DPST--82-839

DE83 005047

SAVANNAH RIVER LABORATORY
TECHNICAL DIVISION

DPST-82-839

CC: R. Maher, SRP
J. A. Kelley, SRL
J. L. Crandall
R. W. Benjamin
L. A. Heinrich
J. E. Hoisington
D. E. Hostetler
I. M. Macafee
F. J. McCrosson
W. R. McDonell
TIS Files (2)

MEMORANDUM

October 4, 1982

TO: P. L. ROGGENKAMP

FROM: G. F. O'NEILL

ADDITIONAL Pu-238 PRODUCTION

INTRODUCTION

Possible DOD demands for up to 1 MW thermal of heat sources[1] could be partially met by increasing SRP Pu-238 production. The Pu-238 would be an alternate or supplement to Sr-90 in these heat sources. There is a growing surplus of Np-237 target material which could be used to produce high-assay Pu-238 (83.5%). In addition SRP produces low assay Pu-238 (~27%) that could be extracted instead of being sent to the waste tanks.

SUMMARY

About 216 kg or 121 kw thermal of additional high-assay Pu-238 could be produced at SRP through FY1997; it would produce power at an incremental cost of ~$1160/watt. About 77 kg or 44 kw thermal of low assay Pu-238 could also be recovered through FY1997; it would generate power at ~$1850/watt. These quantities would supply only a fraction (~1/6) of the 1 MW demand projection. Also the costs are considerably higher than the costs for Sr-90 fission product heat sources. Sr-90 from SRP and Hanford could supply the total 1 MW thermal requirement (150 MCi at $1 to $3 per Ci) at costs in the range of $150 to $450 per watt.[1]

...T IS UNLIMITED

DISCUSSION

High Assay Pu-238

The summary tables[2] in the 1982 Materials Management Report for the Mark 15/Mark 22 operational mode at SRP were used to estimate the surplus Np-237 that would be available each year. This surplus Np-237 was assumed to be irradiated to supply the high-assay Pu-238 for the heat sources.* The data are shown in Table 1.

The incremental cost per kg of extra high assay Pu-238 in FY'83 dollars was estimated as follows:

300 Area[a]	$ 4,000	
100 Area	-	
200 Area[a]	110,000	
PuFF[b]	211,000	
Waste	30,000	
Equiv. Pu Lost[c]	245,000	
Np Burned[d]	31,000	
	$631,000	Rounded to $650,000

a. From Ref. 3 escalated to FY'83 dollars.

b. Private communication from D. C. Nichols, SRP Separations Dept.

c. Assumes 1.5 kg of equivalent W.G. Pu lost per kg of Pu-238 made. The incremental value of W.G. Pu (from the "L" startup) is taken as $163/gr.

d. Value of 1.4 kg of Np burned - incremental recovery cost of surplus Np taken as $22/gr.

*The 1982 Material Management Plan assumes that the U-236/U-235 ratio in the Mark 22 is maintained at near the current value (0.14). If this ratio is allowed to rise (to 0.6 - 0.8), so as to limit the SRP requirements for new oralloy from Oak Ridge, the surplus neptunium and thus extra Pu-238 production could increase by a factor of 2 or 3.

Low Assay Pu-238

The low assay Pu-238 production was estimated from the neptunium schedules shown in Table 1. The Mark 22 lattices were assumed to generate the low-assay Pu-238 at an annual rate of 13% of the Np-237 production.[4] The Mark 16-31 charges in the years prior to FY1985 (before being replaced by Mark 15) were assumed to produce low assay Pu-238 at 9% of the Np-237 production rate.[4]

The cost of low assay Pu-238 recovery through the HB-line was developed from an earlier study.[5] Capital costs of $2.5 million were required for ion exchange facilities; additional capital costs of $1.3 million were required for HB-line shielding modifications. Operating costs through the canyon and HB-line of ~$300,000 per kg were assumed. The current H Area frame capacity may be a pinch point if both the low-assay and high-assay Pu-238 are produced at the same time. In Ref. 3 it was noted that this capacity could be increased by several methods. The PuFF source fabrication costs at ~$600,000 per kg of Pu-238 were added. These PuFF charges were high compared to the high assay costs because of the large source volume per watt required by the low-assay material.

Production and Costs

The production and cost values for heat source high-assay Pu-238 are given in Table 2 and for low assay Pu-238 in Table 3. The costs and production are discounted each year by 10% and summed to get "Net Present Values". The unit costs are the quotients of the "Net Present Values".

Power Intensity of Pu-238 Sources

Current high assay Pu-238 sources are fabricated from PuO_2 at 85% of theoretical density with 83.5% Pu-238 in total plutonium. These sources have a physical density of 9.7 g/cc and a power density of 4.0 watt/cc. If low assay Pu-238 sources were fabricated in the same way, at 27% Pu-238 in the total plutonium, these sources would have a power density of 1.3 watt/cc. Sr-90 sources have a minimum acceptable power density of ~1.0 watt/cc. Therefore, the power density of the Pu-238 sources would be more than adequate.

