5. PRODUCTION, IMPORT/EXPORT, USE, AND DISPOSAL

5.1 PRODUCTION

Aluminum is the most abundant metal and the third most abundant element in the earth's crust, comprising about 8.8% by weight (88 g/kg). It is rarely found free in nature and is found in most rocks, particularly igneous rocks, which contain aluminum as aluminosilicate minerals (Staley and Haupin 1992). Bauxite is a naturally occurring, heterogeneous material consisting of primarily one or more aluminum hydroxide minerals in addition to a variety of aluminosilicates, iron oxide, silica, titania, and other impurities in trace amounts. It is the most important raw material for the production of aluminum. More than 90% of the bauxite consumed in the United States in 2006 was converted to alumina (Al_2O_3) for the production of aluminum (USGS 2007d). Other raw materials sometimes used in the production of aluminum include cryolite, aluminum fluoride, fluorspar, corundum, and kaolin minerals (Browning 1969; Dinman 1983; IARC 1984; Lide 2005; O'Neil et al. 2001; USGS 2007a).

In 2006, primary aluminum was produced in 42 countries, with China, Russia, Canada, and the United States, in decreasing order of metal produced, accounting for 53% of the total world production of 31.9 million metric tons. In 2006, 5 U.S. companies, operating 13 primary aluminum smelters, produced an estimated 2.3 million metric tons of aluminum metal. Six smelters were temporarily idled. In the United States, about 3 million metric tons of aluminum were recovered from purchased scrap in 2006, with 64% of this coming from new (manufacturing) scrap and 36% from old scrap (discarded aluminum products) (USGS 2007b, 2007c).

In 2006, Australia, Brazil, and China accounted for approximately 58% of the total world bauxite product of 178 million metric tons. World production of alumina was estimated to be 69.2 million metric tons in 2006, with Australia and China as leading producers, accounting for 46% of the world's alumina production. U.S. production of alumina, which is nearly all derived from imported metallurgical-grade bauxite, was 4.61 million metric tons in 2006 (USGS 2007a, 2007d).

The principal method used in producing aluminum metal involves three major steps: refining of bauxite by the Bayer process to produce alumina, electrolytic reduction of alumina by the Hall-Héroult process to produce aluminum, and casting of aluminum into ingots (Browning 1969; Dinman 1983; IARC 1984).

In the first step (Bayer process), bauxite ($Al_2O_3 \cdot H_2O$) is digested at high temperature and pressure in a strong solution of caustic soda. The resulting hydrate is then crystallized and calcined in a kiln to produce alumina (aluminum oxide). In the second step (Hall-Héroult process), alumina is reduced to aluminum metal by an electrolytic process involving carbon electrodes and cryolite flux ($3NaF \cdot AlF_3$). The electrolytic reduction process of transforming alumina into aluminum is carried out in electrolytic cells or pots. The areas where this occurs are called potrooms. Two types of electrolytic cells may be used, a prebake or a Söderberg cell. Their design differs, but the principle is the same. Alumina is dissolved in the cell in an electrolyte at a high temperature (950–970 °C) and a low voltage (4–6 volts). A high current is applied to the melted fraction. The alumina is reduced to aluminum at the cathode and the metal sinks to the bottom of the electrolytic cell. The aluminum is then removed by siphoning. The oxygen from the alumina migrates to the carbon anode of the cell, where it reacts to form carbon dioxide and carbon monoxide. The aluminum produced using the Hall-Héroult electrolytic reduction process may be refined to a maximum purity of 99.9%. In the third step (casting), aluminum is taken from the cell to holding furnaces from which it is poured into molds and cast into aluminum ingots (IARC 1984; Lewis 2001; Staley and Haupin 1992). Current U.S. manufacturers of aluminum are given in Table 5-1.

Aluminum is also an integral part of a variety of aluminum compounds used in industrial, domestic, consumer, and medicinal products. The methods of production for these compounds are described in the following section. Current U.S. manufacturers of selected aluminum compounds are given in Table 5-2.

Aluminum chloride can be produced by the reaction of purified gaseous chlorine with molten aluminum, as well as by the reaction of bauxite with coke and chlorine at about 875 °C (Lewis 2001).

Aluminum fluoride can be produced by heating ammonium hexafluoroaluminate to red heat in a stream of nitrogen. Other methods include the action of hydrogen fluoride gas on aluminum trihydrate; the reaction of hydrogen fluoride on a suspension of aluminum trihydrate followed by calcining the hydrate formed; fusion of cryolite or sodium fluoride with aluminum sulfate; or the reaction of fluosilicic acid on aluminum hydrate (HSDB 2007; Lewis 2001; O'Neil et al. 2001).

