MASTER

BAW-3867-7
March 1969

RECEIVED BY DTIC MAY 2 1969

PARAMETRIC EVALUATION OF THE
INFLUENCE OF ^{239}Pu AND FISSION
PRODUCT CAPTURE CROSS SECTIONS
ON LMFBR PERFORMANCE

Babcock & Wilcox

REPRODUCTION OF THIS DOCUMENT IS UNLIMITED

—LEGAL NOTICE—

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights, or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

PARAMETRIC EVALUATION OF THE
INFLUENCE OF ^{239}Pu AND FISSION
PRODUCT CAPTURE CROSS SECTIONS
ON LMFBR PERFORMANCE

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights, or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

by

J. E. Stewart
Advanced Programs Engineering
Nuclear Power Generation
Department

Approved by B. W. Whitaker
Project Manager

D. H. Roy
Technical Manager

AEC Contract No. AT(30-1)-3867
B&W Contract No. 859-3105

Prepared for
THE UNITED STATES ATOMIC ENERGY COMMISSION
by

BABCOCK & WILCOX
Power Generation Division
P.O. Box 1260
Lynchburg, Virginia 24505

ALL RIGHTS RESERVED. NO PART OF THIS DOCUMENT IS UNLIMITED

Babcock & Wilcox

FOREWORD

In March 1967, Babcock & Wilcox (B&W) initiated a program of analytical methods development applicable to the physics design of fast breeder reactors. One phase of this effort has as its goal the development and utilization of a design-oriented, one-dimensional criticality and depletion code applicable to the physics analysis of fast reactors. This phase of the methods development effort is under full sponsorship of the U.S. Atomic Energy Commission (AEC). Utilization of the code will consist of an investigation in which the design code FARED will be used to relate the sensitivity of certain fast reactor design parameters to the complexity of the physics model used to evaluate them. Finally, several fast reactor critical experiments will be analyzed to verify the applicability of the code and its cross-section libraries. Future topics of study under the FARED project include (1) extension of the criticality and depletion segments to two dimensions with provision for complex fuel management studies, and (2) study of the importance of generating multigroup cross sections using space-dependent spectrum weighting.

In April 1968, a sensitivity study relating to burnup and fuel management in fast reactors was initiated as Task 4 of the FARED project. The objectives of this study were to derive burnup reactivity balances and to give a preliminary indication of the contribution of fission products to the change in reactor characteristics with burnup for selected fast reactor cases. The effects of uncertainties in the nuclear data for fission products and one other important isotope (^{239}Pu) were compared; all calculations were made with the ZEUS criticality and depletion package (DRIP + DHRG3 + GAMMIX + SIZZLE). The results of this study are described in this report.

D. H. Roy
Manager, Methods Development
Advanced Programs Engineering

ABSTRACT

This study investigated large uncertainties, over the entire spectrum, in the capture cross sections of ^{239}Pu and lumped plutonium fission fragments. Emphasis was placed on determining the effects of the uncertainties on the depletion and fuel management characteristics of two LMFBR core sizes. Comparisons were made for the approach to equilibrium and particularly for the equilibrium cycle itself.

Two-zone spherical cores with volumes of 2000 and 8000 liters were considered. The composition of both cores was 37% PuO_2 - UO_2 ceramic fuel, 20% steel structure, and 43% sodium coolant. The blanket for both core sizes was 45 cm thick with an average composition of 45% UO_2 , 20% steel, and 35% sodium. A 30-cm reflector composed of 50% steel and 50% sodium was incorporated in the model.

Using a two-batch core refueling scheme, depletion calculations were performed from startup to equilibrium for all cases. The depletion calculations were performed with the ZEUS (BWIG-GAMMIX-SIZZLE) fast reactor design package. (ZEUS, B&W report to be published.) For each core size, depletion calculations were performed with three cross-section libraries: a reference set, the reference set with the lumped fission product capture cross section increased by 50% at all energies, and the reference set with the ^{239}Pu capture cross section increased by 50% at all neutron energies. ENDF/B reaction cross sections and resonance parameters for Na, O, ^{238}U , ^{239}Pu , ^{240}Pu , and lumped plutonium fission products were used to construct the reference 68-group cross-section libraries used by the BWIG (DRIP + DHRG3) portion of ZEUS. Data for other materials were taken from standard B&W libraries.

In all cases the beginning-of-cycle feed enrichments were adjusted to obtain the desired initial k_{eff} and a reasonably flat power distribution. The initial excess reactivity was chosen so that the maximum discharge heavy atom burnup in the core did not exceed 10%.

To show the effects of the altered libraries, breeding ratios, mass balances, enrichments, power peaking factors, and discharge plutonium isotopic mixes were compared for all fuel cycles. For the equilibrium cycle, isotopic worths for fuel, fission products and sodium, and the Doppler coefficients were compared. The changes due to the increased σ_c for ^{239}Pu are consistently greater than those caused by the increased σ_c for the lumped plutonium fission fragments.

Isotopic worths were calculated using the one-dimensional worth compiler of the SCRAMBLE code. Doppler coefficients resulted from SCRAMBLE criticality calculations.

