Life Cycle Inventory of Molybdenum Chemicals

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Executive Summary

IMOA®

INTERNATIONAL MOLYBDENUM ASSOCIATION

Prepared for:

International Molybdenum Association

Rue Père Eudore Devroye 245

1150 Brussels

BELGIUM

Tel: +32 2 770 8878

E-mail: info@imoa.info

Web: www.imoa.info

By:

First Environment, Inc.

91 Fulton Street

Boonton, NJ 07005, USA

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Introduction

Life Cycle Assessment (LCA) has become one of the most valuable environmental tools for assessing the environmental footprint of a product or process. LCA provides quantitative and scientific analyses of the environmental impacts of products and their associated industrial systems. In quantifying environmental inputs and outputs over each stage of the life of a product, LCA offers valuable information on the product's value chain and helps to identify positive attributes and potential areas of weakness of a product.

Over the past 10 years, the non-ferrous and ferrous metals industries have adopted LCA as an environmental tool of choice to supply environmental information to customers, help identify areas for process improvement, and measure environmental performance. As part of this effort, in 2000, the International Molybdenum Association (IMOA) performed a worldwide Life Cycle Inventory (LCI) study on intermediate molybdenum products ("Metallurgical Study"). In 2004, IMOA commissioned an LCI study on eight molybdenum chemicals.

There is an ever-increasing demand for environmental LCA-related information within all industrial sectors. The building and construction industry, which includes the vast array of materials, products, and industries pertaining to the built environment, is embracing LCA as a means to finding green solutions and improvements for new and existing buildings. Materials suppliers use LCA to highlight positive environmental attributes of their products in buildings, and builders and designers are choosing materials based on these environmental attributes.

Outside the building sector, global companies as part of their sustainable and environmental programs are increasingly asking their suppliers for environmental information that often requires LCAs. On the demand side, consumers and purchasers are using environmental criteria to make their purchasing decisions. LCA is also required in some government purchasing programs; for example, the U.S. federal government is requiring product LCAs to be performed on biobased products under its Federal Preferred Procurement program. In short, environmental information based on LCA is becoming more the norm than the exception.

Goal

The aim of this study was to provide the Molybdenum Industry with LCIs of eight molybdenum chemicals, using current, robust data on the production of molybdenum chemicals. The products studied include:

- Ammonium Dimolybdate
- Ammonium Heptamolybdate
- Sodium Molybdate Dihydrate
- Pure Molybdenum Trioxide (Chemical)
- Pure Molybdenum Trioxide (Sublimed)
- Molybdenum Disulphide (flotation)
- Ammonium Octamolybdate
- Polymolybdate

The LCIs are cradle-to-gate, encompassing the processes that include extracting resources from the earth through the point at which the chemicals are ready for shipment to customers. The LCI is based on current data on process technologies, energy and materials consumed, and environmental outputs. The study results may later be used in the evaluation of potential impacts associated with molybdenum chemical production, using the LCI results and appropriate methodologies, such as the ISO 14042 standards on Life Cycle Impact Assessment.

Drawing on the Metallurgical Study for a major component of molybdenum chemical production, this current study will supply IMOA with robust LCI and other environmental information to provide to interested parties on molybdenum chemicals and can be used as the basis for chemical industry benchmarking and environmental improvement programs.

The geographical scope of the study is worldwide production of molybdenum chemicals excluding those produced in China, Mongolia, and CIS (former USSR).

This project adheres to the LCA guidelines summarised in the International Standardisation Organisation (ISO) 14040 series of standards, which are acknowledged by the main practitioners in the world to be the most accepted standards for performing LCA. The requirements of this study are summarised in the following:

- ISO 14040:1997(E), the International Standard of the International Standardisation Organisation, Environmental management – Life cycle assessment – Principles and framework; and

- ISO 14041:1998(E), the International Standard of the International Standardisation Organisation, Environmental management – Life cycle assessment – Goal and scope definition and inventory analysis.

This study aims to meet the essential requirements formalised by these ISO Standards. Specifically:

- The project aims at taking an inventory of the environmental inflows and outflows associated with the cradle-to-gate production of a product;

- The goal and scope of the project are precisely defined at the beginning of the project;

- Assumptions are clearly stated, and the methodology is as transparent as allowed with protection of confidential data. System boundaries, functional unit, and allocation rules are rigorously defined and described;

- Pertinent data are collected and their quality is rigorously assessed; and

- Reporting requirements are stated.

First Environment worked to ensure that the major LCI-related methodological decisions (allocations rules, etc.) were consistent with the EUROFER and other stainless steel-related LCI studies to the extent that the confidentiality of all studies has been respected.