Aluminum hydroxide is produced from bauxite. The bauxite ore is first dissolved in a solution of sodium hydroxide, and then the aluminum hydroxide is precipitated from the sodium aluminate solution by neutralization (as with carbon dioxide) or by autoprecipitation (Bayer process) (Lewis 2001).

Aluminum nitrate as the nonahydrate is formed by dissolving aluminum or aluminum hydroxide in dilute nitric acid and allowing the resulting solution to crystallize (Grams 1992; Lewis 2001).

Table 5-1. U.S. Manufacturers of Aluminum[a]

Company	Location
Alcan Aluminum Corporation, Alcan Specialty Aluminas	Sebree, Kentucky
Alcoa, Inc., Alcoa Primary Metals	Alcoa, Tennessee
	Badin, North Carolina
	Goose Creek, South Carolina
	Massena, New York
	Wenatchee, Washington
Alcoa Intalco Works	Ferndale, Washington
Century Aluminum	Hawesville, Kentucky
	Ravenswood, West Virginia
Columbia Falls Aluminum Company	Columbia Falls, Montana
Eastalco Aluminum Company	Frederick, Maryland
Noranda Aluminum Inc.	New Madrid, Missouri
Northwest Aluminum Company	The Dalles, Oregon
Ormet Primary Aluminum Corporation	Hannibal, Ohio

[a]Derived from SRI 2007

Table 5-2. U.S. Producers of Selected Aluminum Compounds[a]

Company	Location	Annual capacity (10^3 metric tons)[b]
Alumina, calcined (Aluminum oxide)		
Alcoa, Inc., Alcoa World Alumnia	Point Comfort, Texas	
Almatis, Inc.	Bauxite, Arkansas	
Gramercy Alumina LLC	Gramercy, Louisiana	
Ormet Primary Aluminum Corporation	Burnside, Louisiana	
Sherwin Alumina Company	Corpus Christi, Texas	
Aluminas (specialty grades)		
Albemarle Corporation	Pasadena, Texas	
Almatis, Inc.	Bauxite, Arkansas	
AluChem, Inc.	Cincinnati, Ohio	
Axens North America	Savannah, Georgia	
BASF Catalysts LLC, Adsorbents and Catalysts	Port Allen, Louisiana	
	Vidalia, Louisiana	
Huber Engineered Materials	Fairmount, Georgia	
Porocel Corporation	Little Rock, Arkansas	
Saint-Gobain Ceramics & Plastics, Inc., Grains & Powders Division	Worcester, Massachusetts	
Sasol North America Inc., Ceralox Division	Westlake, Louisiana	
	Tucson, Arizona	
SPI Pharma Group	Lewes, Delaware	
Treibacher Schleifmittel North America, Inc.	Niagara Falls, New York	
UOP, LLC	Baton Rouge, Louisiana	
Washington Mills Electro Minerals Company	Niagara Falls, New York	
Aluminum ammonium sulfate		
Holland Company, Inc.	Adams, Massachusetts	
Aluminum chlorhydrate (aluminum chloride, basic)		
GEO Specialty Chemicals, Inc., Aluminum Products Group	Baltimore, Maryland	
	Bastrop, Louisiana	
	Counce, Tennessee	
The Gillette Company, North Chicago Manufacturing Center	North Chicago, Illinois	
Gulbrandsen Companies, Gulbrandsen Chemicals, Inc.	Orangeburg, South Carolina	
Gulbrandsen Companies, Gulbrandsen Technologies, Inc.	La Porte, Texas Phillipsburg, New Jersey	
Puerto Rico Alum Corporation	Penuelas, Puerto Rico	
Reheis, Inc.	Berkeley Heights, New Jersey	

Table 5-2. U.S. Producers of Selected Aluminum Compounds[a]

