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EPA Office of Compliance Sector Notebook Project

Profile of the Nonferrous Metals Industry

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Office of Compliance
Office of Enforcement and Compliance Assurance
U.S. Environmental Protection Agency
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This report is one in a series of volumes published by the U.S. Environmental Protection Agency (EPA) to provide information of general interest regarding environmental issues associated with specific industrial sectors. The documents were developed under contract by Abt Associates (Cambridge, MA), and Booz-Allen & Hamilton, Inc. (McLean, VA). This publication may be **purchased** from the Superintendent of Documents, U.S. Government Printing Office. A listing of available Sector Notebooks and document numbers is included at the end of this document.

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Cover photograph courtesy of Reynolds Aluminum Recycling Company, Richmond, Virginia. Special thanks to Terry Olbrysh for providing photographs.

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EPA/310-R-95-016.	Rubber and Plastic Industry	Maria Malave	564-7027
EPA/310-R-95-017.	Stone, Clay, Glass and Concrete Industry	Scott Throwe	564-7013
EPA/310-R-95-018.	Transportation Equipment Cleaning Industry	Virginia Lathrop	564-7057

NONFERROUS METAL INDUSTRIES
(SIC 333-334)
TABLE OF CONTENTS

NONFERROUS METAL INDUSTRIES

(SIC 333-334)
TABLE OF CONTENTS (CONT'D)

NONFERROUS METAL INDUSTRIES

(SIC 333-334)
TABLE OF CONTENTS (CONT'D)

Page

NONFERROUS METALS INDUSTRY
(SIC 333-334)
EXHIBITS INDEX

NONFERROUS METALS INDUSTRY
(SIC 333-334)
EXHIBITS INDEX (CONT'D)

NONFERROUS METALS INDUSTRY
(SIC 333-334)
LIST OF ACRONYMS

AFS -	AIRS Facility Subsystem (CAA database)
AIRS -	Aerometric Information Retrieval System (CAA database)
BIFs -	Boilers and Industrial Furnaces (RCRA)
BOD -	Biochemical Oxygen Demand
CAA -	Clean Air Act
CAAA -	Clean Air Act Amendments of 1990
CERCLA -	Comprehensive Environmental Response, Compensation and Liability Act
CERCLIS -	CERCLA Information System
CFCs -	Chlorofluorocarbons
CO -	Carbon Monoxide
COD -	Chemical Oxygen Demand
CSI -	Common Sense Initiative
CWA -	Clean Water Act
D&B -	Dun and Bradstreet Marketing Index
ELP -	Environmental Leadership Program
EPA -	United States Environmental Protection Agency
EPCRA -	Emergency Planning and Community Right-to-Know Act
FIFRA -	Federal Insecticide, Fungicide, and Rodenticide Act
FINDS -	Facility Indexing System
HAPs -	Hazardous Air Pollutants (CAA)
HSDB -	Hazardous Substances Data Bank
IDEA -	Integrated Data for Enforcement Analysis
LDR -	Land Disposal Restrictions (RCRA)
LEPCs -	Local Emergency Planning Committees
MACT -	Maximum Achievable Control Technology (CAA)
MCLGs -	Maximum Contaminant Level Goals
MCLs -	Maximum Contaminant Levels
MEK -	Methyl Ethyl Ketone
MSDSs -	Material Safety Data Sheets
NAAQS -	National Ambient Air Quality Standards (CAA)
NAFTA -	North American Free Trade Agreement
NCDB -	National Compliance Database (for TSCA, FIFRA, EPCRA)
NCP -	National Oil and Hazardous Substances Pollution Contingency Plan
NEIC -	National Enforcement Investigation Center
NESHAP -	National Emission Standards for Hazardous Air Pollutants
NO_2 -	Nitrogen Dioxide
NOV -	Notice of Violation
NO_X -	Nitrogen Oxide
NPDES -	National Pollution Discharge Elimination System (CWA)

NONFERROUS METALS INDUSTRY
(SIC 333-334)
LIST OF ACRONYMS (CONT'D)

