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HANFORD ATOMIC PRODUCTS OPERATION - RICHLAND, WASHINGTON

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IPD PRODUCTION PROJECTIONS

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AUTHOR

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IPD PRODUCTION PROJECTIONS

The attached tables are based on the use of higher levels of slightly enriched uranium for fuel in tritium and U-233 co-production loadings. Although these cases probably will not be considered in Production Studies in the next few months, they are of interest to IPD in product diversification and in securing greater percentages of secondary product from a given reactor. In general the values used are more assumptive than previous drafts. Since this is the case they should be thoroughly checked and corrected where indicated.

Base case enrichment assumed for the reactors in RD 4 is 1.35 percent slightly enriched uranium. A small penalty is assumed in reactor operating efficiency where this metal is used for reactor enrichment (instead of .94 percent material). In E-N cases the active fuel per column will still be more than 80 percent of the charge length of a tube loaded with natural U, and thus tolerable as far as specific power and related metal performance. For thorium loads, some type of segmental charging will have to be worked out so that individual tube powers will not be drastically higher than present fuel columns. If column loadings were considered, a much greater penalty would be envisioned in operating efficiency from using the higher level of enrichment.

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Reactor Inventory

It has been suggested that reactor inventory numbers would be helpful in evaluating metal requirements and load economics. In this regard the small reactors can be considered as having 1500 tubes operating at a reference power. This power would be the reactor power divided by 1500. The actual physical number of tubes then can be classified as 1500 operating at .9 of reference power, and 500 operating at .3 of reference power. In the blanket loadings the E-metal involved will then be operating at the lower figure. The buildup in thoria columns will be measured on the basis of adjacent tube power. Roughly twice as many tubes will be required for 8.5 density thoria as required for uranium metal on a ton basis.

The K areas can be assumed to have 2400 active central tubes; the reference power is then obtained by dividing reactor power by 2400. Some 2400 central zone tubes will then be operating at an average .9 of reference power, and 800 fringe tubes can be considered as averaging one-third of reference power. It is recognized that these are rough rule of thumb, but they may be adequate for projecting reactor inventory with time. Of course, the physical inventory is a constant number of pieces and can be obtained by the ratio of tubes of E-metal to tubes of thoria. This ratio is 5.8 E-metal to 1 thoria for the K reactors, and 5.3 to 1 for the small reactors and C. For fringe loading, this ratio is 2 to 1 for the small reactors and 2.3 to 1 for the K's.

Principal Engineer-Reactor Process

LWL:ewm

Attachments

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Table No. 1

Small Reactors

(Thoria Load with 1.35 Slightly Enriched U)

