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TITLE:

ION EXCHANGE SEPARATION OF PLUTONIUM AND GALLIUM (1) Resource and Inventory Requirements, (2) Waste, Emissions, and Effluent, and (3) Facility Size

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(1) Resource and Inventory Requirements
(2) Waste, Emissions, and Effluent
(3) Facility Size

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Disclaimer

The following summary is intended to represent an order-of-magnitude estimate of (1) resource and inventory requirements, (2) waste, emissions, and effluent amounts, and (3) the facility size, for ion exchange separation of plutonium and gallium. The material balances are based strictly on stoichiometric amounts rather than actual operating experience in order to avoid classification as Unclassified Controlled Nuclear Information. This approximation neglects the thermodynamics and kinetics which can significantly impact the amount of reagents required.

ION EXCHANGE SEPARATION OF PLUTONIUM AND GALLIUM
Resource and Inventory Requirements
Waste, Emissions, and Effluent
Facility Size

Abstract

The following report summarizes an effort intended to estimate within an order-of-magnitude the (1) resource and inventory requirements, (2) waste, emissions, and effluent amounts, and (3) facility size, for ion exchange (IX) separation of plutonium and gallium. This analysis is based upon processing 3.5 MT-Pu/yr.[1] The technical basis for this summary is detailed in Reference 2, "Preconceptual Design for Separation of Plutonium and Gallium by Ion Exchange". The material balances of Reference 2 are based strictly on stoichiometric amounts rather than the details of actual operating experience, in order to avoid classification as Unclassified Controlled Nuclear Information. This approximation neglects the thermodynamics and kinetics which can significantly impact the amount of reagents required. Consequently, the material resource requirements and waste amounts presented here would normally be considered minimums for processing 3.5 MT-Pu/yr; however, the author has compared the inventory estimates presented here with that of an actual operating facility and found them similar. Additionally, the facility floor space presented here is based upon actual plutonium processing systems and can be considered a nominal estimate.

Resources

Table 1 below has been reproduced from Figure 10 of Reference 2, and adjusted for 3.5 MT-Pu.

	Kg
HNO_3 (nitric acid)	2713
HF (hydrofluoric acid)	23
$Al(NO_3)_3 \cdot 9H_2O$ (aluminum nitrate nanohydrate)	146
H_2O_2 (hydrogen peroxide)	498
NH_2OH (hydroxyl amine)	1444
$C_2H_2O_4$ (oxalate)	1274
O_2 (oxygen)	1171
H_2O (water)	7763
resin	13

Table 1. IX resource requirements for 3.5 MT-Pu.

Waste, Emissions & Effluent

Table 2 has also been generated from Figure 10 of Reference 2 by adjusting for 3.5 MT-Pu/yr.

	Kg
TRU Waste (0.5 wt% Am)	162
Mixed waste (resin)	13
Effluent (water)	7763
Emissions:	
- O_2	235
- CO_2	1932
- NO_2	1006
- NO	656

Table 2. IX waste, emissions, and effluent for 3.5 MT-Pu

The TRU was estimated to be a collection of aluminum, gallium, and americium nitrate salts.

TRU waste $= (3.5/10)[93\text{ Kg-}AlF_3 + 366\text{ Kg-}Ga(NO_3)_3 + 4\text{ Kg-}Am(NO_3)_3]$
$= 162$ Kg

This TRU waste is ~0.5 wt% transuranics with americium the predominant species.

$$\{243/[243+3(62)]\}[100(4/463)] = 0.5 \text{ wt\% Am}$$

Facility Inventory

Liquid inventory is based upon six months of processing, plus an additional 25% to reflect uncertainties associated with operating multiple process lines in parallel. Table 3 was generated from the resource requirements for one year as shown in Table 1.

	Kg/6-mo.
HNO_3 (nitric acid)	1356
HF (hydrofluoric acid)	12
$Al(NO_3)_3 \cdot 9H_2O$ (aluminum nitrate nanohydrate)	solid
H_2O_2 (hydrogen peroxide)	249
NH_2OH (hydroxyl amine)	722
$C_2H_2O_4$ (oxalate)	solid
H_2O (water)	3882
O_2 (oxygen)	gas
resin	solid
TOTAL	6221

Table 3. IX inventory requirements for six months of 3.5 MT-Pu/yr processing

Assuming a liquid density of approximately one, and adding the additional 20% for multiple process line complexities, approximately 7500 liters of liquid inventory is required for 3.5 MT-Pu/yr processing. Based upon the author's discussions with those who have operated similar IX systems, 7500 liters inventory is reasonable for 3.5 MT-Pu/yr.

$$1.2(6221 \text{ Kg})(1\text{-liter/Kg}) = 7465 \text{ liters}$$

Facility Size

The author's discussions with those who have operated IX systems for processing plutonium indicate ~2100 ft^2 of hardened facility space should be adequate for a single process line. Based upon Reference 2:

$$\left(\frac{3.5 \text{ MT-Pu/yr}}{0.75 \text{ MT- Pu/yr-process line}}\right) = 4.7 \text{ process lines}$$

Since five parallel process lines will be required to process 3.5 MT-Pu/yr, the hardened facility space can be estimated as follows.

$5(2100\ ft^2) = 10{,}500\ ft^2$ without sharing of processing tanks or equipment

If we assume the total hardened space can be reduced by ~40% due to sharing process tank and equipment for multiple process lines (feed tanks, surge tanks, recycle evaporators, waste tanks, etc.):

$0.6\ (10{,}500\ ft^2) = 6300\ ft^2$

Therefore, approximately 6300 ft^2 total hardened facility space will be required to process 3.5 MT-Pu/yr. The IX utilities and support services could be obtained from the MOX Fuel Fabrication facility or the Pits Disassembly and Conversion facility without any significant changes in their current floor space.

References

[1] *Initial Response to the Surplus Plutonium Disposition Environmental Impact Statement Data Call for a Mixed Oxide Fuel Fabrication Facility located at the Pantex Plant*, Los Alamos National Laboratory, LA-UR-97-2067, September 1997.

[2] S.F. DeMuth, *Preconceptual Design for Separation of Plutonium from Gallium by Ion Exchange*, Los Alamos National Laboratory, LA-UR-97-3769, 24 September 1997.