NPL - National Priorities List
NRC - National Response Center
NSPS - New Source Performance Standards (CAA)
OAR - Office of Air and Radiation
OECA - Office of Enforcement and Compliance Assurance
OPA - Oil Pollution Act
OPPTS - Office of Prevention, Pesticides, and Toxic Substances
OSHA - Occupational Safety and Health Administration
OSW - Office of Solid Waste
OSWER - Office of Solid Waste and Emergency Response
OW - Office of Water
P2 - Pollution Prevention
PCS - Permit Compliance System (CWA Database)
POTW - Publicly Owned Treatments Works
RCRA - Resource Conservation and Recovery Act
RCRIS - RCRA Information System
SARA - Superfund Amendments and Reauthorization Act
SDWA - Safe Drinking Water Act
SPL - Spent Potliner
SEPs - Supplementary Environmental Projects
SERCs - State Emergency Response Commissions
SIC - Standard Industrial Classification
SO_2 - Sulfur Dioxide
TOC - Total Organic Carbon
TRI - Toxic Release Inventory
TRIS - Toxic Release Inventory System
TCRIS - Toxic Chemical Release Inventory System
TSCA - Toxic Substances Control Act
TSS - Total Suspended Solids
UIC - Underground Injection Control (SDWA)
UST - Underground Storage Tanks (RCRA)
VOCs - Volatile Organic Compounds

NONFERROUS METALS INDUSTRY
(SIC 333-334)

I. INTRODUCTION TO THE SECTOR NOTEBOOK PROJECT

I.A. Summary of the Sector Notebook Project

Environmental policies based upon comprehensive analysis of air, water, and land pollution are an inevitable and logical supplement to traditional single-media approaches to environmental protection. Environmental regulatory agencies are beginning to embrace comprehensive, multi-statute solutions to facility permitting, enforcement and compliance assurance, education/outreach, research, and regulatory development issues. The central concepts driving the new policy direction are that pollutant releases to each environmental medium (air, water, and land) affect each other, and that environmental strategies must actively identify and address these inter-relationships by designing policies for the "whole" facility. One way to achieve a whole facility focus is to design environmental policies for similar industrial facilities. By doing so, environmental concerns that are common to the manufacturing of similar products can be addressed in a comprehensive manner. Recognition of the need to develop the industrial "sector-based" approach within the EPA Office of Compliance led to the creation of this document.

The Sector Notebook Project was initiated by the Office of Compliance within the Office of Enforcement and Compliance Assurance (OECA) to provide its staff and managers with summary information for eighteen specific industrial sectors. As other EPA offices, States, the regulated community, environmental groups, and the public became interested in this project, the scope of the original project was expanded. The ability to design comprehensive, common sense environmental protection measures for specific industries is dependent on knowledge of several inter-related topics. For the purposes of this project, the key elements chosen for inclusion are: general industry information (economic and geographic); a description of industrial processes; pollution outputs; pollution prevention opportunities; Federal statutory and regulatory framework; compliance history; and a description of partnerships that have been formed between regulatory agencies, the regulated community, and the public.

For any given industry, each topic listed above could alone be the subject of a lengthy volume. However, in order to produce a manageable document, this project focuses on providing summary information for each topic. This format provides the reader with a synopsis of each issue, and references where more in-depth information is available. Text within each profile was researched from a variety of sources, and was usually condensed from more detailed sources pertaining to specific topics. This approach allows for a wide coverage of activities that can be further explored based upon the citations and references listed at the end of this profile. As a check on the information included, each notebook went through an external review process. The Office of Compliance appreciates the efforts of all those that participated in this process and enabled us to develop more complete, accurate, and up-to-date summaries. Many of those who reviewed this notebook are listed as contacts in Section IX and may be sources of additional information. The individuals and groups on this list do not necessarily concur with all statements within this notebook.

I.B. Additional Information

Providing Comments

OECA's Office of Compliance plans to periodically review and update the notebooks and will make these updates available both in hard copy and electronically. If you have any comments on the existing notebook, or if you would like to provide additional information, please send a hard copy and computer disk to the EPA Office of Compliance, Sector Notebook Project, 401 M St., SW (2223-A), Washington, DC 20460. Comments can also be uploaded to the Enviroene Bulletin Board or the Enviroene World Wide Web for general access to all users of the system. Follow instructions in Appendix A for accessing these data systems. Once you have logged in, procedures for uploading text are available from the on-line Enviroene Help System.

