

Aluminum Production

Aluminum is produced by aluminum ore refining and reduction (*primary production*) or from recycling aluminum (*secondary production*). The U.S. aluminum industry is the world's largest, producing 7.5 million tons in 1996. Aluminum production in the U.S is approximately 52% primary aluminum and 48% secondary aluminum. In 1996, 62.8 billion aluminum cans were recycled in the U.S. The Pacific Northwest aluminum facilities carry 38.6% of the U.S. primary aluminum capacity and have the ability to produce 1.8 million tons of aluminum. The largest markets for aluminum are transportation, packaging (beverage cans), and infrastructure. (Aluminum Association, Inc., 1997)

In Washington, primary aluminum production facilities are one of the largest producers of toxic emissions. There are currently seven primary aluminum production facilities and one secondary aluminum production facility in Washington. The largest toxic emissions from primary aluminum production are from fluorides and polycyclic organic matter. The largest toxic emissions from secondary aluminum production are chlorine and hydrogen chloride.

Primary Aluminum

Primary aluminum production encompasses two processes:

- I. Refining: grinding and handling of the bauxite ore
- II. Reduction: aluminum is removed from crystalline alumina

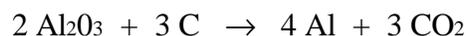
The refining process produces mainly particulate emissions and controls are used to recover much of this valuable dust. Since there are no refining processes in Washington and emissions are low and mostly comprised of particulate matter, the refining process will not be included in this report. If needed, more information can be found in *AP-42*¹.

The rest of this section will focus on the reduction process.

Description of Process

The aluminum enters the reduction process as crystalline alumina (Al_2O_3) from the refining process. To produce aluminum metal the alumina is electrolytically reduced using the Hall-Heroult Process.

Reduction occurs by reacting the alumina with carbon, as in the following reaction:



The carbon is in the form of an anode (negatively charged) which is continuously depleted. The *pots* (shallow rectangular steel shells) are also lined with carbon, which is positively charged and

¹ U.S. Environmental Protection Agency, *Compilation of Air Pollutant Emissions Factors Volume 1: Stationary Point and Area Sources*, Fifth Edition with Supplements, October 1997, Document No. AP-42.

acts as a cathode where the molten aluminum is deposited. Molten cryolite is used as the electrolyte and also as a solvent.

The molten aluminum is tapped from the cathode every 24 - 48 hours using a vacuum siphon and is sent to a reverberatory holding furnace where it is alloyed, fluxed, and degassed to remove trace impurities. There are many different methods used to accomplish this. One method is to add chloride and fluoride salts and then bubble chlorine gas through the molten aluminum. The impurities will react with the chlorine to form hydrogen chloride, aluminum oxide, and metal chlorine emissions.

There are three types of aluminum reduction cells: the prebaked anode cell, and the horizontal and vertical stud Soderberg anode cell (HSS and VSS). All these cells are prepared with petroleum coke mixed with pitch binder to make a paste. The coke is crushed, ground, and screened before being mixed with the pitch binder in a steam jacketed mixer. The paste is added directly to the anode casings of the Soderberg cells, but in the prebaked anode cells it is then baked in a direct-fired ring furnace or an indirectly-heated Reid Hammer furnace. The prebaked anode cells are most common because they are more efficient electrically and they emit fewer organic compounds. There are four pre-baked, two HSS and one VSS facility in Washington.

Methods of Determining Emissions

The most common toxic emissions from potlines are fluorides (especially hydrogen fluoride) and polycyclic organic matter. There is little information available to estimate toxic emissions from aluminum facilities. There are emissions factors available from *AP-42* for gaseous and particulate fluorides for all emission points, as well as for different control scenarios.

A wet scrubber (or a combination of wet scrubbers) is typically used to control gaseous and particulate fluorides as well as particulate matter in all cell types and anode bake furnaces. Additional control devices for particulate matter are wet or dry electrostatic precipitators, multiple cyclones, or dry alumina scrubbers. Gaseous and particulate fluoride can also be controlled by a fluoride adsorption system, which consists of a fluidized alumina bed and filter. The emission stream is passed through the crystalline alumina and then through a filter to catch the entrained alumina dust. The alumina is then recycled back to the potlines. This process has an overall control efficiency of 99%. (*AP-42*). Typical control devices used in Washington facilities are alumina scrubbers, fabric filters, and wet scrubbers.

On October 7, 1997, EPA adopted MACT for primary aluminum production plants. Sources will have between 2 and 4 years to come into compliance with the provisions of the MACT. (New or reconstructed sources are subject to MACT provisions upon startup.) Emissions estimations made after MACT has become effective should be sure to take emissions limitations due to MACT into account. The MACT provisions are found in Part 63, Subpart LL, sections 63.840 - 63.859 of the Code of Federal Regulations.

Secondary Aluminum Production

The process of retrieving aluminum from recycled materials, rather than refining it from bauxite ore, is becoming increasingly popular, especially since the automobile industry has increased its use of aluminum. Producing one ton of aluminum from recycled materials takes 5% of the energy required to refine a ton of aluminum from bauxite ore. (AP-42)

Secondary aluminum production consists of two basic processes:

- I. Scrap Pretreatment: sorting and cleaning of scraps
- II. Smelting/Refining: cleaning, melting, refining, and alloying of aluminum

The process differs for each facility. Plants can have a combination of the processes described here and in a different order, depending on the source of aluminum.

Description of Process

First the scrap is sorted and processed to remove unwanted material such as other metals and plastics. The aluminum metal is then cleaned to remove contaminants by one of these methods: mechanical, pyrometallurgical (heat) or hydrometallurgical (water) cleaning.

The aluminum scraps are then heated and melted in a furnace. Primarily, this is a batch process and is done in a reverberatory furnace. A reverberatory furnace is brick-lined and has a curved roof in which the heat is reflected (reverberated). Other furnaces can be used to hold the melted aluminum and for other processes. The aluminum can go through processes to remove impurities, reduce magnesium content, and combine aluminum with other metals to create an alloy. One process that could potentially produce a lot of toxic emissions is the demagging process. The demagging process involves reducing the magnesium content, and occurs when chlorine and fluorine are injected under pressure into the molten aluminum.

More detailed information on the processes involved in secondary aluminum production can be found in AP-42.

Methods of Determining Emissions

There are no emission factors currently available in AP-42 for toxic emissions from secondary aluminum production.

Emissions from the smelting and refining process can be controlled by fabric filters (baghouses) or electrostatic precipitators. (AP-42)

The MACT requirements for secondary aluminum are scheduled to be adopted in 2000.

References

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U.S. Environmental Protection Agency, *Compilation of Air Pollutant Emissions Factors Volume I: Stationary Point and Area Sources*, Fifth Edition with Supplements, January 1995, Document No. AP-42. (Section 12.1, Primary Aluminum Production, October 1986)
(available by section on Internet at <http://www.epa.gov/ttn/chief/ap42.html>)

Washington State Department of Ecology, *Facility/Site on the Web*, accessed 1/20/98.
(<http://www.wa.gov/ecology/iss/fsweb/fshome.html>)

Other Resources that may be of Interest

Books

World Aluminum Capacity Handbook

Periodicals

Metal Bulletin

Light Age Metal

Mining Journal

Aluminum Statistical Review

Web-Sites

Aluminum Association, Inc. <http://www.aluminum.org/>

American Metal Market (AMM) <http://www.amm.com/index.htm>

EnvironSense (EPA) <http://es.inel.gov/>

Recycling Spent Potliner from Aluminum Smelters <http://es.inel.gov/studies/spent-d.html>

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Report/Case Studies

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