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**Preliminary Evaluation of
Alternate-Fueled Gas
Cooled Fast Reactors**

J. R. White
T. J. Burns

MASTER

OPERATED BY
UNION CARBIDE CORPORATION
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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Printed in the United States of America. Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road, Springfield, Virginia 22161
NTIS price codes—Printed Copy. A04, Microfiche A01

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ORNL/TM-7432
Distribution Category UC-77
Gas Cooled Reactor Technology

Contract W-7405-eng-26

Engineering Physics Division

Preliminary Evaluation of Alternate-Fueled
Gas Cooled Fast Reactors

J. R. White* and T. J. Burns

Date Published - December 1980

* UCND Computer Sciences Division.

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ABSTRACT

A preliminary evaluation of various alternative fuel cycles for the Gas-Cooled Fast Reactor (GCFR) is presented. Both homogeneous and heterogeneous oxide-fueled GCFRs are considered. The scenario considered is the energy center/dispersed reactor concept in which proliferation-resistant denatured reactors are coupled to ^{233}U production reactors operating in secure energy centers. Individual reactor performance characteristics and symbiotic system parameters are summarized for several possible alternative fuel concepts. Comparisons are made between the classical homogeneous GCFR and the advanced heterogeneous concept on the basis of breeding ratio, doubling time, and net fissile gain. In addition, comparisons are made between a three-dimensional reactor model and the R-Z heterogeneous configuration utilized for the depletion and fuel management calculations. Lastly, thirty-year mass balance data are given for the various GCFR fuel cycles studied.

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I. INTRODUCTION

In light of recent proliferation concerns regarding the use of the plutonium/uranium fuel cycles in nuclear power reactors, a preliminary evaluation of the impact of several proposed alternative fuel cycles was performed. The study encompassed two major reactor types, the Liquid Metal Fast Breeder Reactor (LMFBR) and the Gas Cooled Fast Reactor (GCFR). The intent of this report is to summarize the results of the GCFR portion of that evaluation.^{1,2} A companion document, ORNL-5389,¹ is the primary documentation for the alternate-fueled homogeneous LMFBR preliminary evaluation. Due to the similarity of the two studies, much of the material in the LMFBR report is directly applicable to the GCFR and thus will not be repeated in the present report.

The primary alternate fuel cycle scenario analyzed is the energy center/dispersed reactor concept in which proliferation-resistant denatured reactors are coupled to ^{233}U production reactors operating in secure energy centers. Such a symbiotic system involving two or more types of reactors is depicted in Fig. 1. In this study the transmuted and denatured fast breeder reactors (FBR) would be either homogeneous or heterogeneous 1200 MW(e) GCFRs.

The principal feature of such a scenario is that no plutonium-bearing fresh fuel is ever required to leave the energy center complex. All fuel shipped from the center is denatured, and the plutonium-bearing spent fuel shipped back from the denatured reactors is contaminated with highly radioactive fission products. The mature system as depicted by Fig. 1 is an example of a true symbiotic relationship in which the transmuters consume the plutonium generated in the denatured systems and produce ^{233}U . The dispersed denatured reactors in turn consume the ^{233}U and produce plutonium.

For the purpose of this evaluation, a General Atomic preliminary 1200 MW(e) design³ was adopted as the reference reactor. This reference homogeneous (Pu-U) O_2/UO_2 reactor model served as the basis for both the homogeneous and heterogeneous configurations described in Sections II

Fig. 1. Energy Center/Dispersed Reactor Fuel Cycle Scenario.

and III, respectively. In the case of the heterogeneous model (i.e., interspersed fissile and fertile assemblies) it was assumed that the same fuel and blanket assemblies as in the homogeneous model could be used, although in a somewhat different geometric arrangement. This simplification gives some common ground for comparison of the two models. It should be noted, however, that comparison of designs optimized for each case may lead to somewhat different conclusions.

Some of the principal features of the reference reactor model are given in Table 1. In addition, Table 2 contains the plutonium isotopic compositions used as feed material for the reference calculations. These isotopic fractions were specified in the Large Heterogeneous Reference Fuel Design Study (LHRFDS),⁴ and differ somewhat from those used in Ref. 3. In addition, the depleted uranium used for fertile material feed was assumed to contain 0.20% ^{235}U .

Table 1. Summary of 1200 MW(e) Reference GCFR Characteristics

<u>Core Design Parameters</u>		
Reactor Power	MW(t) MW(e)	3158 1200
Maximum Allowable Linear Heat Rate	KW/m	49.2
<u>Fuel Specifications</u>	<u>Core Assembly</u>	<u>Blanket Assembly</u>
Type	Oxide	Oxide
Pins/Assembly	331	127
Assembly Pitch (cm)	17.8	17.8
Pin Pitch (cm)	0.95	2.32
Pin Diameter (cm)	0.66	1.37
Fraction of Theoretical Density	0.82	0.90
Clad Material	SS 316	SS 316
Clad Thickness (cm)	0.033	0.065
<u>Volume Fractions</u>	<u>Core Assembly</u>	<u>Blanket Assembly</u>
Helium	0.65	0.34
Fuel	0.22	0.50
Structure	0.13	0.16

Table 2. Isotopic Plutonium Composition

Isotope	Wt %
$^{238}\text{Pu}^*$	0.00997
^{239}Pu	0.67272
^{240}Pu	0.19209
^{241}Pu	0.10127
^{242}Pu	0.02395

*Not considered in this study.

The various GCFR fuel cycles considered are listed in Table 3. The fissile/fertile combinations were constructed by replacing the reference fuel with $(^{233}\text{U}-\text{U})\text{O}_2$ and/or substituting ThO_2 for UO_2 as the primary fertile material. The fissile and fertile assembly volume fractions given for the reference case were maintained for each of the combinations analyzed. Nuclide atom densities were adjusted to reflect differences in the theoretical density of the various oxides involved [e.g. $(\text{Pu}-\text{U})\text{O}_2$, UO_2 , ThO_2]. However, no attempt was made to account for differences in the thermophysical properties (e.g. melting point, thermal conductivity, etc.) of the alternate materials relative to the reference systems. Thus, the results presented here are for non-optimized alternate-fueled reactors.

A single nine-group cross section library, derived from ENDF/B-IV data, was used throughout the study. This consisted of several region-averaged (core, blanket, structure) cross-section sets generated via the AMPX⁵ modular code system and collapsed using the spectra from a reference $(\text{Pu}-\text{U})\text{O}_2/\text{UO}_2$ homogeneous configuration. The resultant library included only the more important thorium, uranium, and plutonium isotopes as heavy metal nuclides. Also, it was assumed that the helium coolant had little effect on the neutronic performance of the reactor and, therefore, was not treated in the model. A complete list of the nuclides included in the neutronic calculations is given in Table 4.

The principal neutronic analysis tool used in this evaluation was the CITATION⁶ computer code. A three-step calculational procedure was employed for the fuel burnup calculations within CITATION. An initial multicycle depletion calculation was performed to determine the reload enrichment necessary to achieve an effective multiplication factor of unity at the end of the equilibrium cycle (i.e., the cycle for which the discharge isotopics are identical with those for the preceding cycle). Additional computations were then performed to determine the minimum first-cycle fissile loading consistent with criticality requirements over the initial cycles. Finally, using the initial core and reload specifications determined in the above two steps, a final burnup calculation was done in which the control material was adjusted so as to maintain a just-critical configuration at each depletion time step.

Table 3. Various Fissile/Fertile Combinations Considered in the Alternate-Fueled GCFR Evaluation

Case	Core	Axial Blanket	Internal Blanket	Radial Blanket
1A	(Pu-U)O ₂	UO ₂	—	UO ₂
1B	(Pu-U)O ₂	UO ₂	UO ₂	UO ₂
2A	(Pu-U)O ₂	UO ₂	—	ThO ₂
2B	(Pu-U)O ₂	UO ₂	ThO ₂	ThO ₂
3A	(Pu-Th)O ₂	ThO ₂	—	ThO ₂
3B	(Pu-Th)O ₂	ThO ₂	ThO ₂	ThO ₂
4A	(²³³ U-U)O ₂ (min.)	UO ₂	—	ThO ₂
4B	(²³³ U-U)O ₂ (min.)	UO ₂	ThO ₂	ThO ₂
5A	(²³³ U-U)O ₂ (min.)	ThO ₂	—	ThO ₂
5B	(²³³ U-U)O ₂ (min.)	ThO ₂	ThO ₂	ThO ₂
6A	(²³³ U-U-Th)O ₂ (20%)	ThO ₂	—	ThO ₂
7A	(²³³ U-U-Th)O ₂ (40%)	ThO ₂	—	ThO ₂
7B	(²³³ U-U-Th)O ₂ (40%)	ThO ₂	ThO ₂	ThO ₂
8A	(²³³ U-Th)O ₂	ThO ₂	—	ThO ₂
8B	(²³³ U-Th)O ₂	ThO ₂	ThO ₂	ThO ₂

Table 4. Nuclides Included in Neutronic Calculations

<u>HEAVY METALS</u>	
Th-232	Pu-239
U-233	Pu-240
U-235	Pu-241
U-238	Pu-242
<u>STRUCTURE</u>	
Fe	Cr
Ni	Mn
<u>CONTROL</u>	
B-10	C-12
B-11	
<u>OTHER</u>	
O-16	
FISSP (Lumped Fission Product)	

This calculational procedure was utilized to address the effects of the $^{233}\text{U}/^{232}\text{Th}$ alternate fuels on typical homogeneous and heterogeneous GCFR reactor models. Due to the inherent uncertainties in the basic nuclear data,⁷⁻⁸ the use of a single collapsing spectrum for all the fissile/fertile combinations, and the lack of detailed design optimization for the various loadings and configurations, it is recognized that the results reported in the following sections are preliminary and hence subject to revision as more precise data and/or more current designs become available. However, although the results specific to a given design are subject to these qualifications, the generic results of this study should be applicable in identifying general trends in the performance of alternate-fueled homogeneous and heterogeneous GCFRs.

II. IMPACT OF ALTERNATE FUELS ON HOMOGENEOUS GCFR PERFORMANCE

The initial portion of the alternate GCFR fuel cycle evaluation was devoted to the analysis of the classical four core-zone homogeneous model. The 1200 MW(e) R-Z calculational model utilized for all the homogeneous cores is given in Fig. 2. The four core zones and corresponding axial blanket regions are modeled using three subzones while the radial blanket region (3 rows of assemblies) utilized six subzones.

The subzone representation within the calculational model was utilized to simulate fuel management operations in the GCFR. Typically, a single subzone in each zone is refueled every cycle. Thus, the core and axial blanket regions in the above model have a three-cycle fuel residence time with one-third of the assemblies being replaced with fresh fuel each cycle. Similarly, the radial blanket assemblies, whose burnup and fluence levels per cycle are much less than the core assemblies, have a six-cycle residence time with one-sixth of the assemblies being refueled during each refueling outage. Additionally it should be noted that a cycle length of one year with an average annual capacity factor of 0.75 was assumed, resulting in a depletion cycle length of 274 full power days per calendar year.

Fig. 2. R-Z Configuration of Reference 1200 MW(e) Homogeneous GCFR.

Using this model and the calculational procedure described above, a complete set of fuel cycle calculations were performed for each homogeneous alternate fissile/fertile combination listed in Table 3. The detailed thirty-year mass balance data generated from these computations are tabulated in Appendix A. However, a summary of the major performance indicators for the alternate-fueled homogeneous GCFRs is also presented in Table 5, clearly displaying the impact of the alternate fuels on this particular GCFR representation.

As indicated, the overall breeding performance of the alternative fuels is reduced relative to the reference fuel (case 1A). Correspondingly, the compound fissile doubling time,¹ which is inversely related to the breeding gain and growth rate, increases significantly as more of the reference fissile and fertile materials are replaced (a negative doubling time implies net consumption of fissile material). Thus, the use of ^{233}U

Table 5. Equilibrium Cycle Results for Alternate Fuel Cycle 1200 MW(e) Homogeneous GCFRs

Case	Description					Mass Balance Data (kg/yr)						
	Core	Axial Blanket	Radial Blanket	% ^{233}U in U	MOEC ^a B.R.	Initial Fissile Loading (kg)	Fissile Charge	Discharge		Net Gain		CFDT ^b (yr)
								^{233}U	Pu	^{233}U	Pu	
1A	(Pu-U)O ₂	UO ₂	UO ₂	—	1.301	3169	1158	—	1395	—	237	12.7
2A	(Pu-U)O ₂	UO ₂	ThO ₂	—	1.276	3232	1184	269	1129	269	-55	14.3
3A	(Pu-Th)O ₂	ThO ₂	ThO ₂	—	1.150	3804	1389	752	743	752	-646	34.0
4A	(^{233}U -U)O ₂	UO ₂	ThO ₂	17.5	1.088	3046	1201	805	480	-396	480	35.0
5A	(^{233}U -U)O ₂	ThO ₂	ThO ₂	17.7	1.074	3104	1223	987	307	-236	307	42.2
6A	(^{233}U -U-Th)O ₂	ThO ₂	ThO ₂	20.0	1.060	3264	1237	1045	250	-192	250	53.8
7A	(^{233}U -U-Th)O ₂	ThO ₂	ThO ₂	40.0	1.004	3547	1357	1265	97	-92	97	680.
8A	(^{233}U -Th)O ₂	ThO ₂	ThO ₂	100.0	0.970	3730	1430	1403	—	-27	—	-132.

^aMiddle of equilibrium cycle breeding ratio.