Adapting Notebooks to Particular Needs

The scope of the existing notebooks reflect an approximation of the relative national occurrence of facility types that occur within each sector. In many instances, industries within specific geographic regions or States may have unique characteristics that are not fully captured in these profiles. For this reason, the Office of Compliance encourages State and local environmental agencies and other groups to supplement or re-package the information included in this notebook to include more specific industrial and regulatory information that may be available. Additionally, interested States may want to supplement the "Summary of Applicable Federal Statutes and Regulations" section with State and local requirements. Compliance or technical assistance providers may also want to develop the "Pollution Prevention" section in more detail. Please contact the appropriate specialist listed on the opening page of this notebook if your office is interested in assisting us in the further development of the information or policies addressed within this volume.

If you are interested in assisting in the development of new notebooks for sectors not covered in the original eighteen, please contact the Office of Compliance at 202-564-2395.

II. INTRODUCTION TO THE NONFERROUS METALS INDUSTRY

This section provides background information on the Nonferrous Metals Industry and the organization of this sector's notebook.

II.A. Introduction and Background of the Notebook

The Standard Industrial Classification (SIC) code 33 is composed of establishments that engage in: the primary and secondary smelting and refining of ferrous and nonferrous metal from ore or scrap; rolling, drawing, and alloying; and the manufacturing and casting of basic metal products such as nails, spikes, wire, and cable. Primary smelting and refining produces metals directly from ores, while secondary refining and smelting produces metals from scrap and process waste. Scrap is bits and pieces of metal parts, bars, turnings, sheets, and wire that are off-specification or worn-out but are capable of being recycled.

Two metal recovery technologies are generally used to produce refined metals. Pyrometallurgical technologies are processes that use heat to separate desired metals from other less or undesirable materials. These processes capitalize on the differences between constituent oxidation potential, melting point, vapor pressure, density, and/or miscibility when melted. Examples of pyrometallurgical processes include drying, calcining, roasting, sintering, retorting, and smelting. Hydrometallurgical technologies differ from pyrometallurgical processes in that the desired metals are separated from undesirables using techniques that capitalize on differences between constituent solubilities and/or electrochemical properties while in aqueous solutions. Examples of hydrometallurgical processes include leaching, chemical precipitation, electrolytic recovery, membrane separation, ion exchange, and solvent extraction.

During pyrometallic processing, an ore, after being concentrated by beneficiation (crushing, washing, and drying) is sintered, or combined by heat, with other materials such as baghouse dust and flux. The concentrate is then smelted, or melted, in a blast furnace in order to fuse the desired metals into an impure molten bullion. This bullion then undergoes a third pyrometallic process to refine the metal to the desired level of purity. Each time the ore or bullion is heated, waste materials are created. Air emissions such as dust may be captured in a baghouse and are either disposed of or returned to the process depending upon the residual metal content. Sulfur is also captured, and when concentrations are above four percent it can be turned into sulfuric acid, a component of fertilizers. Depending upon the origin of the ore and its residual metals content, various metals such as gold and silver may also be produced as by-products.

Production operations under this SIC code are subject to a number of regulations, including those imposed by the Resource Conservation and Recovery Act (RCRA), the Clean Water Act (CWA), and the Clean Air Act (CAA). A number of RCRA-listed hazardous wastes are produced during primary refining operations which require the heating of ores to remove impurities. Specific pretreatment standards under the CWA apply to the processes associated with copper and aluminum. Lastly, large amounts of sulfur are released during copper, lead, and zinc smelting operations which are regulated under the CAA.

The Department of Commerce classification codes divide this industry by production process. The two-digit SIC code is broken down as follows:

SIC 331 - Steel Works, Blast Furnaces, and Rolling and Finishing Mills (covered in a separate profile)
SIC 332 - Iron and Steel Foundries (covered in a separate profile)
SIC 333 - Primary Smelting and Refining of Nonferrous Metals
SIC 334 - Secondary Smelting and Refining of Nonferrous Metals
SIC 335 - Rolling, Drawing, and Extruding of Nonferrous Metals (not covered in this profile)
SIC 336 - Nonferrous Foundries (castings) (not covered in this profile)
SIC 339 - Miscellaneous Primary Metal Products (not covered in this profile).

