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### NUCLEAR MASS INVENTORY, PHOTON DOSE RATE AND THERMAL DECAY HEAT OF SPENT RESEARCH REACTOR FUEL ASSEMBLIES\*

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# NUCLEAR MASS INVENTORY, PHOTON DOSE RATE AND THERMAL DECAY HEAT OF SPENT RESEARCH REACTOR FUEL ASSEMBLIES

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#### SUMMARY

This document has been prepared to assist research reactor operators possessing spent fuel containing enriched uranium of United States origin to prepare part of the documentation necessary to ship this fuel to the United States. Data are included on the nuclear mass inventory, photon dose rate, and thermal decay heat of spent research reactor fuel assemblies.

Isotopic masses of U, Np, Pu and Am that are present in spent research reactor fuel are estimated for MTR, TRIGA and DIDO fuel assembly types. The isotopic masses of each fuel assembly type are given as functions of U-235 burnup in the spent fuel, and of initial U-235 enrichment and U-235 mass in the fuel assembly.

Photon dose rates of spent MTR, TRIGA and DIDO-type fuel assemblies are estimated for fuel assemblies with up to 80% U-235 burnup and specific power densities between 0.089 and 2.857 MW/kg<sup>235</sup>U, and for fission product decay times of up to 20 years.

Thermal decay heat loads are estimated for spent fuel based upon the fuel assembly irradiation history (average assembly power vs. elapsed time) and the spent fuel cooling time.

#### INTRODUCTION

As part of the Department of Energy's spent nuclear fuel acceptance criteria, the mass of uranium and transuranic elements in spent research reactor fuel must be specified. These data are, however, not always known or readily determined. It is the purpose of this report to provide estimates of these data for some of the more common research reactor fuel assembly types. The specific types considered here are MTR, TRIGA and DIDO fuel assemblies.

The degree of physical protection given to spent fuel assemblies is largely dependent upon the photon dose rate of the spent fuel material. These data also, are not always known or readily determined. Because of a self-protecting dose rate level of radiation (dose rate greater than 100 rem/h at 1 m in air), it is important to know the dose rate of spent fuel assemblies at all time. Estimates of the photon dose rate for spent MTR, TRIGA and DIDO-type fuel assemblies are given in this report. For safe spent fuel assembly containment, the thermal heat load generated by the decay of fission products in spent fuel material is an important consideration. This heat load can be estimated by a simple analytical expression that is given in this report.

# NUCLEAR MASS INVENTORY

The mass inventory of the heavy metals in research reactor fuels has been calculated using the WIMS code<sup>1</sup> for unit-cell models of MTR, TRIGA and DIDO fuel assembly types. Models of each fuel assembly type were neutronically burned for a length of time corresponding to typical fuel-cycle lengths and U-235 burnup<sup>2</sup>. Table 1 summarizes the fuel assembly models for which mass inventory calculations were made.

Assembly Type	U-235 Burnup, %	U-235 Enrichment, %	U-235 Mass, g
MTR	5, 10, 20, 30, 40, 50, 60, 70, 80	93	100 200 300 400
(19 fuel plates)		45	200 300 400
	· · · · · · · · · · · · · · · · · · ·	19.75	100 200 300 400 500
TRIGA	5, 10, 15, 20, 25, 30, 35	70 (8.5wt% U)	133
(single rod)		20 (20wt% U)	98
		20 (12wt% U)	54
		20 (8.5wt% U)	38
TRIGA	10, 20, 30, 40, 50, 60	93.1 (10wt% U)	41.4
(25 rod cluster)		19.7 (45wt% U)	53.6
DIDO	10, 20, 30, 40, 50, 60	93, 80, 60	150
(4 fuel tubes)		20	200

#### Table 1. Fuel Assembly Models

Mass inventory calculations for MTR models were made for 19-fuel plate assemblies with up to 80% U-235 burnup, for 93, 45 and 19.75% U-235 enrichments, and for initial U-235 masses of 100 to 500 g. The mass inventory of MTR-type fuel assemblies is not a strong function of the number of fuel plates<sup>3</sup>. Similar calculations were made for two TRIGA assembly types – a single rod model and a 25-rod cluster model. The maximum U-235 burnup in these models were respectively, 35 and 60%. There were four fuel types for the single rod model and two fuel types for the cluster model. For DIDO fuel assembly types, mass inventory calculations were made for a 4-fuel tube model with up to 60% U-235 burnup, and for four fuel enrichments and assembly masses.

The results of the mass inventory calculations are shown in the following tables:

Table 2 — MTR Fuel 93% Enrichment	Table 5 — TRIGA Fuel Single-Rod Model
Table 3 — MTR Fuel 45% Enrichment	Table 6 - TRIGA Fuel 25-Rod Cluster Model
Table 4 — MTR Fuel 19.75% Enrichment	Table 7 — DIDO Fuel

The tables show the isotopic masses of U, Np, Pu and Am that are present in spent fuel as functions of the fuel assembly U-235 burnup and initial U-235 mass. As will be noted in the tables for most fuel assembly types, the uranium fuel compositions have excluded initial enrichments of U-234 and U-236. In order to account for initial enrichments of U-234 and/or U-236 in the tables, initial U-234 and U-236 masses can be simply added to the spent fuel mass