^bCompound fissile doubling time assuming no reprocessing losses. Negative doubling time implies net consumption of fissile material.

as the fissile material and/or the use of ^{232}Th as the fertile material in an oxide-fueled homogeneous GCFR incurs a significant breeding ratio and doubling time penalty relative to Pu and ^{238}U . However, this is not surprising since, as detailed in Ref. 1, these penalties are similar to those observed for alternate-fueled LMFBRs and, in general, can be traced to basic differences in the neutronic behavior of the various fissile/fertile isotopes. Thus, although design improvements can potentially improve the alternative fuel performance, it is unlikely that the breeding performance can exceed that of an analogous $(\text{Pu-U})\text{O}_2/\text{UO}_2$ system.

Another important characteristic of the individual reactors within the context of a symbiotic system is their degree of self-sufficiency, especially true for the denatured cores (cases 4A - 7A). As mentioned previously, it is assumed that the makeup denatured ^{233}U feed necessary to balance the input feed requirements of the dispersed (denatured) reactors can be supplied by secure energy center transmuters (see Fig. 1). However, the larger the fraction of fissile discharge of the dispersed reactors that is attributable to ^{233}U production the less dependent they will be on feed from the transmuters. This degree of self-sufficiency essentially defines the number of dispersed reactors that can be supported per energy center transmuter.

For symbiotic systems in general, two characteristic parameters are of key interest:¹ the system growth potential (compound system doubling time - CSDT) and the asymptotic support ratio (equilibrium number of dispersed reactors supported per transmuter - P_∞). The CSDT is related to the total breeding performance of the individual reactors within the system as well as the ratio of the number of dispersed reactors supported per transmuter. Thus from the above arguments it is apparent that the asymptotic support ratio and compound system doubling time are functions of the degree of self-sufficiency of the individual reactors.

The self-sufficiency of several homogeneous denatured GCFRs is illustrated in Fig. 3, where the two components (^{233}U and Pu) of the breeding ratio are displayed. As indicated, the ^{233}U component of the breeding ratio increases as the allowable degree of denaturing is increased, thereby permitting more ^{232}Th in the fuel material. Thus, even

Fig. 3. Breeding Ratio Components of Denatured Homogeneous GCFRs.

though the overall breeding ratio decreases as the allowable enrichment (and hence the ^{232}Th content) is raised, the decrease in the required ^{233}U makeup is quite significant and thus presents a strong incentive to set the allowable enrichment as high as practicable. It also should be noted that cases 4A and 5A (differing only in the composition of the axial blanket) represent the minimum average $^{233}\text{U}/\text{U}$ enrichment possible for the reactor model utilized. The average enrichment was approximately 17.7% with a maximum $^{233}\text{U}/\text{U}$ ratio of about 20% in core zone #4.

Since all the denatured systems require an initial inventory of ^{233}U as well as varying amounts of ^{233}U as makeup material, a ^{233}U producer must also be considered in evaluating the overall fuel cycle within the energy center/dispersed reactor scenario. The self-sufficiency versus ^{233}U production capability of the $(\text{Pu-U})\text{O}_2/\text{ThO}_2$, $(\text{Pu-Th})\text{O}_2/\text{ThO}_2$, and $(^{233}\text{U-Th})\text{O}_2/\text{ThO}_2$ energy center reactor options (cases 2A, 3A, and 8A respectively) are displayed in Fig. 4. From the standpoint of ^{233}U

Fig. 4. Net Fissile Production for Homogeneous GCFR ^{233}U Producers.

production the $(\text{Pu-Th})\text{O}_2/\text{ThO}_2$ homogeneous GCFR is clearly superior. However, it does require a significant quantity of fissile plutonium as makeup feed since it essentially transmutes plutonium to ^{233}U . The $(\text{Pu-U})\text{O}_2/\text{ThO}_2$ GCFR, on the other hand, generates significantly less ^{233}U , but also markedly reduces the required plutonium feed. (Case 8A has been included only for completeness.)

The trade-off in plutonium or ^{233}U production (and in breeding performance) becomes more apparent when considering a coupled symbiotic system of ^{233}U consumers/Pu producers and Pu consumers/ ^{233}U producers. Table 6 displays the asymptotic support ratio (P_∞), compound system doubling time (CSDT), and system growth rate for various energy center and dispersed reactor combinations. In addition, the corresponding parameters for the reference fuel are listed for comparison. This latter case assumes that no restrictions on reactor location are appropriate, yielding an infinite support ratio.

Table 6. Equilibrium Symbiotic Parameters for Oxide-Fueled Homogeneous GCFRs

Energy Center GCFR	Dispersed Denatured GCFR	Asymptotic Support Ratio	CSDT ^a (yr)	Energy Growth Rate (%)
(Pu-U)O ₂ /ThO ₂ (case 2A)	case 4A	0.48	21.3	3.3
	5A	0.69	24.2	2.9
	6A	0.80	26.9	2.6
	7A	1.46	53.5	1.3
(Pu-Th)O ₂ /ThO ₂ (case 3A)	case 4A	1.57	50.3	1.4
	5A	2.41	60.1	1.2
	6A	2.91	77.8	0.9
	7A	6.89	348.	—
—	(Pu-U)O ₂ /UO ₂ (case 1A)	∞	14.4	4.8

^aCompound system doubling time assuming 2% reprocessing losses and 1 year out-of-reactor time.

From a strict nonproliferation viewpoint, minimizing the number of high-risk energy center reactors (maximizing P_{∞}) would be the goal. However, as indicated in Table 6, maximizing the support ratio also implies a large increase in the system doubling times. Such a trade-off exists due to the dominance of different types of reactors in the various symbiotic systems. At low support ratios, the dominant reactors are the transmuters, which are inherently higher breeding performance machines. Thus, these symbiotic systems have relatively low doubling times and high growth rates. On the other hand, at the higher support ratios the lower performance denatured systems become the dominant influence, markedly

increasing the system doubling time and decreasing the system growth rate. (Case 3A coupled with case 7A produces the largest support ratio, but the system is not self-sufficient.)

Finally, it must be emphasized that the above results are for non-optimized, oxide-fueled homogeneous GCFRs. Three possible areas of investigation that may result in improvements to both the support ratio and system doubling time of the homogeneous GCFR models utilized in the above study are (1) optimization of the homogeneous design, (2) utilization of carbide or metallic fuels, and (3) use of advanced heterogeneous designs. A preliminary investigation of the third alternative, the heterogeneous GCFR configuration, is reported in the next section.

III. ALTERNATE-FUELED HETEROGENEOUS GCFRs

A preliminary investigation of the merits of the heterogeneous GCFR core concept was performed in an attempt to improve upon the characteristics of the reference and alternate-fueled homogeneous GCFR models. The motivation for this study stemmed from the excellent results obtained in a similar comparison of the breeding performance of several homogeneous and heterogeneous LMFBR configurations.⁹ The use of intra-core fertile blanket assemblies in the heterogeneous LMFBR cores significantly increased the equilibrium breeding ratios with a subsequent reduction in the fissile doubling times. Thus, based on this experience a similar study was initiated for the GCFR concept.

The reference reactor utilized for the heterogeneous GCFR evaluation was identical to that used in the homogeneous reactor analyses. A heterogeneous design with 60° symmetry was constructed from the same fuel and blanket assemblies as those used in the homogeneous reference case.³ After some iteration (primarily concerned with the peak linear power and the radial power profile), a tentative core design of four fissile rings, separated from one another by single rows of fertile blanket assemblies, was adopted. As in the reference design, a three-row radial blanket encompassed the core regions. Reactivity adjustments were possible with twenty-four control rods and six safety rods located symmetrically throughout the core.

The final hexagonal configuration of this heterogeneous GCFR model is depicted in Fig. 5. An R-Z calculational model, required for the fuel burnup calculations, was then derived from the hexagonal model by conserving the areas of the various regions. The resultant R-Z configuration is given in Fig. 6.

Of particular concern in this modeling procedure was the treatment of the control material. Therefore, early in the study an effort was made to verify that the R-Z concentric annuli reactor model (to be used in all subsequent fuel cycle calculations) did indeed represent a realistic simplification of the three-dimensional (3-D) fast reactor. The position and reactivity worth of the control rods in the R-Z model were of particular interest. Thus, static beginning-of-life (BOL) three-dimensional hexagonal-Z calculations were performed for both a rodged and unrodged control configuration for one specific heterogeneous design. Table 7 contrasts the results of these 3-D static BOL computations with analogous R-Z representations for a 1200 MW(e) GCFR with (Pu-U) O_2 driver assemblies and ThO_2 radial and internal blankets (case 2B).

In the unrodged cases, a fissile enrichment search was performed for a BOL K_{eff} of 1.010. As indicated in Table 7, the required fissile enrichments to meet this criteria for the 2-D and 3-D cases were in good agreement. Additionally, the maximum power densities (linear heat rates), the instantaneous breeding ratios (BOR), and the radial power profiles for the two cases also compared quite well. The shutdown cases (safety rods still out) showed similar good agreement, with a difference in the shutdown reactivity level of only -0.07% $\Delta K/K$ relative to the 3-D calculation. This comparison indicates that the simplified R-Z calculational model produces accurate results with a significantly reduced cost and effort. Thus, the heterogeneous R-Z geometry displayed in Fig. 6 was judged to be adequately representative for use in the subsequent burnup analyses.

Fuel cycle calculations similar to those performed for the homogeneous models were then completed for each of the heterogeneous fissile/fertile combinations listed in Table 3. For these computations a fuel management scheme was utilized in which one-third of each fissile region,

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Fig. 5. Hexagonal Configuration of Heterogeneous GCFR Model.

Fig. 6. R-Z Configuration of 1200 MW(e) Heterogeneous GCFR.

Table 7. Comparison of 2-D and 3-D Computational Models for a (Pu-U) O_2 /Th O_2 Heterogeneous GCFR

Beginning of Life Parameters	2-D (RZ) Model	3-D (Hex-Z) Model
K_{eff} (Control in)	0.9646	0.9653
K_{eff} (Control out)	1.0100	1.0100
Max. Power Density (W/cc)	419.0	421.6
Max. Linear Heat Rate (kW/m)	38.7	39.0
Fissile Enrichment	0.283	0.286
Total Breeding Ratio	1.527	1.521
^{233}U Component	1.122	1.121
Fissile Pu Component	0.405	0.400

one-half of each internal fertile row, and one-sixth of the radial blanket assemblies were replaced annually. A capacity factor of 0.75 was assumed. The two-year residence time of the internal blankets was mandated by the peak linear heat rate requirement. The high linear heat rate was due mainly to the relatively large diameter pins within the blanket assemblies coupled with the increased fissile production rate associated with the intra-core blankets relative to the radial blanket regions.

The detailed thirty-year mass flow data generated from the seven heterogeneous GCFR configurations are included in Appendix B. In addition, a summary of the major performance parameters for the alternate-fueled heterogeneous GCFRs is presented in Table 8 (see Table 5 for a summary of the homogeneous GCFR evaluation).

Upon substitution of the ^{233}U and ^{232}Th alternate fuels for Pu and ^{238}U , trends similar to those observed for the homogeneous systems also become apparent for the heterogeneous cases. These results lend confirmation to the thesis that the breeding ratio and doubling time penalties

Table 8. Equilibrium Cycle Results for Alternate Fuel Cycle 1200 MW(e) Heterogeneous GCFRs

Case	Description					Initial Fissile Loading (kg)	Mass Balances (kg/yr)						CFDT ^b (yr)
	Driver	Axial Blanket	Inner & Radial Blankets	% ²³³ U in U	MOEC ^a B.R.		Fissile Charge	Discharge		Net Gain			
								²³³ U	Pu	²³³ U	Pu		
1B	(Pu-U)O ₂	UO ₂	UC ₂	—	1.530	5163	1721	—	2139	—	418	11.4	
2B	(Pu-U)O ₂	UO ₂	ThO ₂	—	1.456	5647	1882	797	1450	797	-432	14.3	
3B	(Pu-Th)O ₂	ThO ₂	ThO ₂	—	1.371	6110	2037	1025	1309	1025	-728	19.0	
4B	(²³³ U-U)O ₂	UO ₂	ThO ₂	29.2	1.246	5510	1837	1816	244	-21	244	22.8	
5B	(²³³ U-U)O ₂	ThO ₂	ThO ₂	29.2	1.241	5510	1837	1889	165	52	165	23.5	
7B	(²³³ U-U-Th)O ₂	ThO ₂	ThO ₂	40.0	1.218	5665	1889	1984	104	95	104	26.3	
8B	(²³³ U-Th)O ₂	ThO ₂	ThO ₂	100.0	1.168	6017	2006	2162	—	156	—	35.6	

^aMiddle of equilibrium cycle breeding ratio.

^bCompound fissile doubling time assuming no reprocessing losses.

associated with the use of the alternate fuels are relatively independent of reactor configurations. However, in the present comparison the absolute performance (in terms of breeding ratio and doubling time) of the heterogeneous designs is superior to that of the analogous homogeneous configurations.

The greatest reduction in doubling times relative to the homogeneous cases is observed for the ^{233}U -fueled heterogeneous reactors. This is due to the fact that the homogeneous cases were only marginal breeders at best, with breeding gains ($\text{BR} - 1$) typically less than 0.1. However, the breeding gains associated with the heterogeneous ^{233}U -fueled reactors are between 0.17 and 0.25, thus resulting in substantial decreases in fissile doubling time.