GFO:pph

Table 1. Np-237 and Pu-238 Schedules at SRP

FY	Total Np Produced, kg	Np Burnup and Loss, kg	Surplus Np, kg	Extra Pu-238, kg
1982	40.0	26.0	14.0	10.0
1983	42.8	10.5	32.3	23.1
1984	53.2	38.8	14.4	10.3
1985	27.9	14.6	13.3	9.5
1986	27.9	13.9	14.0	10.0
1987	39.2	26.3	12.9	9.2
1988	46.7	23.9	22.8	16.3
1989	50.9	25.5	25.4	18.1
1990	49.2	21.3	27.9	19.9
1991	49.9	31.2	18.7	13.4
1992	50.9	27.4	23.5	16.8
1993	38.3	24.8	13.5	9.6
1994	49.2	22.0	27.2	19.4
1995	44.1	27.3	16.8	12.0
1996	39.7	25.6	14.1	10.1
1997	38.0	25.8	12.2	8.7
1998	37.7	30.2	7.5	5.4

Table 2. High-Assay Pu-238 Production and Costs
Discount Rate = 0.1

Fiscal Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	Total
Oper. Cost,* M$	21.5	6.7	6.2	6.5	5.9	10.6	11.8	12.9	8.7	10.9	6.2	12.6	7.8	6.6	5.7	140.6
Total Cost,M$	21.5	6.7	11.2	21.5	15.9	10.6	11.8	12.9	8.7	10.9	6.2	12.6	7.8	6.6	5.7	140.6
Pu-238, kgs	33.1	10.3	9.5	10.0	9.2	16.3	18.1	19.9	13.4	16.8	9.6	19.4	12.0	10.1	8.7	216.4
Pu-238, kw	18.5	5.7	5.3	5.5	5.1	9.1	10.1	11.1	7.4	9.3	5.3	10.8	6.7	5.6	4.8	121.0
Discount Factor	1.0	0.9090	0.8264	0.7513	0.6830	0.6209	0.5644	0.5131	0.4665	0.4240	0.3855	0.3504	0.3186	0.2896	0.2633	
Net Present Values (NPV)																
Oper. NPV	21.5	6.0	5.1	4.8	4.0	6.5	6.6	6.6	4.0	4.6	2.3	4.4	2.4	1.9	1.5	82.9
Total NPV	21.5	6.0	5.1	4.8	4.0	6.5	6.6	6.6	4.0	4.6	2.3	4.4	2.4	1.9	1.5	82.9
NPV of kg Pu-238	33.1	9.3	7.8	7.5	6.2	10.1	10.2	10.2	6.2	7.1	3.7	6.7	3.8	2.9	2.2	127.6
NPV of kw Pu-238	18.5	5.2	4.3	4.1	3.5	5.6	5.7	5.7	3.4	3.9	2.0	3.8	2.1	1.6	1.2	71.3
Unit Cost, $/kg																650000
Unit Cost, $/watt																1160.0

*FY'83 $

Table 3. Low-Assay Pu-238 Recovery and Costs
Discount Rate = 0.1

Fiscal Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	Total
Capital Cost,* M$	0			0.8	3.0											3.8
Oper. Cost,* M$	5.4	6.1	3.0	3.0	4.9	5.3	5.9	5.7	5.7	5.9	4.1	5.7	4.9	4.8	4.1	74.5
Total Cost,M$	5.4	6.1	3.0	3.8	7.9	5.3	5.9	5.7	5.7	5.9	4.1	5.7	4.9	4.8	4.1	78.3
Pu-238, kgs	5.1	5.8	2.8	2.8	4.6	5.7	6.4	6.1	6.2	6.4	4.4	6.1	5.3	4.6	4.4	76.7
Pu-238, kw	2.9	3.3	1.6	1.6	2.6	3.2	3.6	3.5	3.5	3.6	2.5	3.5	3.0	2.6	2.5	43.6
Discount Factor	1.0	0.9090	0.8264	0.7513	0.6830	0.6209	0.5644	0.5131	0.4665	0.4240	0.3855	0.3504	0.3186	0.2896	0.2633	
Net Present Values (NPV)																
Capital NPV	0	0	0	0.6	2.0	0	0	0	0	0	0	0	0	0	0	2.7
Oper. NPV	5.4	5.5	2.5	2.3	3.3	3.3	3.3	2.9	2.6	2.5	1.6	2.0	1.6	1.4	1.1	41.3
Total NPV	5.4	5.5	2.5	2.9	5.3	3.3	3.3	2.9	2.6	2.5	1.6	2.0	1.6	1.4	1.1	44.0
NPV of kg Pu-238	5.1	5.3	2.3	2.1	3.1	3.5	3.6	3.1	2.9	2.7	1.7	2.1	1.7	1.3	1.1	41.8
NPV of kw Pu-238	2.9	3.0	1.3	1.2	1.8	2.0	2.0	1.8	1.6	1.5	1.0	1.2	1.0	0.7	0.6	23.8
Unit Cost, $/kg																1050000
Unit Cost, $/watt																1850.0

*FY'83 $

References

1. "Sr-90 and Pm-147 Recovery", J. E. Hoisington and W. R. McDonell, DPST-82-813, August 30, 1982.

2. "FY-82 SR Materials Management Plan - Summary Report", DPSPWD-82-9-1, August 6, 1982 (Secret-WD).

3. Pu-238 Production Capability, I. M. Macafee and G. F. O'Neill, DPST-80-255, February 14, 1980.

4. "Reactor Dept. - June 1982 Quarterly Forecast Data", DPSP-82-159-2, R. S. Downey, June 27, 1982 (Secret).

5. "Low Assay Pu-238 at SRP", DPST-80-379, G. F. O'Neill, April 23, 1980 (Secret).