NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Gravity Separation

Reference Flow: 1 kg of Rare earth concentrate

Brief Description: Mined crude ore to rare earth concentrate gravity separation process for Mountain Pass, CA

Section I: Meta Data

Geographical Coverage: United States **Region:** Mountain Pass, CA

Year Data Best Represents: 2010

Process Type: Energy Conversion (EC)

Process Scope: Gate-to-Gate Process (GG)

Allocation Applied: No

Completeness: All Relevant Flows Captured

Flows Aggregated in Data Set:

☑ Process ☑ Energy Use ☐ Energy P&D ☐ Material P&D

Relevant Output Flows Included in Data Set:

Releases to Air:	☐ Greenhouse Gases	☐ Criteria Air	☐ Other
Releases to Water:	☐ Inorganic	☐ Organic Emissions	☐ Other
Water Usage:	☐ Water Consumption	☐ Water Demand (throughput)	
Releases to Soil:	☐ Inorganic Releases	☐ Organic Releases	☐ Other

Adjustable Process Parameters:

Recovery_rate	*[kg/kg] kg of recovered REO per kg of REO input*
REO_crude	*[kg/kg] kg of REO equivalent per kg of crude ore inpu*
REO_product	*[kg/kg] kg REO-equivalent in product per kg of rare earth concentrate*
Slurry_solids	*[m³/m³] m³ of solids per m³ of slurry*

Motor_factor	*[kWh/m^3] Motor energy requirements for slurry*
water_recover	*[kg/kg] kg of water recycled from process per kg of water into the separator*

Tracked Input Flows:

Crude ore feed [Intermediate products]	*[Technosphere]*
Water (unspecified) [Water]	*[Resource]*
Electricity [Electric power]	*[Technosphere]*

Tracked Output Flows:

Rare earth concentrate [intermediate product]	*Reference flow*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage1_O_Gravity_Separation_2014.01.xlsx*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

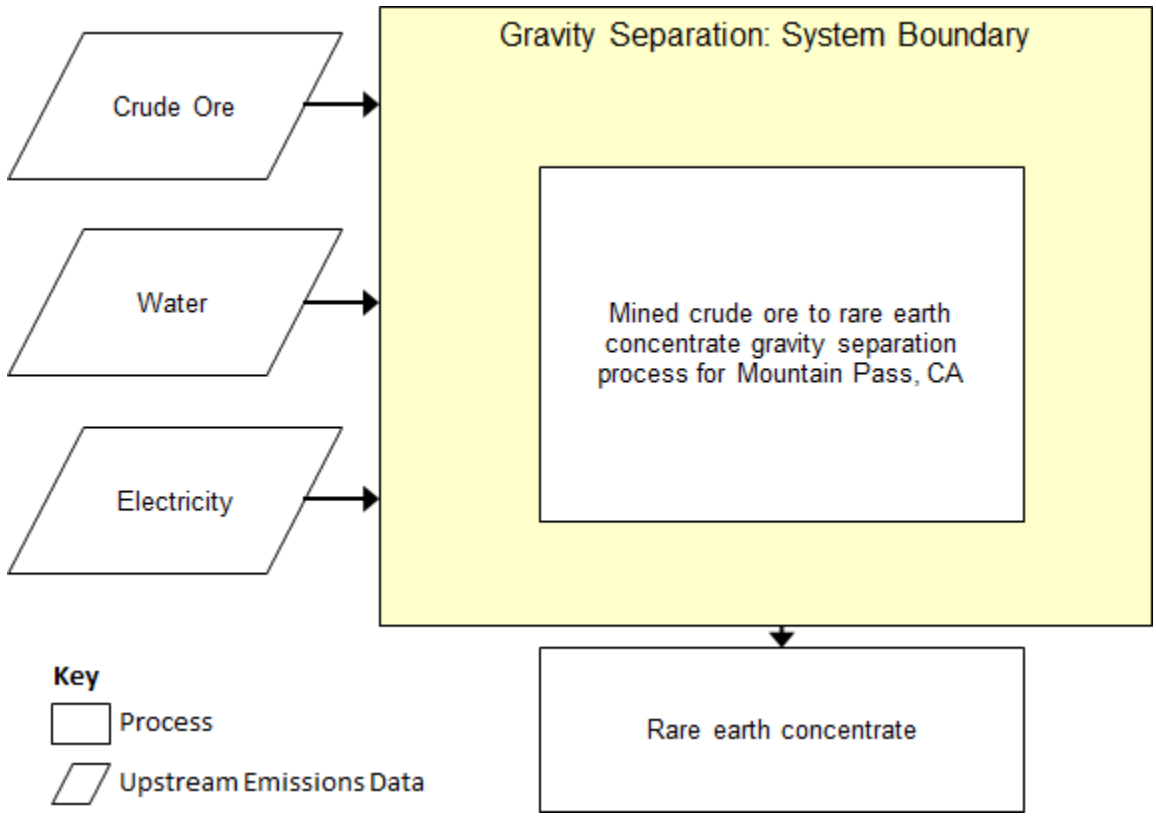
This unit process provides a summary of relevant input and output flows associated with the conversion of mined crude ore to rare earth concentrate via gravity separation. The reference flow of this unit process is: 1 kg of rare earth concentrate.

