NETL Life Cycle Inventory Data
Process Documentation File

Process Name:	Brine Chlor-alkali Processing
Reference Flow:	1 kg of Brine Wastewater
Brief Description:	This process captures the inputs and outputs for chlor-alkali processing of brine wastewater from solvent extraction of rare earth elements.

Section I: Meta Data

Geographical Coverage: United States **Region:** California

Year Data Best Represents: 2010

Process Type: Auxiliary Process (AP)

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:

water_frac	*[kg/kg] kg of water per kg of brine wastwater*
hcl_frac	*[kg/kg] kg of HCl per kg of brine wastwater*
naoh_frac	*[kg/kg] kg of NaOH per kg of brine wastwater*

dehpa_frac	*[kg/kg] kg of DEHPA per kg of brine wastwater*
kero_frac	*[kg/kg] kg of kerosene per kg of brine wastwater*
Th_content	*[kg/kg] kg of thorium per kg of brine wastewater*
U_content	*[kg/kg] kg of uranium per kg of brine wastewater*

Tracked Input Flows:

Brine Wastewater	*Reference Flow*
Electricity	*[Technosphere]*
Steam	*[Technosphere]*
Sulfuric Acid	*[Technosphere]*

Tracked Output Flows:

Chlorine	*Material Output*
Hydrogen	*Material Output*
Caustic soda	*Material Output*
DEHPA	*Liquid Waste*
Kerosene, to waste storage	*Liquid Waste*
Hydrochloric acid, to waste storage	*Liquid Waste*
Thorium, to waste storage	*Solid waste*
Uranium, to waste storage	*Solid waste*
Water, process water for plant	*Material Output*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage1_O_brine_cholralkali_2014.01.xlsx*, which provides additional details regarding relevant calculations, data quality, and references.

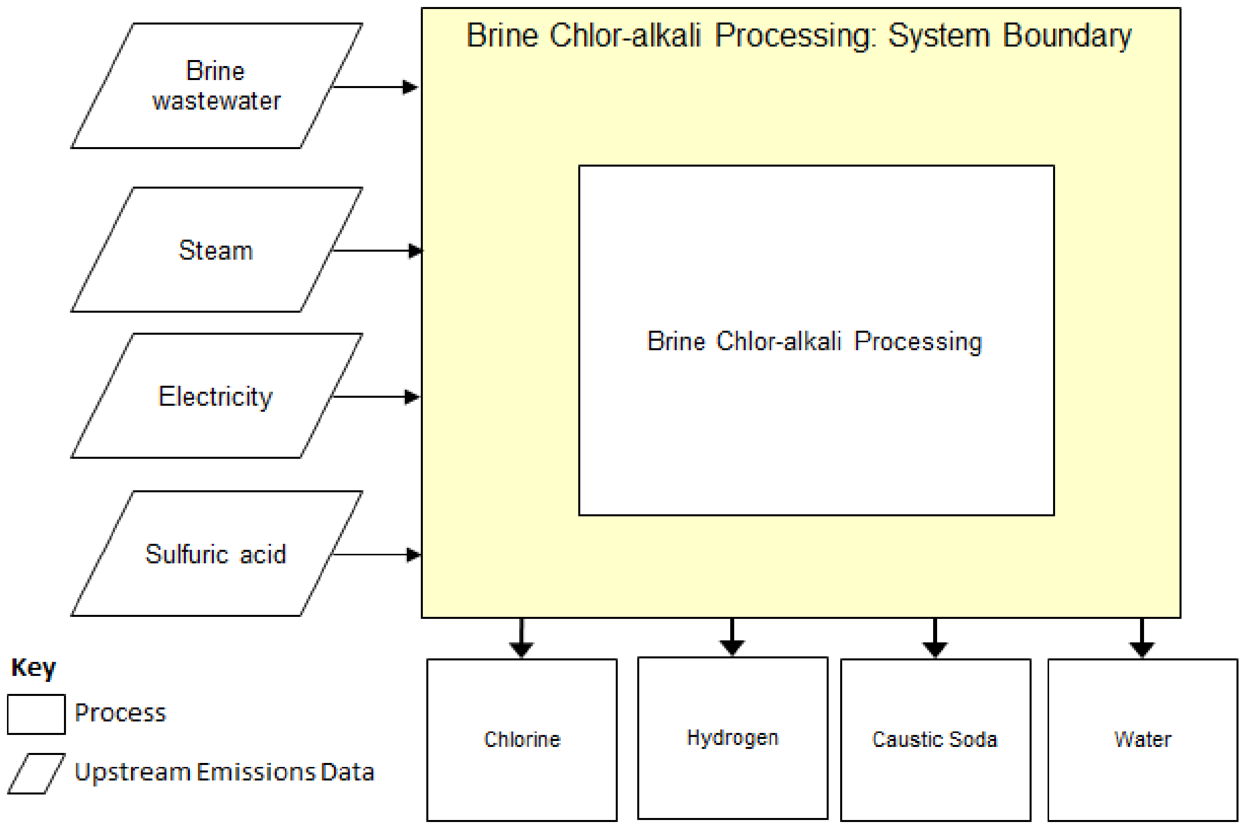
Goal and Scope

This unit process provides a summary of relevant input and output flows associated with membrane technology-based chlor-alkali processing of wastewater brines from solvent extraction of a rare earth elements. The process takes place in a series of steps for brine saturation, precipitation, filtration, purification, electrolysis, and cooling. The process also accounts for wastes incurred during the chlor-alkali process. The reference flow of this unit process is: 1 kg of Brine Wastewater