	<u>Nat U Loadings</u>		<u>Blanket Loading</u>		<u>Full Reactor</u>	
	<u>Forecast</u>	<u>AEC Case</u>	<u>Forecast</u>	<u>AEC Case</u>	<u>Forecast</u>	<u>AEC Case</u>
<u>Power Level</u>	1 960	1 960	1 960	1 960	1 960	1 960
<u>Percent to Nat</u>	92.0	92.0	86.7	86.7	-	-
E	8.0	8.0	13.3	13.3	100	100
<u>Operating Efficiency</u>	75.8	72.5	74.1	70.9	67.7	64.8
<u>KMWD to Nat</u>	497.7	477.0	459.7	440.0	-	-
Spike	32.2	30.8	31.5	30.1	28.8	27.5
Blanket	12.2	11.2	39.0	37.4	35.6	34.2
Core	-	-	-	-	420.0	402.1
Total	<u>542.1</u>	<u>519.0</u>	<u>530.2</u>	<u>507.5</u>	<u>484.4</u>	<u>463.8</u>
<u>Exposure - Nat (MWD/T)</u>	600	600	600	600	-	-
E (MWD/T)	1 060	1 060	1 060	1 060	1 060	1 060
Thoria Fringe (MWD/AT)	-	-	1 080	1 080 (1285 g/T)	1 080	1 080
Core	-	-	-	-	661	661 (135 g/T)
<u>Conversion Ratio</u>						
Pu - Nat	.848	.848	.848	.848	-	-
E - Spike	.564	.564	.564	.564	.564	.564
Fringe	-	-	.553	.553	.553	.553
Core	-	-	-	-	.553	.553
U-233 - Fringe	-	-	.353	.353	.353	.353
Leakage	-	-	.017	.017	.017	.017
Core	-	-	-	-	.353	.353
<u>Tonnage - Nat</u>	829.5	795.0	766.2	733.3	-	-
E (1.35) Spike	30.4	29.1	29.7	28.4	27.2	25.9
Blanket	11.5	10.6	36.8	35.3	33.6	32.3
Core	-	-	-	-	396.2	379.3
Thoria - Blanket	-	-	17.7	17.0	16.1	15.9
Core	-	-	-	-	109.8	105.0
<u>Production (annual kg)</u>						
Pu - Nat	422.0	404.5	389.8	373.1	-	-
E - Spike	18.2	17.4	17.8	17.0	16.2	15.5
Fringe	6.9	6.3	21.6	20.7	19.7	18.9
Core	-	-	-	-	232.2	222.4
U-233 - Blanket	-	-	13.8	13.2	12.6	12.5
Core	-	-	-	-	148.3	141.9
Leakage	-	-	9.0	8.6	8.2	7.9
T ₂	<u>6.3</u>	<u>6.0</u>	-	-	-	-
Total Pu	<u>447.1</u>	<u>428.2</u>	<u>429.2</u>	<u>410.8</u>	<u>268.1</u>	<u>256.8</u>
Total U-233	-	-	<u>22.8</u>	<u>21.8</u>	<u>169.1</u>	<u>162.3</u>
Total T ₂	<u>6.3</u>	<u>6.0</u>	-	-	-	-

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Table No. 2

C Reactor

Thoria Load (1.35 Percent U-235 Fuel)

	<u>Regular</u>	<u>Blanket Loading</u>	<u>E-Q</u>
<u>Power Level</u> - Avg MW	2 191	2 191	2 191
Percent to Nat	86.2	82.0	-
1.35 % Enriched	13.8	18.0	100
<u>Operating Efficiency</u>	74.7	73.0	66.0
<u>KMWD</u> - Nat	515.6	479.4	-
E - Spike	82.5	43.3	39.2
Blanket	-	61.9	56.4
Core	-	-	433.3
Total	<u>598.1</u>	<u>584.6</u>	<u>528.9</u>
<u>Exposure</u> - Nat (MWD/T)	600	600	-
Enr. (MWD/T)	1 080	1 080	1 080
Thoria - Blanket (MWD/AT)	-	1 080 (1285 g/T)	1 080
Core (MWD/AT)	-	-	661 (1351 g/T)
<u>Conversion Ratio</u>			
Pu - Nat	.856	.856	-
E - All Zones	.564	.564	.564
Q - Blanket	-	.345	.345
Core	-	-	.350
Leakage	-	.017	.017
<u>Tonnage</u> - Nat	859.3	799.0	-
E - Spike	76.4	40.1	36.3
Core	-	-	401.1
Blanket	-	57.3	52.2
Thoria - Core	-	-	112.3
Blanket	-	16.6	15.2
<u>Production</u>			
Pu - Nat	441.4	410.4	-
E - Spike	46.5	24.4	22.1
Core	-	-	244.4
Blanket	-	34.9	31.8
Q - Core	-	-	151.7
Blanket	-	21.3	19.5
Leakage	-	9.9	9.0
Total Pu	<u>487.9</u>	<u>469.7</u>	<u>298.3</u>
Total U-233	-	<u>31.2</u>	<u>180.2</u>

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Table No. 3

K Reactors

Thoria Load (1.35 Percent U-235 Fuel)