Boundary and Description

Rare earth concentrate recovery from crude ore by gravity separation is a less commonly utilized beneficiation process for rare earth oxide production. Nevertheless, Falcon Concentrators are used in rare earth extraction subsequent to the milling stage. This unit process is based on Falcon Continuous© Concentrators, which can pull high mass recoveries for mineral recovery by gravity (Sepro Mineral Systems 2013). Crushed and milled bastnaesite crude ore, which contains gangue minerals barite, calcite, strontianite, and quartz (Gupa & Krishnamurthy 2004), is made into a slurry and fed

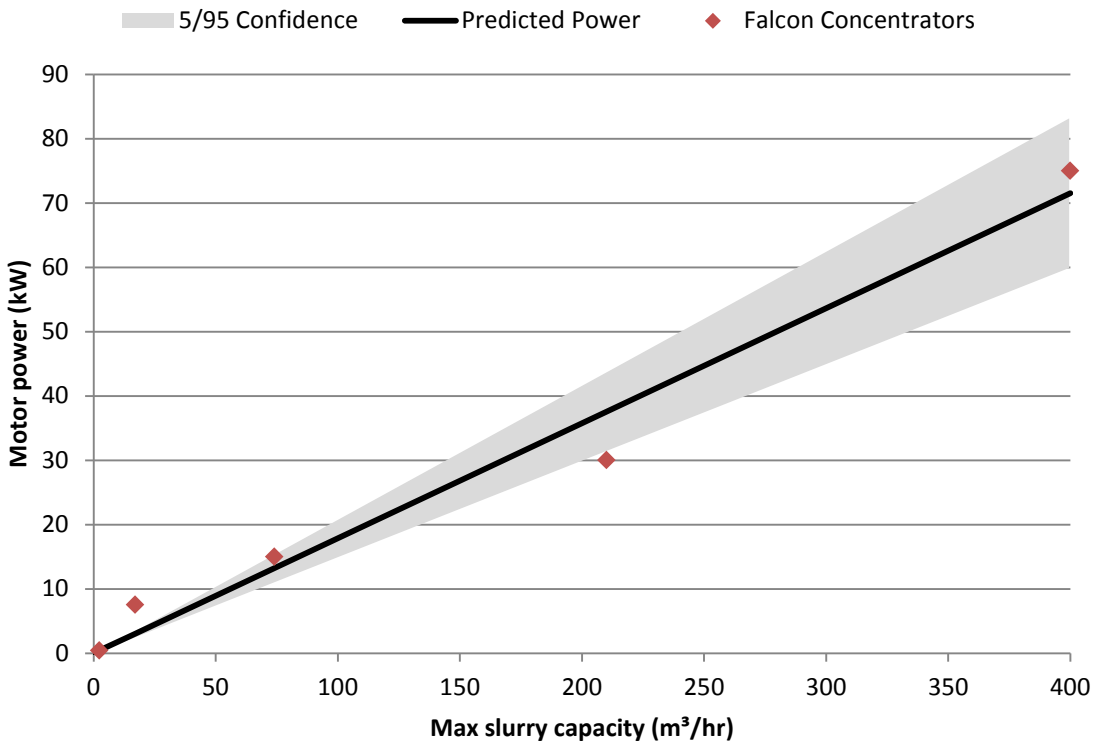
into a rotating bowl that is spun at 300 Gs (2,942 m/s^2). The gravitational or centrifugal force separates the bastnaesite from the gangue due to differences in density. This process assumes a 20% recovery rate (0% and 40% minimum and maximum, respectively) (Sepro Mineral Systems 2013, NETL) and a rare earth oxide equivalent content of 7% in crude ore (Pradip, Fuerstenau D.W. 2013). **Figure 1** shows the boundaries for this unit process. **Table 1** shows the parameters utilized in developing the unit process for rare earth concentrate recovery from crude ore via gravity separation.

