At Kennecott, sustainable development is integral to our survival as a mining, smelting and refining company. It is essential to delivering value on the social and financial investment our stakeholders and surrounding communities have made in us.

This Sulfuric Acid Environmental Profile is intended to inform our stakeholders of our Life Cycle Assessment efforts for sulfuric acid from Kennecott’s flash converting, flash smelting copper smelter. A more detailed Profile can also be obtained to help our customers to better understand the environmental impacts of their products or services when conducting their own life cycle studies.

“We are going to get to a point where everything we do is driven by sustainable development.”

Bill Champion, President & CEO, Kennecott Utah Copper Corporation

Cover Photo: A key component in fertilizers and pesticides, sulfuric acid is vital to our nation’s agricultural industry and also is used with corn starch to manufacture biodegradable synthetic polymers for food packaging, carpet and even clothing.
What is Sulfuric Acid?

Sulfuric acid is a corrosive, clear, colorless, odorless, oily liquid that is the largest-volume industrial chemical produced in the world and is the most commonly used strong acid. Sulfuric acid plays some part in the production of nearly all manufactured goods.

Kennecott Utah Copper produces about one million tons (907 ktonnes) of sulfuric acid (H₂SO₄) each year as a byproduct of the smelting process. Salable sulfuric acid products are 93% and 98% sulfuric acid. Delivery is made in 100-ton (91-tonne) capacity rail cars and 24-ton (22-tonne) or 35-ton (32-tonne) capacity trucks to customers throughout the United States.

Customers include gold, copper, uranium, and beryllium metal producers, fertilizer producers, chemical manufacturers, power plants, steel companies, farmers, and companies involved in water treatment.

How is it Produced?

Many of the world’s most important metal ore bodies are sulfides – that is, mineral compounds that contain sulfur. The Bingham Canyon Mine contains veins of copper sulfide, so the ore extracted contains sulfur, which needs to be separated from the copper.

Ore from the mine is upgraded using a flotation process to produce copper concentrate. The copper concentrate entering the smelter is about one-third copper, one-third iron, and one-third sulfur, with other trace minerals. The smelting process breaks the elements apart and the sulfur is driven off as sulfur dioxide gas. Early in the 20th century, most of that gas went up the smokestack. Smelters started capturing some of the sulfur in the 1920s. By 1990, Kennecott’s acid plants recovered about 93% of the sulfur.

Kennecott’s new smelter – the cleanest in the world – is designed to capture 99.9% of the sulfur dioxide emissions produced. Once the sulfur dioxide gas is cleaned, it is piped to the double contact acid plant where the sulfur dioxide is converted to sulfuric acid. In this way, the acid plant acts as a pollution control device that also produces a high-quality commercial product.

Sulfuric acid is a highly corrosive material, and strict safety guidelines must be followed for handling, storing, and working with sulfuric acid.

<table>
<thead>
<tr>
<th>2004 KENNECOTT UTAH COPPER PRODUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
</tr>
<tr>
<td>246,700 metric tonnes</td>
</tr>
<tr>
<td>Gold</td>
</tr>
<tr>
<td>300,000 troy ounces</td>
</tr>
<tr>
<td>Silver</td>
</tr>
<tr>
<td>3,344,000 troy ounces</td>
</tr>
<tr>
<td>Molybdenum</td>
</tr>
<tr>
<td>6,788 metric tonnes</td>
</tr>
<tr>
<td>Sulfuric Acid</td>
</tr>
<tr>
<td>869,196 metric tonnes</td>
</tr>
</tbody>
</table>

Figure 1 – Process Flow – Mining to Refining
Life Cycle Assessment

Life Cycle Assessment (LCA) studies involve the collection, assessment and interpretation of data from an environmental perspective over a product’s life cycle (production, use, and end-of-life). Studies can evaluate:

- the entire product life cycle, often referred to as cradle-to-grave or cradle-to-cradle studies, or
- parts of a product life cycle, referred to as cradle-to-gate or gate-to-gate studies.

This profile covers a cradle to gate LCA of Kennecott’s Sulfuric Acid.

Goal and Scope

This project included a complete cradle to gate LCA study for copper cathode, molybdenum oxide and sulfuric acid, consistent with ISO 14040 series LCA standards.1 The functional unit for the study was 1000kg of each product produced. Data gathered for the study represents operations at Kennecott’s facilities from July 2002 to June 2003.

The study was undertaken for internal use by Kennecott and for communication in a confidential, aggregated manner to select customers and LCA database providers.

The purpose of the project was to assess the environmental performance of Kennecott’s operations and products. The analysis examined how the results for copper, molybdenum and sulfuric acid contribute to environmental inputs and outputs such as water and hazardous waste as well as indicators such as smog, acid rain, energy, and greenhouse gases from a cradle to gate perspective. The results can be used to enhance communication with clients as well as process improvement and scenario analysis.

A key step in LCA is the Life Cycle Inventory or LCI

Depending on the goal and scope definition, data may be collected first-hand from measurements and estimates of key activities, or the data will be based on information drawn from existing LCA databases. At Kennecott, the majority of inventory data is collected on-site and modeled using GaBi 4.0™ LCA software. Data included or excluded from the study is dependent on the system boundaries identified during the goal and scope definition. The LCA system boundaries for the study are described in Table 1 and Figure 3.

