NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Gas Centrifuge Uranium Enrichment, Operations

Reference Flow: 1 kg of Enriched UF_6

Brief Description: This process recieves UF6 from a conversion facility and enriches the percent composition of Uranium 235 in the fuel. This process includes energy consumption, air emissions, water use, water emissions, and solid waste.

Section I: Meta Data

Geographical Coverage: US **Region:** Southwest

Year Data Best Represents: 2005

Process Type: Energy Conversion (EC)

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

Allocation Applied: No

Completeness: Individual Relevant Flows Recorded

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:

UF6 (natural) [Energy carrier]	*Quantity of natural uranium hexafluoride entering the enrichment facility, in kg*
Power [Electric Power]	*U.S. National Average electricity profile, in kilowatt hours*

Thermal Energy from Natural Gas Combusted in Industrial Boiler [Valuable substances]	*Natural gas requirements in an industrial boiler for the enrichment facility*
Diesel [Crude oil products]	*Quantity of diesel entering the enrichment facility*
Corrosion Inhibitor [Valuable substance]	*Quantity of a corrosion inhibitor entering the enrichment facility*
Biogrowth Inhibitor [Valuable substance]	*Quantity of a biogrowth inhibitor entering the enrichment facility*

Tracked Output Flows:

UF6 (enriched) [Energy carrier]	*Reference Flow*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage1_O_Centrifuge_Enrichment_2010.01.xls*, which provides additional details regarding relevant, calculations, data quality, and references.

Goal and Scope

This unit process describes the operation of a gas centrifuge enrichment facility. The enrichment operations process receives natural uranium fluoride (UF_6) from the conversion facility and separates uranium isotopes to increase the concentration of uranium-235 in the fuel. Enriched uranium from the facility is then transported to the fuel fabrication facility. All steps are contained within lifecycle Stage #1 of the uranium life cycle.

Boundary and Description

This gas centrifuge enrichment process is used to increase the concentration of uranium-235 in UF_6 for effective use of the fuel. Natural concentrations of uranium-235 are less than one weight percent. For optimal light water nuclear fission in a commercial power plant, the uranium-235 concentration must be above 3 weight percent.

Gas centrifuge enrichment is the primary enrichment type used in Europe. Centrifuge enrichment achieves significant energy savings over gaseous diffusion enrichment, an older technology which is the only type used in the United States. However, a license application was submitted in 2005 to the U.S. Nuclear Regulatory Commission (NRC) to construct, operate, and decommission a gas centrifuge uranium enrichment facility near

Eunice, New Mexico. The proposed National Enrichment Facility would produce enriched uranium-235 up to 5 weight percent by the gas centrifuge process with a nominal production of 3 million separative work units per year. The Environmental Impact Statement for the proposed facility (NRC 2005) is used as the primary source for development of this unit process. The process is used in the life cycle model of nuclear power to represent centrifuge enrichment in both the United States and in Europe.

The centrifuge enrichment process uses a number of large rotating cylinders to separate heavier uranium-238 isotopes from lighter uranium-235 isotopes. Heavier isotopes are collected as they move to the outside of the cylinder, then the remaining lighter material continues to another cylinder to repeat the process. The fuel goes through numerous cascades (normally over 100) until it reaches a desired concentration.

All data energy and emissions data for this unit process were obtained from the Environmental Impact Statement for the Proposed Enrichment Facility in Lea County, New Mexico (NRC 2005). The stack emissions include factors for uranium, helium, argon, nitrogen, hydrogen fluoride, methylene chloride, and ethanol. Inputs to the unit process, as shown in **Figure 1**, include electricity, natural gas, and natural UF_6.

