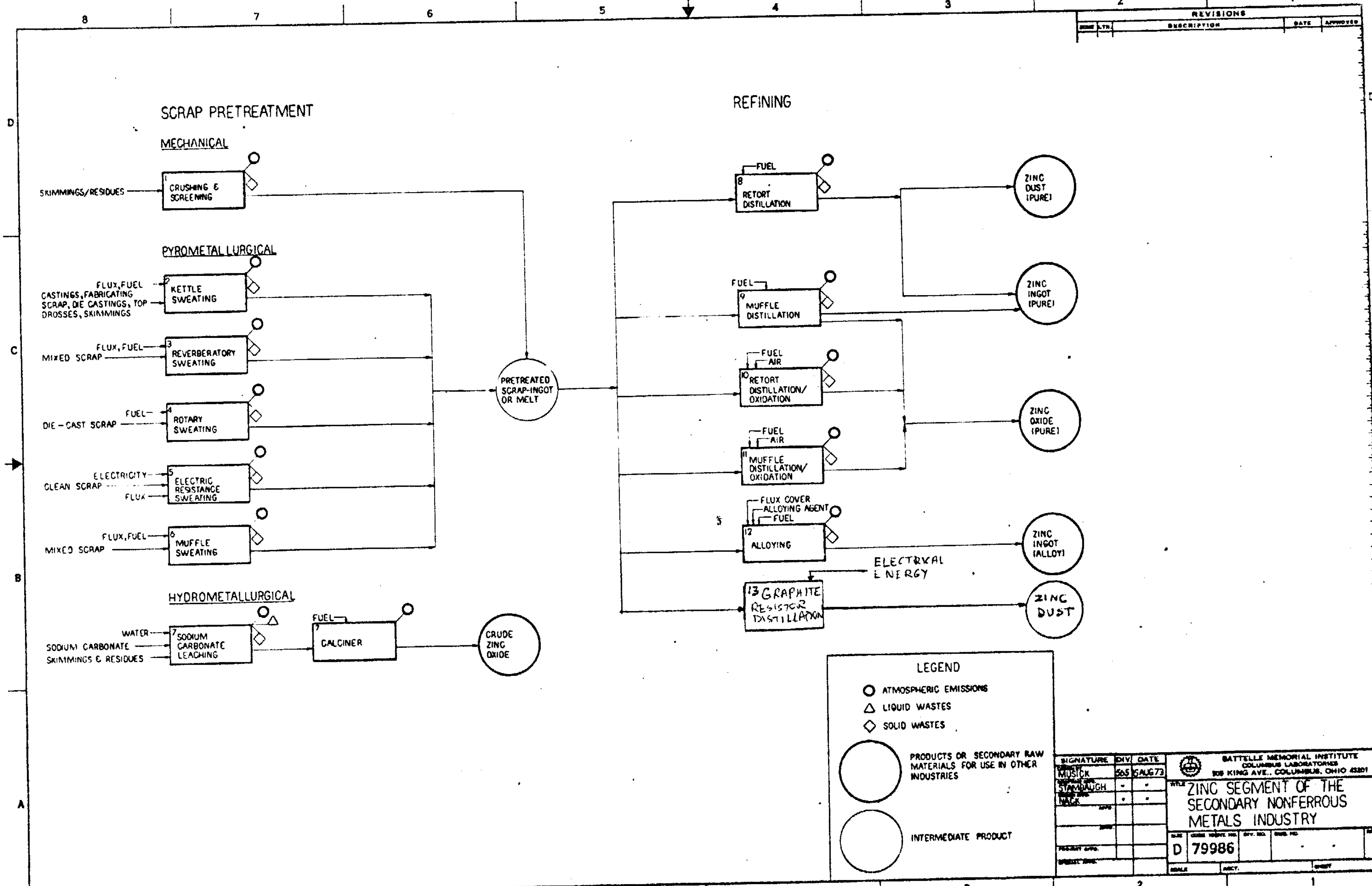
(22) SIPI Metals Corporation
1722 N. Elston Avenue
Chicago, Illinois

(23) Solken-Galamba Corporation
Second and Riverview Streets
Kansas City, Kansas 66118
Telephone: (913) MA1-4100

(24) St. Joseph Lead Company
250 Park Avenue
New York 10017
Telephone: YU6-7474

(25) U.S. Metal Products Company
Post Office Box 1067
Erie, Pennsylvania 16512
Telephone: (814) 838-2051

(26) Hyman Viener & Sons
Post Office Box 573
Richmond, Virginia 23205
Telephone: (703) 648-6563



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