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FEBRUARY 1963 PRODUCTION STUDIES ADDENDUM

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FEBRUARY 1963 PRODUCTION STUDIES ADDENDUM

L. W. Lang
J. W. McCurry
IRRADIATION PROCESSING DEPARTMENT

February 13, 1964

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FEBRUARY 1963 PRODUCTION STUDIES ADDENDUM

ASSUMPTIONS

The neptunium calculations are based on the alternate budget cases with the following assumptions:

- (1) Separated neptunium yields are assumed to be 90 per cent. An 18-month schedule is assumed for cycling slightly enriched uranium.
- (2) Blending is accomplished with 1.8 per cent U-235 enriched uranium after FY-1964; 1.2 per cent during FY-1963 and FY-1964.
- (3) No recycle of natural uranium.
- (4) Self-shielding corrections are allowed.
- (5) The following data were used for calculating conversion:

		<u>K</u>	<u>Old</u>	<u>NPR</u>	<u>Old Overbore</u>
<u>Natural Uranium</u>					
n,2n	mg/MWD	2.60	2.60	3.10	
U-236	mg/MWD/g/T	.0176	.0160	-	
g U-236/T at goal (625)		115	115		
<u>Enriched Uranium</u>					
n,2n	mg/MWD	2.60	2.60	3.10	3.64
U-236	mg/MWD/g/T	.0176	.0160	.0320	0.0256
g U-236 at goal (800)		147	147	214	147

These data are in agreement with experimental values obtained from the old and K Reactors, but are extrapolations for NPR and overbore cases.

DISCUSSION

Cycle times of close to two years presently exist in the slightly enriched uranium fuel stream. The cycle time could be reduced to eighteen months but inventory reductions at both the Feed Sites and Reactor Sites must be made.

The yields are based upon a limited number of analyses of once-through and recycled material. They will be refined as more data becomes available.

Pu production losses are proportional to incremental neptunium formed from recycling slightly enriched uranium. Gram per gram equivalence of delivered incremental Neptunium-237 from the recycle process closely approximates the Pu product loss.

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The costs of incremental neptunium production, other than lost production, are essentially those of U-235 burnout. These increased costs amount to \$383/ton for recycle of depleted .94 uranium blended with 1.2 per cent material; \$566/ton if 1.8 per cent U-235 is used for restoring the depleted uranium. The February Production Studies document, HW-76227, included all costs for separating Neptunium-227 in the chemical processing plants. The indicated Pu production losses associated with recycle material were not allowed. Thus the cost figures of the Production Studies document need not be amended.

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TABLE NO. 1

SUMMARY OF NEPTUNIUM-237 PRODUCED AND DELIVERED
WITHOUT RECYCLE FROM FY-1963 - FY-1972

Basin
Inventory
Kg @ 6/30/77

Total Ten
Years Incl.
NRD NR

FY-63 FY-64 FY-65 FY-66 FY-67 FY-68 FY-69 FY-70 FY-71 FY-72

Nine Reactors
Kgs Neptunium-237 Generated

E-N Base	16.7	17.4	22.4	27.4	28.2	28.2	28.2	28.2	28.2	28.2	28.2	253.1	46.4	14.1
E-N Shutdown	16.7	15.7	19.6	23.9	24.7	24.7	24.7	24.7	24.7	24.7	24.7	222.7	46.4	11.7
E-N Shutdown	16.7	13.0	15.7	20.0	20.8	20.8	20.8	20.8	20.8	20.8	20.8	184.9	46.4	9.4
E-N Shutdown	16.7	9.4	12.7	15.4	16.2	16.2	16.2	16.2	16.2	16.2	16.2	146.0	46.4	6.3
E-N Base/Aluminum Tubes	16.7	17.6	22.3	26.4	27.2	27.2	27.2	27.2	27.2	27.2	27.2	246.2	46.4	13.6
E-N Overbore	16.7	17.7	21.9	32.4	32.3	32.3	32.3	32.3	32.3	32.3	32.3	282.5	46.4	16.2
Natural U Base	16.7	17.3	21.6	26.2	27.0	27.0	27.0	27.0	27.0	27.0	27.0	243.8	46.4	13.5
Natural U Shutdown	16.7	17.3	20.4	24.5	25.3	25.3	25.3	25.3	25.3	25.3	25.3	227.3	46.4	11.9
Natural U Shutdown	16.7	14.3	17.1	20.2	19.8	19.8	19.8	19.8	19.8	19.8	19.8	187.1	46.4	9.9
Natural U Shutdown	16.7	9.4	12.3	15.3	16.1	16.1	16.1	16.1	16.1	16.1	16.1	148.1	46.4	8.1
Reduced Production Level 50,000	16.7	15.6	19.8	24.4	25.2	25.2	25.2	25.2	25.2	25.2	25.2	227.7	46.4	12.6
Reduced Production Level 40,000	16.7	11.7	15.7	19.9	20.7	20.7	20.7	20.7	20.7	20.7	20.7	188.2	46.4	10.4
Reduced Production Level 30,000	16.7	7.8	11.4	15.5	16.3	16.3	16.3	16.3	16.3	16.3	16.3	149.2	46.4	8.2
Natural U Base/Aluminum Tubes	16.7	17.6	21.6	25.2	26.0	26.0	26.0	26.0	26.0	26.0	26.0	237.1	46.4	13.0
Natural U Overbore	16.7	17.3	20.8	31.0	31.8	31.8	31.8	31.8	31.8	31.8	31.8	276.6	46.4	15.9