	<u>Regular</u>	<u>Blanket Loading</u>	<u>E-Q</u>
<u>Power Level</u>	4 400	4 400	4 400
Percent - Nat	93.6	88.3	-
1.35	6.4	11.7	100
<u>Operating Efficiency</u>	81.0	79.5	77.5
<u>KMWD</u> - Nat	1 223.9	1 127.3	-
1.35 Spike	76.9	67.6	65.9
Blanket	-	81.8	79.7
Core	-	-	1 099.0
Total	<u>1 300.8</u>	<u>1 276.7</u>	<u>1 244.6</u>
<u>Exposure</u> - Nat (MWD/T)	630	630	-
1.35 (MWD/T)	1 150	1 150	1 150
Thoria (MWD/AT) - Fringe	-	686(989 g/T)	686(878 g/T)
Core	-	-	386(902 g/T)
<u>Tonnage</u> - Nat	1 942.7	1 789.4	-
1.35 - Spike	66.9	58.8	57.3
Fringe	-	71.1	69.3
Core	-	-	955.7
Thoria Fringe	-	41.4	40.4
Core	-	-	377.7
<u>Conversion Ratio</u>			
Nat	.918	.918	-
1.35	.641	.641	.641
U-233 - Fringe	-	.305	.305
Core	-	-	.310
Leakage	-	.009	.009
<u>Production</u>			
Pu - Nat	1 123.5	1 034.9	-
E - Spike	49.3	43.3	42.2
Fringe	-	52.4	51.1
Core	-	-	704.4
U-233 - Fringe	-	24.9	24.3
Core	-	-	340.7
Leakage	-	11.5	11.2
Total Pu	<u>1 172.8</u>	<u>1 130.7</u>	<u>797.7</u>
Total U-233	-	<u>36.4</u>	<u>376.2</u>

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Table No. 4

Small Reactors

E-N Load (1.35 Percent Enriched U)

	<u>Nat U Loadings</u>		<u>Blanket Loading</u>		<u>Full Reactor</u>	
	<u>Forecast</u>	<u>AEC Case</u>	<u>Forecast</u>	<u>AEC Case</u>	<u>Forecast</u>	<u>AEC Case</u>
<u>Power Level</u>	1 960	1 960	1 960	1 960	1 960	1 960
<u>Percent to Nat</u>	92.0	92.0	86.7	86.7	-	-
1.35	8.0	8.0	13.3	13.3	100	100
<u>Operating Efficiency</u>	75.8	72.5	75.4	72.1	73.5	70.3
<u>KMWD - Nat</u>	497.7	475.7	467.7	446.6	-	-
1.35 - Spike	32.2	30.8	32.0	30.6	31.2	29.8
Blanket	12.2	11.7	39.7	37.9	38.7	37.0
Core	-	-	-	-	455.9	435.7
Total	<u>542.1</u>	<u>518.2</u>	<u>539.4</u>	<u>515.1</u>	<u>525.8</u>	<u>502.5</u>
<u>Exposure - Nat</u>	600	600	600	600	-	-
E	1 060	1 060	1 060	1 060	1 060	1 060
<u>Conversion Ratio</u>						
Pu - Nat	.848	.848	.848	.848	-	-
Spike	.564	.564	.575	.575	.587	.587
Fringe	.575	.575	.587	.587	.587	.587
Core	-	-	-	-	.587	.587
T ₂ - Fringe	.364	.364	.364	.364	.364	.364
Core	-	-	-	-	.364	.364
Leakage	.004	.004	.017	.017	.017	.017
<u>Tonnage-Nat</u>	833.0	793.0	779.6	744.5	-	-
1.35 Spike	30.4	29.1	30.2	28.9	29.4	28.1
Fringe	11.5	11.0	37.4	35.8	36.5	34.9
Core	-	-	-	-	430.1	411.0
Li - Fringe	0.5	0.5	1.5	1.5	7.6	7.6
<u>Production</u>						
Pu - Nat	422.0	403.4	396.6	378.7	-	-
1.35 Spike	18.2	17.4	18.4	17.6	18.3	17.5
Fringe	6.9	6.6	23.3	22.2	22.7	21.7
Core	-	-	-	-	267.6	255.8
T ₂ - Leakage	2.2	2.1	9.2	8.8	8.9	8.5
Blanket	4.1	3.9	-	-	14.1	12.7
Core	-	-	14.6	13.8	165.9	158.6
Total Pu (kg)	<u>447.1</u>	<u>437.4</u>	<u>438.3</u>	<u>418.5</u>	<u>308.6</u>	<u>295.0</u>
Total T ₂ (kg equiv)	<u>6.3</u>	<u>6.0</u>	<u>23.8</u>	<u>22.6</u>	<u>188.9</u>	<u>180.6</u>

