NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Uranium Conversion Facility, Operation

Reference Flow: 1 kg of UF_6 (natural)

Brief Description: This process converts yellowcake (U3O8) from the milling facility into natural (un-enriched) uranium hexafluoride (UF6). This process includes energy and emissions to air and water.

Section I: Meta Data

Geographical Coverage: Canada **Region:** N/A

Year Data Best Represents: 2009

Process Type: Basic Process (BP)

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

Allocation Applied: No

Completeness: Individual 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 Pollutants	☒ Other
Releases to Water:	☐ Inorganic Emissions	☐ Organic Emissions	☒ Other
Water Usage:	☒ Water Consumption	☐ Water Demand (throughput)	
Releases to Soil:	☐ Inorganic Releases	☐ Organic Releases	☐ Other

Adjustable Process Parameters:

Tracked Input Flows:

U_3O_8 [Valuable substance] — *Amount of U_3O_8 required for operation of the conversion facility*

Power [Electric power] — *Amount of electricity required for operation of the conversion facility*

Thermal Energy from Natural Gas Combusted in Industrial Boiler — *Amount of thermal energy from natural gas required for operation of the conversion facility*

Tracked Output Flows:

UF6 (natural) [Valuable substances]	*Uranium hexafluoride in its natural state*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage1_O_Uranium_Conversion_Facility_2010.01.xls*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

The scope of this unit process encompasses the material inputs necessary to operate a conversion facility, to conduct chemical reactions to change the triuranium octoxide (U_3O_8) into uranium hexafluoride (UF_6) for enrichment. Therefore this process includes all isotopes of uranium. The process is based on the reference flow of 1 kg of natural UF_6, as described below and shown in **Figure 1**. Considered is the usage of electricity, thermal energy from natural gas and water.

Boundary and Description

The purpose of a uranium conversion facility is to convert milled yellowcake into a gaseous state for subsequent fuel enrichment. Because UF_6 is gaseous at low temperatures, a conversion facility uses strong acids and alkalis to remove impurities and combine uranium with fluorine. The UF_6 is then pressurized and slow cooled to a solid state for transport to an enrichment facility.

Operation of the conversion facility is based on publicly available information from the Port Hope Conversion Facility in Port Hope, Canada (Cameco 2010). It is assumed that the conversion facility has a fuel conversion efficiency of 85%. Best estimates for air and water emissions were made using 2009 averages. Variation of these emissions are captured through minimum and maximum emission rates in 2009. Emissions values are provided in kilograms per kilogram of UF_6 produced.

Energy usages for the Port Hope facility were neither provided in the publicly available documents nor available for release through employee contacts. This data limitation required the use of an older source (Rotty 1975) for an estimate of energy inputs. Energy values are provided in an energy unit per kilogram of UF_6 produced.

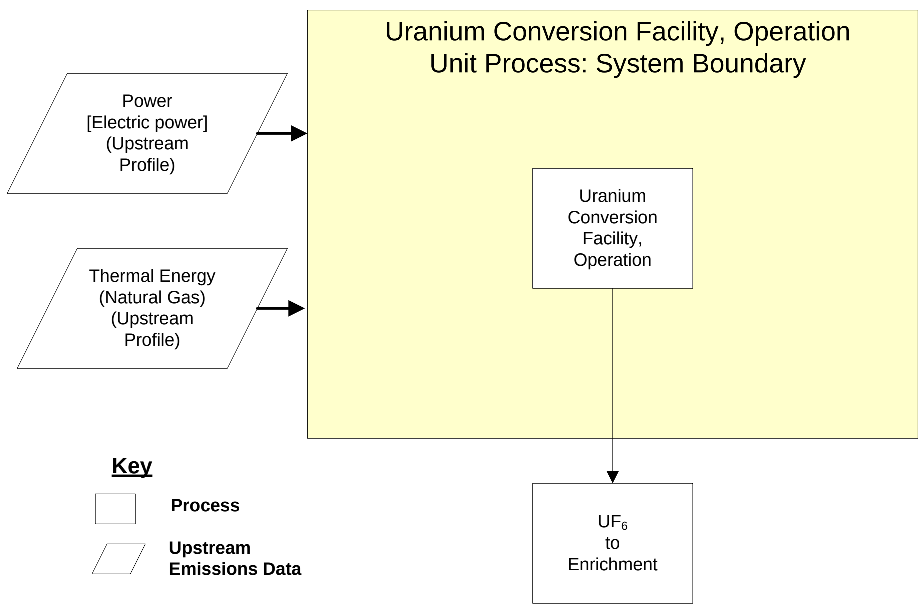
The Port Hope facility receives the U_3O_8 in large drums from the extraction points. The first step of processing is reducing the size of the compound. It is crushed into a fine powder. Once at the correct size particles, the compound is reacted with hydrogen gas.