Table 2A.	100	g U-23	5 MTR	Fuel,	93% E	Enrich	ment				Table 2B.	200	g U-23	5 MTR	Fuel,	93%	Inrich	ment			
U-235:											U-235:										
Burnup, %	0	5	10	20	30	-40	50	60	70	80	Bumup, %	0	5	10	20	30	40	50	60	70	80
Burned, g	0	5	10	20	30	40	50	60	_ 70	80	Burned, g	0	10	20	40	60	_ 80_	100	120	140	160
U-234	0	0	0	0	0	0	0	0	0	0	U-234	0	0	0	0	0	0	0	0	0	0
U-235	100	95	90	80	70	60	50	40	30	20	U-235	200	190	180	160	140	120	100	80	60	40
U-236	0	1	2	3	5	6	8	9	11.	12	U-236	0	2	3	6	10	13	16	19	21	24
U-238	8	8	- 8	8	7	7	7	7	7	7	U-238	15	15	15	15	15	15	15	15	14	14
U	108	103	99	91	82	74	65	56	48	39	U	215	207	198	181	164	147	130	113	96	78
Np-237	0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.3	Np-237	0	0.0	0.0	0.0	0.1	0.2	0.3	0.4	0.6	0.8
Np	0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.3	Np	0	0.0	0.0	0.0	0.1	0.2	0.3	0.4	0.6	0.8
Pu-238	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pu-238	0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Pu-239	0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	Pu-239	0	0.0	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3
Pu-240	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pu-240	0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
Pu-241	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pu-241	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pu-242	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pu-242	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pu	0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2	Pu	0	0.0	0.1	0.2	0.2	0.3	0.3	0.4	0.5	0.6
Am-241	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Am-241	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Am	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Am	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Table 2C	200	a 11 22	5 MTC	Fuel	029/	Enrich	mont				Table 2D	400	a 11 22	5 MTC	Fuel	029/	Enrich	mont			
Table 2C.	300	g U-23	5 MTF	l Fuel,	93% I	Enrich	ment				Table 2D.	400	g U-23	5 MTF	R Fuel	93%	Enrich	ment			
Table 2C. U-235:	300	g U-23	5 MTF	R Fuel,	93% I	Enrich	ment	60	70	80	Table 2D. U-235: Burpup %	400	g U-23	5 MTF	R Fuel	93%	Enrich	ment	60	70	
Table 2C. U-235: Burnup, % Burned o	<b>300</b>	g U-23 5 15	5 MTF 10 30	20 60	93%   30 90	40	50	60 180	70 210	80 240	Table 2D. U-235: Burnup, % Burned, o	400 0	g U-23 5 20	5 MTF	20 80	93% 30	Enrich 40 160	ment 50	60 240	70 280	80 320
Table 2C.           U-235:           Burnup, %           Burned, g           U-234	300 0 0	g U-23 5 15 0	5 MTF 10 30	20 60	93%   30 90	Enrich 40 120	50 50 150	60 180	70 210	80 240	Table 2D.           U-235:           Burnup, %           Burned, g           U-234	400 0 0	g U-23 5 20	10 40	20 80	93% 30 120	40 160	50 200	60 240	70 280	80 320
Table 2C. U-235: Burnup, % Burned, g U-234 U-235	300 0 0 300	g U-23 5 15 0 285	5 MTF 10 30 0 270	20 60 0 240	93%   30 90 0 210	40 120 0 180	50 150 0 150	60 180 0 120	70 210 0 90	80 240 0 60	Table 2D.           U-235:           Bumup, %           Burned, g           U-234           U-235	400 0 0 400	g U-23 5 20 0 380	10 40 360	20 80 320	93% 30 120 0 280	40 160 240	50 200 0 200	60 240 0	70 280 0 120	80 320 0 80
Table 2C.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236	300 0 0 300 0	g U-23 5 15 0 285 3	5 MTF 10 30 0 270 5	20 60 0 240 10	93%   30 90 0 210 15	Enrich 40 120 0 180 19	50 150 0 150 24	60 180 0 120 28	70 210 0 90 33	80 240 0 60 37	Table 2D.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236	400 0 0 400 0	g U-23 5 20 0 380 3	10 40 360 7	20 80 0 320 14	93% 30 120 0 280 20	40 160 240 26	50 200 0 200 33	60 240 0 160 39	70 280 0 120 44	80 320 0 80 50
Table 2C.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238	300 0 0 300 0 23	g U-23 5 15 0 285 3 23	10 30 270 5 22	20 60 0 240 10 22	93%   30 90 210 15 22	40 120 0 180 19 22	50 150 0 150 24 22	60 180 0 120 28 21	70 210 0 90 33 21	80 240 0 60 37 21	Table 2D.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238	400 0 0 400 0 30	g U-23 5 20 0 380 3 30	10 40 0 360 7 30	20 80 0 320 14 30	93% 30 120 0 280 20 29	40 160 240 26 29	50 200 0 200 33 29	60 240 0 160 39 28	70 280 0 120 44 28	80 320 0 80 50 27
Table 2C.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U	300 0 0 300 0 23 323	5 15 0 285 3 23 310	5 MTF 10 30 270 5 22 297	20 60 240 10 22 272	93%   30 90 210 15 22 247	40 120 0 180 19 22 221	50 150 0 150 24 22 196	60 180 120 28 21 170	70 210 90 33 21 144	80 240 0 60 37 21 118	Table 2D.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238	400 0 0 400 0 30 430	5 20 380 3 30 413	5 MTF 10 40 0 360 7 30 397	20 80 0 320 14 30 363	30 120 0 280 20 29 329	40 160 240 26 29 295	50 200 0 200 33 29 261	60 240 160 39 28 227	70 280 0 120 44 28 192	80 320 0 80 50 27 157
Table 2C.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U	300 0 0 300 0 23 323 0	g U-23 5 15 0 285 3 23 310 0.0	5 MTF 10 30 270 5 22 297 0.0	20 60 240 10 272 0.1	93%   30 90 210 15 22 247 0.2	40 120 0 180 19 22 221 0.4	50 150 0 150 24 22 196 0.6	60 180 0 120 28 21 170 0.8	70 210 90 33 21 144 1.1	80 240 0 60 37 21 118 1.5	Table 2D.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U	400 0 0 400 0 30 430 0	5 20 380 30 413 0.0	10 40 360 7 30 397 0.0	20 80 0 320 14 30 363 0.2	30 120 0 280 20 29 329 0.4	40 160 240 26 29 295 0.6	50 200 0 200 33 29 261 0.9	60 240 160 39 28 227 1.3	70 280 0 120 44 28 192 1.7	80 320 0 80 50 27 157 2.2
Table 2C.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U           Np-237           Np	300 0 300 0 23 323 0 0	g U-23 5 15 0 285 3 23 310 0.0 0.0	5 MTF 10 30 270 5 22 297 0.0 0.0	20 60 0 240 10 22 272 0.1 0.1	93%   30 90 210 15 22 247 0.2 0.2	40 120 0 180 19 22 221 0.4 0.4	50 150 0 150 24 22 196 0.6 0.6	60 180 0 120 28 21 170 0.8 0.8	70 210 90 33 21 144 1.1 1.1	80 240 0 60 37 21 118 1.5 1.5	Table 2D.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Np-237         Np	400 0 0 400 0 30 430 0 0	5 20 380 30 413 0.0 0.0	10 40 0 360 7 30 397 0.0 0.0	20 80 0 320 14 30 363 0.2 0.2	30 120 0 280 20 29 329 0.4 0.4	40 160 0 240 26 29 295 0.6 0.6	ment] 50 200 0 200 33 29 261 0.9 0.9	60 240 160 39 28 227 1.3 1.3	70 280 0 120 44 28 192 1.7 1.7	80 320 0 80 50 27 157 2.2 2.2
Table 2C.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U           Np-237           Np           Pu-238	300 0 300 0 23 323 0 0 0	g U-23 5 15 0 285 3 23 310 0.0 0.0 0.0	5 MTF 10 30 270 5 22 297 0.0 0.0 0.0	20 60 0 240 10 272 0.1 0.1 0.0	93%   30 90 210 15 22 247 0.2 0.2 0.0	40 120 0 180 19 22 221 0.4 0.4 0.0	ment 50 150 0 150 24 22 196 0.6 0.6 0.1	60 180 0 120 28 21 170 0.8 0.8 0.1	70 210 90 33 21 144 1.1 1.1 0.2	80 240 0 60 37 21 118 1.5 1.5 0.3	Table 2D.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Np-237         Np         Pu-238	400 0 400 0 30 430 0 0 0 0	5 20 380 330 413 0.0 0.0 0.0	10 40 360 7 30 397 0.0 0.0 0.0	20 80 0 320 14 30 363 0.2 0.2 0.0	30 120 0 280 20 29 329 0.4 0.4 0.4	40 160 240 26 29 295 0.6 0.6 0.1	ment 50 200 200 33 29 261 0.9 0.9 0.1	60 240 160 39 28 227 1.3 1.3 0.2	70 280 0 120 44 28 192 1.7 1.7 0.3	80 320 0 80 50 27 157 2.2 2.2 0.5
Table 2C.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Pu-237         Np         Pu-238         Pu-238         Pu-238         Pu-239	300 0 0 300 0 23 323 0 0 0 0 0	5 15 0 285 3 23 310 0.0 0.0 0.0 0.0	5 MTF 10 30 0 270 5 22 297 0.0 0.0 0.0 0.0 0.2	20 60 0 240 10 22 272 0.1 0.1 0.0 0.3	93%   30 90 210 15 22 247 0.2 0.2 0.2 0.0 0.4	40 120 0 180 19 22 221 0.4 0.4 0.0 0.4	ment 50 150 24 22 196 0.6 0.6 0.1 0.5	60 180 0 120 28 21 170 0.8 0.8 0.1 0.5	70 210 90 33 21 144 1.1 1.1 0.2 0.5	80 240 0 60 37 21 118 1.5 1.5 0.3 0.5	Table 2D.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Np-237         Np         Pu-238         Pu-238         Pu-238	400 0 400 0 30 430 0 0 0 0 0 0	5 20 380 330 413 0.0 0.0 0.0 0.0	10 40 0 360 7 30 397 0.0 0.0 0.0 0.0 0.2	20 80 0 320 14 30 363 0.2 0.2 0.2 0.0 0.4	<b>93%</b> 30 120 0 280 20 29 329 0.4 0.4 0.4 0.0 0.6	Enrich 40 160 240 26 29 295 0.6 0.6 0.1 0.7	ment 50 200 200 33 29 261 0.9 0.9 0.1 0.7	60 240 160 39 28 227 1.3 1.3 0.2 0.7	70 280 0 120 44 28 192 1.7 1.7 0.3 0.7	80 320 0 80 50 27 157 2.2 2.2 0.5 0.7
Table 2C.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Np-237         Np         Pu-238         Pu-239         Pu-240	300 0 0 300 0 23 323 0 0 0 0 0 0	5 15 0 285 3 23 310 0.0 0.0 0.0 0.0 0.1 0.0	5 MTF 10 30 270 5 22 297 0.0 0.0 0.0 0.0 0.2 0.0	20 60 0 240 10 22 272 0.1 0.1 0.0 0.3 0.0	93%   90 0 210 15 22 247 0.2 0.2 0.2 0.0 0.4 0.0	Enrich 40 120 0 180 19 22 221 0.4 0.4 0.4 0.0 0.4 0.1	ment 50 150 24 22 196 0.6 0.6 0.1 0.5 0.1	60 180 120 28 21 170 0.8 0.8 0.1 0.5 0.1	70 210 90 33 21 144 1.1 1.1 0.2 0.5 0.1	80 240 0 60 37 21 118 1.5 1.5 0.3 0.5 0.2	Table 2D.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Np-237         Np         Pu-238         Pu-239         Pu-240	400 0 400 0 30 430 0 0 0 0 0 0	5 20 380 3 30 413 0.0 0.0 0.0 0.0 0.1 0.0	10 40 0 360 7 30 397 0.0 0.0 0.0 0.0 0.0 0.2 0.0	20 80 0 320 14 30 363 0.2 0.2 0.0 0.4 0.0	30 120 0 280 20 29 329 0.4 0.4 0.4 0.0 0.6 0.1	Enrich 40 160 240 26 29 295 0.6 0.6 0.1 0.7 0.1	ment 50 200 0 200 33 29 261 0.9 0.9 0.1 0.7 0.1	60 240 160 39 28 227 1.3 1.3 0.2 0.7 0.2	70 280 0 120 44 28 192 1.7 1.7 0.3 0.7 0.2	80 320 0 80 50 27 157 2.2 2.2 0.5 0.7 0.2
Table 2C.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U           Pu-237           Np           Pu-238           Pu-239           Pu-240           Pu-241	300 0 0 300 0 23 323 0 0 0 0 0 0 0 0 0	g U-23 5 15 0 285 3 23 310 0.0 0.0 0.0 0.1 0.0 0.0	5 MTF 10 30 270 5 22 297 0.0 0.0 0.0 0.0 0.2 0.0 0.0	20 60 0 240 10 22 272 0.1 0.1 0.0 0.3 0.0 0.0	93%   90 0 210 15 22 247 0.2 0.2 0.0 0.4 0.0 0.0	Enrich 40 120 0 180 19 22 221 0.4 0.4 0.4 0.0 0.4 0.1 0.0	ment 50 150 24 22 196 0.6 0.6 0.1 0.5 0.1 0.0	60 180 120 28 21 170 0.8 0.8 0.1 0.5 0.1 0.1	70 210 90 33 21 144 1.1 1.1 0.2 0.5 0.1 0.1	80 240 0 60 37 21 118 1.5 1.5 0.3 0.5 0.2 0.1	Table 2D.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Np-237         Np         Pu-238         Pu-239         Pu-240         Pu-241	400 0 400 0 30 430 0 430 0 0 0 0 0 0	g U-23 5 20 380 3 30 413 0.0 0.0 0.0 0.0 0.1 0.0 0.0	5 MTF 10 40 360 7 30 397 0.0 0.0 0.0 0.0 0.2 0.0 0.0	<b>Fuel</b> 20 80 0 320 14 30 363 0.2 0.2 0.0 0.4 0.0 0.0	30 120 0 280 20 29 329 0.4 0.4 0.4 0.0 0.6 0.1 0.0	Enrich 40 160 240 26 29 295 0.6 0.6 0.1 0.7 0.1 0.0	ment 50 200 0 200 33 29 261 0.9 0.9 0.1 0.7 0.1 0.1	60 240 160 39 28 227 1.3 1.3 0.2 0.7 0.2 0.1	70 280 0 120 44 28 192 1.7 1.7 0.3 0.7 0.2 0.1	80 320 0 80 50 27 157 2.2 2.2 0.5 0.7 0.2 0.1
Table 2C.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Pu-238         Pu-239         Pu-240         Pu-241         Pu-242	300 0 0 300 23 323 0 0 0 0 0 0 0 0 0 0 0	g U-23 5 15 0 285 3 23 310 0.0 0.0 0.0 0.1 0.0 0.0 0.0 0.0	5 MTF 10 30 270 5 22 297 0.0 0.0 0.0 0.2 0.0 0.0 0.0 0.0	20 60 0 240 10 22 272 0.1 0.1 0.0 0.3 0.0 0.0 0.0	93%   30 90 210 15 22 247 0.2 0.2 0.2 0.0 0.4 0.0 0.0 0.0	Enrich 40 120 0 180 19 22 221 0.4 0.4 0.4 0.0 0.4 0.1 0.0 0.0	ment 50 150 0 150 24 22 196 0.6 0.6 0.1 0.5 0.1 0.0 0.0	60 180 120 28 21 170 0.8 0.1 0.5 0.1 0.1 0.0	70 210 90 33 21 144 1.1 1.1 0.2 0.5 0.1 0.1 0.0	80 240 0 60 37 21 118 1.5 1.5 0.3 0.5 0.2 0.1 0.0	Table 2D.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Np-237         Np         Pu-238         Pu-239         Pu-240         Pu-241         Pu-242	400 0 400 0 30 430 0 0 0 0 0 0 0 0 0 0 0	g U-23 5 20 380 330 413 0.0 0.0 0.0 0.1 0.0 0.0 0.0 0.0	5 MTF 10 40 0 360 7 30 397 0.0 0.0 0.0 0.0 0.2 0.0 0.0 0.0 0.0	<b>Fuel</b> 20 80 0 320 14 30 363 0.2 0.2 0.0 0.4 0.0 0.0 0.0	30 120 0 280 20 29 329 0.4 0.4 0.4 0.0 0.6 0.1 0.0 0.0	40 160 240 26 29 295 0.6 0.6 0.1 0.7 0.1 0.0 0.0	ment 50 200 0 200 33 29 261 0.9 0.9 0.1 0.7 0.1 0.1 0.0	60 240 160 39 28 227 1.3 1.3 0.2 0.7 0.2 0.1 0.0	70 280 120 44 28 192 1.7 1.7 0.3 0.7 0.2 0.1 0.0	80 320 0 80 50 27 157 2.2 2.2 0.5 0.7 0.2 0.1 0.1
Table 2C.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Pu-238         Pu-239         Pu-240         Pu-241         Pu-242         Pu	300 0 0 300 23 323 0 0 0 0 0 0 0 0 0 0 0 0 0	g U-23 5 15 0 285 3 23 310 0.0 0.0 0.0 0.1 0.0 0.0 0.0 0.0 0.0	5 MTF 10 30 270 5 22 297 0.0 0.0 0.0 0.2 0.0 0.0 0.0 0.0	20 60 240 10 22 272 0.1 0.1 0.0 0.3 0.0 0.0 0.0 0.3	93%   30 90 210 15 22 247 0.2 0.2 0.2 0.0 0.4 0.0 0.0 0.4	Enrich 40 120 0 180 19 22 221 0.4 0.4 0.4 0.4 0.4 0.4 0.4 0.1 0.0 0.5	ment 50 150 24 22 196 0.6 0.1 0.5 0.1 0.0 0.0 0.7	60 180 0 120 28 21 170 0.8 0.1 0.5 0.1 0.1 0.0 0.8	70 210 90 33 21 144 1.1 1.1 0.2 0.5 0.1 0.1 0.0 0.9	80 240 0 60 37 21 118 1.5 1.5 0.3 0.5 0.2 0.1 0.0 1.1	Table 2D.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Np-237         Np         Pu-238         Pu-239         Pu-240         Pu-241         Pu-242         Pu	400 0 400 0 30 430 0 430 0 0 0 0 0 0 0 0	5 20 380 330 413 0.0 0.0 0.0 0.1 0.0 0.0 0.0 0.0 0.0	10 40 360 7 30 397 0.0 0.0 0.0 0.0 0.2 0.0 0.0 0.0 0.0 0.0	R Fuel 20 80 0 320 14 30 363 0.2 0.2 0.0 0.4 0.0 0.0 0.0 0.5	30 120 0 280 29 329 0.4 0.4 0.0 0.6 0.1 0.0 0.0 0.0 0.7	Enrich 40 160 240 26 29 295 0.6 0.6 0.1 0.7 0.1 0.0 0.0 0.0 0.9	ment 50 200 0 200 33 29 261 0.9 0.9 0.1 0.7 0.1 0.1 0.0 1.1	60 240 160 39 28 227 1.3 1.3 0.2 0.7 0.2 0.7 0.2 0.1 0.0	70 280 120 44 28 192 1.7 1.7 0.3 0.7 0.2 0.1 0.0 1.4	80 320 0 80 50 27 157 2.2 2.2 0.5 0.7 0.2 0.1 0.1
Table 2C.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Pu-238         Pu-238         Pu-239         Pu-240         Pu-241         Pu-242         Pu         Am-241	300 0 300 23 323 0 0 0 0 0 0 0 0 0 0 0 0	g U-23 5 15 0 285 3 23 310 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0	5 MTF 10 30 270 5 22 297 0.0 0.0 0.0 0.2 0.0 0.0 0.0 0.0	20 60 240 10 22 272 0.1 0.1 0.0 0.3 0.0 0.0 0.3 0.0	93%   30 90 210 15 22 247 0.2 0.2 0.0 0.4 0.0 0.4 0.0 0.4 0.0	Enrich 40 120 0 180 19 22 221 0.4 0.4 0.4 0.4 0.1 0.0 0.0 0.5 0.0	ment 50 150 0 150 24 22 196 0.6 0.1 0.5 0.1 0.0 0.0 0.7 0.0	60 180 0 120 28 21 170 0.8 0.1 0.5 0.1 0.1 0.0 0.8 0.0	70 210 90 33 21 144 1.1 1.1 0.2 0.5 0.1 0.1 0.0 0.9 0.0	80 240 0 60 37 21 118 1.5 1.5 0.3 0.5 0.2 0.1 0.0 1.1 0.0	Table 2D.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Np-237         Np         Pu-238         Pu-239         Pu-240         Pu-241         Pu-242         Pu         Am-241	400 0 400 0 30 430 430 0 0 0 0 0 0 0 0 0	g U-23 5 20 380 330 413 0.0 0.0 0.0 0.1 0.0 0.0 0.0 0.0 0.0 0.0	10 40 0 360 7 30 397 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	<b>Fuel</b> 20 80 0 320 14 30 363 0.2 0.2 0.0 0.4 0.0 0.0 0.0 0.0 0.5 0.0	30 120 0 280 29 329 0.4 0.4 0.0 0.6 0.1 0.0 0.0 0.7 0.0	Enrich 40 160 240 26 29 295 0.6 0.1 0.7 0.1 0.7 0.1 0.0 0.0 0.0 0.0	ment 50 200 0 200 33 29 261 0.9 0.9 0.1 0.7 0.1 0.1 0.0 1.1 0.0	60 240 160 39 28 227 1.3 1.3 0.2 0.7 0.2 0.1 0.0 1.2 0.0	70 280 120 44 28 192 1.7 1.7 0.3 0.7 0.2 0.1 0.0 1.4 0.0	80 320 0 80 50 27 157 2.2 2.2 0.5 0.7 0.2 0.1 0.1 1.7 0.0
Table 2C.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U           Np-237           Np           Pu-238           Pu-239           Pu-240           Pu-241	300 0 0 300 0 23 323 0 0 0 0 0 0 0 0 0	g U-23 5 15 0 285 3 23 310 0.0 0.0 0.0 0.0 0.1 0.0 0.0	5 MTF 10 30 270 5 22 297 0.0 0.0 0.0 0.0 0.2 0.0 0.0	20 60 0 240 10 22 272 0.1 0.1 0.0 0.3 0.0 0.0	93%   90 0 210 15 22 247 0.2 0.2 0.0 0.4 0.0 0.0	Enrich 40 120 0 180 19 22 221 0.4 0.4 0.4 0.0 0.4 0.1 0.0	ment 50 150 24 22 196 0.6 0.6 0.1 0.5 0.1 0.0	60 180 120 28 21 170 0.8 0.8 0.1 0.5 0.1 0.1	70 210 90 33 21 144 1.1 1.1 0.2 0.5 0.1 0.1	80 240 0 60 37 21 118 1.5 1.5 0.3 0.5 0.2 0.1	Table 2D.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Np-237         Np         Pu-238         Pu-239         Pu-240         Pu-241	400 0 400 0 30 430 0 430 0 0 0 0 0 0	5 20 380 3 30 413 0.0 0.0 0.0 0.1 0.0 0.0	5 MTF 10 40 360 7 30 397 0.0 0.0 0.0 0.0 0.2 0.0 0.0	<b>Fuel</b> 20 80 0 320 14 30 363 0.2 0.2 0.0 0.4 0.0 0.0	30 120 0 280 20 29 329 0.4 0.4 0.4 0.0 0.6 0.1 0.0	Enrich 40 160 240 26 29 295 0.6 0.6 0.1 0.7 0.1 0.0	ment 50 200 0 200 33 29 261 0.9 0.9 0.1 0.7 0.1 0.1	60 240 160 39 28 227 1.3 1.3 0.2 0.7 0.2 0.1	70 280 120 44 28 192 1.7 1.7 0.3 0.7 0.2 0.1	80 320 0 80 50 27 157 2.2 2.2 0.5 0.7 0.2 0.1
Table 2C.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Np-237         Np         Pu-238         Pu-239         Pu-240         Pu-241         Pu-242         Pu         Am-241	300 0 300 23 323 0 0 0 0 0 0 0 0 0 0 0	g U-23 5 15 0 285 3 23 310 0.0 0.0 0.0 0.1 0.0 0.0 0.1 0.0 0.1 0.0	5 MTF 10 30 270 5 22 297 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	20 60 0 240 10 22 272 0.1 0.1 0.0 0.3 0.0 0.0 0.0 0.3 0.0	93%   30 90 210 15 22 247 0.2 0.2 0.0 0.4 0.0 0.0 0.4 0.0 0.4 0.0 0.2 0.2 0.2 0.2 0.2 0.2 0.2	Enrich 40 120 0 180 19 22 221 0.4 0.4 0.4 0.0 0.4 0.1 0.0 0.5 0.0 0.5 0.0	ment 50 150 0 150 24 22 196 0.6 0.1 0.5 0.1 0.0 0.0 0.7 0.0	60 180 120 28 21 170 0.8 0.1 0.5 0.1 0.1 0.0 0.8 0.0	70 210 90 33 21 144 1.1 1.1 0.2 0.5 0.1 0.1 0.0 0.9 0.0	80 240 0 60 37 21 118 1.5 1.5 0.3 0.5 0.2 0.1 0.0 1.1 0.0	Table 2D.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Np-237         Np         Pu-238         Pu-239         Pu-240         Pu-241         Pu         Am-241	400 0 400 0 30 430 0 430 0 0 0 0 0 0 0 0	5 20 380 380 413 0.0 0.0 0.0 0.1 0.0 0.0 0.1 0.0 0.1 0.0	10 40 360 7 30 397 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	<b>Fuel</b> 20 80 0 320 14 30 363 0.2 0.2 0.0 0.4 0.0 0.0 0.5 0.0 0.5 0.0	30 120 0 280 20 29 329 0.4 0.4 0.4 0.0 0.6 0.1 0.0 0.0 0.7 0.0	40 160 240 26 29 295 0.6 0.6 0.1 0.7 0.1 0.0 0.0 0.0 0.0 0.0	ment 50 200 0 200 33 29 261 0.9 0.9 0.1 0.7 0.1 0.1 0.0 1.1 0.0	60 240 160 39 28 227 1.3 1.3 0.2 0.7 0.2 0.7 0.2 0.1 0.0 1.2 0.0	70 280 0 120 44 28 192 1.7 1.7 0.3 0.7 0.2 0.1 0.0 1.4 0.0	8: 32: 8: 5: 2: 15: 2: 2: 2: 2: 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.