It is also significant to note that the ^{233}U -fueled reactors were proposed as candidates for the proliferation-resistant denatured reactor group [except for the $(^{233}\text{U}-\text{Th})\text{O}_2/\text{ThO}_2$ reactor, which is considered for completeness only]. Reactors in this category are likely to be restricted in the allowable $^{233}\text{U}/\text{U}$ enrichment (with a maximum upper bound of around 20%). However, as indicated in Table 8, the minimum denaturing (cases 4B and 5B) for the present heterogeneous model is approximately 29% $^{233}\text{U}/\text{U}$. Such a ^{233}U concentration in the fresh fuel would essentially eliminate this GCFR concept from the proliferation-resistant dispersed reactor role. Thus, further investigation into the detailed performance characteristics of the denatured heterogeneous GCFRs is not warranted. On the other hand, the large breeding ratio and ^{233}U production capability of cases 1B-3B make the Pu-fueled heterogeneous GCFRs very attractive candidates as energy center reactors. The next section discusses more fully the characteristics of the reactors in this latter category relative to their homogeneous counterparts.

IV. COMPARISON OF Pu-FUELED HETEROGENEOUS AND HOMOGENEOUS GCFRs

As pointed out in the previous section, the Pu-fueled heterogeneous GCFRs have very attractive breeding characteristics. This is emphasized even further in Table 9, which contrasts the major performance parameters of the Pu-fueled heterogeneous and homogeneous GCFR systems. As indicated,

Table 9. Comparison of Pu-Fueled Homogeneous and Heterogeneous GCFR Core Configurations

<u>Reactor</u>	<u>Model</u>	<u>Average Enrichment</u>	<u>Initial Loading (kg)</u>	<u>MOEC B.R.</u>	<u>Fissile Charge (kg)</u>	<u>Net Fissile Gain (kg)</u>	<u>Fissile Doubling Time (yrs)</u>
(Pu-U) O_2/UO_2	Homo (1A)	0.145	3169	1.30	1158	237	12.7
	Het (1B)	0.267	5163	1.53	1721	418	11.4
(Pu-U) O_2/ThO_2	Homo (2A)	0.147	3232	1.28	1184	214	14.3
	Het (2B)	0.292	5647	1.46	1882	365	14.3
(Pu-Th) O_2/ThO_2	Homo (3A)	0.181	3804	1.15	1389	106	34.0
	Het (3B)	0.329	6110	1.37	2037	297	19.0

substantial increases in the middle-of-equilibrium-cycle (MOEC) breeding ratios are observed for all three heterogeneous cases. This benefit is somewhat offset by the larger fissile Pu feed requirements of the advanced heterogeneous concept. However, the fissile doubling time (given in the last column of Table 9) shows a general decrease relative to the homogeneous concept, indicating that the increased breeding ratio of the Pu-fueled heterogeneous GCFRs more than compensates for their increased fissile feed requirements.

As mentioned previously in conjunction with the homogeneous GCFR study, the self-sufficiency and ^{233}U production capability of the individual energy center reactors are also of considerable importance. Figure 7 compares these characteristics for the heterogeneous and homogeneous Pu-fueled GCFRs investigated in this study. The reference heterogeneous $(\text{Pu-U})\text{O}_2/\text{UO}_2$ model produces no ^{233}U , but it has a net fissile Pu production capability 1.76 times that of the comparable homogeneous design. However, the $(\text{Pu-U})\text{O}_2/\text{ThO}_2$ and $(\text{Pu-Th})\text{O}_2/\text{ThO}_2$ configurations do produce substantial amounts of ^{233}U , with the heterogeneous concepts having a higher production capacity relative to the analogous homogeneous systems. Correspondingly, these heterogeneous models also require considerable more fissile Pu feed than do the classical designs. Thus once again a trade-off exists between the ^{233}U production and fissile Pu destruction properties of the various designs.

This trade-off is illustrated in Table 10, which presents data on the important symbiotic system parameters for homogeneous and heterogeneous GCFR transmuters coupled to 20% denatured fast breeder reactors. In all cases the heterogeneous systems will support the larger asymptotic support ratio. However, if growth rate is the main criteria, the $(\text{Pu-U})\text{O}_2/\text{ThO}_2$ homogeneous transmuter coupled with the denatured systems allows a slightly larger growth rate than that of the corresponding heterogeneous system. This is due to the large Pu destruction rate of the $(\text{Pu-U})\text{O}_2/\text{ThO}_2$ heterogeneous system relative to the homogeneous system [net fissile gain is -361 kg/GW(e)-yr for the heterogeneous design and only -46 kg/GW(e)-yr for the homogeneous concept]. Thus the self-sufficiency of the ^{233}U producers within the energy center does impact the overall system

Fig. 7. Fissile Production Components of Pu-Fueled Homogeneous and Heterogeneous GCFRs.

performance. Also, it should be noted that the possibility of using a mixed-blanket (UO_2 and ThO_2 assemblies) heterogeneous GCFR represents a means of adjusting the net production rates of ^{233}U and Pu to optimize the overall system performance.

If, alternatively, an adequate supply of fissile Pu is assumed [obtained from light water reactor spent fuel or $(\text{Pu-U})\text{O}_2/\text{UO}_2$ breeders], the Pu-fueled transmuters can be utilized primarily as ^{233}U producers. In this case the higher ^{233}U production capability of the heterogeneous design clearly makes this concept the superior of the two. This point is illustrated in Table 11, where the outside/inside support ratio is tabulated for two homogeneous and heterogeneous GCFR transmuters coupled to typical denatured PWR and HTGR systems.¹⁰ As seen in Table 11, the heterogeneous ^{233}U producers would support by far the greater number of dispersed reactors.

Table 10. Symbiotic Parameters for Various GCFR Transmuters with Dispersed FBRs

Energy Center GCFR	Dispersed 20% Denatured FBR	Asymptotic Support Ratio	CSDT ^a (yrs)	Energy Growth Rate Supported (%)
(Pu-U)O ₂ /ThO ₂	LMFBR			
Homo (2A)		0.90	22.4	3.1
Het (2B)		2.79	25.4	2.7
(Pu-U)O ₂ /ThO ₂	LMFBR			
Homo (3A)		3.10	44.5	1.6
Het (3B)		3.88	32.3	2.1
Pu-UO ₂ /ThO ₂	GCFR			
Homo (2A)		0.79	26.2	2.6
Het (2B)		2.54	32.8	2.1
Pu-ThO ₂ /ThO ₂	GCFR			
Homo (3A)		2.90	75.3	0.9
Het (3B)		3.58	46.1	1.5

	Pu-UO ₂ /UO ₂ GCFR			
	Homo	∞	14.4	4.8
	Het	∞	12.7	5.5

^aCompound system doubling time assuming 2% reprocessing losses and 1 year out-of-reactor time.

Table 11. Comparison of Maximum Outside/Inside Support Ratios
for Various GCFR Transmuters^a

Energy Center Reactor	Dispersed Denatured Reactor (²³³ U Requirements)	Outside/Inside Support Ratio
(Pu-U)O ₂ /ThO ₂	PWR	
Homo (2A)		0.74
Het (2B)	[304 kg/GW(e)-yr]	2.13
(Pu-Th)O ₂ /ThO ₂	PWR	
Homo (3A)		2.06
Het (3B)	[304 kg/GW(e)-yr]	2.81
Pu-UO ₂ /ThO ₂	HTGR	
Homo (2A)		0.91
Het (2B)	[246 kg/GW(e)-yr]	2.63
Pu-ThO ₂ /ThO ₂	HTGR	
Homo (3A)		2.54
Het (3B)	[246 kg/GW(e)-yr]	3.47

^aExternal Pu source required.

In comparing the heterogeneous and homogeneous reactor concepts only the overall fissile production characteristics have been discussed. These characteristics generally indicate that the heterogeneous design is superior to comparable homogeneous models. However, more complete analyses (including thermal-hydraulic and safety-related studies) are needed before final comparisons and selection of a best design can be made.

Figures 8 and 9 illustrate one obvious difference in the two designs that has not been treated explicitly in the foregoing evaluation. These figures display the radial power profiles typical of each design. As indicated, the heterogeneous system's power distribution is radically different from the classical design. The large power gradients between fissile and fertile assemblies as well as the large power variation over a cycle within the intra-core blankets pose some interesting thermal-hydraulic and safety-related questions. However, analysis of the potential problems associated with this particular difference (as well as other differences) between the heterogeneous and homogeneous designs was beyond the scope of the preliminary alternate GCFR fuel cycle evaluation presented here.

V. SUMMARY AND CONCLUSIONS

Although the results given in this study must be regarded as preliminary evaluations, certain generic effects and trends concerning the alternative fuel cycles and heterogeneous/homogeneous GCFR comparisons are apparent.

- (a) The use of ^{233}U as the fissile material and/or the use of ^{232}Th as the fertile material in oxide-fueled GCFRs (regardless of configuration) incurs a significant breeding ratio penalty relative to $\text{Pu}/^{238}\text{U}$. This penalty can be traced to basic differences in the neutronic behavior of the various isotopes. Hence, although design improvements can potentially improve the alternative fuel performance, it is unlikely that the breeding performance can exceed that of an analogous $(\text{Pu-U})\text{O}_2/\text{UO}_2$ system.

Fig. 8. Radial Power Profile of 1200 MW(e) Homogeneous $(\text{Pu-U})\text{O}_2/\text{ThO}_2$ GCFR.

Fig. 9. Radial Power Profile of 1200 MW(e) Heterogeneous $(\text{Pu-U})\text{O}_2/\text{ThO}_2$ GCFR.

- (b) The relatively high minimum $^{233}\text{U}/\text{U}$ enrichments associated with both the homogeneous and heterogeneous denatured GCFRs (approximately 20% and 29% respectively) tend to eliminate these designs as possible candidates for the proliferation-resistant dispersed breeder reactors. (The homogeneous model's minimum enrichment may just fall below the maximum allowable denaturing percentage.)
- (c) In considering symbiotic systems of reactors, a trade-off in the ^{233}U production and fissile Pu destruction properties for the transmuters (and the ^{233}U destruction and fissile Pu production characteristics for the denatured reactors) has been shown to be an important consideration in the analysis of system performance. In general, a trade-off in the asymptotic support ratio and system doubling time (or growth rate) was also observed.
- (d) The comparison of the heterogeneous and homogeneous models utilized in this study indicated that the breeding performance and doubling time of a particular heterogeneous GCFR was superior to the analogous classical model. In addition, it was found that the better individual performance of the Pu-fueled heterogeneous GCFRs typically resulted in better system performance (higher support ratio and growth rate) when they were coupled to the same denatured ^{233}U consumer/fissile Pu producer. However, as a final note, it should be emphasized that the use of optimized designs coupled with more detailed analyses than those performed in this study may modify these conclusions for more specific heterogeneous/homogeneous GCFR comparisons.

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APPENDIX A

Thirty-Year Mass Flow Data for Several Alternate-Fueled 1200 MW(e) Homogeneous GCFRs

Table A-1. Initial Core Loadings for Homogeneous GCFRs Utilizing Alternate Oxide Fuels (kg)

Case	Region	²³² Th	²³³ U	²³⁵ U	²³⁸ U	²³⁹ Pu	²⁴⁰ Pu	²⁴¹ Pu	²⁴² Pu	Fissile Pu	Total HM
1A	Core			36.2	17791.4	2754.4	786.5	414.7	139.6	3169.1	21922.8
	Ax1 Blkt			39.5	19397.4						19436.8
	Rad Blkt			88.2	43382.9						43471.2
	Total			163.9	80571.8	2754.4	786.5	414.7	139.6	3169.1	84830.7
2A	Core			36.0	17710.4	2808.5	802.0	422.8	142.3	3231.3	21922.1
	Ax1 Blkt			39.5	19397.4						19436.8
	Rad Blkt	41299.3									41299.3
	Total	41299.3		75.5	37107.8	2808.5	802.0	422.8	142.3	3231.3	82658.2
3A	Core	16048.8				3306.0	944.0	497.7	167.5	3803.7	20964.0
	Ax1 Blkt	18471.0									18471.0
	Rad Blkt	41299.3									41299.3
	Total	75819.1				3306.0	944.0	497.7	167.5	3803.7	80734.2
4A	Core		3046.0	38.1	18747.1						21831.3
	Ax1 Blkt			39.5	19397.4						19436.8
	Rad Blkt	41299.3									41299.3
	Total	41299.3	3046.0	77.6	38144.5						82567.4
5A	Core		3704.9	38.0	18687.7						21830.6
	Ax1 Blkt	18471.0									18471.0
	Rad Blkt	41299.3									41299.3
	Total	59770.3	3704.9	38.0	18687.7						81600.9
6A	Core	4868.1	3264.3	27.1	13312.6						21472.0
	Ax1 Blkt	18471.0									18471.0
	Rad Blkt	41299.3									41299.3
	Total	64638.4	3264.3	27.1	13312.6						81242.3
7A	Core	12136.8	3546.6	11.0	5421.4						21115.9
	Ax1 Blkt	18471.0									18471.0
	Rad Blkt	41299.3									41299.3
	Total	71907.1	3546.6	11.0	5421.4						80886.1
8A	Core	17095.6	3730.1								20825.7
	Ax1 Blkt	18471.0									18471.0
	Rad Blkt	41299.3									41299.3
	Total	76865.9	3730.1								80596.0

Table A-2. Equilibrium Cycle Reloadings for Homogeneous GCFRs Utilizing Alternate Oxide Fuels (kg)