This forms uranium dioxide (UO_2). To add fluorine to the compound, hydrogen fluoride is mixed with the UO_2. The resulting compound is uranium tetrafluoride (UF_4). The products of this reaction are heated to precipitate out the water from the mixture and purify the UF_4. The remaining UF_4 compound is mixed with fluorine gas. This results in the creation of uranium hexafluoride (UF_6) gas. To transform the gas into a liquid for transportation, the gaseous UF_6 gets passed through cold traps to solidify the compound into crystallized form and collect it. Once the compound is collected, it is heated to liquid form and packaged in steel cylinders for shipment (Cameco 2010).

Water withdrawal values, but not consumption or discharge values, were available from Cameco. It is assumed that 10% of water withdrawal is consumed by the plant.

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, upstream emissions associated with the production and delivery of electricity are accounted for outside of the boundary of this unit process, based on proprietary profiles available within the GaBi model.

Table 1 shows relevant production values of the Port Hope conversion facility. **Table 2** provides a summary of modeled input and output flows. Additional detail regarding input and output flows, including calculation methods, is contained in the associated DS



sheet.

Figure 1. Unit Process Scope and Boundary

Table 1: Properties of Process

Material	Value	Reference
License Limit	2,119 kg UF_6/hr	Personal Contact
Capacity Factor	85%	Assumption
Facility Output	1,891 kg UF_6/hr	Calculated
Facility Input	5,058 kg U_3O_8/hr	Calculated

Table 2: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)
Inputs		
U_3O_8	**2.81**	**kg/kg UF_6**
Power [Electric power]	**0.01**	**MWh/kg UF_6**
Thermal Energy from Natural Gas Combusted in Industrial Boiler	**885.53**	**MJ/kg UF_6**
Water (lake water) [Water]	331.60	L/kg UF_6
Water (municipal) [Water]	26.86	L/kg UF_6
		Outputs
UF_6 (natural)	1.00E+00	kg
Uranium (total) [Radioactive emissions to air]	4.37E-06	kg/kg UF_6
Nitrogen oxides [Inorganic emissions to air]	2.06E-03	kg/kg UF_6
Ammonia [Inorganic emissions to air]	2.70E-03	kg/kg UF_6
Uranium (total) [Radioactive emissions to water]	2.11E-06	kg/kg UF_6
Fluoride [Inorganic emissions to fresh water]	7.59E-05	kg/kg UF_6
Ammonium / ammonia [Inorganic emissions to fresh water]	3.29E-05	kg/kg UF_6
Nitrate [Inorganic emissions to fresh water]	2.95E-04	kg/kg UF_6
Water (wastewater) [Water]	24.42	L/kg UF_6
Water (lake water) [Water]	301.46	L/kg UF_6

* **Bold face** clarifies that the value shown *does not* include upstream environmental flows. Upstream environmental flows were added during the modeling process using GaBi modeling software, as shown in Figure 1.

Embedded Unit Processes

None.

References

Cameco 2010	Cameco Corp. 2010. *Refining and Conversion: Port Hope: Process.* Cameco Corp.

	http://www.cameco.com/fuel_and_power/refining_and_conversion/port_hope/process/ (Accessed November 4, 2010)
Rotty 1975	Rotty, R.M., Perry, A.M., and Reister, D.B. 1975. Net Energy from Nuclear Power. Oak Ridge, US. 1975.

Section III: Document Control Information

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