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**Pacific Northwest Laboratory
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HANFORD CATEGORY C-65

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AECOP STUDIES OF Pu-238 PRODUCTION

W. K. Woods

November 21 1967

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AECOP STUDIES OF Pu-238 PRODUCTION

This memorandum summarizes the results of meetings held in Germantown on November 14 and 15, and the decisions reached by the Pu-238 Task Force in a meeting on November 21.

I. CAGE CASES

It is planned to compute total costs for the production complex for six different cases as described below. For each case the Pu-238 content of the product is the only thing of interest, and each site is free to produce Pu-238 of any isotopic purity they wish provided the purity is equal or greater than 80 percent. For purposes of these calculations, all neptunium will be irradiated at Savannah River Plant (SRP) through FY 1971.

Each site is to establish a base case which does not involve any Np irradiation. Subsequent Pu-238 production will be done at the expense of production of weapons-grade plutonium. Each site must advise the other how much neptunium they produce annually when they are not irradiating neptunium.

It is assumed that neptunium purchased from power reactor operations will cost \$100/gram, but that a credit of \$100/gram will be given for residual neptunium present at the end of FY 1980, which is the end of the campaign period. After costs have been computed by CAGE, it is planned that AECOP (Driggers) will discount annual costs at 5 percent back to 1968 as a means of penalizing for large neptunium inventories.

Results of the calculations are to be transmitted to AECOP early in January, 1968.

In the following definition of cases, the letters NS stand for "Neptunium Study."

Case NS-1

On July 1, 1971, all neptunium inventory at SRP is transferred to Hanford, and neptunium subsequently recovered or produced is also shipped to Hanford. This supply of neptunium is augmented by purchase of 60 kg of neptunium from power reactors in FY 1972, 80 kg of neptunium in FY 1973, and 150 kg of neptunium annually each year FY 1974 through FY 1980. It is assumed that 25 percent of these annual quantities is available at the beginning of each quarter in the year.

It is assumed that power reactor neptunium will be purchased as a nitrate. SRP neptunium would actually be shipped as an oxide; however, CAGE will assume that SRP neptunium is shipped as a nitrate and hand calculations will be made subsequently to correct the CAGE results. This is an easier procedure than to reprogram CAGE.

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The objective of this case is to maximize profit, assuming that Pu-238 can be sold for \$270 per gram, and that there is no depreciation charge nor inventory charge other than for neptunium inventory.

Case NS-2

All neptunium irradiations are done at SRP through FY 1980. Hanford neptunium is shipped to SRP and SRP buys power reactor neptunium at the same rate specified for Hanford in Case NS-1.

Case NS-3

Beginning in FY 1972 Hanford retains and irradiates its own neptunium. Hanford also purchases 60 kg of power reactor neptunium in FY 1972 and 80 kg of neptunium in FY 1973. SRP retains its own neptunium inventory throughout. During the period FY 1974 to 1980 Hanford and SRP each purchase 75 kg of power reactor neptunium annually.

It is known that Case NS-3 will be more expensive than either Case NS-1 or NS-2. The objective of this case is to identify what the cost would be to establish and maintain two-site capability during the 1970's.

Case NS-4

On July 1, 1971, all neptunium inventory at SRP is transferred to Hanford, and neptunium subsequently recovered or produced is also shipped to Hanford. Hanford can purchase additional neptunium as required, within the limits of neptunium availability, in order to meet a specific market demand for Pu-238, as shown below. Pu-238 may be preproduced if there is any economic incentive.

	Maximum annual availability of power reactor neptunium, kg	Required cumulative production of Pu-238 by end of year, kg
FY 1972	60	40
1973	80	100
1974	150	160
FY 1975	250	240
1976	350	360
1977	500	480
FY 1978	700	600
1979	900	720
1980	1200	840

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The objective of this case is to produce the required amount of Pu-238 at minimum cost.

Case NS-5

All neptunium irradiations are done at SRP through FY 1980. Hanford neptunium is shipped to SRP, and SRP buys additional neptunium as required, within the limits of neptunium availability, in order to meet specific market demand for Pu-238, as shown in Case NS-4. Pu-238 produced prior to FY 1972 does not count.

Case NS-6

This case was requested by Hanford. In this case neptunium is stock-piled and is not irradiated. Comparison of this case with others will show incremental cost of producing Pu-238 instead of weapons-grade plutonium.

II. HANFORD BASE CASE

N Reactor uses 95 driver and 125 spike to produce plutonium containing 12 percent Pu-240.

B, C, K Reactors irradiate lithium in the fringe tubes. (Note: CAGE is set up to have either lithium or thorium in the fringes. Irradiated thorium complicates chemical processing capability.)

In addition, K Reactors will produce about 1 kilogram of tritium in the core. This is desirable in order to help with flux alterations in neptunium-bearing cores. G. F. Owsley will define this number more accurately by about November 27.

All other production will be weapons-grade plutonium.

N-Reactor levels are assumed to ascend on the following schedule:

FY 68 - 1st quarter	2600 MW
2nd quarter	10 MW
3rd and 4th quarters	4000 MW
FY 69 - 1st and 2nd quarters	4200 MW
3rd and 4th quarters	4400 MW
FY 70 - 1st and 2nd quarters	4600 MW
3rd and 4th quarters	4800 MW
FY 71 - through FY 80	4800 MW

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K Reactors are currently on administrative power level limits, which average 4385 MW. It is assumed that the K Reactors will switch to power levels controlled by bulk outlet water temperature (averaging 4710 MW) on July 1, 1968.

In CAGE calculations, uranium values will be computed by CAGE methods in current use at SRP, which are based on the most recent discounted values

for cascade constants. This is being done in the interest of consistency, after discussion with Driggers. Hanford still recommends that uranium values should reflect chemical form of the uranium more accurately than is presently being done at SRP.

III. GENERAL

To date, the displacement of Pu-239 by Pu-238 has been glibly dismissed by saying that the weapons-grade plutonium "floats." Actual practice will vary greatly with value assigned to Pu-239 not made. If this value is high, we would operate with high Pu-238 quality in order to minimize diversion of neutrons away from U-238. If this value is low we would operate with low Pu-238 quality in order to minimize neptunium handling and processing costs.

Part of the answer is to have as high a Pu-239 production as possible in order to spread the fixed charges over a wide base when we finally get around to allocating costs to specific products. Since we get no credit for Pu-239 made from Pu-238, this argues for high quality Pu-238. This still does not tell us how much extra cost in Pu-238 production we can afford to pay in order to minimize Pu-239 losses.

W. K. Woods, Consulting Engineer
Advanced Concepts and Planning

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