Table 3A.	200	g U-23	5 MTF	Fuel,	45%	Enrich	ment				Table 3B.	300	g U-23	5 MTF	l Fuel,	45%	Enrich	ment			
U-235:											U-235:										
Burnup, %	0	5	10	20	30	40	50	60	70	80	Bumup, %	0	5	10	20	30	40	50	60	70	80
Burned, g	0	10	20	40	60	80	100	120	140	160	Burned, g	0	15	30	60	90	120	150	180	210	240
U-234	0	0	0	0	0	0	0	0	0	0	U-234	0	0	0	0	0	0	0	0	0	0
U-235	200	190	180	160	140	120	100	80	60	40	U-235	300	285	270	240	210	180	150	120	90	60
U-236	0	2	3	6	10	13	16	19	21	24	U-236	0	3	5	10	15	19	24	29	33	37
U-238	244	244	244	243	242	241	240	239	237	236	U-238	367	366	365	364	362	361	359	357	355	352
U	444	436	427	409	391	374	356	337	319	300	U	667	654	640	614	587	560	533	505	477	449
Np-237	0	0.0	0.0	0.0	0.1	0.2	0.3	0.4	0.6	0.8	Np-237	0	0.0	0.0	0.1	0.2	0.4	0.6	0.9	1.2	1.5
Np	0	0.0	0.0	0.0	0.1	0.2	0.3	0.4	0.6	0.8	Np	0	0.0	0.0	0.1	0.2	0.4	0.6	0.9	1.2	1.5
Pu-238	0	0.0	0.0	0.0	0.0	0.0	0,0	0.1	0.1	0.2	Pu-238	0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3
Pu-239	0	0.4	0.7	1.3	1.7	2.0	2.3	2.4	2.3	2.2	Pu-239	0	0.6	1.2	2.2	2.9	3.4	3.8	3.9	3.8	3.6
Pu-240	0	0.0	0.0	0.1	0.2	0.3	0.5	0.6	0.8	0.9	Pu-240	0	0.0	0.0	0.2	0.3	0.6	0.8	1.0	1.2	1.4
Pu-241	0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.3	0.4	Pu-241	0	0.0	0.0	0.0	0.1	0.2	0.3	0.5	0.6	0.7
Pu-242	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	Pu-242	0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.3
Pu	0	0.4	0.7	1.4	2.0	2.5	2.9	3.3	3.6	3.8	Pu	0	0.6	1.3	2.4	3.4	4.2	5.0	5.6	6.0	6.3
Am-241	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Am-241	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Am	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Am	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Table 3C.	400	g U-23	5 MTF	R Fuel	45%	Enrich	ment				Table 4A.	100	g U-23	5 MTF	l Fuel	19.75	% Enr	ichme	nt		
U-235:											U-235:		<b></b>								
Burnup, %	0	5	10	20	30	40	50	60	70	80	Burnup, %	0	5	10	20	30	40	50	60	70	80
Burned, g	0	20	40	80	120	160	200	240	280	320	Burned, g	0	5	10	20	30	40	50	60	70	_ 80
U-234	0	0	0	0	0	0	0	0	0	0	U-234	0	0	0	0	0	0	0	0	0	0
U-235	400	380	360	320	280	240	200	160	120	80	U-235	100	95	90	80	70	60	50	40	30	20
U-236	0	3	7	14	20	27	33	39	45	50	U-236	0	1	2	3	5	6	8	9	11	12
U-238	489	488	487	485	482	480	477	474	471	467	U-238	406	406	406	405	404	403	402	401	399	398
U	889	871	854	818	782	746	710	673	636	597	U	506	502	497	488	479	469	460	450	440	429
Np-237	0	0.0	0.0	0.2	0.4	0.6	1.0	1.4	1.8	2.4	Np-237	0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.3
Np	0	0.0	0.0	0.2	0.4	0.6	1.0	1.4	1.8	2.4	Np	0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.3
Pu-238	0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.5	Pu-238	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Pu-239	0	0.9	1.8	3.2	4.2	4.9	5.4	5.5	5.4	5.0	Pu-239	0	0.3	0.7	1.2	1.7	2.0	2.3	2.5	2.5	2.5
Pu-240	0	0.0	0.1	0.3	0.5	0.8	1.1	1.4	1.6	1.9	Pu-240	0	0.0	0.0	0.1	0.2	0.3	0.4	0.6	0.8	1.0
Pu-241	0	0.0	0.0	0.1	0.2	0.3	0.6	0.8	1.0	1.1	Pu-241	0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.3
Pu-242	0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.3	0.5	Pu-242	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
Pu	0	0.9	1.9	3.5	4.9	6.2	7.2	8.1	8.7	9.1	Pu	0	0,3	0.7	1.3	1.9	2.4	2.9	3.3	3.7	4.0
Am-241	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Am-241	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Am	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Am	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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Table 4B.	200	g U-23	5 MTF	R Fuel	19.75	<u>% Enr</u>	ichme	nt			Table 4C.	300	g U-23	<u>35 MTI</u>	R Fuel	, 19.75	i% Eni	ichme	ent		
U-235:											U-235:										
Burnup, %	0	5	10	20	30	40	50	60	70	80	Burnup, %	0	5	10	20	30	40	50	60	70	80
Burned, g	0	10	20	40	60	80	100	120	140	160	Bumed, g	0	15	30	60	90	120	150	180	210	240
U-234	0	0	0	0	0	0	0	0	0	0	U-234	0	. 0	0	0	0	0	0	0	0	0
U-235	200	190	180	160	140	120	100	80	60	40	U-235	300	285	270	240	210	180	150	120	90	60
U-236	0	2	3	6	10	13	16	19	22	24	U-236	0	3	5	10	15	20	24	29	33	37
U-238	813	812	811	809	807	805	802	800	796	792	U-238	1219	1218	1216	1213	1209	1205	1201	1197	1191	1184
U	1013	1003	994	975	957	937	918	898	878	856	U	1519	1505	1491	1463	1434	1405	1375	1345	1314	1281
Np-237	0	0.0	0.0	0.0	0.1	0.2	0.3	0.5	0.6	0.9	Np-237	0	0.0	0.0	0.1	0.2	0.4	0.6	0.9	1.2	1.6
Np	0	0.0	0.0	0.0	0.1	0.2	0.3	0.5	0.6	0.9	Np	0	0.0	0.0	0.1	0.2	0.4	0.6	0.9	1.2	1.6
Pu-238	0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	Pu-238	0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.3
Pu-239	0	0.8	1.5	2.8	3.8	4.6	5.1	5.4	5.5	5.3	Pu-239	0	1.3	2.6	4.7	6.3	7.5	8.3	8.7	8.7	8.4
Pu-240	0	0.0	0.1	0.2	0.4	0.7	1.0	1.4	1.7	2.1	Pu-240	0	0.0	0.1	0.4	0.7	1.2	1.7	2.2	2.7	3.2
Pu-241	0	0.0	0.0	0.0	0.1	0.2	0.3	0.5	0.7	0.9	Pu-241	0	0.0	0.0	0.1	0.2	0.4	0.7	1.0	1.4	1.6
Pu-242	0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	Pu-242	0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.7
Pu	0	0.8	1.6	3.1	4.4	5.5	6.6	7.5	8.2	8.8	Pu	0	1.4	2.7	5.1	7.3	9.2	10.9	12.3	13.4	14.3
Am-241	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Am-241	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Am	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Am	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
															-						
Table 4D.	400	g U-23	35 MTI	R Fuel	, 19.75	i% Enr	ichme	ent			Table 4E.	500	g U-2	35 MT	R Fuel	, 19.7	5% En	richme	ent		
Table 4D. U-235:	400	g U-23	85 MTI	R Fuel	, 19.75	i% Enr	ichme	ent			<b>Table 4E.</b> U-235:	500	g U-2:	35 MT	R Fuel	, 19.75	5% En	richmo	ent		
<b>Table 4D.</b> U-235: Burnup, %	<b>400</b> 0	g U-23 5	10	<b>R Fuel</b> 20	<u>, 19.75</u> 30	<mark>i% Enr</mark> 40	ichme 50	ent 60	70	80	<b>Table 4E.</b> U-235: Burnup, %	<b>500</b> 0	g U-2: 5	35 MT	<b>R Fue</b> 20	<mark>, 19.7</mark> 5 30	5 <mark>% En</mark> 40	richmo 50	ent 60	70	80
Table 4D. U-235: Burnup, % Burned, g	<b>400</b> 0 0	g U-23 5 20	10 40	20 80	, 19.75 30 120	40 160	ichme 50 200	ent 60 240	70 280	80 320	<b>Table 4E.</b> U-235: Burnup, % Burned, g	<b>500</b> 0 0	<b>g U-2</b> 5 25	10 50	20 100	<mark>, 19.7</mark> 5 30 150	5 <mark>% En</mark> 40 200	<b>50</b> 250	ent 60 300	70 350	80 400
Table 4D. U-235: Burnup, % Burned, g U-234	400 0 0	<b>g U-2</b> : 5 20 0	10 40 0	20 80 0	, 19,75 30 120 0	40 160 0	ichme 50 200 0	ent 60 240 0	70 280 0	80 320 0	Table 4E.           U-235:           Burnup, %           Burned, g           U-234	500 0 0	g U-2: 5 25 0	10 50 0	20 100 0	, <b>19.7</b> 5 30 150 0	5% En 40 200 0	50 250 0	ent 60 300 0	70 350 0	80 400 0
Table 4D. U-235: Burnup, % Burned, g U-234 U-235	400 0 0 400	<b>g U-2</b> 3 5 20 0 380	10 40 360	20 80 320	30 120 0 280	40 160 0 240	ichme 50 200 0 200	60 240 0 160	70 280 0 120	80 320 0 80	Table 4E.           U-235:           Burnup, %           Burned, g           U-234           U-235	500 0 0 500	g U-2: 5 25 0 475	10 50 0 450	20 100 0 400	, <b>19.7</b> 5 30 150 0 350	5% En 40 200 0 300	50 250 0 250	ent 60 300 0 200	70 350 0 150	80 400 0 100
Table 4D.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236	400 0 0 400 0	g U-23 5 20 0 380 4	10 40 0 360 7	20 80 0 320 14	30 120 0 280 20	40 160 0 240 27	ichme 50 200 0 200 33	60 240 0 160 39	70 280 0 120 45	80 320 0 80 50	Table 4E.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236	500 0 0 500 0	g U-2: 5 25 0 475 4	10 50 0 450 9	20 100 0 400 18	30 150 350 26	40 200 0 300 34	50 250 0 250 42	ent 60 300 0 200 50	70 350 0 150 57	80 400 0 100 64
Table 4D.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238	400 0 0 400 0 1625	g U-23 5 20 0 380 4 1623	10 40 360 7 1621	20 80 0 320 14 1616	30 120 0 280 20 1611	40 160 240 27 1605	50 200 0 200 33 1599	60 240 0 160 39 1592	70 280 0 120 45 1584	80 320 0 80 50 1574	Table 4E.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238	500 0 0 500 0 2032	g U-2 5 25 0 475 4 2029	10 50 0 450 9 2026	20 100 0 400 18 2019	30 150 0 350 26 2012	40 200 0 300 34 2004	50 250 0 250 250 42 1996	ent 60 300 0 200 50 1987	70 350 0 150 57 1976	80 400 0 100 64 1962
Table 4D.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U	400 0 0 400 0 1625 2025	g U-23 5 20 0 380 4 1623 2007	10 40 0 360 7 1621 1988	20 80 0 320 14 1616 1950	30 120 0 280 20 1611 1911	40 160 0 240 27 1605 1872	ichme 50 200 0 200 33 1599 1832	ent 60 240 0 160 39 1592 1791	70 280 0 120 45 1584 1749	80 320 0 80 50 1574 1704	Table 4E.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238	500 0 0 500 0 2032 2532	g U-2: 5 25 0 475 4 2029 2508	10 50 0 450 9 2026 2484	20 100 0 400 18 2019 2437	30 150 0 350 26 2012 2388	40 200 0 300 34 2004 2338	50 250 0 250 42 1996 2288	ent 60 300 0 200 50 1987 2236	70 350 0 150 57 1976 2183	80 400 100 64 1962 2126
Table 4D.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U	400 0 0 400 0 1625 2025 0	g U-23 5 20 0 380 4 1623 2007 0.0	10 40 0 360 7 1621 1988 0.0	20 80 0 320 14 1616 1950 0.2	30 120 0 280 20 1611 1911 0.4	40 160 240 27 1605 1872 0.7	ichme 50 200 0 200 33 1599 1832 1.0	ent 60 240 0 160 39 1592 1791 1.4	70 280 0 120 45 1584 1749 1.9	80 320 0 80 50 1574 1704 2.5	Table 4E.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U	500 0 500 0 2032 2532 0	g U-2: 5 25 0 475 4 2029 2508 0.0	10 50 0 450 9 2026 2484 0.1	20 100 0 400 18 2019 2437 0.3	30 150 0 350 26 2012 2388 0.6	40 200 0 300 34 2004 2338 1.0	richme 50 250 0 250 42 1996 2288 1.5	ent 60 300 0 200 50 1987 2236 2.1	70 350 0 150 57 1976 2183 2.8	80 400 0 100 64 1962 2126 3.6
Table 4D.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U           Np-237           Np	400 0 0 400 0 1625 2025 0 0	g U-23 5 20 0 380 4 1623 2007 0.0 0.0	10 40 0 360 7 1621 1988 0.0 0.0	<b>R Fuel</b> 20 80 0 320 14 1616 1950 0.2 0.2	30 120 0 280 20 1611 1911 0.4 0.4	40 160 240 27 1605 1872 0.7 0.7	ichme 50 200 0 200 33 1599 1832 1.0 1.0	ent 60 240 0 160 39 1592 1791 1.4 1.4	70 280 0 120 45 1584 1749 1.9 1.9	80 320 0 80 50 1574 1704 2.5 2.5	Table 4E.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U           Np-237           Np	500 0 500 0 2032 2532 0 0	<b>g U-2</b> : 5 25 0 475 4 2029 2508 0.0 0.0	10 50 0 450 9 2026 2484 0.1 0.1	R Fuel 20 100 0 400 18 2019 2437 0.3 0.3	30 150 0 350 26 2012 2388 0.6 0.6	40 200 0 300 34 2004 2338 1.0 1.0	richme 50 250 0 250 42 1996 2288 1.5 1.5	ent 60 300 0 200 50 1987 2236 2.1 2.1	70 350 0 150 57 1976 2183 2.8 2.8	80 400 0 100 64 1962 2126 3.6 3.6