Case	Region	²³² Th	²³³ U	²³⁵ U	²³⁸ U	²³⁹ Pu	²⁴⁰ Pu	²⁴¹ Pu	²⁴² Pu	Fissile Pu	Total HM
1A	Core			11.8	5799.8	1006.6	287.4	151.5	51.0	1158.1	7308.2
	Ax1 B1kt			13.2	6465.8						6478.9
	Rad B1kt			14.7	7230.5						7245.2
	Total			39.7	19496.1	1006.6	287.4	151.5	51.0	1158.1	21032.3
2A	Core			11.7	5766.6	1029.1	293.8	154.9	52.1	1184.1	7308.4
	Ax1 B1kt			13.2	6465.8						6478.9
	Rad B1kt	6883.2									6883.2
	Total	6883.2		24.9	12232.4	1029.1	293.8	154.9	52.1	1184.1	20670.6
3A	Core	5197.9				1207.3	344.7	181.8	61.2	1389.1	6992.9
	Ax1 B1kt	6157.0									6157.0
	Rad B1kt	6883.2									6883.2
	Total	18238.1				1207.3	344.7	181.8	61.2	1389.1	20033.2
4A	Core		1200.6	12.6	6060.4						7273.3
	Ax1 B1kt			13.2	6465.8						6478.9
	Rad B1kt	6883.2									6883.2
	Total	6883.2	1200.6	25.5	12526.2						20635.5
5A	Core		1223.3	12.3	6037.2						7272.0
	Ax1 B1kt	6157.0									6157.0
	Rad B1kt	6883.2									6883.2
	Total	13040.2	1223.3	12.3	6037.2						20313.1
6A	Core	883.1	1236.8	10.3	5042.8						7173.0
	Ax1 B1kt	6157.0									6157.0
	Rad B1kt	6883.2									6883.2
	Total	13923.4	1236.8	10.3	5042.8						20213.2
7A	Core	3611.6	1356.6	4.2	2073.9						7046.4
	Ax1 B1kt	6157.0									6157.0
	Rad B1kt	6883.2									6883.2
	Total	16651.8	1356.6	4.2	2073.9						20086.6
8A	Core	5512.3	1430.4								6942.7
	Ax1 B1kt	6157.0									6157.0
	Rad B1kt	6883.2									6883.2
	Total	18552.5	1430.4								19982.9

Table A-3. Discharge Data for a 1200 MW(e) Homogeneous GCFR
with (Pu-U)O₂ Core, UO₂ Axial and Radial Blankets
(Case 1A)

Discharge Data (kg)

Reactor Core											
YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	0.0	0.0	9.5	5841.0	817.6	252.7	100.4	43.5	918.0	7064.7
2	0.7500	0.0	0.0	7.2	5484.9	854.2	296.3	92.5	49.1	946.7	6784.2
3	0.7500	0.0	0.0	5.5	5247.7	827.4	314.9	81.0	50.2	908.4	6526.7
4	0.7500	0.0	0.0	5.4	5205.6	839.0	323.6	83.2	51.8	922.2	6508.6
5	0.7500	0.0	0.0	5.5	5213.2	840.2	323.1	83.5	51.8	923.7	6517.3
6	0.7500	0.0	0.0	5.5	5218.9	841.0	322.7	83.7	51.8	924.7	6523.7
7	0.7500	0.0	0.0	5.6	5221.4	841.4	322.5	83.8	51.8	925.2	6526.5
8	0.7500	0.0	0.0	5.6	5222.4	841.6	322.5	83.9	51.8	925.4	6527.7
9	0.7500	0.0	0.0	5.6	5222.7	841.6	322.5	83.9	51.8	925.5	6528.0
10	0.7500	0.0	0.0	5.6	5222.8	841.6	322.5	83.9	51.8	925.5	6528.1
11	0.7500	0.0	0.0	5.6	5222.8	841.6	322.5	83.9	51.8	925.5	6528.1
12	0.7500	0.0	0.0	5.6	5222.8	841.6	322.5	83.9	51.8	925.5	6528.1
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	0.0	0.0	21.0	16231.7	2677.0	939.1	303.5	156.5	2980.4	20329.6

Axial Blanket

YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	0.0	0.0	11.9	6388.7	69.4	0.8	0.0	0.0	69.4	6470.8
2	0.7500	0.0	0.0	10.8	6307.9	135.3	3.3	0.1	0.0	135.3	6457.3
3	0.7500	0.0	0.0	9.8	6228.2	194.1	7.2	0.2	0.0	194.3	6439.4
4	0.7500	0.0	0.0	9.7	6225.0	196.0	7.3	0.2	0.0	196.2	6438.1
5	0.7500	0.0	0.0	9.8	6226.9	194.5	7.1	0.2	0.0	194.7	6438.5
6	0.7500	0.0	0.0	9.8	6229.1	193.0	7.0	0.2	0.0	193.2	6439.0
7	0.7500	0.0	0.0	9.8	6230.1	192.4	6.9	0.2	0.0	192.5	6439.3
8	0.7500	0.0	0.0	9.8	6230.5	192.1	6.9	0.2	0.0	192.2	6439.4
9	0.7500	0.0	0.0	9.8	6230.6	192.0	6.9	0.2	0.0	192.2	6439.4
10	0.7500	0.0	0.0	9.8	6230.6	192.0	6.9	0.2	0.0	192.1	6439.4
11	0.7500	0.0	0.0	9.8	6230.7	191.9	6.9	0.2	0.0	192.1	6439.5
12	0.7500	0.0	0.0	9.8	6230.7	191.9	6.9	0.2	0.0	192.1	6439.5
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	0.0	0.0	32.8	18925.1	397.3	10.8	0.2	0.0	307.6	19366.1

Radial Blanket

YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	0.0	0.0	13.7	7176.3	49.7	0.5	0.0	0.0	49.7	7240.3
2	0.7500	0.0	0.0	12.8	7117.9	99.7	1.9	0.0	0.0	99.7	7232.4
3	0.7500	0.0	0.0	11.9	7059.1	146.5	4.2	0.1	0.0	146.7	7221.9
4	0.7500	0.0	0.0	11.0	6999.9	190.5	7.3	0.3	0.0	190.8	7209.1
5	0.7500	0.0	0.0	10.3	6940.5	231.6	11.1	0.5	0.0	232.1	7194.0
6	0.7500	0.0	0.0	9.5	6881.4	269.7	15.4	0.8	0.0	270.5	7176.9
7	0.7500	0.0	0.0	9.5	6874.2	273.9	15.8	0.8	0.0	274.7	7174.2
8	0.7500	0.0	0.0	9.5	6871.5	275.3	15.9	0.8	0.0	276.2	7173.0
9	0.7500	0.0	0.0	9.5	6869.6	276.3	16.0	0.8	0.0	277.2	7172.2
10	0.7500	0.0	0.0	9.5	6868.7	276.8	16.0	0.9	0.0	277.6	7171.6
11	0.7500	0.0	0.0	9.5	6868.3	277.0	16.1	0.9	0.0	277.6	7171.6
12	0.7500	0.0	0.0	9.5	6868.2	277.0	16.1	0.9	0.0	277.9	7171.6
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	0.0	0.0	68.7	42105.7	1033.2	42.4	1.8	0.0	1035.1	43251.9

Entire Reactor

YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	0.0	0.0	35.2	19406.0	936.7	254.0	100.5	43.5	1037.1	20775.8
2	0.7500	0.0	0.0	30.7	18910.7	1089.1	301.6	92.6	49.1	1181.7	20473.8
3	0.7500	0.0	0.0	27.1	18535.0	1169.1	326.3	81.3	50.2	1249.4	20188.0
4	0.7500	0.0	0.0	26.2	18430.4	1225.6	338.1	83.6	51.8	1309.2	20155.8
5	0.7500	0.0	0.0	25.5	18380.6	1266.3	341.3	84.2	51.8	1350.5	20149.8
6	0.7500	0.0	0.0	24.9	18329.4	1303.7	345.1	84.7	51.8	1388.4	20139.6
7	0.7500	0.0	0.0	24.8	18325.7	1307.6	345.3	84.8	51.8	1392.4	20140.0
8	0.7500	0.0	0.0	24.8	18324.4	1309.0	345.3	84.9	51.8	1393.8	20140.1
9	0.7500	0.0	0.0	24.8	18322.9	1309.9	345.3	84.9	51.8	1394.8	20139.6
10	0.7500	0.0	0.0	24.8	18322.1	1310.4	345.4	84.9	51.8	1395.3	20139.3
11	0.7500	0.0	0.0	24.8	18321.7	1310.6	345.4	84.9	51.8	1395.4	20139.2
12	0.7500	0.0	0.0	24.8	18321.7	1310.6	345.4	84.9	51.8	1395.5	20139.2
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	0.0	0.0	123.1	77262.5	4107.5	992.4	305.5	155.6	4413.0	82947.4

Table A-4. Discharge Data for a 1200 MW(e) Homogeneous GCFR
with (Pu-U)₂O₃ Core, UO₂ Axial Blankets,
and ThO₂ Radial Blankets (Case 2A)

Discharge Data (kg)

Reactor Core											
YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	0.0	0.0	9.5	5829.5	820.3	253.8	100.5	43.7	920.8	7057.3
2	0.7500	0.0	0.0	7.1	5448.7	866.0	302.4	94.4	50.2	960.4	6768.7
3	0.7500	0.0	0.0	5.4	5205.3	838.5	322.0	83.2	51.5	921.7	6505.9
4	0.7500	0.0	0.0	5.4	5175.7	849.0	328.8	85.2	52.8	934.2	6497.0
5	0.7500	0.0	0.0	5.5	5184.0	850.5	328.4	85.6	52.8	936.1	6506.8
6	0.7500	0.0	0.0	5.5	5190.3	851.5	327.9	85.8	52.9	937.3	6514.0
7	0.7500	0.0	0.0	5.6	5192.2	852.0	327.8	85.9	52.9	937.9	6517.4
8	0.7500	0.0	0.0	5.6	5194.4	852.2	327.7	86.0	52.9	938.2	6518.7
9	0.7500	0.0	0.0	5.6	5194.7	852.3	327.7	86.0	52.9	938.3	6519.1
10	0.7500	0.0	0.0	5.6	5194.9	852.3	327.7	86.0	52.9	938.3	6519.3
11	0.7500	0.0	0.0	5.6	5194.9	852.3	327.7	86.0	52.9	938.3	6519.3
12	0.7500	0.0	0.0	5.6	5194.9	852.3	327.7	86.0	52.9	938.3	6519.4
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	0.0	0.0	21.8	16142.6	2719.1	956.1	311.0	159.8	3030.1	20310.5

Axial Blanket

YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	0.0	0.0	11.9	6386.8	70.8	0.9	0.0	0.0	70.8	6470.6
2	0.7500	0.0	0.0	10.8	6306.0	135.4	3.4	0.1	0.0	136.4	6456.6
3	0.7500	0.0	0.0	9.8	6226.6	194.7	7.3	0.2	0.0	194.9	6438.5
4	0.7500	0.0	0.0	9.7	6225.3	195.2	7.3	0.2	0.0	195.4	6437.7
5	0.7500	0.0	0.0	9.8	6227.6	193.5	7.1	0.2	0.0	193.7	6438.2
6	0.7500	0.0	0.0	9.8	6230.0	191.9	7.0	0.2	0.0	192.0	6438.8
7	0.7500	0.0	0.0	9.8	6231.2	191.1	6.9	0.2	0.0	191.2	6439.1
8	0.7500	0.0	0.0	9.8	6231.7	190.7	6.9	0.2	0.0	190.9	6439.3
9	0.7500	0.0	0.0	9.8	6231.8	190.6	6.8	0.2	0.0	190.8	6439.3
10	0.7500	0.0	0.0	9.8	6231.9	190.6	6.8	0.2	0.0	190.7	6439.3
11	0.7500	0.0	0.0	9.8	6231.9	190.6	6.8	0.2	0.0	190.7	6439.3
12	0.7500	0.0	0.0	9.8	6232.0	190.6	6.8	0.2	0.0	190.7	6439.3
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	0.0	0.0	32.6	18927.7	394.5	10.9	0.2	0.0	394.7	19365.9

Radial Blanket

YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	6931.6	49.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6981.0
2	0.7500	6776.8	98.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6875.0
3	0.7500	6721.5	143.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6865.3
4	0.7500	6665.8	186.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6852.1
5	0.7500	6610.1	225.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6835.7
6	0.7500	6554.6	261.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6816.4
7	0.7500	6548.7	265.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6814.2
8	0.7500	6546.2	267.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6813.2
9	0.7500	6544.5	268.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6812.5
10	0.7500	6543.7	268.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6812.2
11	0.7500	6543.3	268.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6812.1
12	0.7500	6543.3	268.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6812.0
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	40101.0	1008.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41109.9

Entire Reactor

YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	6931.6	49.5	21.4	12216.3	891.2	254.7	100.5	43.7	991.7	20408.8
2	0.7500	6776.8	98.2	17.0	11754.7	1002.4	305.8	94.4	50.2	1096.8	20100.3
3	0.7500	6721.5	143.8	15.2	11431.8	1033.3	329.2	83.4	51.5	1116.6	19809.7
4	0.7500	6665.8	186.3	15.2	11401.0	1044.3	336.1	85.4	52.8	1129.6	19786.8
5	0.7500	6610.1	225.6	15.3	11411.6	1044.0	335.5	85.7	52.9	1129.8	19780.7
6	0.7500	6554.6	261.7	15.3	11420.3	1043.4	334.9	86.0	52.9	1129.4	19769.2
7	0.7500	6548.7	265.5	15.4	11424.4	1043.1	334.7	86.1	52.9	1129.2	19770.7
8	0.7500	6546.2	267.0	15.4	11426.1	1042.9	334.5	86.1	52.9	1129.1	19771.2
9	0.7500	6544.5	268.0	15.4	11426.6	1042.9	334.5	86.2	52.9	1129.1	19770.9
10	0.7500	6543.7	268.5	15.4	11426.8	1042.9	334.5	86.2	52.9	1129.1	19770.8
11	0.7500	6543.3	268.7	15.4	11426.8	1042.9	334.5	86.2	52.9	1129.0	19770.7
12	0.7500	6543.3	268.8	15.4	11426.9	1042.9	334.5	86.2	52.9	1129.1	19770.7
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	40101.0	1008.9	54.4	35070.3	3113.6	967.0	311.2	159.8	3424.8	80786.2