Boundary and Description

Figure 1 provides an overview of the boundary of this unit process. Rectangular boxes represent relevant sub-processes, while trapezoidal boxes indicate upstream data that are outside of the boundary of this unit process. As shown, the upstream emissions from the brine waste water, steam, electricity, and sulfuric acid are calculated in another unit process. The methods for calculating these operating activities are described below.

Figure 1: Unit Process Scope and Boundary



This unit process covers the recycling of wastewater from rare earth metal solvent extraction. This process utilizes sodium hydroxide to neutralize the hydrochloric acid in the wastewater, producing a brine solution (ENSR International, 2004). This solution is then filtered and processed using a membrane chlor-alkali process which remove solvents and radioactive impurities and generates Hydrogen Gas, Chlorine Gas, and Sodium Hydroxide (IL&FS EcoSmart, 2010).

The membrane chlor-alkali process utilizes an electrolytic cell with the anode and cathode separated by a water-impermeable ion conducting membrane. Brine flows through the anode compartment where chloride ions are oxidized to chlorine gas. The sodium ions migrate through the membrane to the cathode compartment which contains flowing sodium hydroxide solution. The demineralized water added to the catholyte circuit is hydrolysed, releasing hydrogen gas and hydroxide ions. The sodium and hydroxide ions combine to produce sodium hydroxide. The membrane prevents the migration of chloride ions from the anode compartment to the cathode compartment (IL&FS EcoSmart, 2010).

The default value for process yield was calculated using an Environmental Impact Statement prepared for the Indian Government and is based on the composition of the incoming brine solution (IL&FS EcoSmart, 2010). The default composition of the wastewater stream is based on annual consumption values listed in an environmental impact report for the Molycorp Mountain Pass facility (ENSR International, 2004).

Electricity, steam, and sulphuric acid (used for chlorine drying) consumption values were estimated using industry values cited in literature (IL&FS EcoSmart, 2010).

Parameters are provided for thorium and uranium content of the waste water. The default values are calculated based on the thorium content of Mountain Pass bastnaesite and the crustal average of uranium multiplied by the amount of ore mined to get a kg of rare earth mineral concentrate in the default flotation process (Olson et al., 2014; NETL, 2014; Winter, 2014). The implication is that all of the thorium and uranium in the mined ore follows the same process chain as the rare earths but is separated at the solvent extraction stage and disposed of in this process.

Table 1: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)
Inputs		
Brine Wastewater	1.00E+00	kg
Electricity	1.85E-01	kwh
Steam	8.33E+03	kJ
Sulfuric Acid	1.54E-03	kg
Outputs		
Chlorine	7.71E-02	kg
Hydrogen	2.19E-03	kg
Caustic soda	8.70E-02	kg
DEHPA	5.18E-04	kg
Kerosene, to waste storage	4.20E-03	kg
Hydrochloric acid, to waste storage	1.67E-01	kg
Thorium, to waste storage	1.34E-03	kg
Uranium, to waste storage	2.74E-05	kg
Water, process water for plant	6.62E-01	kg

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

Embedded Unit Processes

None.

References

IL&FS Ecosmart Limited, 2010 — IL&FS Ecosmart Limited (2010) Technical EIA Guidance Manual for Chlor-Alkali Industry

Molycorp, 2005 — Molycorp (2005) Revised Waste Discharge Requirements For Molycorp, Inc., Mountain Pass Mine and Mill On-site, Lined Evaporation Ponds Apptendix B: Proposed Onsite Evaporation Pond Flow Diagram

NETL, 2014 — NETL (2014). NETL Life Cycle Inventory Data – Unit Process: Froth Flotation - Version 01. U.S. Department of Energy, National Energy Technology Laboratory. Retrieved from www.netl.doe.gov/LCA

Olson, J.C., Shawe, D.R., Pray, L.C., Sharp, W.N. (1954). Rare-Earth Mineral Deposits of the Mountain Pass Disctrict San

	Bernardino County California. Washington, D.C.: US GPO. Retrieved July 15 from http://pubs.usgs.gov/pp/0261/report.pdf
Winter, 2014	Winter, M.J. (2014). Uranium: geological information. Retrieved July 15, 2014 from http://www.webelements.com/uranium/geology.html

Section III: Document Control Information

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Original/no revisions

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Section IV: Disclaimer