Company	Location	Annual capacity (10^3 metric tons)[b]
Summit Research Labs	Huguenot, New York	
	Phoenix, Arizona	
	Somerset, New Jersey	
Thatcher Company	Salt Lake City, Utah	
Aluminum chloride (anhydrous)[c]		
Gulbrandsen Companies, Gulbrandsen Chemicals, Inc.	Orangeburg, South Carolina	25
Toth Aluminum Corporation	Vacherie, Louisiana	10[d]
Vanchlor Company, Inc.	Lockport, New York	15
Aluminum chloride (hydrous)[e]		
Arkema, Inc., Specialty Chemicals Division	Axis, Alabama	2
Chattem, Chemicals, Inc.	Chattanooga, Tennessee	1
Delta Chemical Corporation	Ashtabula, Ohio	10
	Baltimore, Maryland	50
GEO Specialty Chemicals, Inc., Aluminum Products Group	Baltimore, Maryland	9
	Bastrop, Louisiana	6
The Gillette Company, North Chicago Manufacturing Center	North Chicago, Illinois	Not applicable
Gulbrandsen Companies, Gulbrandsen Technologies, Inc.	Phillipsburg, New Jersey	9
Holland Company, Inc.	Adams, Massachusetts	Not applicable
Puerto Rico Alum Corporation	Penuelas, Puerto Rico	1
Reheis, Inc.	Berkeley Heights, New Jersey	3
Southern Ionics, Inc.	Westlake, Louisiana	60
Summit Research Labs	Huguenot, New York	Not applicable
	Phoenix, Arizona	Not applicable
	Somerset, New Jersey	Not applicable
Aluminum chloride (aluminum trichloride)		
Mallinckrodt, Inc., Pharmaceuticals Group	St. Louis, Missouri	
Aluminum chlorohydrate (polyaluminum chloride)		
Delta Chemical Corporation	Ashtabula, Ohio	
	Baltimore, Maryland	
GEO Specialty Chemicals, Inc., Aluminum Products Group	Baltimore, Maryland Bastrop, Louisiana	
Gulbrandsen Companies, Gulbrandsen Chemicals, Inc.	Orangeburg, South Carolina	
Gulbrandsen Companies, Gulbrandsen Technologies, Inc.	La Porte, Texas Phillipsburg, New Jersey	
Holland Company, Inc.	Adams, Massachusetts	

Table 5-2. U.S. Producers of Selected Aluminum Compounds[a]

Company	Location	Annual capacity (10^3 metric tons)[b]
Kemiron Companies, Inc.	Kalama, Washington	
	Savannah, Georgia	
	Spokane, Washington	
Puerto Rico Alum Corporation	Penuelas, Puerto Rico	
Summit Research Labs	Huguenot, New York	
	Phoenix, Arizona	
	Somerset, New Jersey	
Aluminum fluoride		
Alcoa, Inc., Alcoa World Alumina	Point Comfort, Texas	60
CERAC, Inc.	Milwaukee, Wisconsin	Not applicable
ConocoPhillips	Billings, Montana	<1[f]
	Ponca City, Oklahoma	<1[f]
Ozark Fluorine Specialties, Inc.	Tulsa, Oklahoma	<2
Aluminum hydroxide		
Almatis, Inc.	Bauxite, Arkansas	
Franklin Industries, Inc., Franklin Industrial Minerals	Dalton, Georgia	
Gramercy Alumina LLC	Gramercy, Louisiana	
Huber Engineered Materials	Fairmount, Georgia	
	Kennesaw, Georgia	
	Quincy, Illinois	
IMERYS Pigments & Additives	Talking Rock, Georgia	
Sherwin Alumina Company	Corpus Christi, Texas	
Aluminum nitrate		
Blue Grass Chemical Specialties, LLC	New Albany, Indiana	
Mallinckrodt Baker, Inc.	Phillipsburg, New Jersey	
Mineral Research and Development	Harrisburg, North Carolina	
Thatcher Company	Salt Lake City, Utah	
Aluminum phosphate (aluminum orthophosphate)		
Innophos, Inc.	Chicago Heights, Illinois	
Johnson Matthey, Inc., Alfa Aesar	Ward Hill, Massachusetts	
PCS Phosphate Co., Inc.	Cincinnati, Ohio	
United-Erie, Inc.	Erie, Pennsylvania	
Aluminum phosphide[g]		
Bernardo Chemical, Ltd, Inc.		
Degesch America, Inc.		
Inventa Corporation		
Midland Fumigant, Inc.		
Pestcon Systems, Inc.		