II.B. Organization of the Nonferrous Metals Notebook

SIC 33 is a diverse industrial area which is comprised of many different manufacturing processes. It is because of this diversity of processes and related pollutant issues that this notebook focuses only on SIC 333 and 334; Primary and Secondary Nonferrous Metals Processing. The metals aluminum, copper, lead, and zinc were chosen for inclusion in this profile because they are the four most widely used nonferrous metals in the United States. Where possible, information for the four metals is discussed separately. However, due to the SIC groupings, in many instances data for all four metals and other processes are intermingled. Every effort will be made to highlight where separate information is available and where information concerning more than one of the metals has been intermingled.

The notebook begins with a discussion of the primary and secondary aluminum industries. This discussion is comprised of economic and geographic characterizations of the industries and detailed discussions of the industrial processes involved, including production line raw material inputs and pollution outputs. The following three sections provide the same information for copper, lead, and zinc, respectively. The notebook continues with EPA Toxics Release Inventory data for the nonferrous metals industry. Much of this information is intermingled, but where possible has been separated. The notebook concludes with sections discussing pollution prevention opportunities, pending and proposed regulatory requirements, compliance and enforcement information, and compliance activities and initiatives.

III. PRIMARY AND SECONDARY ALUMINUM PROCESSING INDUSTRY

III.A. Characterization of Industry - Aluminum

This section provides background information on the size, geographic distribution, employment, production, sales, and economic condition of the Primary and Secondary Aluminum Industry. The type of facilities described within the document are also described in terms of their Standard Industrial Classification (SIC) codes.

III.A.1. Industry Size and Geographic Distribution - Aluminum

The following discussion is based upon the following materials: "Aluminum Know the Facts, July 1994," the Aluminum Association; "Industry & Trade Summary - Aluminum," the U.S. Trade Commission; and "U.S. Industrial Outlook 1994 - Metals," U.S. Department of Commerce.

Variation in facility counts occur across data sources due to many factors, including reporting and definitional differences. This document does not attempt to reconcile these differences, but rather reports the data as they are maintained by each source.

In 1993, the majority of primary aluminum producers (SIC 3334) in the U.S. were located either in the Northwest (39.1 percent of U.S. capacity) or the Ohio River Valley (31.1 percent of U.S. capacity), while most secondary aluminum smelters were located in Southern California and the Great Lakes Region. The reason for the difference in plant locations is due to the energy intensive nature of the primary aluminum smelting process and the cost of fuels. Primary smelters are located in the Northwest and Ohio River Valley to take advantage of the abundant supplies of hydroelectric and coal-based energy, while secondary smelters locate themselves near major industrial and consumer centers to take advantage of the large amounts of scrap generated. Secondary smelting uses 95 percent less energy to produce the same product than primary reduction. On the average, a third of primary production costs are attributable to the cost of energy.

The domestic primary aluminum smelting industry consists of 23 smelting facilities operated by 13 firms which employ approximately 20,000. Of the thirteen firms, four integrated producers, Alcoa, Alumax, Reynolds, and Kaiser, accounted for 63 percent of 1993's capacity. The secondary smelting industry operates an estimated 68 plants employing 3,600. These figures have remained stable since 1988 and reflect an industry that emerged strong and competitive following the contractions and restructuring of the early 1980's that were caused by worldwide price swings and supply/demand disequilibrium.

About 40 percent of the domestic supply of aluminum is recovered by secondary refiners (SIC 334) from both purchased new and old aluminum scrap. New scrap is material generated during the fabrication of aluminum products. Old scrap includes products such as aluminum pistons and other aluminum engine or body parts from junked cars, used aluminum beverage cans, doors and siding, and used aluminum foil. In 1993, 2.3 million metric tons (Mmt) of metal, valued at an estimated $3.5 billion, were recovered from both new and old aluminum scrap. Of this total, approximaterly 55 percent was recovered from old scrap. Recycling rates for aluminum beverage containers reached 63 percent (60 billion cans) in 1993, keeping more than two billion pounds of material out of landfills.

III.A.2. Product Characterization - Aluminum

The primary and secondary aluminum industry produces ingots of pure (greater than 99 percent) aluminum that serve as feedstock for other materials and processes. Within the U.S., the leading end-users of aluminum come from three industries; containers and packaging, transportation, and building and construction. In 1993, demand from the three industries accounted for an estimated 60 percent of the eight Mmt of aluminum ingot and semifabricated products produced, with containers and packaging alone accounting for more than 25 percent of total shipments. Examples of materials produced with aluminum are: sheet metal; aluminum plate and foil; rod, bar, and wire; beverage cans, automobiles, aircraft components, and window/door frames.