Table 4D.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U           Np-237           Np           Pu-238	400 0 0 400 0 1625 2025 0 0 0 0	g U-23 5 20 0 380 4 1623 2007 0.0 0.0 0.0	10 40 0 360 7 1621 1988 0.0 0.0 0.0	<b>R Fuel</b> 20 80 0 320 14 1616 1950 0.2 0.2 0.0	30 120 0 280 20 1611 1911 0.4 0.4 0.0	40 160 240 27 1605 1872 0.7 0.7	ichme 50 200 0 200 33 1599 1832 1.0 1.0 0.1	ent 60 240 0 160 39 1592 1791 1.4 1.4 0.2	70 280 0 120 45 1584 1749 1.9 1.9 0.4	80 320 0 80 50 1574 1574 2.5 2.5 0.6	Table 4E.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U           Pp-237           Np           Pu-238	500 0 500 0 2032 2532 0 0 0	g U-2: 5 25 0 475 4 2029 2508 0.0 0.0 0.0	10 50 0 450 9 2026 2484 0.1 0.1 0.0	R Fuel 20 100 0 400 18 2019 2437 0.3 0.3 0.0	30 150 0 350 26 2012 2388 0.6 0.6 0.0	40 200 0 300 34 2004 2338 1.0 1.0 0.1	fichme 50 250 0 250 42 1996 2288 1.5 1.5 0.2	ent 60 300 0 200 50 1987 2236 2.1 2.1 0.4	70 350 0 150 57 1976 2183 2.8 2.8 2.8 0.6	80 400 100 64 1962 2126 3.6 3.6 0.9
Table 4D.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U           Np-237           Np           Pu-238           Pu-238           Pu-238	400 0 0 400 0 1625 2025 0 0 0 0 0	g U-23 5 20 0 380 4 1623 2007 0.0 0.0 0.0 0.0 2.0	10 40 0 360 7 1621 1988 0.0 0.0 0.0 3.8	<b>Fuel</b> 20 80 0 320 14 1616 1950 0.2 0.2 0.0 6.8	30 120 0 280 20 1611 1911 0.4 0.4 0.0 9.1	40 160 240 27 1605 1872 0.7 0.7 0.1 10.8	ichme 50 200 0 200 33 1599 1832 1.0 1.0 0.1 11.8	ent 60 240 0 160 39 1592 1791 1.4 1.4 0.2 12.4	70 280 0 120 45 1584 1749 1.9 1.9 0.4 12.3	80 320 0 80 50 1574 1704 2.5 2.5 0.6 11.7	Table 4E.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U           Pu-237           Np           Pu-238           Pu-238           Pu-238           Pu-238	500 0 500 2032 2532 0 0 0 0 0	g U-2: 5 25 0 475 4 2029 2508 0.0 0.0 0.0 0.0 2.6	10 50 0 450 9 2026 2484 0.1 0.1 0.0 5.0	R Fuel 20 100 0 400 18 2019 2437 0.3 0.3 0.0 9.0	30 150 0 350 26 2012 2388 0.6 0.6 0.0 12.1	40 200 0 300 34 2004 2338 1.0 1.0 0.1 14.3	50 250 0 250 42 1996 2288 1.5 1.5 0.2 15.6	ent 60 300 0 200 50 1987 2236 2.1 2.1 0.4 16.2	70 350 0 150 57 1976 2183 2.8 2.8 0.6 16.1	80 400 100 64 1962 2126 3.6 3.6 0.9 15.3
Table 4D.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U           Np-237           Np           Pu-238           Pu-239           Pu-240	400 0 0 400 0 1625 2025 0 0 0 0 0 0 0	g U-23 5 20 0 380 4 1623 2007 0.0 0.0 0.0 0.0 2.0 0.0	10 40 0 360 7 1621 1988 0.0 0.0 0.0 3.8 0.2	<b>Fuel</b> 20 80 0 320 14 1616 1950 0.2 0.2 0.0 6.8 0.6	30 120 0 280 20 1611 1911 0.4 0.4 0.0 9.1 1.1	40 160 240 27 1605 1872 0.7 0.7 0.7 0.1 10.8 1.7	50 200 200 33 1599 1832 1.0 1.0 0.1 11.8 2.4	ent 60 240 0 160 39 1592 1791 1.4 1.4 0.2 12.4 3.1	70 280 0 120 45 1584 1749 1.9 1.9 0.4 12.3 3.7	80 320 0 80 50 1574 1704 2.5 2.5 0.6 11.7 4.3	Table 4E.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Pu-237         Np         Pu-238         Pu-239         Pu-240	500 0 500 2032 2532 0 0 0 0 0 0 0	g U-2: 5 25 0 475 4 2029 2508 0.0 0.0 0.0 0.0 2.6 0.1	10 50 0 450 9 2026 2484 0.1 0.1 0.0 5.0 0.2	R Fuel 20 100 0 400 18 2019 2437 0.3 0.3 0.3 0.0 9.0 0.8	30 150 0 350 26 2012 2388 0.6 0.6 0.0 12.1 1.5	40 200 0 300 34 2004 2338 1.0 1.0 0.1 14.3 2.3	fichme 50 250 0 250 42 1996 2288 1.5 1.5 0.2 15.6 3.2	ent 60 300 0 200 50 1987 2236 2.1 2.1 0.4 16.2 4.0	70 350 0 150 57 1976 2183 2.8 2.8 2.8 0.6 16.1 4.7	80 400 100 64 1962 2126 3.6 3.6 3.6 9.9 15.3 5.4
Table 4D.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U           Np-237           Np           Pu-238           Pu-239           Pu-240           Pu-241	400 0 400 0 1625 2025 0 0 0 0 0 0 0 0 0	g U-23 5 20 0 380 4 1623 2007 0.0 0.0 0.0 0.0 0.0 0.0 0.0	10 40 0 360 7 1621 1988 0.0 0.0 0.0 3.8 0.2 0.0	20 80 0 320 14 1616 1950 0.2 0.2 0.2 0.2 0.0 6.8 0.6 0.1	30 120 0 280 20 1611 1911 0.4 0.4 0.0 9.1 1.1 0.4	40 160 240 27 1605 1872 0.7 0.7 0.7 0.1 10.8 1.7 0.7	50 200 200 33 1599 1832 1.0 1.0 0.1 11.8 2.4 1.2	ent 60 240 0 160 39 1592 1791 1.4 1.4 0.2 12.4 3.1 1.7	70 280 0 120 45 1584 1749 1.9 0.4 12.3 3.7 2.2	80 320 0 80 50 1574 1704 2.5 2.5 0.6 11.7 4.3 2.6	Table 4E.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Np-237         Np         Pu-238         Pu-239         Pu-240         Pu-241	500 0 500 0 2032 2532 0 0 0 0 0 0 0 0 0 0	g U-2: 5 25 0 475 4 2029 2508 0.0 0.0 0.0 0.0 2.6 0.1 0.0	10 50 0 450 9 2026 2484 0.1 0.1 0.0 5.0 0.2 0.0	R Fuel 20 100 0 400 18 2019 2437 0.3 0.3 0.3 0.0 9.0 0.8 0.2	30 150 0 350 26 2012 2388 0.6 0.6 0.0 12.1 1.5 0.6	40 200 0 300 34 2004 2338 1.0 1.0 0.1 14.3 2.3 1.1	fichme 50 250 0 250 42 1996 2288 1.5 1.5 0.2 15.6 3.2 1.8	ent 60 300 0 200 50 1987 2236 2.1 2.1 0.4 16.2 4.0 2.5	70 350 0 150 57 1976 2183 2.8 2.8 0.6 16.1 4.7 3.2	80 400 100 64 1962 2126 3.6 3.6 3.6 15.3 5.4 3.6
Table 4D.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U           Np-237           Np           Pu-238           Pu-239           Pu-240           Pu-241           Pu-242	400 0 400 0 1625 2025 0 0 0 0 0 0 0 0 0 0 0	g U-23 5 20 0 380 4 1623 2007 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	10 40 0 360 7 1621 1988 0.0 0.0 0.0 3.8 0.2 0.0 0.0	<b>Fuel</b> 20 80 0 320 14 1616 1950 0.2 0.2 0.0 6.8 0.6 0.1 0.0	, 19.75 30 120 0 280 20 1611 1911 0.4 0.0 9.1 1.1 0.4 0.0	40 160 240 27 1605 1872 0.7 0.7 0.7 0.1 10.8 1.7 0.7 0.1	50 200 200 33 1599 1832 1.0 1.0 0.1 11.8 2.4 1.2 0.2	ent 60 240 0 160 39 1592 1791 1.4 1.4 0.2 12.4 3.1 1.7 0.4	70 280 0 120 45 1584 1749 1.9 0.4 12.3 3.7 2.2 0.7	80 320 0 80 50 1574 1704 2.5 2.5 0.6 11.7 4.3 2.6 1.2	Table 4E.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U           Np-237           Np           Pu-238           Pu-239           Pu-240           Pu-241           Pu-242	500 0 500 0 2032 2532 0 0 0 0 0 0 0 0 0 0 0 0 0	g U-2: 5 25 0 475 4 2029 2508 0.0 0.0 0.0 2.6 0.1 0.0 0.0	10 50 0 450 9 2026 2484 0.1 0.1 0.0 5.0 0.2 0.0 0.0	R Fuel 20 100 0 400 18 2019 2437 0.3 0.3 0.0 9.0 0.8 0.2 0.0	30 150 0 350 26 2012 2388 0.6 0.6 0.0 12.1 1.5 0.6 0.0	40 200 0 300 34 2004 2338 1.0 1.0 0.1 14.3 2.3 1.1 0.1	fichme 50 250 0 250 42 1996 2288 1.5 1.5 0.2 15.6 3.2 1.8 0.3	ent 60 300 0 200 50 1987 2236 2.1 2.1 0.4 16.2 4.0 2.5 0.6	70 350 0 150 57 1976 2183 2.8 2.8 0.6 16.1 4.7 3.2 1.0	80 400 100 64 1962 2126 3.6 3.6 0.9 15.3 5.4 3.6 1.7
Table 4D.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U           Np-237           Np           Pu-238           Pu-239           Pu-240           Pu-241           Pu-242           Pu	400 0 400 0 1625 2025 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	g U-23 5 20 0 380 4 1623 2007 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	10 40 0 360 7 1621 1988 0.0 0.0 0.0 3.8 0.2 0.0 0.0 3.9	<b>Fuel</b> 20 80 0 320 14 1616 1950 0.2 0.2 0.2 0.0 6.8 0.6 0.1 0.0 7.5	30 120 0 280 20 1611 1911 0.4 0.4 0.0 9.1 1.1 0.4 0.0 10.6	40 160 240 27 1605 1872 0.7 0.7 0.7 0.1 10.8 1.7 0.7 0.1 13.4	50 200 200 33 1599 1832 1.0 1.0 0.1 11.8 2.4 1.2 0.2 15.8	ent 60 240 0 160 39 1592 1791 1.4 1.4 1.4 0.2 12.4 3.1 1.7 0.4 17.7	70 280 0 120 45 1584 1749 1.9 1.9 0.4 12.3 3.7 2.2 0.7 19.3	80 320 0 80 50 1574 1704 2.5 2.5 0.6 11.7 4.3 2.6 1.2 20.4	Table 4E.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Np-237         Np         Pu-238         Pu-239         Pu-240         Pu-241         Pu-242         Pu	500 0 500 0 2032 2532 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	g U-2: 5 25 0 475 4 2029 2508 0.0 0.0 0.0 2.6 0.1 0.0 0.0 2.7	10 50 0 450 9 2026 2484 0.1 0.1 0.1 0.0 5.0 0.2 0.0 0.0 5.3	R Fuel 20 100 0 400 18 2019 2437 0.3 0.3 0.3 0.3 0.0 9.0 0.8 0.2 0.0 10.0	300 150 0 350 2012 2388 0.6 0.6 0.0 12.1 1.5 0.6 0.0 14.2	40 200 0 300 34 2004 2338 1.0 1.0 0.1 14.3 2.3 1.1 0.1 17.9	richme 50 250 0 250 42 1996 2288 1.5 1.5 0.2 15.6 3.2 1.8 0.3 21.1	ent 60 300 0 200 50 1987 2236 2.1 2.1 0.4 16.2 4.0 2.5 0.6 23.7	70 350 0 150 57 1976 2183 2.8 2.8 0.6 16.1 4.7 3.2 1.0 25.7	80 400 100 64 1962 2126 3.6 3.6 0.9 15.3 5.4 3.6 1.7 27.0
Table 4D.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U           Np-237           Np           Pu-238           Pu-239           Pu-240           Pu-241           Pu-242           Pu           Am-241	400 0 0 400 0 1625 2025 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	g U-23 5 20 0 380 4 1623 2007 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	10 40 0 360 7 1621 1988 0.0 0.0 0.0 3.8 0.2 0.0 0.0 3.9 0.0	<b>Fuel</b> 20 80 0 320 14 1616 1950 0.2 0.2 0.0 6.8 0.0 6.8 0.1 0.0 7.5 0.0	30 120 0 280 20 1611 1911 0.4 0.4 0.0 9.1 1.1 0.4 0.0 10.6 0.0	40 160 0 240 27 1605 1872 0.7 0.7 0.7 0.1 10.8 1.7 0.7 0.1 13.4 0.0	50 200 200 33 1599 1832 1.0 1.0 1.0 0.1 11.8 2.4 1.2 0.2 15.8 0.0	ent 60 240 0 160 39 1592 1791 1.4 1.4 0.2 12.4 3.1 1.7 0.4 17.7 0.0	70 280 0 120 45 1584 1749 1.9 1.9 0.4 12.3 3.7 2.2 0.7 19.3 0.1	80 320 0 80 50 1574 1704 2.5 2.5 0.6 11.7 4.3 2.6 1.2 20.4 0.1	Table 4E.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U           Np-237           Np           Pu-238           Pu-239           Pu-240           Pu-241           Pu-242           Pu           Am-241	500 0 500 0 2032 2532 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	g U-2: 5 25 0 475 4 2029 2508 0.0 0.0 0.0 2.6 0.1 0.0 2.6 0.1 0.0 2.7 0.0	10 50 0 450 9 2026 2484 0.1 0.1 0.0 5.0 0.0 5.0 0.0 5.3 0.0	R Fuel 20 100 0 400 18 2019 2437 0.3 0.3 0.3 0.3 0.0 9.0 0.8 0.2 0.0 10.0 0.0	30 150 0 350 26 2012 2388 0.6 0.6 0.0 12.1 1.5 0.6 0.0 14.2 0.0	40 200 0 300 34 2004 2338 1.0 1.0 0.1 14.3 2.3 1.1 0.1 17.9 0.0	richme 50 250 0 250 42 1996 2288 1.5 1.5 0.2 15.6 3.2 1.8 0.3 21.1 0.0	ent 60 300 0 200 50 1987 2236 2.1 2.1 0.4 16.2 4.0 2.5 0.6 23.7 0.1	70 350 0 150 57 1976 2183 2.8 2.8 0.6 16.1 4.7 3.2 1.0 25.7 0.1	80 400 0 100 64 1962 2126 3.6 3.6 0.9 15.3 5.4 3.6 1.7 27.0 0.1