Table 5-2. U.S. Producers of Selected Aluminum Compounds[a]

Company	Location	Annual capacity (10^3 metric tons)[b]
Aluminum potassium sulfate (Potash alum)		
Holland Company, Inc.	Adams, Massachusetts	
Aluminum sodium sulfate (Soda alum)		
General Chemical Corporation	East St. Louis, Illinois	
Aluminum sulfate (Alum, commercial)		
Alchem, Inc.	Rockwell, North Carolina	
Bay Chemical and Supply Company	Odem, Texas	
C & S Chemicals, Inc.	Austell, Georgia	
	Bartow, Florida	
	Joliet, Illinois	
	Randolph, Minnesota	
	Waycross, Georgia	
Delta Chemical Corporation	Ashtabula, Ohio	
	Baltimore, Maryland	
GAC Chemical Corporation	Searsport, Maine	
Gemini Industries, Inc.	Santa Ana, California	
General Chemical Corporation	Ashdown, Arkansas	
	Augusta, Georgia	
	Catawba, South Carolina	
	Cedar Springs, Georgia	
	Cleveland, Ohio	
	Covington, Virginia	
	Denver, Colorado	
	Detroit, Michigan	
	East Point, Georgia	
	East St. Louis, Illinois	
	Hopewell, Virginia	
	Indianapolis, Indiana	
	Jacksonville, Florida	
	Johnsonburg, Pennsylvania	
	Kalamazoo, Michigan	
	Macon, Georgia	
	Marrero, Louisiana	
	Menasha, Wisconsin	
	Middletown, Ohio	
	Pine Bluff, Arkansas	
	Pittsburg, California	
	Port St. Joe, Florida	
	Saukville, Wisconsin	
	Savannah, Georgia	

Table 5-2. U.S. Producers of Selected Aluminum Compounds[a]

Company	Location	Annual capacity (10^3 metric tons)[b]
	Springfield, Tennessee	
	Tacoma, Washington	
	Tampa, Florida	
	Toledo, Ohio	
	Vancouver, Washington	
	Wisconsin Rapids, Wisconsin	
GEO Specialty Chemicals, Inc., Aluminum Products Group	Bastrop, Louisiana	
	Chattanooga, Tennessee	
	Childersburg, Alabama	
	Counce, Tennessee	
	Demopolis, Alabama	
	De Ridder, Louisiana	
	Georgetown, South Carolina	
	Monticello, Mississippi	
	Pennington, Alabama	
	Plymouth, North Carolina	
	Savannah, Georgia	
W. R. Grace & Co., Grace Davison	Curtis Bay, Maryland	
	Lake Charles, Louisiana	
Holland Company, Inc.	Adams, Massachusetts	
Kemira Companies, Inc.	Antioch, California	
	Savannah, Georgia	
	Spokane, Washington	
Mallinckrodt Baker, Inc.	Paris, Kentucky	
Mallinckrodt, Inc., Pharmaceuticals Group	St. Louis, Missouri	
National Alum Corporation	Woodbine, Georgia	
Puerto Rico Alum Corporation	Penuelas, Puerto Rico	
Rhodia, Inc., Services & Specialties Division	Dominguez, California	
	Portland, Oregon	
Russ Chemical Company, Inc.	Odessa, Texas	
Southern Ionics, Inc.	Baton Rouge, Louisiana	
	Calhoun, Tennessee	
	Chickasaw, Alabama	
	Pasadena, Texas	
	Westlake, Louisiana	
	West Point, Mississippi	
Thatcher Company	Henderson, Nevada	
	Missoula, Montana	
	Salt Lake City, Utah	

Table 5-2. U.S. Producers of Selected Aluminum Compounds[a]

Company	Location	Annual capacity (10^3 metric tons)[b]
U.S. Aluminate Company, Inc.	Fairfield, Ohio	
	Michigan City, Indiana	
Sodium aluminosilicate		
Albemarle Corporation	Pasadena, Texas	
W.R. Grace & Co., Grace Division	Curtis Bay, Maryland	
	Lake Charles, Louisiana	
Huber Engineered Materials	Etowah, Tennessee	
	Havre de Grace, Maryland	
	Longview, Washington	
The PQ Corporation, Zeolyst and Catalyst Division	Kansas City, Kansas	
UOP, LLC	Chickasaw, Alabama	
Zeolyst International	Kansas City, Kansas	
Sodium aluminum phosphate		
ICL Performance Products L.P.	Carondelet, Missouri	
Innophos, Inc.	Chicago Heights, Illinois	
	Nashville, Tennessee	

[a]Derived from SRI 2007
[b]SRI Consulting estimates as of February 1, 2007; annual capacities were only reported for aluminum chloride (anhydrous), aluminum chloride (hydrous), and aluminum fluoride.
[d]Unit is currently idle.
[c]Capacities are on 100% $AlCl_3$ basis.
[e]Capacities, which are expressed as 100% $AlCl_3$, are nominal and easily expandable.
[f]Aluminum fluoride is reclaimed from refinery operations in small quantities.
[g]Manufacturers for aluminum phosphide were obtained from EPA 1998.