Table A-5. Discharge Data for a 1200 MW(e) Homogeneous GCFR
with (Pu-Th) O_2 Core, Th O_2 Axial and Radial Blankets
(Case 3A)

Discharge Data (kg)

Reactor Core

YFAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	5341.8	149.2	0.0	0.0	789.4	289.1	119.2	50.7	908.6	6739.5
2	0.7500	4973.5	245.8	0.0	0.0	724.1	331.6	111.8	57.9	835.8	6444.7
3	0.7500	4709.3	307.9	0.0	0.0	625.4	349.4	100.6	61.1	726.1	6153.7
4	0.7500	4704.9	306.4	0.0	0.0	629.7	350.7	100.9	61.3	730.5	6153.8
5	0.7500	4712.2	304.0	0.0	0.0	635.1	351.0	101.4	61.4	736.5	6165.0
6	0.7500	4716.6	302.5	0.0	0.0	638.3	351.1	101.7	61.4	740.0	6171.6
7	0.7500	4719.0	301.7	0.0	0.0	639.9	351.2	101.9	61.4	741.8	6175.0
8	0.7500	4719.9	301.4	0.0	0.0	640.6	351.2	101.9	61.4	742.5	6176.4
9	0.7500	4720.2	301.3	0.0	0.0	640.8	351.2	101.9	61.4	742.7	6176.8
10	0.7500	4720.3	301.2	0.0	0.0	640.9	351.2	101.9	61.4	742.8	6178.9
11	0.7500	4720.3	301.2	0.0	0.0	640.9	351.2	102.0	61.4	742.9	6177.0
12	0.7500	4720.4	301.2	0.0	0.0	640.9	351.2	102.0	61.4	742.9	6177.1
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	14628.1	573.8	0.0	0.0	2407.0	1061.8	769.6	186.0	2776.6	19323.2

Axial Blanket

[illegible]

Radial Blanket

[illegible]

Entire Reactor

CAPACITY										FISSILE	TOTAL
YEAR	FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	PU	MM
1	0.7500	18258.1	266.4	0.0	0.0	789.4	289.1	119.2	50.7	908.6	19773.0
2	0.7500	17759.6	474.8	0.0	0.0	724.1	331.6	111.8	57.9	835.8	19459.7
3	0.7500	17366.5	373.2	0.0	0.0	625.4	349.4	100.6	61.1	726.1	19140.3
4	0.7500	17305.5	678.9	0.0	0.0	629.7	350.7	100.9	61.3	730.5	19126.9
5	0.7500	17260.0	713.8	0.0	0.0	635.1	351.0	101.4	61.4	736.5	19122.7
6	0.7500	17211.4	746.9	0.0	0.0	638.3	351.1	101.7	61.4	740.0	19110.8
7	0.7500	17208.3	749.5	0.0	0.0	639.9	351.2	101.9	61.4	741.8	19112.2
8	0.7500	17207.4	750.3	0.0	0.0	640.6	351.2	101.9	61.4	742.5	19112.9
9	0.7500	17206.2	751.1	0.0	0.0	640.8	351.2	101.9	61.4	742.7	19112.6
10	0.7500	17205.5	751.5	0.0	0.0	640.9	351.2	101.9	61.4	742.8	19112.4
11	0.7500	17205.2	751.7	0.0	0.0	640.9	351.2	102.0	61.4	742.9	19112.4
12	0.7500	17205.2	751.7	0.0	0.0	640.9	351.2	102.0	61.4	742.9	19112.4
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	72772.4	2953.3	0.0	0.0	2407.0	1061.8	369.6	186.0	2776.6	78849.9

Table A-6. Discharge Data for a 1200 MW(e) Homogeneous GCFR
with $(^{233}\text{U-U})\text{O}_2$ Core, UO_2 Axial Blankets,
and ThO_2 Radial Blankets (Case 4A)

Discharge Data (kg)											
Reactor Core											
YEAR	CAPACITY FACTOR	TH232	U233	U235	U239	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	0.0	587.0	10.5	5286.1	153.4	3.2	0.0	0.0	150.4	7038.1
2	0.7500	0.0	616.7	9.7	5822.0	243.3	10.4	0.3	0.0	248.6	6705.1
3	0.7500	0.0	640.1	6.3	5513.8	323.0	15.9	0.7	0.0	320.8	6400.9
4	0.7500	0.0	645.0	6.4	5530.0	315.7	19.0	0.7	0.0	316.4	6417.7
5	0.7500	0.0	648.3	6.5	5535.7	313.9	18.7	0.7	0.0	314.6	6423.8
6	0.7500	0.0	651.5	6.5	5540.0	312.1	18.4	0.7	0.0	312.8	6429.2
7	0.7500	0.0	653.3	6.5	5542.4	311.1	18.2	0.6	0.0	311.8	6432.2
8	0.7500	0.0	654.1	6.5	5543.5	310.6	18.2	0.6	0.0	311.3	6433.6
9	0.7500	0.0	654.3	6.5	5544.0	310.4	18.1	0.6	0.0	311.0	6434.0
10	0.7500	0.0	654.3	6.5	5544.2	310.3	18.1	0.6	0.0	310.9	6434.2
11	0.7500	0.0	654.4	6.5	5544.4	310.2	18.1	0.6	0.0	310.8	6434.3
12	0.7500	0.0	654.4	6.5	5544.5	310.2	18.1	0.6	0.0	310.8	6434.4
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	0.0	2195.6	24.5	17136.8	672.4	29.5	0.9	0.0	673.3	20061.8
Axial Blanket											
YEAR	CAPACITY FACTOR	TH232	U233	U235	U239	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	0.0	0.0	12.0	5393.2	65.1	0.7	0.0	0.0	65.1	6471.1
2	0.7500	0.0	0.0	11.0	6323.2	122.5	2.7	0.0	0.0	122.5	6459.5
3	0.7500	0.0	0.0	10.1	6253.9	174.9	5.7	0.1	0.0	174.9	6444.6
4	0.7500	0.0	0.0	10.1	6256.3	172.8	5.5	0.1	0.0	172.9	6444.8
5	0.7500	0.0	0.0	10.1	6257.7	171.7	5.4	0.1	0.0	171.8	6443.1
6	0.7500	0.0	0.0	10.2	6250.5	170.4	5.3	0.1	0.0	170.6	6445.5
7	0.7500	0.0	0.0	10.2	6260.5	169.7	5.3	0.1	0.0	169.8	6445.8
8	0.7500	0.0	0.0	10.2	6261.0	169.3	5.2	0.1	0.0	169.4	6445.9
9	0.7500	0.0	0.0	10.2	6261.0	169.4	5.2	0.1	0.0	169.5	6445.9
10	0.7500	0.0	0.0	10.2	6260.9	169.4	5.3	0.1	0.0	169.5	6445.8
11	0.7500	0.0	0.0	10.2	6260.7	169.5	5.3	0.1	0.0	169.6	6445.8
12	0.7500	0.0	0.0	10.2	6260.8	169.5	5.3	0.1	0.0	169.6	6445.8
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	0.0	0.0	33.4	18985.8	349.4	8.3	0.1	0.0	349.5	19377.0
Radial Blanket											
YEAR	CAPACITY FACTOR	TH232	U233	U235	U239	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	4034.4	46.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6881.2
2	0.7500	4784.2	01.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6875.9
3	0.7500	4733.3	134.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6867.5
4	0.7500	6482.2	174.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6856.1
5	0.7500	6631.1	210.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6842.0
6	0.7500	6680.1	245.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6823.9
7	0.7500	6674.2	247.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6823.9
8	0.7500	6673.9	249.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6823.1
9	0.7500	6672.6	250.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6822.6
10	0.7500	6671.9	250.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6822.4
11	0.7500	6671.6	250.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6822.3
12	0.7500	6671.5	250.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6822.2
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	40201.0	936.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41137.1
Entire Reactor											
YEAR	CAPACITY FACTOR	TH232	U233	U235	U239	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	4034.4	434.7	22.5	12679.4	215.5	4.0	0.1	0.0	215.5	20390.5
2	0.7500	4784.2	708.0	10.0	12146.1	370.5	13.0	0.3	0.0	371.2	20241.6
3	0.7500	4733.3	674.3	15.4	11767.8	404.3	25.6	0.9	0.0	405.7	19713.0
4	0.7500	6482.2	718.0	16.5	11787.1	488.5	24.5	0.8	0.0	489.3	19718.7
5	0.7500	6631.1	750.3	16.5	11793.4	485.5	24.1	0.8	0.0	486.4	19715.0
6	0.7500	6680.1	706.7	16.7	11799.5	482.6	23.7	0.8	0.0	483.3	19700.0
7	0.7500	6674.2	801.0	16.7	11803.0	490.8	23.5	0.8	0.0	481.3	19701.9
8	0.7500	6673.9	803.3	16.7	11804.5	490.0	23.4	0.7	0.0	480.7	19702.6
9	0.7500	6672.6	804.4	16.7	11804.9	479.8	23.4	0.7	0.0	480.5	19702.5
10	0.7500	6671.9	804.9	16.7	11805.1	479.7	23.3	0.7	0.0	480.4	19702.4
11	0.7500	6671.6	805.2	16.7	11805.2	479.7	23.3	0.7	0.0	480.4	19702.4
12	0.7500	6671.5	805.3	16.7	11805.2	479.7	23.3	0.7	0.0	480.4	19702.5
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	40201.0	3131.7	57.9	34124.6	1021.9	37.9	1.0	0.0	1022.9	80575.7

Table A-7. Discharge Data for a 1200 MW(e) Homogeneous GCFR
with ($^{233}\text{U-U}$)O₂ Core, ThO₂ Axial and Radial Blankets
(Case 5A)

Discharge Data (kg)

Reactor Core										
YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU
1	0.7500	0.0	509.5	10.5	6272.4	149.0	3.2	0.0	0.0	149.1
2	0.7500	0.0	509.5	0.0	5805.8	245.8	10.1	0.3	0.0	246.0
3	0.7500	0.0	552.9	6.3	5494.4	316.5	19.4	0.7	0.0	317.2
4	0.7500	0.0	558.0	6.4	5513.0	312.1	18.5	0.7	0.0	312.8
5	0.7500	0.0	561.5	6.5	5518.1	310.1	18.2	0.6	0.0	310.8
6	0.7500	0.0	564.7	6.5	5522.4	309.3	17.9	0.6	0.0	309.0
7	0.7500	0.0	566.5	6.5	5524.9	307.3	17.7	0.6	0.0	307.9
8	0.7500	0.0	567.3	6.5	5526.0	306.8	17.6	0.6	0.0	307.4
9	0.7500	0.0	567.4	6.5	5526.3	306.7	17.6	0.6	0.0	307.3
10	0.7500	0.0	567.7	6.5	5526.4	306.6	17.6	0.6	0.0	307.2
11	0.7500	0.0	567.7	6.5	5526.4	306.6	17.6	0.6	0.0	307.2
12	0.7500	0.0	567.7	6.5	5526.5	306.6	17.6	0.6	0.0	307.2
YEARS 13 THRU 29 SAME AS ABOVE										
30	0.7500	0.0	2243.8	24.5	17079.8	664.3	28.8	0.9	0.0	665.2

Axial Blanket										
YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU
1	0.7500	6086.8	66.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.7500	6019.3	123.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.7500	6052.4	174.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.7500	6054.8	172.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.7500	6056.1	171.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.7500	6057.7	170.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.7500	6058.6	169.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.7500	6059.0	169.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.7500	6059.1	169.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.7500	6059.2	169.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.7500	6059.2	169.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.7500	6059.2	169.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
YEARS 13 THRU 29 SAME AS ABOVE										
30	0.7500	18073.9	351.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Radial Blanket										
YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU
1	0.7500	6834.6	46.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.7500	6784.7	91.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.7500	6734.1	117.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.7500	6683.3	173.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.7500	6632.4	209.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.7500	6581.7	244.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	0.7500	6577.9	246.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.7500	6575.7	248.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.7500	6574.4	248.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.7500	6473.7	249.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.7500	6573.5	249.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.7500	6573.4	249.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
YEARS 13 THRU 29 SAME AS ABOVE										
30	0.7500	40208.0	930.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Entire Reactor										
YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU
1	0.7500	12021.4	712.3	10.5	6272.4	149.0	3.2	0.0	0.0	149.1
2	0.7500	12003.9	844.0	0.0	5805.8	245.8	10.1	0.3	0.0	246.0
3	0.7500	12186.5	860.7	6.3	5494.4	316.5	19.4	0.7	0.0	317.2
4	0.7500	12538.1	903.5	6.4	5513.0	312.1	18.5	0.7	0.0	312.8
5	0.7500	12588.5	943.0	6.5	5518.1	310.1	18.2	0.6	0.0	310.8
6	0.7500	12590.4	979.2	6.5	5522.4	309.3	17.9	0.6	0.0	309.0
7	0.7500	12536.5	982.0	6.5	5524.9	307.3	17.7	0.6	0.0	307.9
8	0.7500	12534.6	984.8	6.5	5526.0	306.8	17.6	0.6	0.0	307.4
9	0.7500	12533.5	985.8	6.5	5526.3	306.7	17.6	0.6	0.0	307.3
10	0.7500	12532.9	986.3	6.5	5526.4	306.6	17.6	0.6	0.0	307.2
11	0.7500	12532.6	986.4	6.5	5526.4	306.6	17.6	0.6	0.0	307.2
12	0.7500	12532.6	986.5	6.5	5526.5	306.6	17.6	0.6	0.0	307.2
YEARS 13 THRU 29 SAME AS ABOVE										
30	0.7500	58281.9	3525.6	24.5	17079.8	664.3	28.8	0.9	0.0	665.2