Nine Reactors
Kgs Recovered

E-N Base	15.0	15.3	17.9	22.5	25.1	25.5	25.5	25.5	25.5	25.5	25.5	223.3	39.0
E-N Shutdown	15.0	14.5	15.9	19.6	21.8	22.2	22.2	22.2	22.2	22.2	22.2	197.2	39.0
E-N Shutdown	15.0	13.4	12.9	16.1	18.3	18.7	18.7	18.7	18.7	18.7	18.7	165.6	39.0
E-N Shutdown	15.0	11.7	9.9	12.7	14.2	14.6	14.6	14.6	14.6	14.6	14.6	133.2	39.0
E-N Base/Aluminum Tubes	15.0	15.4	18.0	22.0	24.1	24.5	24.5	24.5	24.5	24.5	24.5	217.0	39.0
E-N Overbore	15.0	15.5	17.8	24.5	29.1	29.1	29.1	29.1	29.1	29.1	29.1	247.4	39.0
Natural U Base	15.0	15.3	17.5	21.6	24.0	24.4	24.4	24.4	24.4	24.4	24.4	215.4	39.0
Natural U Shutdown	15.0	15.3	17.0	20.2	22.4	22.8	22.8	22.8	22.8	22.8	22.8	201.6	39.0
Natural U Shutdown	15.0	13.9	14.1	16.8	18.0	17.9	17.9	17.9	17.9	17.9	17.9	167.3	39.0
Natural U Shutdown	15.0	11.7	9.8	12.5	14.1	14.5	14.5	14.5	14.5	14.5	14.5	134.6	39.0
Reduced Power Level	15.0	14.5	15.9	19.9	22.3	22.7	22.7	22.7	22.7	22.7	22.7	201.1	39.0
Reduced Power Level	15.0	12.8	12.3	16.0	18.3	18.7	18.7	18.7	18.7	18.7	18.7	167.9	39.0
Reduced Power Level	15.0	11.0	8.6	12.1	14.3	14.7	14.7	14.7	14.7	14.7	14.7	134.5	39.0
Natural U Base/Aluminum Tubes	15.0	15.4	17.6	21.1	23.0	23.4	23.4	23.4	23.4	23.4	23.4	209.1	39.0
Natural U Overbore	15.0	15.3	17.1	23.3	28.2	28.6	28.6	28.6	28.6	28.6	28.6	241.9	39.0