Aluminum oxide is produced during the recovery of bauxite, which is crushed, ground, and kiln dried, followed by leaching with sodium hydroxide, forming sodium aluminate, from which alumina trihydrate is precipitated and calcined (Bayer process). Aluminum sulfate obtained from coal mine waste waters can be reduced to aluminum oxide (HSDB 2007; Lewis 2001).

Aluminum phosphide can be manufactured in a high degree of purity, by heating aluminum and phosphorus. It can also be prepared from red phosphorus and aluminum powder, or from aluminum and zinc phosphide (HSDB 2007; O'Neil et al. 2001).

Aluminum sulfate is manufactured by reacting freshly precipitated pure aluminum hydroxide, bauxite, or kaolin, with an appropriate quantity of sulfuric acid. The resulting solution is evaporated and allowed to crystallize. Aluminum sulfate can also be produced by the treatment of pure kaolin or aluminum hydroxide or bauxite with sulfuric acid. The insoluble silic acid is removed by filtration and the sulfate is obtained by crystallization. It can be prepared similarly from waste coal mining shale and sulfuric acid (HSDB 2007; Lewis 2001).

Table 5-3 lists the facilities in each state that manufacture or process aluminum (fume or dust), the intended use, and the range of maximum amounts of aluminum that are stored on site. Table 5-4 lists the facilities in each state that manufacture or process aluminum oxide (fibrous form), the intended use, and the range of maximum amounts of aluminum oxide that are stored on site. The data listed in Tables 5-3 and 5-4 are derived from the Toxics Release Inventory (TRI05 2007). Only certain types of facilities were required to report (EPA 1995). Therefore, this is not an exhaustive list.

5.2 IMPORT/EXPORT

In 2006, nearly all of the 12.3 million metric tons of bauxite used in the United States was imported. Domestic mines have supplied <1% of the U.S. requirements for bauxite for many years. Import sources for bauxite (2002–2005) are Jamaica (31%), Guinea (30%), Brazil (17%), Guyana (12%), and other (10%). Import sources for alumina (2002–2005) are Australia (19%), Suriname (29%), Jamaica (9%), and other (12%). More than 90% of the bauxite consumed in the United States in 2006 was converted to alumina (USGS 2007a, 2007d).

Table 5-3. Facilities that Produce, Process, or Use Aluminum (Fume or Dust)

State[a]	Number of facilities	Minimum amount on site in pounds[b]	Maximum amount on site in pounds[b]	Activities and uses[c]
AK	1	10,000	99,999	12
AL	37	0	9,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
AR	39	0	499,999,999	1, 3, 4, 5, 6, 7, 8, 11, 12, 13, 14
AZ	17	0	9,999,999	1, 3, 4, 5, 6, 7, 8, 11, 12, 13
CA	71	0	999,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
CO	11	1,000	999,999	1, 2, 4, 5, 8, 11, 12
CT	20	0	9,999,999	1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
DE	4	1,000	9,999	2, 3, 4, 6, 7, 8, 11
FL	15	0	999,999	1, 5, 7, 8, 9, 11, 12
GA	21	0	9,999,999	1, 2, 3, 4, 5, 7, 8, 9, 11, 12, 13, 14
IA	41	0	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14
ID	7	10,000	999,999	1, 3, 4, 5, 7, 12, 13
IL	93	0	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
IN	113	0	99,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
KS	25	0	9,999,999	1, 2, 3, 5, 7, 8, 9, 10, 11, 12
KY	63	0	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
LA	16	0	9,999,999	1, 5, 6, 7, 8, 10, 11, 12, 13
MA	10	0	999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
MD	13	1,000	999,999	1, 2, 3, 4, 5, 6, 7, 8, 9
ME	5	100	99,999	1, 3, 4, 5, 8, 9, 12
MI	80	0	99,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
MN	28	100	9,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
MO	49	0	99,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
MS	16	0	9,999,999	1, 3, 5, 7, 8, 10, 11, 12
NC	39	0	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
ND	2	1,000	9,999	1, 5, 8
NE	5	1,000	99,999	1, 5, 6, 7, 8, 11, 12
NH	3	100	499,999,999	8
NJ	52	0	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13
NV	11	100	499,999,999	1, 2, 3, 5, 7, 8, 9, 10, 12, 13
NY	36	0	999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 12
OH	120	0	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
OK	26	0	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13
OR	29	0	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
PA	105	0	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
PR	6	100	99,999	4, 8, 12
RI	3	1,000	999,999	7, 8, 9
SC	29	0	9,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12
TN	60	0	99,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13