Table 5A.	133 g	U-235	TRIGA	Fuel, 8.	5wt% U	, 70% E	nrichm	ent	Table 5B.	98 g	U-235	TRIGA	Fuel, 20	wt% U,	20% E	nrichme	ent
U-235:									U-235:								
Burnup, %	0	5	10	15	20	25	30	35	Burnup, %	0	5	10	15	20	25	30	35
Burned, g	0	7	13	20	27	33	40	47	Burned, g	0	5	10	15	20	25	29	34
U-234	0	0	0	0	. 0	0	0	0	U-234	0	0	0	0	0	0	0	0
U-235	133	126	120	113	106	100	93	87	U-235	98	93	88	83	78	74	69	64
U-236	0	. 1	3	4	5	6	7	8	U-236	0	1	2	3	4	4	5	6
U-238	57	57	56	56	56	56	55	55	U-238	392	391	391	390	389	388	388	387
U	190	184	179	173	167	162	156	150	U	490	485	481	476	471	466	461	457
Np-237	0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	Np-237	0	0.0	0.0	0.0	0.1	0.1	0.1	0.2
Np	0	0.0	0.0	0.1	0.1	0.1	0.2	0.3	Np	0	0.0	0.0	0.0	0.1	0.1	0.1	0.2
Pu-238	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pu-238	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pu-239	0	0.3	0.5	0.7	0.8	0.9	1.0	1.1	Pu-239	0	0.6	1.1	1.6	2.0	2.4	<b>2</b> .7	2.9
Pu-240	0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	Pu-240	0	0.0	0.1	0.1	0.2	0.3	0.3	0.4
Pu-241	0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	Pu-241	0	0.0	0.0	0.0	0.0	0.1	0.1	0.2
Pu-242	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Pu-242	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pu	0	0.3	0.5	0.7	0.9	1.1	1.2	1.4	Pu	0	0.6	1.2	1.7	2.3	2.7	3.2	3.6
Am-241	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Am-241	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Am	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Am	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Table 5C.	54 g	U-235	TRIGA	Fuel, 12	2wt% U,	20% E	nrichme	ent	Table 5D.	38 g	U-235	TRIGA	Fuel, 8.	5wt% U	, 20% E	Inrichm	ent
Table 5C. U-235:	54 ç	U-235	TRIGA	Fuel, 12	2wt% U,	20% E	nrichme	ent	<b>Table 5D.</b> U-235:	38 g	U-235	TRIGA	Fuel, 8.	5wt% U	, 20% E	nrichm	ent
Table 5C. U-235: Burnup, %	54 g 0	1 U-235 5	TRIGA	Fuel, 12	2 <mark>wt% U,</mark> 20	20% E	nrichme 30	ent 35	<b>Table 5D.</b> U-235: Bumup, %	38 g 0	U-235 5	TRIGA	Fuel, 8. 15	5 <b>wt% U</b> 20	<mark>, 20% E</mark> 25	nrichm 30	ent 35
Table 5C. U-235: Burnup, % Burned, g	54 ç 0 0	5 3	<b>TRIGA</b> 10 5	Fuel, 12 15 8	2wt% U, 20 11	20% E 25 14	nrichme 30 16	ent 35 19	Table 5D. U-235: Burnup, % Burned, g	38 g 0 0	U-235 5 2	<b>TRIGA</b> 10 4	Fuel, 8. 15 6	<mark>5wt% U</mark> 20 8	<mark>, 20% E</mark> 25 10	anrichm 30 11	ent 35 13
Table 5C. U-235: Burnup, % Burned, g U-234	54 ç 0 0	5 3 0	<b>TRIGA</b> 10 5 0	Fuel, 12 15 8 0	2wt% U, 20 11 0	20% E 25 14 0	nrichme 30 16 0	ent 35 19 0	<b>Table 5D.</b> U-235: Burnup, % Burned, g U-234	38 g 0 0	5 2 0	10 10 4 0	Fuel, 8. 15 6 0	5wt% U 20 8 0	20% E 25 10 0	30 11 0	ent 35 13 0
Table 5C.           U-235:           Burnup, %           Burned, g           U-234           U-235	54 g 0 0 0 54	5 3 0 51	10 5 0 49	Fuel, 12 15 8 0 46	2wt% U, 20 11 0 43	20% E 25 14 0 41	nrichme 30 16 0 38	35 19 0 35	Table 5D.           U-235:           Burnup, %           Burned, g           U-234           U-235	38 g 0 0 0 38	5 2 0 36	10 4 0 34	Fuel, 8. 15 6 0 32	5wt% U 20 8 0 30	20% E 25 10 0 29	30 11 0 27	ent 35 13 0 25
Table 5C. U-235: Burnup, % Burned, g U-234 U-235 U-236	54 g 0 0 0 54 0	5 3 0 51 0	10 5 0 49 1	Fuel, 12 15 8 0 46 1	2wt% U, 20 11 0 43 2	20% E 25 14 0 41 2	30 30 16 0 38 3	35 19 0 35 3	Table 5D.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236	38 g 0 0 0 38 0	5 2 0 36 0	10 4 0 34 1	Fuel, 8. 15 6 0 32 1	5wt% U 20 8 0 30 1	20% E 25 10 0 29 2	30 11 0 27 2	ent 35 13 0 25 2
Table 5C.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238	54 g 0 0 54 0 216	5 3 0 51 0 216	10 5 0 49 1 215	Fuel, 12 15 8 0 46 1 215	200 11 0 43 2 215	20% E 25 14 0 41 2 215	30 16 0 38 3 214	35 19 0 35 3 214	Table 5D.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238	38 g 0 0 38 0 152	5 2 0 36 0 152	10 4 0 34 1 152	Fuel, 8. 15 6 0 32 1 151	5wt% U 20 8 0 30 1 151	25 10 0 29 2 151	30 11 0 27 2 151	ent 35 13 0 25 2 151
Table 5C.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U	54 g 0 0 54 0 216 270	5 3 0 51 0 216 268	10 5 0 49 1 215 265	Fuel, 12 15 8 0 46 1 215 262	200 11 0 43 2 215 260	20% E 25 14 0 41 2 215 257	30 16 0 38 3 214 255	35 19 0 35 3 214 252	Table 5D.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U	38 g 0 0 38 0 152 190	5 2 0 36 0 152 188	10 4 0 34 1 152 186	Fuel, 8. 15 6 0 32 1 151 185	5wt% U 20 8 0 30 1 151 183	25 10 0 29 2 151 181	30 11 0 27 2 151 179	ent 35 13 0 25 2 151 177
Table 5C. U-235: Burnup, % Burned, g U-234 U-235 U-236 U-238 U U-238 U Np-237	54 g 0 0 54 0 216 270 0	5 3 0 51 0 216 268 0.0	10 5 0 49 1 215 265 0.0	Fuel, 12 15 8 0 46 1 215 262 0.0	2wt% U, 20 11 0 43 2 215 260 0.0	20% E 25 14 0 41 2 215 257 0.0	30 16 0 38 3 214 255 0.0	35 19 0 35 3 214 252 0.1	Table 5D.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Np-237	38 g 0 0 38 0 152 190 0	5 2 0 36 0 152 188 0.0	10 4 0 34 1 152 186 0.0	Fuel, 8. 15 6 0 32 1 151 185 0.0	5wt% U 20 8 0 30 1 151 183 0.0	25 10 0 29 2 151 181 0.0	30 11 0 27 2 151 179 0.0	ent 35 13 0 25 2 151 177 0.0
Table 5C.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U           Np-237           Np	54 g 0 0 54 0 216 270 0 0	5 3 0 51 0 216 268 0.0 0.0	10 5 0 49 1 215 265 0.0 0.0	Fuel, 12 15 8 0 46 1 215 262 0.0 0.0	200 11 0 43 2 215 260 0.0 0.0	20% E 25 14 0 41 2 215 257 0.0 0.0	30 16 0 38 3 214 255 0.0 0.0	35 19 0 35 3 214 252 0.1 0.1	Table 5D.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U           Np-237           Np	38 g 0 0 38 0 152 190 0 0	5 2 0 36 0 152 188 0.0 0.0	10 4 0 34 1 152 186 0.0 0.0	Fuel, 8. 15 6 0 32 1 151 185 0.0 0.0	5wt% U 20 8 0 30 1 151 183 0.0 0.0	25 10 0 29 2 151 181 0.0 0.0	30 11 0 27 2 151 179 0.0 0.0	ent 35 13 0 25 2 151 177 0.0 0.0
Table 5C.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U           Pp-237           Np           Pu-238	54 g 0 0 54 0 216 270 0 0	5 3 0 51 0 216 268 0.0 0.0 0.0 0.0	10 5 0 49 1 215 265 0.0 0.0 0.0	Fuel, 12 15 8 0 46 1 215 262 0.0 0.0 0.0 0.0	200 11 0 43 2 215 260 0.0 0.0 0.0 0.0	20% E 25 14 0 41 2 215 257 0.0 0.0 0.0	30 16 0 38 3 214 255 0.0 0.0 0.0 0.0	35 19 0 35 3 214 252 0.1 0.1 0.0	Table 5D.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Np-237         Np         Pu-238	38 g 0 0 38 0 152 190 0 0 0	5 2 0 36 0 152 188 0.0 0.0 0.0	TRIGA           10           4           0           34           1           152           186           0.0           0.0           0.0	Fuel, 8. 15 6 0 32 1 151 185 0.0 0.0 0.0	5wt% U 20 8 0 30 1 151 183 0.0 0.0 0.0	25 10 0 29 2 151 181 0.0 0.0 0.0	30 11 0 27 2 151 179 0.0 0.0 0.0 0.0	ent 35 13 0 25 2 151 177 0.0 0.0 0.0
Table 5C.           U-235:           Burnup, %           Burned, g           U-234           U-235           U-236           U-238           U           Np-237           Np           Pu-238           Pu-237           Np           Pu-238           Pu-239	54 g 0 0 54 0 216 270 0 0 0 0	5 3 0 51 0 216 268 0.0 0.0 0.0 0.0 0.3	TRIGA           10           5           0           49           1           215           265           0.0           0.0           0.0           0.0           0.5	Fuel, 12 15 8 0 46 1 215 262 0.0 0.0 0.0 0.0 0.7	200 11 0 43 2 215 260 0.0 0.0 0.0 0.0 0.0 0.9	20% E 25 14 0 41 2 215 257 0.0 0.0 0.0 1.1	30 16 0 38 3 214 255 0.0 0.0 0.0 0.0 1.2	35 19 0 35 3 214 252 0.1 0.1 0.1 0.0 1.3	Table 5D.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Np-237         Np         Pu-238         Pu-238         Pu-237         Np         Pu-238         Pu-239	38 g 0 0 38 0 152 190 0 0 0 0	5 2 0 36 0 152 188 0.0 0.0 0.0 0.0 0.2	TRIGA           10           4           0           34           1           152           186           0.0           0.0           0.0           0.3	Fuel, 8. 15 6 32 1 151 185 0.0 0.0 0.0 0.0 0.5	5wt% U 20 8 0 30 1 151 183 0.0 0.0 0.0 0.0 0.6	25 10 29 2 151 181 0.0 0.0 0.0 0.7	30 11 0 27 2 151 179 0.0 0.0 0.0 0.0 0.8	ent 35 13 0 25 2 151 177 0.0 0.0 0.0 0.0 0.9
Table 5C.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Np-237         Np         Pu-238         Pu-239         Pu-240	54 g 0 54 0 216 270 0 0 0 0 0 0	5 3 0 51 0 216 268 0.0 0.0 0.0 0.0 0.3 0.0	TRIGA           10           5           0           49           1           215           265           0.0           0.0           0.0           0.5           0.0	Fuel, 12 15 8 0 46 1 215 262 0.0 0.0 0.0 0.0 0.7 0.0	200 11 0 43 2 215 260 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	20% E 25 14 0 41 2 215 257 0.0 0.0 0.0 1.1 0.1	30 16 0 38 3 214 255 0.0 0.0 0.0 1.2 0.1	35 19 0 35 3 214 252 0.1 0.1 0.0 1.3 0.2	Table 5D.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Np-237         Np         Pu-238         Pu-237         Np         Pu-237         Np         Pu-238         Pu-239         Pu-240	38 g 0 0 38 0 152 190 0 0 0 0 0	5 2 0 36 0 152 188 0.0 0.0 0.0 0.0 0.2 0.0	TRIGA 10 4 0 34 1 152 186 0.0 0.0 0.0 0.3 0.0	Fuel, 8. 15 6 0 32 1 151 185 0.0 0.0 0.0 0.5 0.0	5wt% U 20 8 0 30 1 151 183 0.0 0.0 0.0 0.0 0.0	25 10 0 29 2 151 181 0.0 0.0 0.0 0.7 0.1	30 11 0 27 2 151 179 0.0 0.0 0.0 0.0 0.8 0.1	ent 35 13 0 25 2 151 177 0.0 0.0 0.0 0.0 0.9 0.1
Table 5C.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Np-237         Np         Pu-238         Pu-239         Pu-239         Pu-240         Pu-241	54 g 0 54 0 216 270 0 0 0 0 0 0 0 0 0	5 3 0 51 0 216 268 0.0 0.0 0.0 0.0 0.3 0.0 0.0	TRIGA           10           5           0           49           1           215           265           0.0           0.0           0.0           0.5           0.0           0.0	Fuel, 12 15 8 0 46 1 215 262 0.0 0.0 0.0 0.0 0.7 0.0 0.0	200 11 0 43 2 215 260 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0	20% E 25 14 0 41 2 215 257 0.0 0.0 0.0 1.1 0.1 0.0	30 16 0 38 3 214 255 0.0 0.0 0.0 0.0 1.2 0.1 0.0	35 19 0 35 3 214 252 0.1 0.1 0.0 1.3 0.2 0.1	Table 5D.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Np-237         Np         Pu-238         Pu-237         Np         Pu-238         Pu-231         Pu-232         Pu-233         Pu-234	38 g 0 0 38 0 152 190 0 0 0 0 0 0 0	5 2 0 36 0 152 188 0.0 0.0 0.0 0.0 0.2 0.0 0.0	TRIGA 10 4 0 34 1 152 186 0.0 0.0 0.0 0.3 0.0 0.0 0.0	Fuel, 8. 15 6 0 32 1 151 185 0.0 0.0 0.0 0.5 0.0 0.0 0.0	5wt% U 20 8 0 30 1 151 153 0.0 0.0 0.0 0.0 0.0 0.0	25 10 0 29 2 151 181 0.0 0.0 0.0 0.7 0.1 0.0	30 11 0 27 2 151 179 0.0 0.0 0.0 0.0 0.0 0.8 0.1 0.0	ent 35 13 0 25 2 151 177 0.0 0.0 0.0 0.0 0.9 0.1 0.0
Table 5C.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Pu-237         Np         Pu-238         Pu-239         Pu-240         Pu-241         Pu-242	54 g 0 54 0 216 270 0 0 0 0 0 0 0 0 0 0	5 3 0 51 0 216 268 0.0 0.0 0.0 0.0 0.3 0.0 0.0 0.0 0.0 0.0	TRIGA 10 5 0 49 1 215 265 0.0 0.0 0.0 0.5 0.0 0.0 0.0 0.	Fuel, 12 15 8 0 46 1 215 262 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	2wt% U, 20 11 0 43 2 215 260 0.0 0.0 0.0 0.0 0.0 0.9 0.1 0.0 0.0 0.0	20% E 25 14 0 41 2 215 257 0.0 0.0 0.0 1.1 0.1 0.0 0.0	30 16 0 38 3 214 255 0.0 0.0 0.0 1.2 0.1 0.0 0.0 0.0	35 19 0 35 3 214 252 0.1 0.1 0.0 1.3 0.2 0.1 0.0	Table 5D.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Np-237         Np         Pu-238         Pu-239         Pu-240         Pu-241         Pu-242	38 g 0 0 38 0 152 190 0 0 0 0 0 0 0 0 0	5 2 0 36 0 152 188 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	TRIGA 10 4 0 34 1 152 186 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	Fuel, 8. 15 6 0 32 1 151 185 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	5wt% U 20 8 0 30 1 151 183 0.0 0.0 0.0 0.0 0.0 0.0 0.0	25 10 0 29 2 151 181 0.0 0.0 0.7 0.1 0.0 0.0	30 11 0 27 2 151 179 0.0 0.0 0.0 0.0 0.8 0.1 0.0 0.0 0.0	ent 35 13 0 25 2 151 177 0.0 0.0 0.0 0.9 0.1 0.0 0.0 0.0
Table 5C.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Np-237         Np         Pu-238         Pu-239         Pu-240         Pu-241         Pu-242         Pu	54 g 0 54 0 216 270 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	5 3 0 51 0 216 268 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	TRIGA 10 5 0 49 1 215 265 0.0 0.0 0.0 0.5 0.0 0.0 0.0 0.	Fuel, 12 15 8 0 46 1 215 262 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	2wt% U, 20 11 0 43 2 215 260 0.0 0.0 0.0 0.0 0.9 0.1 0.0 0.0 1.0	20% E 25 14 0 41 2 215 257 0.0 0.0 0.0 1.1 0.1 0.0 0.0 1.2	30 16 0 38 3 214 255 0.0 0.0 0.0 1.2 0.1 0.0 0.0 1.4	35 19 0 35 3 214 252 0.1 0.1 0.0 1.3 0.2 0.1 0.0 1.6	Table 5D.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Np-237         Np         Pu-238         Pu-239         Pu-240         Pu-241         Pu-242         Pu	38 g 0 0 38 0 152 190 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	5 2 0 36 0 152 188 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0	TRIGA 10 4 0 34 1 152 186 0.0 0.0 0.0 0.3 0.0 0.0 0.0 0.0	Fuel, 8. 15 6 0 32 1 151 185 0.0 0.0 0.0 0.5 0.0 0.0 0.0 0.	5wt% U 20 8 0 30 1 151 183 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	25 10 0 29 2 151 181 0.0 0.0 0.7 0.1 0.0 0.0 0.0 0.0 0.0 0.0 0.0	30 11 0 27 2 151 179 0.0 0.0 0.0 0.0 0.8 0.1 0.0 0.0 0.0 0.0 0.0 0.0	ent 35 13 0 25 2 151 177 0.0 0.0 0.0 0.9 0.1 0.0 0.0 1.0
Table 5C.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Np-237         Np         Pu-238         Pu-239         Pu-240         Pu-241         Pu-242         Pu         Am-241	54 g 0 54 0 216 270 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	5 3 0 51 0 216 268 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	TRIGA           10           5           0           49           1           215           265           0.0           0.0           0.0           0.0           0.5           0.0           0.5           0.0           0.5           0.0           0.5           0.0	Fuel, 12 15 8 0 46 1 215 262 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	200 11 0 43 2 215 260 0.0 0.0 0.0 0.0 0.0 0.1 0.0 0.0 1.0 0.0	20% E 25 14 0 41 2 215 257 0.0 0.0 0.0 1.1 0.0 0.0 1.2 0.0	30 16 0 38 3 214 255 0.0 0.0 0.0 1.2 0.1 0.0 0.0 1.4 0.0	35 19 0 35 3 214 252 0.1 0.1 0.0 1.3 0.2 0.1 0.0 1.6 0.0	Table 5D.         U-235:         Burnup, %         Burned, g         U-234         U-235         U-236         U-238         U         Np-237         Np         Pu-238         Pu-239         Pu-240         Pu-241         Pu-242         Pu         Am-241	38 g 0 0 38 0 152 190 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	5 2 0 36 0 152 188 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0	TRIGA           10           4           0           34           1           152           186           0.0           0.0           0.3           0.0           0.3           0.0           0.3           0.0           0.3           0.0           0.3           0.0           0.3           0.0	Fuel, 8. 15 6 0 32 1 151 185 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	5wt% U 20 8 0 30 1 151 183 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	25 10 0 29 2 151 181 0.0 0.0 0.0 0.7 0.1 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	30 11 0 27 2 151 179 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	ent 35 13 0 25 2 151 177 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0