III.A.3. Economic Trends - Aluminum

The amount of aluminum a plant could produce if working at engineered (full) capacity held steady in 1993. This was due to two factors: reduced hydroelectric supplies in the Northwest and falling aluminum prices. Hydroelectric supplies were reduced in the Northwest due to drought. Prices for primary aluminum fell to record-lows in 1993 despite a slight global increase in demand, due in large part to a flood of exports from the former Soviet republics.

U.S. aluminum shipments increased 12 percent in 1994, based on increased demands in the beverage can stock and transportation sectors. At present, the automotive sector is the largest end-user. The next largest end-user is the beverage can stock.

Automotive use of aluminum is expected to sky-rocket as the sector increases its use of aluminum to increase fuel efficiency. Chrysler Corporation may begin building an aluminum-intensive car in 1996, employing 600-700 pounds of aluminum per car. The reduction in weight for a midsize vehicle would cut gasoline consumption by one gallon for each 100 miles driven.

III.B. Industrial Process Description - Aluminum

This section describes the major industrial processes within the Primary and Secondary Aluminum industry, including the materials and equipment used, and the processes employed. The section is designed for those interested in gaining a general understanding of the industry, and for those interested in the inter-relationship between the industrial process and the topics described in subsequent sections of this profile -- pollutant outputs, pollution prevention opportunities, and Federal regulations. This section does not attempt to replicate published engineering information that is available for this industry. Refer to Section XII for a list of reference documents that are available.

This section specifically contains a description of commonly used production processes, associated raw materials, the byproducts produced or released, and the materials either recycled or transferred off-site. This discussion, coupled with schematic drawings of the identified processes, provides a concise description of where wastes may be produced in the process. This section also describes the potential fate (air, water, land) of these waste products.

III.B.1. Industrial Processes in the Primary and Secondary Aluminum Industry

The following discussion is based in part upon the following documents: "Background Listing Document for K088," and AP42 from the U.S. Environmental Protection Agency, and materials provided by The Aluminum Association, Incorporated.

Primary Aluminum Processing

Primary aluminum producers generally employ a three step process to produce aluminum alloy ingots. First, alumina is extracted from bauxite ore using the Bayer process (See Exhibit 1). In the Bayer process, finely crushed bauxite is mixed with an aqueous sodium hydroxide (caustic soda) solution to form a slurry. The slurry is then reacted at a high temperature under steam pressure in a vessel known as a digester, and creates a mixture of dissolved aluminum oxides and bauxite residues. During the reaction a majority of the impurities such as silicon, iron, titanium, and calcium oxides drop to the bottom of the digester and form a sludge. The remaining sodium aluminate slurry is then flash cooled by evaporation and sent for clarification. During clarification, agents such as starch are added to help any fine impurities that remain in the slurry, such as sand, to drop out, further purifying the sodium aluminate solution. The solution is then fed into a precipitation tank to be crystallized. In the precipitator the solution is allowed to cool with the addition of a small amount of aluminum hydroxide "seed." The seed stimulates the precipitation of solid crystals of aluminum hydroxide and sodium hydroxide.

Exhibit 1 - Bayer Process (Alumina Refining)

Source: Air Pollution Engineering Manual, Anthony J. Buonicore and Wayne T. Davis, ed., Air & Waste Management Association, Van Norstrand Reinhold.

The aluminum hydroxide crystals settle to the tank bottom, and are removed. The crystals are then washed to remove any caustic soda residues, vacuum dewatered, and sent on for calcination. In the calciners (a type of rotating kiln) the aluminum hydroxide is roasted for further dewatering.