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TABLE NO. 2

INCREMENTAL NEPTUNIUM-237 PRODUCED AND DELIVERED
FROM RECYCLE FROM FY-1963 - FY-1972

	Total Ten Years Incl.										NRD	Basin Inventory Kg @ 6/30/72	
	FY-63	FY-64	FY-65	FY-66	FY-67	FY-68	FY-69	FY-70	FY-71	FY-72			
<u>Nine Reactors</u>													
<u>Kgs Neptunium-237 Generated</u>													
E-N Base	1.4	3.5	5.8	13.3	22.5	32.5	36.9	41.5	48.6	51.7	257.7	61.2	25.9
E-N Shutdown - - - - 50,000	1.4	3.3	5.2	13.5	19.6	28.3	32.5	35.9	42.0	42.0	223.7	61.3	21.0
E-N Shutdown - - - - 40,000	1.4	2.7	5.4	10.6	19.8	23.2	26.7	30.1	31.4	33.5	184.8	62.1	16.8
E-N Shutdown - - - - 30,000	1.1	1.7	4.0	6.6	13.1	15.5	18.0	21.9	21.1	20.5	123.5	61.4	10.3
E-N Base/Aluminum Tubes	1.4	3.2	4.6	13.8	20.4	28.0	38.2	34.8	46.2	41.4	232.0	60.0	20.7
E-N Overbore	1.8	4.1	6.6	18.8	26.9	38.9	43.9	49.0	57.1	60.5	307.6	60.4	30.3
Natural U Base	1.4	3.2	5.1	9.8	13.4	15.0	17.2	19.0	20.0	21.5	125.6	79.7	10.8
Natural U Shutdown - - 50,000	1.4	3.2	5.0	9.6	13.2	14.8	16.9	18.7	19.2	20.7	122.7	80.0	10.4
Natural U Shutdown - - 40,000	1.4	2.9	4.6	8.9	12.2	13.3	14.9	15.9	16.6	17.5	108.2	75.6	8.8
Natural U Shutdown - - 30,000	1.1	1.7	3.6	7.6	10.9	12.2	13.9	15.5	16.4	16.8	99.7	81.3	8.4
Reduced Power Level - 50,000	1.4	2.9	4.9	9.4	13.0	14.6	16.7	18.5	19.4	20.9	121.7	80.1	10.5
Reduced Power Level - 40,000	1.4	2.1	4.3	8.6	12.1	13.5	15.6	17.2	18.2	19.3	112.3	80.6	9.7
Reduced Power Level - 30,000	1.1	1.1	3.4	7.5	10.7	12.0	13.9	15.2	16.1	17.3	98.3	81.6	8.7
Natural U Base/Aluminum Tubes	1.4	3.2	5.1	9.8	13.4	15.0	17.2	19.0	20.0	21.5	125.6	79.7	10.8
Natural U Overbore	1.8	4.1	5.9	11.8	15.8	17.7	20.3	22.4	23.5	25.3	148.6	79.3	12.7

Nine Reactors
Kgs Recovered

E-N Base	1.3	2.2	3.7	7.3	17.9	24.7	29.5	37.1	40.5	44.5	208.7	49.7	
E-N Shutdown - - - - - 50,000	1.3	2.1	3.4	8.5	14.9	21.5	27.4	30.8	35.0	37.8	182.7	49.2	
E-N Shutdown - - - - - 40,000	1.3	1.9	2.9	7.2	13.7	19.4	22.5	25.6	27.7	29.3	151.5	49.8	
E-N Shutdown - - - - - 30,000	1.0	1.3	1.9	4.8	8.9	12.9	15.0	17.9	19.3	18.7	101.7	49.0	
E-N Base/Aluminum Tubes	1.3	2.1	3.5	8.3	15.4	21.8	29.8	32.8	36.5	39.5	191.0	49.4	
E-N Overbore	1.7	2.7	4.3	11.5	20.6	29.6	37.3	41.8	47.7	52.9	250.1	48.5	
Natural U Base	1.3	2.1	2.6	4.8	10.1	12.8	14.8	16.1	17.5	18.9	101.0	62.2	
Natural U Shutdown - - - 50,000	1.3	2.1	2.5	4.6	9.9	12.6	14.6	15.8	17.1	18.2	98.7	62.4	
Natural U Shutdown - - - 40,000	1.3	1.9	2.2	4.2	9.2	11.6	12.9	13.7	14.7	15.4	87.1	59.1	
Natural U Shutdown - - - 30,000	1.1	1.3	1.3	3.1	8.0	10.3	12.0	13.0	14.4	15.2	79.7	63.5	
Reduced Power Level - - 50,000	1.3	1.9	2.4	4.5	9.7	12.4	14.3	15.6	17.0	18.4	97.5	62.4	
Reduced Power Level - - 40,000	1.3	1.6	1.8	3.9	9.0	11.5	13.5	14.5	15.9	17.1	90.1	62.9	
Reduced Power Level - - 30,000	1.1	1.0	0.9	3.0	7.9	10.3	11.9	12.9	14.0	15.2	78.2	63.7	
Natural U Base/Aluminum Tubes	1.3	2.1	2.5	4.8	10.1	12.8	14.8	16.1	17.5	19.0	101.0	62.3	
Natural U Overbore	1.7	2.7	3.4	6.0	12.4	15.1	17.1	19.2	20.6	21.9	120.1	61.9	