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The ISO 14040 methodology recognizes the need to perform an allocation in certain circumstances. An allocation was performed in the smelter model in order to allocate input and outputs to the sulfuric acid profile. To do so, a method published in a recent book written by Ian Boustead⁵, was utilized for co-product allocation. Boustead provides specific guidance for addressing “co-products,” such as sulfuric acid produced from pollution control equipment at the smelter.

A critical review, or independent verification, was not carried out for this study given the goal definition outlined above and the requirements of ISO 14040. However, internal reviews were carried out by project team members at both Kennecott and Five Winds International. The Five Winds International reviewers included Dr. Konrad Saur and Dr. Jim Fava, internationally recognized experts in the field of LCA.

The sections on the following pages provide an overview of the LCIA results for the production of 1000kg of sulfuric acid at Kennecott’s facilities near Salt Lake City, Utah.

Table 1 – LCA SYSTEM BOUNDARY

<table>
<thead>
<tr>
<th>INCLUDED</th>
<th>EXCLUDED</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Ore and overburden mining</td>
<td>• Capital equipment and maintenance, with the exception of mining equipment</td>
</tr>
<tr>
<td>• Maintenance and operation of mining equipment</td>
<td>• Overhead (heating, lighting) of off-site administrative facilities</td>
</tr>
<tr>
<td>• Internal transportation of materials</td>
<td></td>
</tr>
<tr>
<td>• Extraction, beneficiation and processing of materials</td>
<td></td>
</tr>
<tr>
<td>• Manufacture of raw and processing materials*</td>
<td>• Transportation of finished product from the Kennecott site</td>
</tr>
<tr>
<td>• Transportation of raw and processing materials to Kennecott</td>
<td></td>
</tr>
<tr>
<td>• Packaging of products</td>
<td></td>
</tr>
<tr>
<td>• Manufacture and transport of packaging materials for sulfuric acid</td>
<td></td>
</tr>
<tr>
<td>• On and off-site power generation</td>
<td></td>
</tr>
<tr>
<td>• On and off-site waste management and disposal</td>
<td></td>
</tr>
<tr>
<td>• Overhead (heating, lighting) of on-site administrative and manufacturing facilities</td>
<td></td>
</tr>
</tbody>
</table>

*LCI data was included for process materials from the GaBi 4 Software database.

Life Cycle Impact Assessment

Estimates for potential environmental impacts are organized under four main impact categories (shown below in Table 2). These impact categories were selected based on:

- the geographical location of Kennecott’s operations, or
- issues Kennecott currently addresses either through its internal reporting or its Environmental Management System.

Kennecott uses LCIA to determine the contribution of life cycle stages, groups of processes or individual processes to the results of the inventory and impact assessment. This process helps to pinpoint “hot spots” in the inventory or impact assessment results, as described in the analysis below.

<table>
<thead>
<tr>
<th>IMPACT CATEGORY</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Energy Demand</td>
<td>A measure of the total amount of primary energy extracted from the earth, including petroleum, hydropower and other sources, taking into account the efficiency of electric power and heating processes.</td>
</tr>
<tr>
<td>Greenhouse Gas Emissions</td>
<td>A measure of emissions of greenhouse gases, calculated using the IPCC 1996 Global Warming Potential Index (GWP100).</td>
</tr>
<tr>
<td>Acidification Potential</td>
<td>A measure of emissions to air known to contribute to atmospheric acid deposition (acid rain).</td>
</tr>
<tr>
<td>Photochemical Oxidant Potential</td>
<td>A measure of emissions of precursors that contribute to low level smog, produced by the reaction of nitrogen oxides and VOCs under the influence of UV light.</td>
</tr>
</tbody>
</table>
Primary Energy Demand (PED)

![Pie chart for PED](image)

Figure 4: Breakdown of PED by process for sulfuric acid production

The majority of PED in the sulfuric acid production process results from electricity production.

Greenhouse Gas Emissions (GHG)

![Pie chart for GHG](image)

Figure 5: Breakdown of GHG by process for sulfuric acid production

The majority of greenhouse gases generated as a result of sulfuric acid production result from combustion of fossil fuels to generate electricity.

Photochemical Oxidant Creation Potential (POCP)

![Pie chart for POCP](image)

Figure 6: Breakdown of POCP by process for sulfuric acid production

The majority of the POCP generated in the sulfuric acid system is a result of electricity production. This results from combustion of fossil fuels to generate electricity.

Acidification Potential (AP)

![Pie chart for AP](image)

Figure 7: Breakdown of AP to produce sulfuric acid

The AP emissions resulting from sulfuric acid production are a result of the acid production process itself. This is a result of the SOx emissions remaining after capture.

Conclusion

LCA provides Kennecott with a new, systematic method for evaluating and communicating the environmental aspects of its products and processes. It can help the company ensure that a change made in one of its processes will not result in an increase elsewhere. It also provides Kennecott with a way to benchmark the performance of its products from a sustainable development perspective. Finally, LCA provides Kennecott a broader view of how its products impact the world, both positively and negatively.
Disclaimer: The data reported in this Sulfuric Acid Environmental Profile includes off-site impacts as appropriate for LCA. Consequently, the inclusion of such aspects must be considered when comparing the information included in this Profile to other reported data from Kennecott’s operations that do not include off-site life cycle impacts. For more information, please see Table 1 – LCA SYSTEM BOUNDARY on page 3 of this Profile.

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