In the second step, the aluminum oxide (alumina) produced during the Bayer process is reduced to make pure molten aluminum. Alumina is a fine white powder, and consists of about equal weights of aluminum and oxygen. The strong chemical bond that exists between the aluminum and oxygen makes separating them difficult — pyrometallurgical separation requires a temperature of about 3600 degrees F. However, in 1866 it was discovered that alumina will dissolve when placed in the molten metal cryolite at around only 1742 degrees F. Once dissolved, the aluminum oxide is readily separated into aluminum and oxygen by electric current. The Hall-Heroult process, as this type of electrolytic reduction is known, begins with the placement of the alumina into electrolytic cells, or "pots," filled with molten cryolite (See Exhibit 2). Though the process requires large amounts of electricity (six or seven kilowatts of electricity per pound of aluminum produced), only a low voltage is needed. This allows the pots to be laid out in a series along one long electrical circuit to form what is known as a "potline." Within each pot a positive electric current is passed through the cryolite by means of a carbon anode submerged in the liquid cryolite. The oxygen atoms, separated from aluminum oxide, carry a negative electrical charge and are attracted to the carbon anodes. The carbon and the oxygen combine immediately to form carbon dioxide and carbon monoxide. These gases bubble free of the melt. The aluminum (which is more than 99 percent pure) collects at the bottom of the pot, is siphoned off, placed into crucibles, and then transferred to melting/holding furnaces.

Exhibit 2 - Aluminum Anodes

Source: The Aluminum Association.

The third step consists of either mixing the molten aluminum with other metals to form alloys of specific characteristics, or casting the aluminum into ingots for transport to fabricating shops. Casting involves pouring molten aluminum into molds and cooling it with water. At some plants, the molten aluminum may be batch treated in furnaces to remove oxide, gaseous impurities and active metals such as sodium and magnesium before casting. Some plants add a flux of chloride and fluoride salts and then bubble chlorine gas, usually mixed with an inert gas, through the molten mixture. Chloride reacts with the impurities to form HCL, Al_2O_3, and metal chloride emissions. A dross forms to float on the molten aluminum and is removed before casting.

Two types of anodes may be used during the reduction process; either an anode paste or a pre-baked anode. Because the carbon is consumed during the refining process (about one-half pound of carbon is consumed for every pound of aluminum produced), if anode paste (Soderberg anode) is used, it needs to be continuously fed through an opening in the steel shell of the pot. The drawback to pre-baked anodes is that they require that a pre-baked anode fabricating plant be located nearby or on-site. Most aluminum reduction plants include their own facilities to manufacture anode paste and/or pre-baked anode blocks. These pre-baked blocks, each of which may weigh 600 or 700 pounds, must be replaced after 14 to 20 days of service.

One waste material produced during the primary production of aluminum are fluoride compounds. Fluoride compounds are principally produced during the reduction process. One reason that pre-baked anodes are favored is that the closure of the pots during smelting facilitates the capture of fluoride emissions, though many modern smelters employ other methods to capture and recycle fluorides and other emissions.

The pots used to hold the aluminum during smelting range in size from 30 to 50 feet long, 9 to 12 feet wide, and 3 to 4 feet high, and are lined with refractory brick and carbon. Eventually the carbon linings crack and must be removed and replaced. However, during the aluminum reduction process iron cyanide complexes form in the carbon portion of the liners. When the linings are removed they are "spent," and are considered to be RCRA listed hazardous waste K088.

Secondary Aluminum Processing

In the secondary production of aluminum, scrap is usually melted in gas- or oil-fired reverberatory furnaces of 30,000 to over 100,000 pounds capacity. The furnaces have one or two charging wells separated from the main bath by a refractory wall that permits only molten metal into the main bath. The principal processing of aluminum-base scrap involves the removal of magnesium by treating the molten bath with chlorine or with various fluxes such as aluminum chloride, aluminum fluoride, or mixtures of sodium and potassium chlorides and fluorides. To facilitate handling, a significant proportion of the old aluminum scrap, and in some cases new scrap, is simply melted to form sweated pig that must be processed further to make specification-grade ingot.

Another method of secondary aluminum recovery uses aluminum drosses as the charge instead of scrap. Traditionally, the term dross was defined as a thick liquid or solid phase that forms at the surface of molten aluminum, and is a by-product of melting operations. It is formed with or without fluxing and the free aluminum content of this by-product can vary considerably. Most people in the industry have generally referred to dross as being lower in aluminum content, while the material with a higher aluminum content is referred to as "skim," or "rich" or "white dross." If a salt flux is used in the melting process, the by-product is usually called a "black dross" or "salt cake." Drosses containing about 30 percent metallics are usually crushed and screened to bring the metallic content up to about 60 to 70 percent. They are then melted in a rotary furnace, where the molten aluminum metal collects on the bottom of the furnace and is tapped off. Salt slags containing less than 30 percent metallics may be leached with water to separate the metallics. In addition to this classic dross-recycling process, a new dross treatment process using a water-cooled plasma gas arc heater (plasma torch) installed in a specially-designed rotary furnace was patented recently. The new process eliminates the use of salt flux in the conventional dross treatment process, and reports recovery efficiencies of 85 to 95 percent.