CONTENTS

	Page
1. INTRODUCTION	1
2. GENERAL DESCRIPTION OF CASES.	2
3. PROCEDURE	4
4. PRELIMINARY INVESTIGATIONS	8
5. RESULTS.	18
5.1. Depletion Calculations	18
5.2. Worths and Coefficients	19

List of Tables

Table		
2-1. General Description of Spherical Cores		3
4-1. Comparison of Selected Parameters Obtained Using DHRG3 and BWIG Cross-Section Sets		11
4-2. Comparison of Case Using Library Generated for Both Core and Blanket With That Using Core Library Only		12
4-3. Comparison of Excess Reactivity Lifetime With B ₄ C-Maintained Criticality Lifetime		13
4-4. Comparison of End-of-Cycle Isotopic Densities for B ₄ C-Maintained Criticality (Case 1) and Excess Reactivity (Case 2).		14
4-5. Core Neutron Balance With B ₄ C (Absorptions + Leakage) _{core} $\equiv$ (Productions) _{core} $\equiv$ 1.0.		15
4-6. Core Neutron Balance Without B ₄ C (Absorptions + Leakage) _{core} $\equiv$ (Productions) _{core} $\equiv$ 1.0.		16
4-7. Small Excess Reactivity Lifetime and B ₄ C- Maintained Criticality Lifetime; Comparison of Core Neutron Balance		17
5-1. Total Breeding Ratios (Small Core, Ref Library).		23
5-2. Total Breeding Ratios (Small Core, FF Library).		23
5-3. Total Breeding Ratios (Small Core, Pu Library).		23

Tables (Cont'd)

Table	Page
5-4. Total Breeding Ratios (Large Core, Ref Library)	24
5-5. Total Breeding Ratios (Large Core, FF Library).	24
5-6. Total Breeding Ratios (Large Core, Pu Library).	24
5-7. Power Peaking Factors (Small Core, Ref Library).	25
5-8. Power Peaking Factors (Small Core, FF Library).	25
5-9. Power Peaking Factors (Small Core, Pu Library).	26
5-10. Power Peaking Factors (Large Core, Ref Library)	26
5-11. Power Peaking Factors (Large Core, FF Library).	27
5-12. Power Peaking Factors (Large Core, Pu Library).	27
5-13. Enrichments (Small Core, Ref Library).	28
5-14. Enrichments (Small Core, FF Library).	28
5-15. Enrichments (Small Core, Pu Library).	29
5-16. Enrichments (Large Core, Ref Library).	29
5-17. Enrichments (Large Core, FF Library).	30
5-18. Enrichments (Large Core, Pu Library).	30
5-19. Mass Balance, kg (Small Core, Ref Library, Cycle 1)	31
5-20. Discharge Mass Balance, kg (Small Core, Ref Library, Cycle 1).	31
5-21. Mass Balance, kg (Small Core, Ref Library, Cycle 2)	32
5-22. Discharge Mass Balance, kg (Small Core, Ref Library, Cycle 2).	32
5-23. Mass Balance, kg (Small Core, Ref Library, Cycle 3)	33
5-24. Discharge Mass Balance, kg (Small Core, Ref Library, Cycle 3).	33
5-25. Mass Balance, kg (Small Core, Ref Library, Cycle 4)	34
5-26. Discharge Mass Balance, kg (Small Core, Ref Library, Cycle 4).	34
5-27. Mass Balance, kg (Small Core, Ref Library, Cycle 5)	35
5-28. Discharge Mass Balance, kg (Small Core, Ref Library, Cycle 5).	35
5-29. Mass Balance, kg (Small Core, FF Library, Cycle 1)	36
5-30. Discharge Mass Balance, kg (Small Core, FF Library, Cycle 1).	36
5-31. Mass Balance, kg (Small Core, FF Library, Cycle 2)	37
5-32. Discharge Mass Balance, kg (Small Core, FF Library, Cycle 2).	37
5-33. Mass Balance, kg (Small Core, FF Library, Cycle 3)	38
5-34. Discharge Mass Balance, kg (Small Core, FF Library, Cycle 3).	38

Tables (Cont'd)