Table A-8. Discharge Data for a 1200 MW(e) Homogeneous GCFR
with 20% (^{233}U -U-Th) O_2 Core, ThO₂ Axial
and Radial Blankets (Case 6A)

Discharge Data (kg)

Reactor Core

YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	2452.8	758.9	6.1	3581.9	79.0	1.5	0.0	0.0	79.0	6880.1
2	0.7500	1322.5	731.5	6.1	4341.6	173.5	6.6	0.2	0.0	173.7	6582.1
3	0.7500	823.1	612.8	5.4	4590.6	253.0	14.6	0.5	0.0	254.0	6300.6
4	0.7500	794.8	618.0	5.5	4619.6	253.0	14.4	0.5	0.0	253.5	6305.8
5	0.7500	755.7	620.8	5.5	4622.8	251.8	14.2	0.5	0.0	252.3	6311.3
6	0.7500	796.8	623.7	5.5	4626.2	250.4	13.9	0.5	0.0	250.8	6317.0
7	0.7500	747.3	625.3	5.6	4628.0	249.6	13.8	0.5	0.0	250.1	6320.0
8	0.7500	757.5	626.0	5.6	4628.7	249.3	13.7	0.5	0.0	249.7	6321.3
9	0.7500	797.6	626.2	5.6	4628.9	249.2	13.7	0.5	0.0	249.6	6321.7
10	0.7500	757.6	626.3	5.6	4629.0	249.1	13.7	0.5	0.0	249.6	6321.9
11	0.7500	797.6	626.4	5.6	4629.1	249.1	13.7	0.5	0.0	249.6	6321.9
12	0.7500	757.6	626.4	5.6	4629.1	249.1	13.7	0.5	0.0	249.6	6322.0
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	2476.5	2385.8	20.7	14292.8	538.5	22.4	0.6	0.0	539.1	19737.3

Axial Blanket

YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	6088.0	64.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6152.9
2	0.7500	6020.3	122.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6142.6
3	0.7500	5953.1	173.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6126.8
4	0.7500	5953.9	173.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6127.0
5	0.7500	5954.9	172.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6127.2
6	0.7500	5956.3	171.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6127.7
7	0.7500	5957.2	170.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6127.9
8	0.7500	5957.6	170.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6128.0
9	0.7500	5957.7	170.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6128.1
10	0.7500	5957.8	170.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6128.1
11	0.7500	5957.8	170.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6128.1
12	0.7500	5957.8	170.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6128.1
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	18071.1	353.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18424.2

Radial Blanket

YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	6834.4	46.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6881.2
2	0.7500	6784.5	91.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6875.0
3	0.7500	6734.3	133.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6867.7
4	0.7500	6683.8	172.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6856.5
5	0.7500	6633.3	209.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6842.7
6	0.7500	6582.9	243.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6826.3
7	0.7500	6579.8	245.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6825.2
8	0.7500	6577.7	246.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6824.5
9	0.7500	6576.3	247.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6824.0
10	0.7500	6575.7	248.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6823.7
11	0.7500	6575.4	248.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6823.6
12	0.7500	6575.4	248.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6823.6
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	40215.0	925.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41140.9

Entire Reactor

YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	15375.2	470.6	6.1	3581.9	79.0	1.5	0.0	0.0	79.0	19914.2
2	0.7500	14127.3	945.3	6.1	4341.6	173.5	6.6	0.2	0.0	173.7	19630.6
3	0.7500	13510.5	919.9	5.4	4590.6	253.0	14.6	0.5	0.0	254.0	19295.1
4	0.7500	13432.6	963.7	5.5	4619.6	253.0	14.4	0.5	0.0	253.5	19289.3
5	0.7500	13383.9	1002.5	5.5	4622.8	251.8	14.2	0.5	0.0	252.3	19281.2
6	0.7500	13336.0	1038.4	5.5	4626.2	250.4	13.9	0.5	0.0	250.8	19271.0
7	0.7500	13334.1	1041.6	5.6	4628.0	249.6	13.8	0.5	0.0	250.1	19273.1
8	0.7500	13332.8	1043.3	5.6	4628.7	249.3	13.7	0.5	0.0	249.7	19273.8
9	0.7500	13331.6	1044.2	5.6	4628.9	249.2	13.7	0.5	0.0	249.6	19273.7
10	0.7500	13331.0	1044.7	5.6	4629.0	249.1	13.7	0.5	0.0	249.6	19273.7
11	0.7500	13330.8	1044.9	5.6	4629.1	249.1	13.7	0.5	0.0	249.6	19273.6
12	0.7500	13330.8	1044.9	5.6	4629.1	249.1	13.7	0.5	0.0	249.6	19273.7
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	60762.6	3664.8	20.7	14292.8	538.5	22.4	0.6	0.0	539.1	79302.3

Table A-9. Discharge Data for a 1200 MW(e) Homogeneous GCFR
with 40% (^{233}U -U-Th) O_2 Core, Th O_2 Axial
and Radial Blankets (Case 7A)

Discharge Data (kg)											
Reactor Core											
YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	4379.9	877.4	2.5	1474.2	31.4	0.6	0.0	0.0	31.4	6766.0
2	0.7500	3716.9	900.8	2.5	1763.5	67.7	2.4	0.1	0.0	67.7	6453.8
3	0.7500	3356.3	828.3	2.3	1870.7	98.5	5.3	0.2	0.0	98.6	6161.5
4	0.7500	3307.8	842.9	2.3	1908.5	98.9	5.2	0.2	0.0	99.0	6165.7
5	0.7500	3311.6	846.3	2.4	1910.2	98.1	5.0	0.2	0.0	98.3	6173.8
6	0.7500	3314.7	849.1	2.4	1911.6	97.5	5.0	0.2	0.0	97.7	6180.5
7	0.7500	3316.2	850.5	2.4	1912.3	97.2	4.9	0.2	0.0	97.4	6183.6
8	0.7500	3316.8	851.1	2.4	1912.6	97.1	4.9	0.2	0.0	97.2	6185.0
9	0.7500	3317.1	851.2	2.4	1912.7	97.0	4.9	0.2	0.0	97.2	6185.4
10	0.7500	3317.2	851.3	2.4	1912.8	97.0	4.9	0.2	0.0	97.2	6185.6
11	0.7500	3317.2	851.3	2.4	1912.8	97.0	4.9	0.2	0.0	97.2	6185.7
12	0.7500	3317.2	851.3	2.4	1912.8	97.0	4.9	0.2	0.0	97.1	6185.7
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	10240.3	2783.0	8.7	5896.5	208.7	7.9	0.2	0.0	208.9	17216.4
Axial Blanket											
YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	5088.4	64.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6132.9
2	0.7500	6022.0	120.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6142.8
3	0.7500	5956.5	171.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6127.6
4	0.7500	5959.1	169.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6128.3
5	0.7500	5960.8	168.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6128.8
6	0.7500	5962.9	166.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6129.4
7	0.7500	5963.8	165.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6129.6
8	0.7500	5964.2	165.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6129.7
9	0.7500	5964.0	165.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6129.7
10	0.7500	5964.1	165.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6129.7
11	0.7500	5964.1	165.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6129.7
12	0.7500	5964.1	165.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6129.7
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	18083.8	343.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19426.8
Radial Blanket											
YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	6834.3	46.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6831.2
2	0.7500	6784.5	91.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6875.9
3	0.7500	6734.2	133.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6867.5
4	0.7500	6683.6	172.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6856.3
5	0.7500	6632.9	209.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6842.3
6	0.7500	6582.5	243.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6825.9
7	0.7500	6579.2	245.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6824.7
8	0.7500	6577.0	246.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6823.9
9	0.7500	6575.7	247.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6823.5
10	0.7500	6575.1	248.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6823.2
11	0.7500	6574.8	248.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6823.1
12	0.7500	6574.7	248.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6823.1
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	40212.6	926.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41139.2
Entire Reactor											
YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	17302.6	988.8	2.5	1474.2	31.4	0.6	0.0	0.0	31.4	19300.0
2	0.7500	16523.4	1113.0	2.5	1763.5	67.7	2.4	0.1	0.0	67.7	17472.5
3	0.7500	16046.9	1132.8	2.3	1870.7	98.5	5.3	0.2	0.0	98.6	17156.6
4	0.7500	15950.4	1184.8	2.3	1908.5	98.9	5.2	0.2	0.0	99.0	17150.2
5	0.7500	15905.3	1223.6	2.4	1910.2	98.1	5.0	0.2	0.0	98.3	17144.9
6	0.7500	15860.1	1258.9	2.4	1911.6	97.5	5.0	0.2	0.0	97.7	17135.7
7	0.7500	15859.2	1261.8	2.4	1912.3	97.2	4.9	0.2	0.0	97.4	17137.9
8	0.7500	15858.0	1263.5	2.4	1912.6	97.1	4.9	0.2	0.0	97.2	17138.6
9	0.7500	15856.8	1264.6	2.4	1912.7	97.0	4.9	0.2	0.0	97.2	17138.6
10	0.7500	15856.3	1265.0	2.4	1912.8	97.0	4.9	0.2	0.0	97.2	17138.5
11	0.7500	15856.1	1265.2	2.4	1912.8	97.0	4.9	0.2	0.0	97.2	17138.5
12	0.7500	15856.0	1265.3	2.4	1912.8	97.0	4.9	0.2	0.0	97.1	17138.5
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	68536.6	4252.5	8.7	5896.5	208.7	7.9	0.2	0.0	208.9	78911.1

Reactor Core

Axial Blanket

Radial Blanket

Entire Reactor[illegible]

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WAS INTENTIONALLY
LEFT BLANK**

APPENDIX B

Thirty-Year Mass Flow Data for Several Alternate-Fueled
1200 MW(e) Heterogeneous GCFRs

Table B-1. Initial Core Loadings for Heterogeneous GCFRs Utilizing Alternate Oxide Fuels (kg)

Case	Region	²³² Th	²³³ U	²³⁵ U	²³⁸ U	²³⁹ Pu	²⁴⁰ Pu	²⁴¹ Pu	²⁴² Pu	Fissile Pu	Total HM
1B	Driver			60.4	29698.3	4486.8	1281.5	676.1	227.4	5162.9	36430.5
	Inner Blkt			80.5	39595.1						39675.6
	Rad Blkt			163.8	80566.4						80730.2
	Total			304.7	149860.	4486.8	1281.5	676.1	227.4	5162.9	156836.
2B	Driver			59.2	29078.7	4907.9	1401.2	739.2	243.7	5647.1	36434.8
	Inner Blkt	37593.4									37693.4
	Rad Blkt	76596.9									76696.9
	Total	114390.		59.2	29078.7	4907.9	1401.2	739.2	248.7	5647.1	150825.
3B	Driver	26341.0				5310.7	1515.6	798.9	269.0	6109.6	34835.2
	Inner Blkt	37593.4									37693.4
	Rad Blkt	76596.9									76696.9
	Total	141331.				5310.7	1515.6	798.9	269.0	6109.6	149225.
4B	Driver		5509.7	62.5	30639.3						36271.5
	Inner Blkt	37593.4									37693.4
	Rad Blkt	76696.9									76696.9
	Total	114390.	5509.7	62.5	30639.3						150652.
5B	Driver	16263.2	5509.7	27.7	13622.2						35422.8
	Inner Blkt	37693.4									37693.4
	Rad Blkt	76696.9									76696.9
	Total	130653.	5509.7	27.7	13622.2						149873.
7A	Driver	20765.5	5665.4	17.6	8663.9						35112.5
	Inner Blkt	37693.4									37693.4
	Rad Blkt	76696.9									76696.9
	Total	135156.	5665.4	17.6	8663.9						149503.
8A	Driver	28595.5	6016.8								34612.3
	Inner Blkt	37693.4									37693.4
	Rad Blkt	76696.9									76696.9
	Total	142986.	6016.8								149003.