Figure 1: Unit Process Scope and Boundary



The electricity use factor was calculated by performing a regression analysis for motor power versus volumetric flow rates for the different models of Falcon concentrators. To calculate the electricity required, the electricity use factor is multiplied by the slurry volumetric flow rate for 1 kg of rare earth concentrate. The minimum and maximum values provided on the data summary sheet are based on a 5/95 percent confidence interval. **Figure 2** shows a graphical representation of the regression analysis results.

Figure 2: Regression Analysis Results



Water input to the process is based on the amount of water required to create the correct percent solids for the slurry. The delivered product is assumed to be de-watered or dried. Without specific data for the amount of water that can be recycled after separation, the "water_recover" parameter is provided and assigned a default value of 0.95 kg water recovered for every 1 kg of water into the process.

Table 1: Parameters for Gravity Separation Calculations

Parameter	Value	Max/Min	Unit	Reference
REO content in crude ore	7.0	N/A	%	Pradip, Fuerstenau D.W. 2013
Recovery rate	20.0	40.0/0.0	%	Sepro Mineral Systems 2013, NETL
Density of crude ore	3.586E+03	N/A	kg/m^3	Braun *et al.* 2010, Ralph & Chau 2013
Slurry feed percent solids	42.5	45.0/40.0	%	Sepro Mineral Systems 2013

Table 2: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)
Inputs		
Crude ore feed [intermediate products]	5.14E+01	kg
Water (unspecified) [resource]	1.94E+01	kg
Electricity [electric power]	6.04E-03	kWh
Outputs		
Rare earth concentrate [intermediate product]	1.000E+00	kg
Water [Water]	1.84E+01	kg

* **Bold face** clarifies that the value shown *does not* include upstream environmental flows.

Embedded Unit Processes

None.

References

Braun *et al.* 2010 — Braun T., Swanson B., Volk J. (2010). Engineering Study for Re-Start of the Mountain Pass Rare Earth Element Mine and Processing Facility Mountain Pass, California. SRK Consulting. Lakewood, CO.

Pradip, Fuerstenau D.W. 2013 — Pradip, Fuerstenau D.W. (2013). Design and development of novel flotation reagents for the beneficiation of Mountain Pass rare-earth ore. Minerals and Metallurgical Processing. Vol. 30, No. 1, pp. 1-9Sepro Mineral Systems 2013

Sepro Mineral Systems (2013). Falcon 'C' Continuous Gravity Concentrators. Sepro Mineral Systems Corp. Langley, British Columbia, Canada. http://www.seprosystems.com/falcon-c-gravity-concentrators-specifications

Ralph & Chau 2013 — Ralph J., Chau I. (2013). Mindat Advanced Search. Mindat. http://www.mindat.org/advanced_search.php

Section III: Document Control Information

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