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Table 6A.	41.4	g U-23	5 TRIG	A Fuel			
U-235:		10v	vt% U,	93.1%	Enrichn	nent	
Burnup, %	0	10	20	30	40	50	60
Burned, g	0.0	4.1	8.3	12.4	16.6	20.7	24.8
U-234	0.4	0.4	0.4	0.4	0.4	0.3	0.3
U-235	41.4	37.2	33.1	29,0	24.8	20.7	16.6
U-236	0.2	1.0	1.7	2.4	3.1	3.8	4.4
U-238	2.4	2.4	2.4	2.3	2.3	2.2	2.2
U	44.5	41.0	37.6	34.1	30.6	27.1	23.5
Np-237	0	0.0	0.0	0.1	0.1	0.2	0.2
Np	0	0.0	0.0	0.1	0.1	0.2	0.2
Pu-238	0	0.0	0.0	0.0	0.0	0.0	0.0
Pu-239	0	0.0	0.1	0.1	0.1	0.1	0.1
Pu-240	0	0.0	0.0	0.0	0.0	0.0	0.0
Pu-241	0	0.0	0.0	0.0	0.0	0.0	0.0
Pu-242	0	0.0	0.0	0.0	0.0	0.0	0.0
Pu	0	0.0	0.1	0.1	0.1	0.1	0.2
Am-241	0	0.0	0.0	0.0	0.0	0.0	0.0
Am	0	0.0	0.0	0.0	0.0	0.0	0.0