Table B-2. Equilibrium Cycle Reloadings for Heterogeneous GCFRs Utilizing Alternate Oxide Fuels (kg)

Case	Region	²³² Th	²³³ U	²³⁵ U	²³⁸ U	²³⁹ Pu	²⁴⁰ Pu	²⁴¹ Pu	²⁴² Pu	Fissile Pu	Total HM
1B	Driver			20.1	9899.4	1495.6	427.2	225.4	75.8	1721.0	12143.5
	Inner Blkt			40.3	19797.5						19837.8
	Rad Blkt			27.3	13427.7						13455.0
	Total			87.7	43124.7	1495.6	427.2	225.4	75.8	1721.0	45436.3
2B	Driver			19.7	9692.9	1636.0	467.1	246.4	82.9	1882.4	12144.9
	Inner Blkt	18846.7									18846.7
	Rad Blkt	12782.8									12782.8
	Total	31629.5		19.7	9692.9	1636.0	467.1	246.4	82.9	1882.4	43774.4
3B	Driver	8980.3				1770.2	505.2	266.3	89.7	2036.5	11611.7
	Inner Blkt	18846.7									18846.7
	Rad Blkt	12782.8									12782.8
	Total	40609.8				1770.2	505.2	266.3	89.7	2036.5	43241.2
4B	Driver		1836.6	20.8	10233.1						12090.5
	Inner Blkt	18846.7									18846.7
	Rad Blkt	12782.8									12782.8
	Total	31629.5	1836.6	20.8	10233.1						43720.0
5B	Driver	5421.1	1836.6	9.2	4540.7						11807.6
	Inner Blkt	18846.7									18846.7
	Rad Blkt	12782.8									12782.8
	Total	37050.6	1836.6	9.2	4540.7						43437.1
7B	Driver	6921.8	1888.5	5.9	2888.0						11704.2
	Inner Blkt	18846.7									18846.7
	Rad Blkt	12782.8									12782.8
	Total	38551.4	1888.5	5.9	2888.0						43333.7
8B	Driver	9531.8	2005.6								11537.4
	Inner Blkt	18846.7									18846.7
	Rad Blkt	12782.8									12782.8
	Total	41161.3	2005.6								43166.9

Table B-3. Discharge Data for a 1200 MW(e) Heterogeneous GCFR
with (Pu-U) O_2 Driver and UO_2 Axial, Radial,
and Inner Blankets (Case 1B)

Discharge Data (kg)

Driver											
YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	0.0	0.0	18.3	9772.0	1385.5	439.9	191.2	77.0	1576.7	11383.9
2	0.7500	0.0	0.0	16.7	9645.0	1292.3	449.3	164.0	77.4	1456.3	11644.8
3	0.7500	0.0	0.0	15.3	9517.7	1212.7	455.2	142.4	77.2	1355.2	11421.5
4	0.7500	0.0	0.0	15.2	9513.9	1212.1	457.6	142.2	77.3	1354.3	11418.4
5	0.7500	0.0	0.0	15.2	9512.4	1211.8	458.2	142.0	77.4	1353.8	11417.0
6	0.7500	0.0	0.0	15.2	9513.5	1212.5	458.1	142.2	77.4	1354.7	11418.9
7	0.7500	0.0	0.0	15.2	9514.1	1212.9	458.0	142.2	77.4	1355.1	11419.8
8	0.7500	0.0	0.0	15.2	9514.4	1213.0	458.0	142.3	77.4	1355.3	11420.3
9	0.7500	0.0	0.0	15.2	9514.4	1213.0	459.0	142.3	77.4	1355.3	11420.3
10	0.7500	0.0	0.0	15.2	9514.5	1213.1	458.0	142.3	77.4	1355.3	11420.4
11	0.7500	0.0	0.0	15.2	9514.5	1213.1	459.0	142.3	77.4	1355.4	11421.4
12	0.7500	0.0	0.0	15.2	9514.5	1213.1	458.0	142.3	77.4	1355.4	11420.4
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	0.0	0.0	50.2	28923.8	3889.7	1350.9	496.7	232.1	4386.4	34943.4

Inner Blanket											
YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	0.0	0.0	35.6	19495.6	253.1	4.8	0.1	0.0	253.2	19789.1
2	0.7500	0.0	0.0	31.4	19194.7	475.7	18.0	0.6	0.0	475.2	19710.4
3	0.7500	0.0	0.0	31.2	19163.5	439.3	10.2	0.6	0.0	490.4	19704.3
4	0.7500	0.0	0.0	31.1	19159.4	492.9	19.4	0.6	0.0	493.1	19753.6
5	0.7500	0.0	0.0	31.2	19164.2	489.7	19.2	0.6	0.0	490.3	19754.9
6	0.7500	0.0	0.0	31.2	19157.2	487.8	19.0	0.6	0.0	488.4	19705.8
7	0.7500	0.0	0.0	31.2	19168.5	486.9	18.9	0.6	0.0	487.5	19736.2
8	0.7500	0.0	0.0	31.2	19168.8	486.7	18.9	0.6	0.0	487.3	19706.3
9	0.7500	0.0	0.0	31.2	19169.0	486.6	18.9	0.6	0.0	487.2	19706.3
10	0.7500	0.0	0.0	31.2	19165.1	486.5	18.9	0.6	0.0	487.1	19706.4
11	0.7500	0.0	0.0	31.2	19165.2	486.5	18.9	0.6	0.0	487.1	19706.4
12	0.7500	0.0	0.0	31.2	19165.2	486.5	18.9	0.6	0.0	487.1	19706.4
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	0.0	0.0	56.6	38645.2	751.3	24.0	0.7	0.0	752.5	39492.3

Radial Blanket											
YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	0.0	0.0	26.3	13366.8	54.5	0.3	0.0	0.0	54.5	13449.8
2	0.7500	0.0	0.0	25.3	13312.8	104.3	1.1	0.0	0.0	104.4	13443.6
3	0.7500	0.0	0.0	24.4	13256.0	153.3	2.3	0.0	0.0	153.3	13436.0
4	0.7500	0.0	0.0	23.5	13198.6	200.9	4.0	0.1	0.0	201.0	13427.1
5	0.7500	0.0	0.0	22.6	13140.9	247.1	6.1	0.1	0.0	247.3	13416.9
6	0.7500	0.0	0.0	21.8	13083.1	291.8	7.7	0.2	0.0	292.0	13405.6
7	0.7500	0.0	0.0	21.8	13082.9	291.3	8.6	0.2	0.0	292.0	13405.4
8	0.7500	0.0	0.0	21.8	13080.0	293.9	8.7	0.2	0.0	294.1	13404.6
9	0.7500	0.0	0.0	21.8	13078.2	295.1	8.8	0.2	0.0	295.4	13404.1
10	0.7500	0.0	0.0	21.8	13077.2	295.9	8.8	0.2	0.0	296.1	13403.8
11	0.7500	0.0	0.0	21.8	13076.7	296.2	8.8	0.2	0.0	296.5	13403.7
12	0.7500	0.0	0.0	21.7	13076.5	296.3	8.4	0.2	0.0	296.6	13403.7
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	0.0	0.0	143.8	79332.3	1071.9	22.9	0.5	0.0	1072.4	80571.2

Entire Reactor											
YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	0.0	0.0	80.2	42636.4	1693.1	444.8	191.3	77.0	1884.4	45122.8
2	0.7500	0.0	0.0	73.5	42142.5	1872.3	468.5	164.6	77.5	2036.9	44798.8
3	0.7500	0.0	0.0	70.6	41537.2	1855.8	477.6	143.1	77.2	1998.8	44561.8
4	0.7500	0.0	0.0	69.9	41872.5	1905.5	481.0	142.9	77.3	2048.4	44549.1
5	0.7500	0.0	0.0	69.0	41817.5	1948.6	483.5	142.8	77.4	2091.4	44538.8
6	0.7500	0.0	0.0	68.2	41763.8	1992.1	485.8	143.0	77.4	2135.1	44530.3
7	0.7500	0.0	0.0	68.3	41765.5	1991.6	485.6	143.1	77.4	2134.7	44531.4
8	0.7500	0.0	0.0	68.2	41763.2	1993.0	485.6	143.1	77.4	2136.8	44531.2
9	0.7500	0.0	0.0	68.2	41761.6	1994.9	485.7	143.1	77.4	2137.9	44530.8
10	0.7500	0.0	0.0	68.2	41760.7	1995.4	485.7	143.1	77.4	2138.6	44530.6
11	0.7500	0.0	0.0	68.2	41760.3	1995.7	485.7	143.1	77.4	2138.9	44530.5
12	0.7500	0.0	0.0	68.2	41760.2	1995.8	485.7	143.1	77.4	2139.0	44530.5
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	0.0	0.0	260.6	514693.2	5713.3	1397.8	497.9	232.2	6211.2	155006.8

Table B-4. Discharge Data for a 1200 MW(e) Heterogeneous GCFR
with (Pu-U) O_2 Driver, UO_2 Axial Blankets, and ThO_2 Radial
and Inner Blankets (Case 2B)

Discharge Data (kg)

Driver

YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	0.0	0.0	18.0	9572.4	1501.5	479.4	209.2	84.0	1710.3	11953.5
2	0.7500	0.0	0.0	16.5	9463.5	1388.2	486.3	179.7	84.3	1567.9	11528.6
3	0.7500	0.0	0.0	15.5	9362.1	1312.1	490.4	161.1	84.1	1473.2	11425.2
4	0.7500	0.0	0.0	15.4	9350.3	1312.2	491.7	161.0	84.2	1473.3	11424.8
5	0.7500	0.0	0.0	15.4	9359.6	1312.3	492.2	161.0	84.2	1473.3	11424.9
6	0.7500	0.0	0.0	15.1	9333.6	1292.4	492.9	156.1	84.1	1449.3	11375.9
7	0.7500	0.0	0.0	15.1	9334.3	1293.2	493.0	156.2	84.1	1449.4	11375.9
8	0.7500	0.0	0.0	15.1	9334.0	1293.1	493.1	156.2	84.1	1449.3	11375.7
9	0.7500	0.0	0.0	15.1	9334.3	1293.3	493.1	156.3	84.1	1449.6	11376.1
10	0.7500	0.0	0.0	15.1	9334.4	1293.4	493.1	156.3	84.1	1449.7	11376.4
11	0.7500	0.0	0.0	15.1	9334.5	1293.5	493.1	156.3	84.1	1449.7	11376.5
12	0.7500	0.0	0.0	15.1	9334.5	1293.5	493.1	156.3	84.1	1449.8	11376.5
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	0.0	0.0	49.6	28357.7	4185.7	1461.4	545.2	252.7	4730.9	34852.3

Inner Blanket

YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	18555.1	261.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18816.6
2	0.7500	18256.4	493.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18740.1
3	0.7500	18309.1	447.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18736.7
4	0.7500	18308.5	449.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18736.7
5	0.7500	18243.5	492.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18736.1
6	0.7500	18243.3	492.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18736.3
7	0.7500	18243.3	492.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18736.1
8	0.7500	18244.1	492.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18736.4
9	0.7500	18244.7	491.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18736.6
10	0.7500	18245.1	491.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18736.7
11	0.7500	18245.2	491.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18736.8
12	0.7500	18245.2	491.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18736.8
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	36798.0	763.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37551.2

Radial Blanket

YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	12723.2	57.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12791.0
2	0.7500	12667.5	109.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12777.1
3	0.7500	12322.6	149.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12772.6
4	0.7500	12565.6	199.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12764.7
5	0.7500	12568.3	246.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12754.9
6	0.7500	12450.9	292.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12743.1
7	0.7500	12451.8	251.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12743.3
8	0.7500	12449.0	293.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12742.7
9	0.7500	12434.7	304.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12739.4
10	0.7500	12434.6	304.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12739.4
11	0.7500	12433.9	305.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12739.2
12	0.7500	12433.6	305.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12739.1
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	75469.1	1111.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	76580.6

Entire Reactor

YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	31278.3	319.3	18.0	9572.4	1501.5	478.4	209.2	84.0	1710.8	43461.2
2	0.7500	30922.5	553.3	16.5	9453.5	1388.2	486.3	179.7	84.3	1567.9	43125.8
3	0.7500	30932.5	596.7	15.5	9362.1	1312.1	490.4	161.1	84.1	1473.2	42934.5
4	0.7500	30874.1	547.2	15.4	9350.3	1312.2	491.7	161.0	84.2	1473.3	42946.1
5	0.7500	30751.3	739.2	15.4	9359.6	1312.3	492.2	161.0	84.2	1473.3	42915.9
6	0.7500	30664.3	784.6	15.1	9333.6	1292.4	492.9	156.1	84.1	1449.3	42853.6
7	0.7500	30665.2	784.3	15.1	9334.3	1293.2	493.0	156.2	84.1	1449.4	42855.4
8	0.7500	30673.0	786.0	15.1	9334.0	1293.1	493.1	156.2	84.1	1449.3	42854.8
9	0.7500	30679.4	796.6	15.1	9334.3	1293.3	493.1	156.3	84.1	1449.6	42852.1
10	0.7500	30679.5	796.5	15.1	9334.4	1293.4	493.1	156.3	84.1	1449.7	42852.5
11	0.7500	30679.1	796.9	15.1	9334.5	1293.5	493.1	156.3	84.1	1449.7	42852.5
12	0.7500	30678.8	797.1	15.1	9334.5	1293.5	493.1	156.3	84.1	1449.8	42852.4
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	112257.0	1874.8	49.6	28357.7	4185.7	1461.4	545.2	252.7	4730.9	149933.9

Table B-5. Discharge Data for a 1200 MW(e) Heterogeneous GCFR
with (Pu-Th) O_2 Driver and Th O_2 Axial, Radial,
and Inner Blankets (Case 3B)

Discharge Data (kg)

Driver										FISSILE	TOTAL
YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	PU	HM
1	0.7500	8873.7	95.4	0.0	0.0	1527.7	514.8	226.7	93.7	1754.4	11329.0
2	0.7500	9768.6	176.9	0.0	0.0	1319.5	519.1	195.1	93.9	1514.5	11070.1
3	0.7500	8553.2	247.9	0.0	0.0	1137.1	518.9	169.5	93.4	1306.6	10827.0
4	0.7500	8561.7	249.1	0.0	0.0	1136.7	520.2	169.5	93.5	1306.2	10827.7
5	0.7500	8660.8	249.8	0.0	0.0	1135.9	520.7	169.5	93.6	1305.4	10827.2
6	0.7500	8662.0	249.0	0.0	0.0	1138.0	520.6	169.7	93.6	1307.7	10829.9
7	0.7500	8662.6	248.7	0.0	0.0	1139.0	520.6	169.8	93.6	1308.8	10831.2
8	0.7500	8662.8	248.5	0.0	0.0	1139.4	520.6	169.8	93.6	1309.3	10831.7
9	0.7500	8662.9	248.5	0.0	0.0	1139.5	520.6	169.9	93.6	1309.4	10831.8
10	0.7500	8662.9	248.5	0.0	0.0	1139.6	520.6	169.9	93.6	1309.4	10831.9
11	0.7500	8662.9	248.4	0.0	0.0	1139.6	520.6	169.9	93.6	1309.5	10832.0
12	0.7500	8663.0	248.4	0.0	0.0	1139.6	520.6	169.9	93.6	1309.5	10832.0
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	26302.7	523.4	0.0	0.0	3987.9	1557.8	591.9	272.4	4579.8	33236.2