Figure 1: Unit Process Boundary and Scope

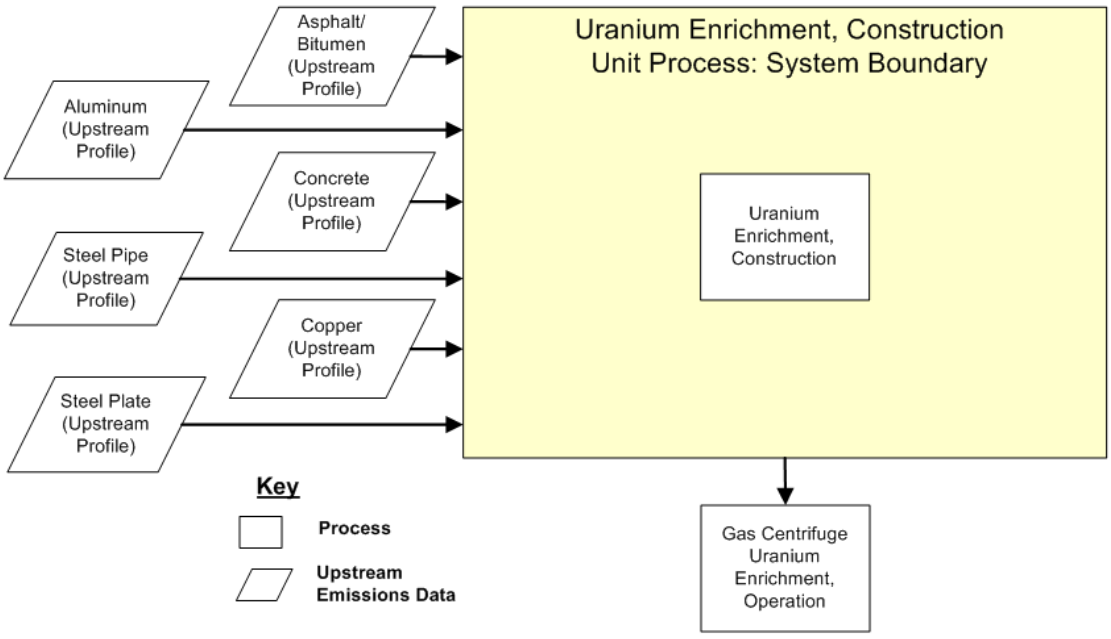

Table 1 shows the plant parameters for the centrifuge enrichment process. **Table 2** provides a summary of modeled input and output flows. Additional details regarding input and output flows, including calculation methods, are contained in the associated DS.

Table 1: Plant Parameters

Property	Value	Units	Reference
Natural UF_6 Input	8,600	metric ton/yr	NRC 2005
SWU Produced	3,000,000	SWU/yr	NRC 2005
Enriched UF_6 Produced	800	metric ton/yr	NRC 2005
Tailings (depleted UF_6)	7,800	metric ton/yr	NRC 2005

Table 2: Unit Process Input and Output Flows

Flow Name*	Value	Units (Per Reference Flow)
Inputs		
UF_6 (natural) [Energy carrier]	**10.75**	**kg/ kg UF_6**
Power [Electric power]	**0.15**	**MWh/ kg UF_6**
Thermal Energy from Natural Gas Combusted in Industrial Boiler [Valuable substances]	**148.57**	**MJ/ kg UF_6**
Diesel [Crude oil products]	**2.95E-04**	**m^3/ kg UF_6**
Water (surface water) [Water]	1.10E+00	m^3/ kg UF_6
Corrosion Inhibitor	**1.00E-02**	**kg/ kg UF_6**
Biogrowth Inhibitor	**2.25E-03**	**kg/ kg UF_6**
Outputs		
UF_6 (enriched) [Energy carrier]	1.00	kg
Tailings - Depleted UF6 [Stockpile goods]	9.75	kg/ kg UF_6
Helium [inorganic emissions to air]	9.82E-05	kg/ kg UF_6
Argon [inorganic emissions to air]	4.24E-04	kg/ kg UF_6
Nitrogen (N-compounds) [inorganic emissions to air]	8.28E-05	kg/ kg UF_6
Hydrogen fluoride [inorganic emissions to air]	1.25E-06	kg/ kg UF_6
Dichloromethane (methylene chloride [halogenated organic emissions to air]	7.63E-07	m^3/ kg UF_6
Ethanol [Group NMVOC to air]	5.00E-08	m^3/ kg UF_6
Dust (PM10) [Particles to air]	1.25E-04	kg/ kg UF_6
NMVOC (unspecified) [Group NMVOC to air]	3.25E-04	kg/ kg UF_6
Nitrogen oxides [Inorganic emissions to air]	1.39E-02	kg/ kg UF_6
Carbon dioxide [Inorganic emissions to air]	7.91E-01	kg/ kg UF_6
Methane [Organic emissions to air (group VOC)]	3.24E-02	kg/ kg UF_6
Nitrous oxide (laughing gas) [Inorganic emissions to air]	6.48E-03	kg/ kg UF_6
Sulphur dioxide [Inorganic emissions to air]	7.45E-06	kg/ kg UF_6
Ammonia [Inorganic emissions to air]	4.26E-01	kg/ kg UF_6
Water (river water) [Water]	3.63E-02	m^3/ kg UF_6
Waste (solid) [Waste for disposal]	2.16E-01	kg/ kg UF_6
Mixed Waste (Hazardous or Radioactive)	1.11E-01	kg/ kg UF_6
radionuclides [Radioactive emissions to air]	3.16E-01	Bq/ 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

NRC 2005 — Division of Waste Management and Environmental Protection. 2005. Environmental Impact Statement for Proposed National Enrichment Facility in Lea County, New Mexico: Chapters 1-10 and Appendices A-G (NUREG-1790, Volume 1). U.S. Nuclear Regulatory Comission. Washington, DC. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1790/v1/ (Accessed June 14, 2010).

Section III: Document Control Information

Date Created: November 9, 2010

Point of Contact: Timothy Skone (NETL), Timothy.Skone@NETL.DOE.GOV

Revision History:

Original/no revisions

How to Cite This Document: This document should be cited as:

NETL (2010). NETL Life Cycle Inventory Data – Process Documentation File: Centrifuge Enrichment, Operation. U.S. Department of Energy, National Energy Technology Laboratory. Last Updated: November 2010 (version 01). www.netl.doe.gov/energy-analyses (http://www.netl.doe.gov/energy-analyses)

Section IV: Disclaimer