Table 7A.	150	U-235	5 DIDO	Fuel, 9	3% En		
U-235:							
Burnup, %	0	10	20	30	40	50	60
Burned, g	0	15	30	45	60	75	90
U-234	0	0	0	0	0	0	. 0
U-235	150	135	120	105	90	75	60
U-236	0	2	5	7	9	12	14
U-238	11	11	. 11	11	11	11	11
U	161	149	136	123	110	98	85
Np-237	0	0.0	0.0	0.1	0.1	0.2	0.3
Np	0	0.0	0.0	0.1	0.1	0.2	0.3
Pu-238	0	0.0	0.0	0.0	0.0	0.0	0.0
Pu-239	0	0.0	0.1	0.1	0.1	0.1	0.2
Pu-240	0	0.0	0.0	0.0	0.0	0.0	0.0
Pu-241	0	. 0.0	0.0	0.0	0.0	0.0	0.0
Pu-242	0	0.0	0.0	0.0	0.0	0.0	0.0
Pu	0	0.0	0.1	0.1	0.2	0.2	0.2
Am-241	0	0.0	0.0	0.0	0.0	0.0	0.0
Am	0	0.0	0.0	0.0	0.0	0.0	0.0

Table 6B.	53.6	g U-23	5 TRIG	A Fuel			
U-235:		45%	vt% U,	19.7% 8	Enrichm	ent	
Burnup, %	0	10	20	30	40	50	60
Burned, g	0.0	5.4	10.7	16.1	21.4	26.8	32.2
U-234	0.4	Ö.4	0.4	0.3	0.3	0.3	0.3
U-235	53.6	48.3	42.9	37.5	32.2	26.8	21.4
U-236	0.7	1.7	2.7	3.7	4.6	5.5	6.4
U-238	217.4	216.5	215.6	214.6	213.5	212.3	210.9
U	272.1	266.9	261.6	256.1	250.6	244.9	239.0
Np-237	0	0.0	0.1	0.1	0.2	0.3	0.4
Np	0	0.0	0.1	0.1	0.2	0.3	0.4
Pu-238	0	0.0	0.0	0.0	0.0	0.1	0.1
Pu-239	0	0.7	1.3	1.7	1.9	2.1	2.1
Pu-240	0	0.0	0.1	0.2	0.3	0.4	0.5
Pu-241	0	0.0	0.0	0.1	0.2	0.3	0.4
Pu-242	0	0.0	0.0	0.0	0.0	0.1	0.1
Pu	. 0	0.8	1.4	2.0	2.5	2.9	3.2
Am-241	0	0.0	0.0	0.0	0.0	0.0	0.0
Am	0	0.0	0.0	0.0	0.0	0.0	0.0

Table 7B.	150 g	y U-235	DIDO	Fuel, 8	0% En	r.	
U-235:							
Burnup, %	0	10	20	30	40	50	60
Burned, g	0	15	30	45	60	75	90
U-234	0	0	0	0	0	0	0
U-235	150	135	120	105	90	75	60
U-236	0	· 2	5	7	9	12	14
U-238	38	37	37	37	37	37	37
U	188	175	162	149	136	123	110
Np-237	0	0.0	0.0	0.1	0.1	0.2	0.3
Np	0	0.0	0.0	0.1	0.1	0.2	0.3
Pu-238	0	0.0	0.0	0.0	0.0	0.0	0.0
Pu-239	. 0	0.1	0.2	0.3	0.3	0.4	0.4
Pu-240	0	0.0	0.0	0.0	0.1	0.1	0.1
Pu-241	0	0.0	0.0	0.0	0.0	0.0	0.0
Pu-242	0	0.0	0.0	0.0	0.0	0.0	0.0
Pu	0	0.1	0.2	0.3	0.4	0.5	0.6
Am-241	0	0.0	0.0	0.0	0.0	0.0	0.0
Am	. 0	0.0	0.0	0.0	0.0	0.0	0.0