Inner Blanket										FISSILE	TOTAL
YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	PU	HM
1	0.7500	18558.9	257.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18816.7
2	0.7500	18266.3	475.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18741.9
3	0.7500	18250.3	486.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18735.9
4	0.7500	18248.1	488.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18736.2
5	0.7500	18253.2	484.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18737.9
6	0.7500	18256.4	482.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18739.0
7	0.7500	18257.7	481.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18739.4
8	0.7500	18258.2	481.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18739.5
9	0.7500	18258.2	481.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18739.6
10	0.7500	18258.3	481.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18739.6
11	0.7500	18258.4	481.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18739.7
12	0.7500	18258.4	481.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18739.7
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	36807.9	746.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37554.8

Radial Blanket										FISSILE	TOTAL
YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	PU	HM
1	0.7500	12725.0	56.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12781.0
2	0.7500	12671.2	106.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12777.3
3	0.7500	12616.6	155.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12771.6
4	0.7500	12561.5	202.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12763.9
5	0.7500	12506.0	248.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12754.3
6	0.7500	12450.6	292.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12742.8
7	0.7500	12451.5	291.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12743.0
8	0.7500	12448.8	293.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12742.4
9	0.7500	12447.0	295.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12742.0
10	0.7500	12445.9	295.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12741.7
11	0.7500	12445.6	296.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12741.6
12	0.7500	12445.4	296.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12741.6
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	75511.1	1075.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	76586.9

Entire Reactor										FISSILE	TOTAL
YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	PU	HM
1	0.7500	40157.6	409.3	0.0	0.0	1527.7	514.8	226.7	93.7	1754.4	42926.8
2	0.7500	39706.0	759.7	0.0	0.0	1319.5	519.1	195.1	93.9	1514.5	42589.3
3	0.7500	39530.1	880.4	0.0	0.0	1137.1	518.9	169.5	93.4	1306.6	42333.4
4	0.7500	39471.3	939.7	0.0	0.0	1136.7	520.2	169.5	93.5	1306.2	42327.8
5	0.7500	39420.0	982.7	0.0	0.0	1135.9	520.7	169.5	93.6	1305.4	42319.4
6	0.7500	39368.9	1023.9	0.0	0.0	1138.0	520.6	169.7	93.6	1307.7	42311.7
7	0.7500	39371.7	1021.0	0.0	0.0	1139.0	520.6	169.8	93.6	1308.8	42313.6
8	0.7500	39369.6	1023.7	0.0	0.0	1139.4	520.6	169.8	93.6	1309.3	42313.6
9	0.7500	39368.1	1024.8	0.0	0.0	1139.5	520.6	169.9	93.6	1309.4	42313.4
10	0.7500	39367.2	1025.5	0.0	0.0	1139.6	520.6	169.9	93.6	1309.4	42313.3
11	0.7500	39366.9	1025.8	0.0	0.0	1139.6	520.6	169.9	93.6	1309.5	42313.2
12	0.7500	39366.8	1025.9	0.0	0.0	1139.6	520.6	169.9	93.6	1309.5	42313.2
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	139421.8	2346.1	0.0	0.0	3987.9	1557.8	591.9	272.4	4579.8	147377.8

Discharge Data (kg)

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Table B-7. Discharge Data for a 1200 MW(e) Heterogeneous GCFR
with $(^{233}\text{U-U})\text{O}_2$ Driver and ThO_2 Axial, Radial,
and Inner Blankets (Case 5B)

Discharge Data (kg)

Driver											
YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	5393.4	1588.4	8.1	4458.1	59.5	0.6	0.0	0.0	59.5	11508.2
2	0.7500	5344.8	1373.0	7.1	4374.7	113.3	2.5	0.0	0.0	113.3	11236.2
3	0.7500	5335.5	1190.5	6.2	4290.5	161.1	5.5	0.1	0.0	161.2	10989.4
4	0.7500	5333.7	1191.2	6.2	4286.2	164.6	5.7	0.1	0.0	164.7	10977.6
5	0.7500	5332.9	1177.5	6.1	4284.4	155.9	5.9	0.1	0.0	166.1	10972.8
6	0.7500	5333.0	1178.7	6.1	4285.0	155.6	5.8	0.1	0.0	165.7	10974.5
7	0.7500	5333.1	1179.4	6.1	4285.4	165.4	5.8	0.1	0.0	165.5	10975.4
8	0.7500	5333.2	1179.8	6.2	4285.5	165.3	5.8	0.1	0.0	165.4	10975.9
9	0.7500	5333.3	1179.8	6.2	4285.6	165.3	5.8	0.1	0.0	165.4	10976.0
10	0.7500	5333.3	1179.0	6.2	4285.6	165.3	5.8	0.1	0.0	165.4	10976.1
11	0.7500	5333.3	1179.9	6.2	4285.6	165.3	5.8	0.1	0.0	165.4	10976.1
12	0.7500	5333.3	1179.0	6.2	4285.6	165.3	5.8	0.1	0.0	165.4	10976.2
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	16787.4	4115.4	21.3	13108.6	347.7	9.3	0.2	0.0	347.8	33689.8

Inner Blanket

YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	18505.8	227.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18823.1
2	0.7500	18332.6	425.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18762.3
3	0.7500	18301.5	847.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18766.1
4	0.7500	18301.5	451.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18753.2
5	0.7500	18304.1	440.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18754.0
6	0.7500	18306.3	448.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18754.7
7	0.7500	18307.3	447.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18755.0
8	0.7500	18307.7	447.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18755.1
9	0.7500	18307.9	447.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18755.2
10	0.7500	18307.9	447.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18755.2
11	0.7500	18308.0	447.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18755.2
12	0.7500	18308.0	447.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18755.2
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	36982.8	602.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37574.9

Radial Blanket

YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	12734.3	47.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12781.5
2	0.7500	12587.7	91.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12778.7
3	0.7500	12540.0	134.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12774.3
4	0.7500	12502.0	176.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12768.4
5	0.7500	12543.4	217.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12761.0
6	0.7500	12495.2	257.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12752.2
7	0.7500	12494.4	257.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12752.1
8	0.7500	12491.6	259.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12751.5
9	0.7500	12490.5	260.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12751.2
10	0.7500	12489.7	261.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12751.1
11	0.7500	12489.4	261.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12751.0
12	0.7500	12489.3	261.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12751.0
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	75566.1	945.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	76611.9

Entire Reactor

YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	36727.5	1562.0	8.1	4458.1	59.5	0.6	0.0	0.0	59.5	43112.8
2	0.7500	36385.0	1894.7	7.1	4374.7	113.3	2.5	0.0	0.0	113.3	42777.3
3	0.7500	36283.5	1771.0	6.2	4290.5	161.1	5.5	0.1	0.0	161.2	42518.7
4	0.7500	36227.1	1800.3	6.2	4286.2	164.6	5.7	0.1	0.0	164.7	42499.2
5	0.7500	36187.7	1844.9	6.1	4284.4	155.9	5.9	0.1	0.0	166.1	42487.9
6	0.7500	36134.5	1844.1	6.1	4285.0	155.6	5.8	0.1	0.0	165.7	42481.4
7	0.7500	36134.9	1844.6	6.1	4285.4	165.4	5.8	0.1	0.0	165.5	42482.5
8	0.7500	36132.2	1845.0	6.2	4285.5	165.3	5.8	0.1	0.0	165.4	42482.6
9	0.7500	36131.6	1847.0	6.2	4285.6	165.3	5.8	0.1	0.0	165.4	42482.5
10	0.7500	36131.0	1848.5	6.2	4285.6	165.3	5.8	0.1	0.0	165.4	42482.4
11	0.7500	36130.7	1849.7	6.2	4285.6	165.3	5.8	0.1	0.0	165.4	42482.4
12	0.7500	36130.7	1849.0	6.2	4285.6	165.3	5.8	0.1	0.0	165.4	42482.4
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	128436.2	5753.4	21.3	13108.6	347.7	9.3	0.2	0.0	347.8	147876.4

Table B-8. Discharge Data for a 1200 MW(e) Heterogeneous GCFR
with $(^{233}\text{U-U-Th})\text{O}_2$ Driver and ThO_2 Axial, Radial,
and Inner Blankets (Case 7B)

Discharge Data (kg)											
Driver											
YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	6967.8	1657.9	5.2	2835.7	37.5	0.4	0.0	0.0	37.5	11404.3
2	0.7500	6912.3	1459.5	4.5	2783.1	71.3	1.5	0.0	0.0	71.3	11131.3
3	0.7500	6766.0	1287.9	4.0	2730.0	121.3	3.4	0.1	0.0	101.4	10882.5
4	0.7500	6752.6	1279.9	3.9	2727.5	103.4	3.5	0.1	0.0	103.5	10870.9
5	0.7500	6751.2	1276.6	3.9	2726.4	104.2	3.6	0.1	0.0	104.3	10866.1
6	0.7500	6751.5	1277.8	3.9	2725.8	104.0	3.6	0.1	0.0	104.1	10867.7
7	0.7500	6751.7	1278.4	3.9	2727.0	103.9	3.6	0.1	0.0	104.0	10868.6
8	0.7500	6751.5	1278.7	3.9	2727.1	103.8	3.6	0.1	0.0	103.9	10869.1
9	0.7500	6751.9	1278.5	3.9	2727.1	103.8	3.6	0.1	0.0	103.9	10869.2
10	0.7500	6752.0	1278.9	3.9	2727.1	103.8	3.6	0.1	0.0	103.9	10869.3
11	0.7500	6752.0	1278.9	3.9	2727.1	103.8	3.6	0.1	0.0	103.9	10869.3
12	0.7500	6752.0	1278.9	3.9	2727.2	103.8	3.6	0.1	0.0	103.9	10869.3
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	20424.4	4372.4	13.6	9340.2	218.3	5.7	0.1	0.0	218.4	33374.7
Inner Blanket											
YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	18504.5	228.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18822.8
2	0.7500	18731.1	430.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18761.8
3	0.7500	18307.9	447.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18755.0
4	0.7500	18301.9	451.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18753.3
5	0.7500	18304.6	449.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18754.1
6	0.7500	18306.7	448.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18754.8
7	0.7500	18307.6	447.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18755.1
8	0.7500	18307.9	447.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18755.2
9	0.7500	18309.1	447.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18755.2
10	0.7500	18309.2	447.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18755.2
11	0.7500	18308.2	447.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18755.2
12	0.7500	18308.3	447.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18755.3
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	36583.1	691.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37574.9
Radial Blanket											
YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	12735.1	46.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12781.5
2	0.7500	12599.1	89.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12778.8
3	0.7500	12542.2	132.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12774.5
4	0.7500	12504.9	173.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12768.8
5	0.7500	12547.2	214.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12761.6
6	0.7500	12490.6	253.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12753.0
7	0.7500	12498.8	254.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12752.8
8	0.7500	12496.4	250.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12752.3
9	0.7500	12496.0	257.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12752.1
10	0.7500	12494.2	257.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12751.9
11	0.7500	12494.0	257.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12751.8
12	0.7500	12493.9	257.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12751.8
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	75582.1	932.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	76614.1
Entire Reactor											
YEAR	CAPACITY FACTOR	TH232	U233	U235	U238	PU239	PU240	PU241	PU242	FISSILE PU	TOTAL HM
1	0.7500	38107.3	1932.4	5.2	2835.7	37.5	0.4	0.0	0.0	37.5	43008.7
2	0.7500	37032.5	1979.9	4.5	2783.1	71.3	1.5	0.0	0.0	71.3	42671.9
3	0.7500	37036.1	1847.2	4.0	2730.0	121.3	3.4	0.1	0.0	101.4	42412.0
4	0.7500	37444.3	1805.2	3.9	2727.5	103.4	3.5	0.1	0.0	103.5	42393.0
5	0.7500	37003.0	1840.4	3.9	2726.4	104.2	3.6	0.1	0.0	104.3	42381.8
6	0.7500	37557.7	1879.3	3.9	2725.8	104.0	3.6	0.1	0.0	104.1	42375.5
7	0.7500	37558.2	1879.9	3.9	2727.0	103.9	3.6	0.1	0.0	104.0	42376.6
8	0.7500	37556.2	1881.9	3.9	2727.1	103.8	3.6	0.1	0.0	103.9	42376.5
9	0.7500	37555.1	1882.0	3.9	2727.1	103.8	3.6	0.1	0.0	103.9	42376.5
10	0.7500	37554.4	1883.3	3.9	2727.1	103.8	3.6	0.1	0.0	103.9	42376.4
11	0.7500	37554.2	1883.7	3.9	2727.1	103.8	3.6	0.1	0.0	103.9	42376.4
12	0.7500	37554.1	1883.8	3.9	2727.2	103.8	3.6	0.1	0.0	103.9	42376.4
YEARS 13 THRU 29 SAME AS ABOVE											
30	0.7500	132589.7	5996.1	13.6	9340.2	218.3	5.7	0.1	0.0	218.4	147563.5

Driver

Inner Blanket

Radial Blanket

Entire Reactor[illegible]

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