This LCI will be the most comprehensive, current record of environmental inflows and outflows associated with the production of molybdenum chemicals. However, it should be borne in mind that LCA, like any other scientific/quantitative study, is a far from perfect tool. There is inherently some margin of error due to various limitations such as imperfections of data and unavailability of some relevant data.

Scope and Methodology

LCA is an analytical tool used to comprehensively quantify and interpret the environmental flows (to and from the environment, including air emissions, water effluents, solid waste, and the consumption/depletion of energy and other resources), over the entire life cycle of a product or process. In LCA, the system boundaries for the product or process are expanded to encompass the entire life cycle, which includes production and extraction of raw materials, manufacturing of intermediate products, transportation, distribution, use, and a final "end-of-life" stage which often includes multiple parallel paths such as recycling, incineration, landfilling, etc.

An LCA involves three main phases according to ISO 14040:1997(E), Section 3:

1. Life Cycle Inventory (LCI), the "phase of the LCA involving the compilation and quantification of inputs and outputs, for a given product system throughout its life cycle." This phase includes:

- defining the project system boundaries as specified by the goal and scope of the project (i.e., defining which steps are included in the system and which are not);
- collecting data required for each step included in the system;
- calculating the final inventory.

2. Life Cycle Impact Assessment (LCIA) is the part of the LCA "aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts of a product system." The LCIA stage involves categorising inventory flows and characterising those flows according to their overall impact to the category, and examples include global warming potential, natural resources depletion, and eutrophication potential. LCIA was not included in this study.

3. Life Cycle Interpretation is the LCA stage in which the "findings of either the inventory analysis or the impact assessment, or both, are combined in line with the defined goal and scope in order to reach conclusions and recommendations." Examples of life cycle interpretation include contribution analyses and scenario analyses, both of which are used to help understand the results of this study.

ISO's representation of LCA actually identifies a process preceding the inventory analysis phase, Goal and Scope Definition. Individualising Goal and Scope Definition as a separate stage was specially intended as a reminder that the key project objective parameters should be carefully established and clearly stated at the outset of an LCA, and that they guide the subsequent stages. All stages of an LCA should be scoped by the particular use or uses for which the study is intended, and that use of the results may entail some results interpretation.

Data for eight molybdenum chemicals were collected from facilities in six countries worldwide and represents 90% of worldwide production, excluding China, Mongolia, and CIS.

Companies in Europe and the Americas were well represented, and a typical range of operating configurations were included and averaged on a weighted basis.

Data from facilities around the world were collected to represent the industries producing molybdenum chemicals. Aggregation of production data included rigorous data checks; application of methodological rules that adhered to the ISO 14040 set of standards; calculation of weighted averages of facility data; and reporting of statistical information for each LCI flow monitored. LCI models were built in an LCA software, utilizing the Metallurgical Study outputs as inputs to the chemical processes.

Results

The LCI results provide average cradle-to-gate data for the defined set of energy and material inputs, air emissions, water effluents and solid wastes for each of the eight molybdenum products studied.

The data included in the study represents cumulatively 90% of the molybdenum chemicals produced in the world, excluding China, Mongolia, and CIS. The cut-off criteria of 99.5% of the mass of inputs was exceeded.

This level of coverage, coupled with robust upstream input data on intermediate molybdenum products, makes IMOA□s chemical LCI study one of the most representative LCI studies carried out for these chemicals and provides a sound basis for LCA studies related to molybdenum chemicals.

IMOA proposes to review and update the LCI data on a regular basis to take account of expanding and improved monitoring procedures. Where possible this review will include the broadening of the geographical coverage and number of participating companies.

Availability of Data

Applications for LCI chemical data are to be made through IMOA, which will designate an LCI manager from one of the participating companies according to geographical location, to liaise with the applicant.

The normal procedure is to complete a questionnaire describing the intended application of the data and to discuss this with that LCI Manager. This will help to ensure that the IMOA methodology and results can be applied appropriately and will be compatible with the goals of the study.

Conclusions

The IMOA chemical LCI study has generated a rigorous and representative database on molybdenum chemicals. With an understanding of the limitations of the study, the results can be used to assist decision-making and for evaluating the performance of molybdenum products through their life cycle (i.e., through use and end-of-life) in the context of sustainable development and practices.

The results also provide the opportunity for participating companies to benchmark and evaluate improvement measures to their processes and product systems.

Industry expertise has been enhanced by involvement in the study and the industry is now better equipped to provide technical support to customers and users of molybdenum chemicals on LCA issues.

A programme has been launched to keep the database current and further enhance the methodology and understanding of the study. Recommendations for improvement concerning both the documentation and the data will be welcome.

For LCA to be used as a reliable tool for decision-making, high quality data, sound methodology and transparent reporting are essential. This study is a major step towards enhancement of these standards and the molybdenum industry intends to continue and encourage this trend in its future programme of work.