III.B.2. Raw Material Inputs and Pollution Outputs

The material inputs and pollution outputs resulting from primary and secondary aluminum processing are presented by media in Exhibit 3.

Exhibit 3
Process Materials Inputs/Pollution Outputs - Aluminum

Process	Material Input	Air Emissions	Process Wastes	Other Wastes
Bauxite Refining	Bauxite, sodium hydroxide	Particulates		Residue containing silicon, iron, titanium, calcium oxides, and caustic
Alumina Clarification and Precipitation	Alumina slurry, starch, water		Wastewater containing starch, sand, and caustic	
Alumina Calcination	Aluminum hydrate	Particulates and water vapor		
Primary Electrolytic Aluminum Smelting	Alumina, carbon anodes, electrolytic cells, cryolite	Fluoride, both gaseous and particulates, carbon dioxide, sulfur dioxide, carbon monoxide, C_2F_6, CF_4, and perflourinated carbons (PFC)		Spent potliners, K088
Secondary Scrap Aluminum Smelting	Aluminum scrap, oil or gas, chlorine or other fluxes (aluminum chloride, aluminum fluoride, sodium and potassium chlorides, and fluorides)	Particulates and HCL/Cl_2		Slag containing magnesium and chlorides
Secondary Aluminum Dross Recycling	Aluminum dross, water	Particulates	Wastewater, salts	

Primary Aluminum Processing

Primary aluminum processing activities result in air emissions, proccess wastes, and other solid-phase wastes. Large amounts of particulates are generated during the calcining of hydrated aluminum oxide, but the economic value of this dust for reuse in the process is such that extensive controls are used to reduce emissions to relatively small quantities. Small amounts of particulates are emitted from the bauxite grinding and materials handling processes. Emissions from aluminum reduction processes are primarily gaseous hydrogen fluoride and particulate fluorides, alumina, carbon monoxide, volatile organics, and sulfur dioxide from the reduction cells; and fluorides, vaporized organics and sulfur dioxide from the anode baking furnaces. A variety of control devices such as wet scrubbers are used to abate emissions from reduction cells and anode baking furnaces.

Wastewaters generated from primary aluminum processing are produced during clarification and precipitation though much of this water is fed back into the process to be reused.

Solid-phase wastes are generated at two stages in the primary aluminum process; red mud produced during bauxite refining, and spent potliners from the reduction process. Red mud normally contains significant amounts of iron, aluminum, silicon, calcium, and sodium. The types and concentrations of minerals present in the mud depends on the composition of the ore and the operating conditions in the digesters. Red mud is managed on site in surface impoundments, and has not been found to exhibit any of the characteristics of hazardous waste (1990 Report to Congress on Special Wastes from Mineral Processing). The process does however, generate hazardous waste. The carbon potliners used to hold the alumina/cryolite solution during electrolytic aluminum reduction process eventually crack and need to be removed and replaced. When the liners are removed they are "spent," and are considered to be RCRA listed hazardous waste K088.

Secondary Aluminum Processing

Secondary aluminum processing also results in air emissions, wastewaters, and solid wastes. Atmospheric emissions from reverberatory (chlorine) smelting/refining represent a significant fraction of the total particulate and gaseous effluents generated in the secondary aluminum industry. Typical furnace effluent gases contain combustion products, chlorine, hydrogen chloride and metal chlorides of zinc, magnesium, and aluminum, aluminum oxide and various metals and metal compounds, depending on the quality of scrap charges. Emissions from reverberatory (fluorine) smelting/refining are similar to those from reverberatory (chlorine) smelting/refining. The use of AlF_3 rather than chlorine in the demagging step reduces demagging emissions. Fluorides are emitted as gaseous fluorides or as dusts. Baghouse scrubbers are usually used for fluoride emission control.

Solid-phase wastes are also generated during secondary scrap aluminum smelting. The slag generated during smelting contains chlorides resulting from the use of fluxes and magnesium. Waste waters are also generated during secondary aluminum processing when water is added to the smelting slags to aid in the separation of metallics. The waste waters are also likely to be contaminated with salt from the various fluxes used.