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Table No. 5

C Reactor

E-N Load (1.35 Percent Enriched Fuel)

	<u>Regular</u>	<u>Blanket Loading</u>	<u>E-N</u>
<u>Power Level</u> - Avg MW	2 191	2 191	2 191
Percent to Nat	86.2	82.0	-
1.35 % to E	13.8	18.0	100
<u>Operating Efficiency</u>	74.7	74.3	72.4
<u>KMWD</u> - Nat	515.6	487.9	-
E - Spike	82.5	44.1	43.0
Blanket	-	63.0	61.4
Core	-	-	475.3
Total	<u>598.1</u>	<u>595.0</u>	<u>579.7</u>
<u>Exposure</u> - Nat	600	600	-
1.35	1 080	1 080	1 080
<u>Conversion Ratio</u>			
Pu - Nat	.856	.856	-
1.35 - Spike	.564	.584	.604
Blanket	-	.564	.584
Core	-	-	.604
T ₂ - Blanket	-	.355	.355
Core	-	-	.355
Leakage	-	.017	.017
<u>Tonnage</u> - Nat	859.3	813.2	-
1.35 - Spike	76.4	40.8	39.8
Blanket	-	58.3	56.8
Core	-	-	440.0
Lithium	-	1.2	7.5
<u>Production</u>			
Pu - Nat	441.4	417.6	-
1.35 - Spike	46.5	25.8	26.0
Blanket	-	35.5	35.9
Core	-	-	287.1
T ₂ - Blanket	-	22.4	21.8
Core	-	-	168.7
Leakage	-	10.1	9.9
Total Pu	<u>487.9</u>	<u>478.9</u>	<u>349.0</u>
Total T ₂		<u>32.5</u>	<u>200.4</u>

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Table No. 6

K Reactors

E-N Loading (1.35 Percent U-235 Fuel)

	<u>Regular</u>	<u>Blanket Loading</u>	<u>Core and Blanket</u>
<u>Power Level</u>	4 400	4 400	4 400
Percent to Nat	93.6	88.3	-
1.35	6.4	11.7	100
<u>Operating Efficiency</u>	81.0	81.0	81.0
<u>KMWD</u> - Nat	1 223.9	1 148.6	-
E - Spike	76.9	68.9	68.9
Blanket	-	83.3	83.3
Core	-	-	1 148.6
Total	<u>1 300.8</u>	<u>1 300.8</u>	<u>1 300.8</u>
<u>Exposure</u> - Nat	630	630	630
E	1 150	1 150	1 150
<u>Tonnage</u> - Nat	1 942.7	1 823.2	-
1.35 - Spike	66.9	59.9	59.9
Fringe	-	72.4	72.4
Core	-	-	998.9
Lithium	-	2.0	19.5
<u>Conversion Ratio</u>			
Nat	.918	.918	-
E - Spike	.641	.656	.671
Fringe	-	.656	.671
Core	-	-	.671
T ₂ - Fringe	-	.330	.330
Core	-	-	.334
Leakage	-	.009	.009
<u>Production</u>			
Pu - Nat	1 123.5	1 054.4	-
E - Spike	49.3	45.2	45.6
Fringe	-	54.6	55.9
Core	-	-	770.7
T ₂ - Fringe	-	27.5	27.5
Core	-	-	383.6
Leakage	-	11.7	11.7
Total Pu (kg)	<u>1 172.8</u>	<u>1 154.2</u>	<u>872.2</u>
Total T ₂ (kg equiv)	-	<u>39.2</u>	<u>422.9</u>

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