# 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 receives $UF_6$ 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 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:**

| | |
|---|---|
| surf_water_f | *[m3/kg UF6] Volume of water input required to produce 1 kg enriched UF6* |
| water_disch | *[m3/kg UF6] Water discharge* |

**Tracked Input Flows:**

| | |
|---|---|
| UF6 (natural) [Energy carrier] | *[Technosphere] UF6 input from the conversion facility to the enrichment facility* |
| Power [Electric power] | *[Technosphere] electricity used by enrichment plant* |
| Thermal Energy from Natural Gas Combusted in Industrial Boiler | *[Technosphere] Natural gas requirements in an industrial boiler for the enrichment facility* |
| Diesel [Crude oil products] | [Technosphere] *Quantity of diesel entering the enrichment facility* |
| Corrosion Inhibitor [Valuable substance] | [Technosphere] *Quantity of a corrosion inhibitor entering the enrichment facility* |
| Biogrowth Inhibitor [Valuable substance] | [Technosphere] *Quantity of a biogrowth inhibitor entering the enrichment facility* |

**Tracked Output Flows:**

| | |
|---|---|
| UF6 (enriched) [Energy carrier] | *Reference flow* |
| Tailings - Depleted UF6 [Stockpile goods] | *Waste Flow for Long-term storage* |

## Section II: Process Description

### Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage1_O_Centrifuge_Enrichment_2010.02.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 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 $UF_6$. Water use is modeled as 100 percent consumption for the expected value because all water discharges are to an evaporative basin; however, the full discharge to the basin is maintained as a high value for uncertainty.

**Figure 1: Unit Process Scope and Boundary**

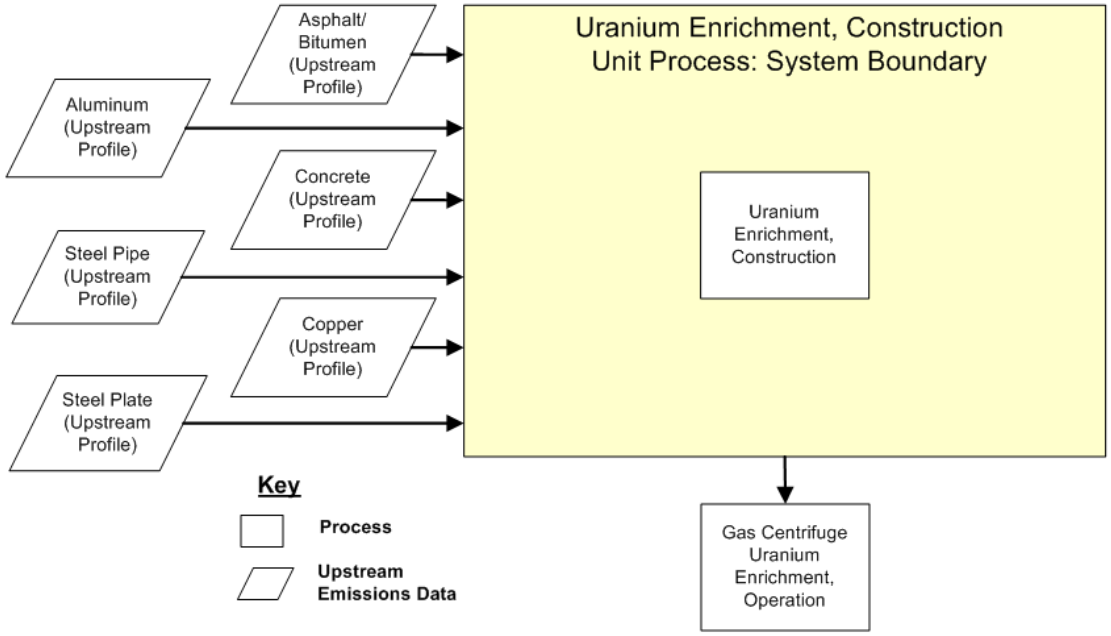


**Table 1** shows the plant parameters for the centrifuge enrichment process. **Table 2** provides a summary of modeled input and output flows. Additional details regarding input and output flows, including calculation methods, are contained in the associated DS.

**Table 1: Plant Parameters**

| Property | Value | Units | Reference |
|---|---|---|---|
| Natural UF6 Input | 8,600 | metric ton/yr | NRC 2005 |
| SWU Produced | 3,000,000 | SWU/yr | NRC 2005 |
| Enriched UF6 Produced | 800 | metric ton/yr | NRC 2005 |
| Tailings (depleted UF6) | 7,800 | metric ton/yr | NRC 2005 |

## Table 2: Unit Process Input and Output Flows

| Flow Name | Value | Units (Per Reference Flow) |
|---|---|---|
| Inputs | | |
| UF6 (natural) [Energy carrier] | 1.08E+01 | **kg/ kg $UF_6$** |
| Power [Electric power] | 1.50E-01 | **MWh/ kg $UF_6$** |
| Thermal Energy from Natural Gas Combusted in Industrial Boiler [Valuable substances] | 1.49E+02 | **MJ/ kg $UF_6$** |
| Diesel [Crude oil products] | 2.95E-04 | **$m^3$/ kg $UF_6$** |
| Water (surface water) [Water] | 1.10E+02 | L/ kg $UF_6$ |
| Corrosion Inhibitor | 1.00E-02 | **kg/ kg $UF_6$** |
| Biogrowth Inhibitor | 2.25E-03 | **kg/ kg $UF_6$** |
| Outputs | | |
| UF6 (enriched) [Energy carrier] | 1.00E+00 | **kg** |
| Tailings - Depleted UF6 [Stockpile goods] | 9.75E+00 | **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 (wastewater) [Water] | 0.00E+00 | L/ 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.

## 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

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