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TABLE NO. 3

SUMMARY OF NEPTUNIUM-237 PRODUCED AND DELIVERED
INCLUDING RECYCLE FROM FY-1963 - FY-1962

	Total Ten Years Incl.										Basin Inventory	
	NRD										Kg @ 6/30/77	
	FY-63	FY-64	FY-65	FY-66	FY-67	FY-68	FY-69	FY-70	FY-71	FY-72		
<u>Nine Reactors</u>												
<u>Kgs Neptunium-237 Generated</u>												
E-N Base	18.1	20.9	28.2	40.7	50.7	60.7	65.1	69.7	76.8	79.9	510.8	107.6
E-N Shutdown - - - - 50,000	18.1	19.0	24.8	37.4	44.3	53.0	57.2	60.6	66.7	65.3	446.4	107.7
E-N Shutdown - - - - 40,000	18.1	15.7	21.1	30.6	40.6	44.0	47.5	49.3	50.6	52.2	369.7	108.5
E-N Shutdown - - - - 30,000	17.8	11.1	16.7	22.0	29.3	31.7	34.2	38.1	35.4	33.2	269.5	107.8
E-N Base/Aluminum Tubes	18.1	20.8	26.9	40.2	47.6	55.2	65.4	62.0	73.4	68.6	478.2	106.4
E-N Overbore	18.5	21.8	28.5	51.2	59.2	71.2	76.2	81.3	89.4	92.8	590.1	106.8
Natural U Base	18.1	20.5	26.7	36.0	40.4	42.0	44.2	46.0	47.0	48.5	369.4	126.1
Natural U Shutdown - - - 50,000	18.1	20.5	25.4	34.1	38.5	40.1	42.2	43.8	42.9	44.4	350.0	126.4
Natural U Shutdown - - - 40,000	18.1	17.2	21.7	29.1	32.0	33.1	34.7	35.7	36.4	37.3	295.3	122.0
Natural U Shutdown - - - 30,000	17.8	11.1	15.9	22.9	27.0	28.3	30.0	31.6	32.5	30.7	247.8	127.7
Reduced Power Level - - 50,000	18.1	18.5	24.7	33.8	38.2	39.8	41.9	43.7	44.6	46.1	349.4	126.5
Reduced Power Level - - 40,000	18.1	13.8	20.0	28.5	32.8	34.2	36.3	37.9	38.9	40.0	300.5	127.0
Reduced Power Level - - 30,000	17.8	8.9	14.8	23.0	27.0	28.3	30.2	31.5	32.4	33.6	247.5	128.0
Natural U Base/Aluminum Tubes	18.1	20.8	26.7	35.0	39.4	41.0	43.2	45.0	46.0	47.5	362.7	126.1
Natural U Overbore	18.5	21.4	26.7	42.8	47.6	49.5	52.1	54.2	55.3	57.1	425.2	125.7

Nine Reactors
Kgs Recovered

E-N Base	16.3	17.5	21.6	29.8	43.0	50.2	55.0	62.6	66.0	70.0	432.0	88.7
E-N Shutdown - - - - 50,000	16.3	16.6	19.3	28.1	36.7	43.7	49.6	53.0	57.2	59.4	379.9	88.2
E-N Shutdown - - - - 40,000	16.3	15.3	15.8	23.3	32.0	38.1	41.2	43.6	45.1	46.4	317.1	88.8
E-N Shutdown - - - - 30,000	16.0	13.0	11.8	17.5	23.1	27.5	29.6	32.5	33.0	30.9	234.9	88.0
E-N Base/Aluminum Tubes	16.3	17.5	21.5	30.3	39.5	46.3	54.3	57.3	61.0	64.0	408.0	88.4
E-N Overbore	16.7	18.2	22.1	36.0	49.7	58.7	66.4	70.9	76.8	82.0	497.5	87.5
Natural U Base	16.3	17.4	20.1	26.4	34.1	37.2	39.2	40.5	41.9	43.3	316.4	101.2
Natural U Shutdown - - - 50,000	16.3	17.4	19.5	24.8	32.3	35.4	37.4	38.5	39.1	39.6	300.3	101.4
Natural U Shutdown - - - 40,000	16.3	15.8	16.3	21.0	27.2	29.5	30.8	31.6	32.6	33.3	254.4	98.1
Natural U Shutdown - - - 30,000	16.1	13.0	11.1	15.6	22.1	24.8	26.5	27.5	28.9	28.7	214.3	102.5
Reduced Power Level - - 50,000	16.3	16.4	18.3	24.4	32.0	35.1	37.0	38.3	39.7	41.1	298.6	101.4
Reduced Power Level - - 40,000	16.3	14.4	14.1	19.9	27.3	30.2	32.2	33.2	34.6	35.8	258.0	101.9
Reduced Power Level - - 30,000	16.1	12.0	9.5	15.1	22.2	25.0	26.6	27.6	28.7	29.9	212.7	102.7
Natural U Base/Aluminum Tubes	16.3	17.5	20.1	25.9	33.1	36.2	38.2	39.5	40.9	42.4	310.1	101.3
Natural U Overbore	16.7	18.0	20.5	29.3	40.6	43.7	45.7	47.8	49.2	50.5	362.0	100.9

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