Table 7C.	150	g U-235	5 DIDO	Fuel, 6	0% En	r		Table 7D.	200	y U-235	5 DIDO	Fuel, 2	0% En	r.	
U-235:								U-235:							
Burnup, %	0	10	20	30	40	50	60	Burnup, %	0	10	20	30	40	50	60
Burned, g	0	15	30	45	60	75	90	Burned, g	0	. 20	40	60	80	100	120
U-234	0	Ō	0	Ö	0	0	0	U-234	0	0	0	0	0	0	0
U-235	150	135	120	105	90	75	60	U-235	200	180	160	140	120	100	80
U-236	0	2	5	7	9	12	14	U-236	0	3	7	10	13	16	19
U-238	100	100	100	99	99	99	98	U-238	800	799	797	796	794	793	791
U	250	237	224	211	198	185	172	U	1000	982	964	946	927	908	890
Np-237	0	0.0	0.0	0.1	0.1	0.2	0.3	Np-237	. 0	0.0	0.1	0.1	0.2	0.3	0.4
Np	0	0.0	0.0	0.1	0.1	0.2	0.3	Np	0	0.0	0.1	0.1	0.2	0.3	0.4
Pu-238	0	0.0	0.0	0.0	0.0	0.0	0.0	Pu-238	0	0.0	0.0	0.0	0.0	0.0	0.1
Pu-239	0	0.2	0.4	0.6	0.7	0.7	0.8	Pu-239	0	1.1	2.0	2.7	3.2	3.5	3.7
Pu-240	0	0.0	0.0	0.1	0.1	0.2	0.2	Pu-240	0	0.0	0.2	0.3	0.6	0.8	1.0
Pu-241	0	0.0	0.0	0.0	0.0	0.1	0.1	Pu-241	0	0.0	0.0	0.1	0.2	0.3	0.4
Pu-242	0.	0.0	0.0	0.0	0.0	0.0	0.0	Pu-242	0	0.0	0.0	0.0	0.0	0.0	0.1
Pu	0	0.2	0.5	0.7	0.8	1.0	1.1	Pu	0	1.2	2.2	3.1	4.0	4.7	5.3
Am-241	0	0.0	0.0	0.0	0.0	0.0	0.0	Am-241	0	0.0	0.0	0.0	0.0	0.0	0.0
Am	0	0.0	0.0	0.0	0.0	0.0	0.0	Am	0	0.0	0.0	0.0	0.0	0.0	0.0

inventory<sup>3</sup>. Within the uncertainty of the calculations, the results in Tables 2–7 can be used to estimate the spent fuel mass inventory in most MTR, TRIGA and DIDO fuel assembly types.

The mass inventories given in Tables 2–7 are at the time of reactor discharge and therefore do not account for decay of Pu-241 to Am-241 for times after discharge. When necessary to estimate mass inventories after discharge, the Pu-241 mass is decreased and the Am-241 mass is increased by an amount  $\Delta M = M_0 \cdot (1 - e^{-\lambda t})$  where  $M_0$  is the Pu-241 mass at discharge,  $\lambda = 1.32 \cdot 10^{-4} d^{-1}$  (Pu-241 half-life, 14.4 y), and t is the time in days after discharge. No mass inventories are given for U-239 (half-life, 23.5 m) and Np-239 (half-life, 2.355 d) as they are assumed to decay instantaneously to Pu-239.

#### **PHOTON DOSE RATE**

Calculated dose rates for MTR-type fuel assemblies are shown in Table 8. These dose rates are from Ref. 4 and are for fuel assemblies with up to 80% U-235 burnup, specific power densities between 0.089 and 2.857 MW/kg<sup>25</sup>U, and fission product decay times of up to 20 years.

The data in Table 8 are photon dose rates in air that are averaged over a 60-cm long cylindrical surface, located at a radius of 1 m from the fuel assembly axial center line. For MTR-type fuel assemblies, these average dose rates are independent of the assembly rotational orientation and the number of fuel plates in the assembly. These data also can be interpolated for specific decay time, burnup and assembly power density. In all cases, the dose rates must be multiplied by the mass of U-235 burned in the fuel assembly to estimate the fuel assembly dose rate. The mass of U-235 burned per fuel assembly that is necessary for an unshielded, 100 rem/h self-protecting dose rate at 1 m, is shown in Fig. 1.

Additional analyses have shown that the photon dose rates of MTR, TRIGA and DIDOtype fuel assemblies are similar, given the same fuel assembly characteristics of U-235 burnup, fission product decay time, and specific fuel assembly power density. The average dose rates at 1 m in air for TRIGA (25-rod) and DIDO (4-tube) fuel assemblies are respectively, 1.04 and 1.05 times the dose rates given in Table 8 for MTR fuel assemblies. The dose rates of all three fuel assembly types are for fuel assembly models (nominally 8cm by 8cm by 60cm) containing spent fuel in the form of either rods (TRIGA fuel), annuli (DIDO fuel) or plates (MTR fuel). The small difference in the dose rates are due to the different shielding effects of the fuel elements in the fuel assemblies.

Decay Time v	Burnup,	Assembly Power Density, MW/kg <sup>25</sup> U											
		2.857	1.429	0.714	0.357	0.179	0.089						
2	1%	1.84+0	1.84+0	1.83+0	1.80+0	1.77+0	1.70+0						
3		1.13+0	1.13+0	1.13+0	1.13+0	1.11+0	1.11+0						
4		9.01-1	9.01-1	9.01-1	9.01-1	9.01-1	8.92-1						
2	10%	1.89+0	1.87+0	1.80+0	1.64+0	1.50+0	1.28+0						
3		1.19+0	1.20+0	1.20+0	1.16+0	1.09+0	9.95-1						
4		9.52-1	9.61-1	9.61-1	9.44-1	9.10-1	8.59-1						
2	20%	2.01+0	1.98+0	1.86+0	1.66+0	1.42+0	1.19+0						
3		1.31+0	1.32+0	1.28+0	1.21+0	1.11+0	9.78-1						
4		1.04+0	1.05+0	1.04+0	9.99-1	9.44-1	8.63-1						
5		8.97-1	9.10-1	9.05-1	8.80-1	8.46-1	7.95-1						
10		6.67-1	6.67-1	6.67-1	6.59-1	6.50-1	6.25-1						
15		5.78-1	5.78-1	5.74-1	5.70-1	5.61-1	5.44-1						
20		5.10-1	5.10-1	5.10-1	5.06-1	4.97-1	4.85-1						
2	40%	2.40+0	2.30+0	2.09+0	1.82+0	1.52+0	1.21+0						
3		1.62+0	1.60+0	1.53+0	1.39+0	1.22+0	1.02+0						
4		1.27+0	1.27+0	1.22+0	1.14+0	1.03+0	8.99-1						
5		1.07+0	1.07+0	1.04+0	9.90-1	9.20-1	8.12-1						
10		7.03-1	7.03-1	6.95-1	6.80-1	6.55-1	6.10-1						
15		5.87-1	5.84-1	5.80-1	5.70-1	5.53-1	5.23-1						
20		5.14-1	5.12-1	5.08-1	5.02-1	4.87-1	4.59-1						
2	60%	2.95+0	2.79+0	2.52+0	2.15+0	1.74+0	1.34+0						
3	•	2.05+0	2.00+0	1.87+0	1.66+0	1.40+0	1.12+0						
4		1.59+0	1.56+0	1.49+0	1.35+0	1.17+0	9.63-1						
5		1.30+0	1.29+0	1.24+0	1.15+0	1.02+0	8.54-1						
10		7.55-1	7.51-1	7.37-1	7.07-1	6.70-1	6.02-1						
15		5.96-1	5.96-1	5.88-1	5.72-1	5.50-1	5.04-1						
20		5.17-1	5.17-1	5.13-1	4.99-1	4.76-1	4.39-1						
2	80%	3.85+0	3.62+0	3.26+0	2.76+0	2.21+0	1.64+0						
3		2.73+0	2.64+0	2.43+0	2.11+0	1.74+0	1.33+0						
4		2.08+0	2.03+0	1.90+0	1.69+0	1.41+0	1.12+0						
5		1.66+0	1.63+0	1.54+0	1.39+0	1.19+0	9.57-1						
10		8.28-1	8.21-1	8.00-1	7.59-1	6.97-1	0.04-1						
15		6.18-1	6.15-1	6.05-1	5.82-1	5.44-1	4.87-1						
20		5.27-1	5.20-1	5.13-1	4.97-1	4.66-1	4.20-1						

Table 8. Photon Dose Rates At 1 M In Air, rem/h per g<sup>24</sup>U burned



Figure 1. Mass of Burned <sup>235</sup>U per Fuel Assembly Necessary for an Unshielded 100 rem/h Dose Rate at 1 m for Fuel Assemblies with 20, 40, 60 and 80% <sup>235</sup>U Burnup and Power Densities from 0.089 to 2.857 MW/kg <sup>235</sup>U

#### THERMAL DECAY HEAT

The heat load from decaying fission products in a fuel assembly is proportional to empirical emission rates of beta and gamma radiation. The rates<sup>5</sup> per U-235 fission, and as a function of decay time  $t_d$  in days, are

$$\beta(t_d) = 1.50 \cdot 10^{-6} \cdot t_d^{-1.2} \text{ MeV/s-f}$$
  

$$\gamma(t_d) = 1.67 \cdot 10^{-6} \cdot t_d^{-1.2} \text{ MeV/s-f}$$

These energy rates are roughly equal for 0.4 MeV mean energy beta particles and 0.7 MeV mean energy gamma-rays.

For a fuel assembly irradiated continuously for  $t_i$  days at a constant fuel assembly power (P), the heat (H) load power per assembly,  $t_d$  days after irradiation is

$$H = 6.85 \cdot 10^{-3} \cdot P \cdot (t_d^{-0.2} - (t_i + t_d)^{-0.2})$$
 Watts

This expression<sup>6</sup> for the heat load is the integral of the above energy rates over the irradiation time, assuming 200 MeV per U-235 fission, and for the fuel assembly power in watts. For a low duty-factor fuel assembly irradiation, the power and irradiation time are replaced by an average power and an elapsed time. With  $\overline{P} \cdot t_{\epsilon} = \sum (P \cdot t_i)$  over all irradiation segments, the heat (H) load power per assembly is

$$H \approx 6.85 \cdot 10^{-3} \cdot \overline{P} \cdot (t_d^{-0.2} - (t_e + t_d)^{-0.2})$$
 Watts

where  $\overline{P}$  is the average fuel assembly power in watts and  $t_e$  is the elapsed time in days from the initial through the final irradiation segment.

A convenient estimate for the average power  $(\overline{P})$  is

$$\overline{P} = (G/t_{\star})/1.25 \cdot 10^{-6}$$
 Watts

where G is the mass of U-235 burned in the fuel assembly in grams, and the constant is  $g^{25}U$  burned per Wd.

Fuel assembly decay heat loads calculated with these expressions are expected to be conservative, and within a factor of two or less of measured heat loads. This same conservative heat load estimate also has been found to be true for heat load calculations made with the ORIGEN code<sup>7</sup>. The thermal heat load of a fuel assembly is independent of the fuel assembly type.

#### CONCLUSIONS

Procedures have been developed to estimate the nuclear mass inventory, the photon dose rate and the thermal decay heat of spent research reactor fuel assemblies. The procedures should provide reasonable estimates based upon known fuel assembly parameters.

Isotopic mass inventories of U, Np, Pu and Am are tabulated in Tables 2–7 for MTR, TRIGA and DIDO fuel assembly types; photon dose rates at 1 m in air are shown in Table 8 for MTR-type fuel assemblies; and an analytical expression is given for the thermal decay heat load of spent uranium fuel. Estimates of TRIGA and DIDO fuel assembly dose rates are respectively, factors of 1.04 and 1.05 times the dose rate for MTR-type fuel assemblies with similar spent fuel material characteristics.

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