Table 5-3. Facilities that Produce, Process, or Use Aluminum (Fume or Dust)

State[a]	Number of facilities	Minimum amount on site in pounds[b]	Maximum amount on site in pounds[b]	Activities and uses[c]
TX	64	0	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
UT	18	0	9,999,999	1, 4, 5, 7, 8, 11, 12, 13
VA	27	0	999,999	1, 2, 3, 5, 7, 8, 11, 12
VT	3	0	999,999	8, 11, 12
WA	20	0	999,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 12, 13
WI	49	0	499,999,999	1, 2, 3, 5, 6, 7, 8, 9, 11, 12, 13, 14
WV	17	0	9,999,999	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12
WY	1	1,000	9,999	7

[a]Post office state abbreviations used
[b]Amounts on site reported by facilities in each state
[c]Activities/Uses:

1. Produce
2. Import
3. Onsite use/processing
4. Sale/Distribution
5. Byproduct
6. Impurity
7. Reactant
8. Formulation Component
9. Article Component
10. Repackaging
11. Chemical Processing Aid
12. Manufacturing Aid
13. Ancillary/Other Uses
14. Process Impurity

Source: TRI05 2007 (Data are from 2005)

Table 5-4. Facilities that Produce, Process, or Use Aluminum Oxide (Fibrous Forms)

State[a]	Number of facilities	Minimum amount on site in pounds[b]	Maximum amount on site in pounds[b]	Activities and uses[c]
AK	2	10,000	999,999	10
AL	56	1,000	99,999,999	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13
AR	41	0	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
AZ	16	1,000	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13
CA	96	0	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
CO	13	100	9,999,999	2, 5, 7, 8, 10, 11, 12, 13
CT	35	0	99,999,999	2, 3, 4, 7, 8, 10, 11, 12
DE	5	10,000	9,999,999	6, 7, 8, 10
FL	24	1,000	9,999,999	1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
GA	59	0	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
HI	3	10,000	999,999	10, 12
IA	21	100	49,999,999	1, 2, 3, 4, 5, 7, 8, 11, 12
IL	89	0	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
IN	89	0	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
KS	25	100	9,999,999	1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12
KY	55	100	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
LA	47	0	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
MA	38	0	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
MD	22	1,000	499,999,999	1, 2, 3, 4, 5, 6, 7, 10, 11, 12, 13
ME	7	1,000	999,999	6, 7, 8, 11, 12
MI	67	0	999,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
MN	27	100	99,999,999	1, 2, 3, 5, 6, 7, 8, 10, 11, 12
MO	56	100	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
MS	22	1,000	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
MT	11	0	499,999,999	2, 3, 6, 10, 11, 12
NC	50	0	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
ND	4	1,000	9,999,999	7, 10
NE	10	1,000	999,999	2, 4, 8, 10, 11, 12, 13
NH	12	1,000	499,999,999	1, 2, 3, 4, 7, 8, 9, 11, 12
NJ	45	0	999,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
NM	6	1,000	999,999	7, 8, 10, 11, 12
NV	3	100	999,999	1, 5, 6, 8, 9, 10
NY	78	0	999,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
OH	145	0	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
OK	41	1,000	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13
OR	14	100	99,999,999	2, 3, 4, 6, 8, 10, 11, 12
PA	115	0	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
PR	9	100	9,999,999	2, 3, 7, 8, 10, 11, 12

Table 5-4. Facilities that Produce, Process, or Use Aluminum Oxide (Fibrous Forms)

State[a]	Number of facilities	Minimum amount on site in pounds[b]	Maximum amount on site in pounds[b]	Activities and uses[c]
RI	2	10,000	99,999	2, 3, 7
SC	42	0	999,999,999	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12
SD	4	1,000	99,999	5, 8, 11
TN	70	100	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
TX	103	0	999,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
UT	19	0	999,999,999	1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13
VA	30	0	9,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
VI	1	1,000,000	9,999,999	10
VT	6	1,000	99,999	8, 11, 12
WA	38	0	999,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
WI	43	100	499,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
WV	34	0	49,999,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
WY	5	10,000	999,999	6, 10, 11

[a]Post office state abbreviations used
[b]Amounts on site reported by facilities in each state
[c]Activities/Uses:

1. Produce
2. Import
3. Onsite use/processing
4. Sale/Distribution
5. Byproduct
6. Impurity
7. Reactant
8. Formulation Component
9. Article Component
10. Repackaging
11. Chemical Processing Aid
12. Manufacturing Aid
13. Ancillary/Other Uses
14. Process Impurity

Source: TRI05 2007 (Data are from 2005)

5.3 USE

In 2006, transportation accounted for an estimated 40% of domestic consumption of aluminum, predominantly as automotive applications, with the remainder used in packaging, 28%; building, 13%; consumer durables, 7%; electrical, 5%; and other, 7% (USGS 2007c).

Aluminum chloride, anhydrous form, is used as an acid catalyst (especially in Friedel-Crafts-type reactions), as a chemical intermediate for other aluminum compounds, in the cracking of petroleum, in the manufacture of rubbers and lubricants, and as an antiperspirant. The hexahydrate form is used in preserving wood, disinfecting stables and slaughterhouses, in deodorants and antiperspirants, in cosmetics as a topical astringent, in refining crude oil, dyeing fabrics, and manufacturing parchment paper (O'Neil et al. 2001).

Aluminum chlorohydrate is an ingredient in commercial antiperspirant and deodorant preparations and is also used for water purification and treatment of sewage and plant effluent (Lewis 2001)

Aluminum hydroxide (alumina trihydrate) is used as an adsorbent, emulsifier, ion-exchanger, mordant in dyeing, and filtering medium. It is also used in the manufacturing of glass, paper, ceramics and pottery, printing inks, lubricating compositions, detergents, in the waterproofing of fabrics, in antiperspirants, dentifrices, and as a vaccine adjuvant (Baylor et al. 2002; Lewis 2001; O'Neil et al. 2001). Aluminum hydroxide is used as a flame retardant in the interiors of automobiles, commercial upholstered furniture, draperies, wall coverings, and carpets (Subcommittee on Flame-Retardant Chemicals 2000). Aluminum hydroxide is used as an antacid (O'Neil et al. 2001). Finely divided (0.1–0.6 microns) aluminum hydroxide is used for rubber reinforcing agent, paper coating, filler, and cosmetics (Lewis 2001). Aluminum hydroxide is also used pharmaceutically, as an antihyperphosphatemic, to lower the plasma phosphorus levels of patients with renal failure (O'Neil et al. 2001).

Aluminum nitrate is used in textiles (mordant), leather tanning, the manufacturing of incandescent filaments, catalysts in petroleum refining, nucleonics, anticorrosion agent, nitrating agent, and antiperspirants (Lewis 2001; O'Neil et al. 2001).

In 2006, 96% of the bauxite consumed in the United States was refined to alumina (aluminum oxide), with the remaining 4% consumed in nonmetallurgical uses, such as abrasives, chemicals, and refactories. Of the total alumina used in the United States in 2006, approximately 87% was used for primary aluminum smelters and the remainder was used for nonmetallurgical uses, including abrasives, chemicals, refactories, and in specialty industries (USGS 2007a, 2007d). Other uses of aluminum oxide are in the manufacture of ceramics, electrical insulators, catalyst and catalyst supports, paper, spark plugs, crucibles and laboratory works, adsorbent for gases and water vapors, chromatographic analysis, fluxes, light bulbs, artificial gems, heat resistant fibers, food additive (dispersing agent), and in hollow-fiber membrane units used in water desalination, industrial ultrafiltration, and hemodialysis (HSDB 2007; Lewis 2001). Another application of aluminum oxide, which may have wide occupational use in the future, is as a dosimeter for measuring personnel radiation exposure (McKeever et al. 1995; Radiation Safety Guide 1999; Radiation Safety Newsletter 1998).

Aluminum phosphate is used in ceramics, dental cements, cosmetics, paints and varnishes, pharmaceuticals (antacid), and in paper and pulp industries (Lewis 2001; O'Neil et al. 2001). It is also used as a vaccine adjuvant (Baylor et al. 2002; Malakoff 2000). Aluminum phosphate, as basic sodium aluminum phosphate (SALP), is used as an emulsifying agent in pasteurized processed cheese, cheese food, and cheese spread. Acidic SALP is used as a leavening agent in cereal foods and related products, such as self-rising flour, prepared cake mixes, pancakes, waffles, and refrigerated or frozen dough or batter products (Chung 1992; Saiyed and Yokel 2005).

Aluminum phosphide is a fumigant used primarily for indoor fumigation of raw agricultural commodities, animal feeds, processed food commodities, and non-food commodities in sealed containers or structures to control insects, and for outdoor fumigation of burrows to control rodents and moles in nondomestic areas, noncropland, and agricultural areas. Aluminum phosphide reacts with the moisture in the atmosphere to produce phosphine gas, which is the substance that is active as a pesticide. Based on available pesticide survey usage information for 1987–1996, the estimated annual usage of aluminum phosphide is about 1.6 million pounds active ingredient. Major uses of aluminum phosphide include fumigation of wheat, peanuts, and stored corn. It was noted that usage estimates for aluminum phosphide are not precise due to scarcity of usage data sources for postharvest agriculture and non-agriculture uses/sites. All aluminum phosphide containing products have been classified as restricted use (EPA 1998). According to the National Pesticide Information Retrieval System, there are five active registrants for aluminum phosphide (NPIRS 2008).

Aluminum sulfate (alum) is used in leather tanning, sizing paper, as a mordent in dyeing, water purification, fireproofing and waterproofing of cloth, clarifying oils and fats, treating sewage, waterproofing concrete, deodorizing and decolorizing of petroleum, antiperspirants, and agricultural pesticide. It is also used as a food additive, a foaming agent in fire foams, and in the manufacturing of aluminum salts (Lewis 2001; O'Neil et al. 2001). Aluminum sulfate, as sodium aluminum sulfate, is a component of household baking powder (Chung 1992). Alum is also used as a vaccine adjuvant (Baylor et al. 2002; Malakoff 2000). Aluminum potassium sulfate (potash alum) is used in dyeing (mordant), paper, matches, paints, tanning agents, waterproofing agents, aluminum salts, food additives, baking powder, water purification, astringent, and cement hardener (Lewis 2001). Aluminum ammonium sulfate (ammonium alum) is used in dyeing (mordant), water and sewage purification, sizing paper, retanning leather, clarifying agent, food additive, the manufacture of lakes and pigments, and fur treatment (Lewis 2001).

Other aluminum compounds that are used as food additives include aluminum silicates (anticaking agents) and aluminum color additives (lakes) (Saiyed and Yokel 2005; Soni et al. 2001).

5.4 DISPOSAL

Production of finished aluminum products by industrial facilities typically results in the generation of very large amounts of solid aluminum hydroxide anodizing residues (Saunders 1988). These aluminum-anodizing residues are currently classified as nonhazardous under the Federal Resource Conservation and Recovery Act (RCRA) regulations. These residues are typically dewatered to reduce the volume of waste prior to being landfilled. However, the heavy metal content of these solid waste residues can be of concern, especially in production processes using two-step anodizing systems that employ solutions containing elevated heavy metal concentrations. For these types of plants, Saunders (1988) has proposed implementation of a caustic-etch recovery system that will limit both the volume of aluminum-anodizing residue and the heavy metal content of the residue. Additional information on regulations and standards for aluminum and aluminum compounds is summarized in Chapter 8.

Approximately 24.7×10^6 and 1.15×10^5 pounds of aluminum (fume or dust) and aluminum oxide (fibrous forms) were reported for on-site disposal and other releases in 2004. On-site disposal or other releases include emissions to the air, discharges to bodies of water, disposal at the facility to land, and disposal in underground injection wells. Approximately 23.7×10^6 and 1.20×10^6 pounds of aluminum (fume or dust) and aluminum oxide (fibrous forms), respectively, were reported for off-site disposal and other releases in 2004. An off-site disposal or other release is a discharge of a toxic chemical to the environment that occurs as a result of a facility's transferring a waste containing a TRI chemical off-site for disposal or other release (TRI04 2006). The TRI data should be used with caution because only certain types of facilities are required to report (EPA 2005). This is not an exhaustive list.

In the United States, about 3 million metric tons of aluminum was recovered from purchased scrap in 2006, with 64% of this coming from new (manufacturing) scrap and 36% from old scrap (discarded aluminum products). Aluminum used beverage cans accounted for about 54% of the reported old scrap consumption in 2006. According to the Aluminum Association, Inc., the recycling rate for used aluminum beverage cans in 2004 was 51.6% (USGS 2007b, 2007c).