Table	Page
5-35. Mass Balance, kg (Small Core, FF Library, Cycle 4)	39
5-36. Discharge Mass Balance, kg (Small Core, FF Library, Cycle 4).	39
5-37. Mass Balance, kg (Small Core, Pu Library, Cycle 1)	40
5-38. Discharge Mass Balance, kg (Small Core, Pu Library, Cycle 1).	40
5-39. Mass Balance, kg (Small Core, Pu Library, Cycle 2)	41
5-40. Discharge Mass Balance, kg (Small Core, Pu Library, Cycle 2).	41
5-41. Mass Balance, kg (Small Core, Pu Library, Cycle 3)	42
5-42. Discharge Mass Balance, kg (Small Core, Pu Library, Cycle 3).	42
5-43. Mass Balance, kg (Small Core, Pu Library, Cycle 4)	43
5-44. Discharge Mass Balance, kg (Small Core, Pu Library, Cycle 4).	43
5-45. Mass Balance, kg (Large Core, Ref Library, Cycle 1)	44
5-46. Discharge Mass Balance, kg (Large Core, Ref Library, Cycle 1).	44
5-47. Mass Balance, kg (Large Core, Ref Library, Cycle 2)	45
5-48. Discharge Mass Balance, kg (Large Core, Ref Library, Cycle 2).	45
5-49. Mass Balance, kg (Large Core, Ref Library, Cycle 3)	46
5-50. Discharge Mass Balance, kg (Large Core, Ref Library, Cycle 3).	46
5-51. Mass Balance, kg (Large Core, Ref Library, Cycle 4)	47
5-52. Discharge Mass Balance, kg (Large Core, Ref Library, Cycle 4).	47
5-53. Mass Balance, kg (Large Core, FF Library, Cycle 1)	48
5-54. Discharge Mass Balance, kg (Large Core, FF Library, Cycle 1).	48
5-55. Mass Balance, kg (Large Core, FF Library, Cycle 2)	49
5-56. Discharge Mass Balance, kg (Large Core, FF Library, Cycle 2).	49
5-57. Mass Balance, kg (Large Core, FF Library, Cycle 3)	50
5-58. Discharge Mass Balance, kg (Large Core, FF Library, Cycle 3).	50

Tables (Cont'd)

Table	Page
5-59. Mass Balance, kg (Large Core, FF Library, Cycle 4)	51
5-60. Discharge Mass Balance, kg (Large Core, FF Library, Cycle 4).	51
5-61. Mass Balance, kg (Large Core, Pu Library, Cycle 1)	52
5-62. Discharge Mass Balance, kg (Large Core, Pu Library, Cycle 1).	52
5-63. Mass Balance, kg (Large Core, Pu Library, Cycle 2)	53
5-64. Discharge Mass Balance, kg (Large Core, Pu Library, Cycle 2).	53
5-65. Mass Balance, kg (Large Core, Pu Library, Cycle 3)	54
5-66. Discharge Mass Balance, kg (Large Core, Pu Library, Cycle 3).	54
5-67. Mass Balance, kg (Large Core, Pu Library, Cycle 4)	55
5-68. Discharge Mass Balance, kg (Large Core, Pu Library, Cycle 4).	55
5-69. EC-EOC Discharge Pu Isotopic Mixes (Core Average, atom %).	56
5-70. Total Fission Product Reactivity Worth and Contribution to Fission Product Worth Resulting From Capture at BOEC	57
5-71. Total Fission Product Reactivity Worth and Contribution to Fission Product Worth Resulting From Capture at EOEC	58
5-72. Worth of ^{238}U Inventory Change Between Beginning and End of Equilibrium Cycle	59
5-73. Worth of ^{239}Pu Inventory Change Between Beginning and End of Equilibrium Cycle	60
5-74. Worth of ^{240}Pu Inventory Change Between Beginning and End of Equilibrium Cycle	61
5-75. Worth of ^{241}Pu Inventory Change Between Beginning and End of Equilibrium Cycle	62
5-76. Worth of ^{242}Pu Inventory Change Between Beginning and End of Equilibrium Cycle	63
5-77. Worth of Blanket Plutonium Inventory Buildup From Cycle Beginning to End	64
5-78. Sodium Worth at Cycle Beginning and End.	65
5-79. Effect of Substitution of BOEC Fission Product Inventory and BOEC Blanket Plutonium Inventory on EOEC Sodium Worth	66
5-80. In-Core Doppler Coefficient	67

1. INTRODUCTION

Reliable prediction of the physics performance of large, fast oxide reactors is contingent upon the accuracy of nuclear data and the calculational model employed. Rather large uncertainties in nuclear data have consistently inhibited LMFBR calculational accuracy. Notably, the recent preliminary British measurements¹ have indicated that the ^{239}Pu α between 0.2 and 25.0 keV has changed from earlier measurements by a factor of two. Significant changes in the physics performance of various fast breeder cores have been shown to result from this change in α .²

This study involved the investigation of quite large uncertainties over the entire range of neutron energies for the capture cross section of lumped plutonium fission fragments and ^{239}Pu . The increases in the capture cross sections considered (50% in each case) are rather arbitrary, but should provide an indication of the penalties that could be imposed because of uncertainties in these cross sections.

- - - - -
¹M. G. Schomberg, M. G. Sowerby, and F. W. Evans, "A New Method of Measuring Alpha(E) for ^{239}Pu ," SM-101/41, IAEA Symp. Fast Reactor Physics and Related Safety Problems, Karlsruhe, October 30 - November 3, 1967.

²D. K. Butler, et al., Trans. Am. Nucl. Soc., 11, 204 - 205 (1968).

2. GENERAL DESCRIPTION OF CASES

Two-zone spherical cores with volumes of 2000 and 8000 liters were considered. The two core zones are composed of 37 vol % PuO_2 - UO_2 ceramic fuel, 20% steel structure, and 43% sodium coolant. The blanket is 45 cm thick and is represented by two compositions, one each for the axial and radial blankets. The average composition of the combined blanket is 45% UO_2 , 20% steel, and 35% sodium. The portion of the blanket corresponding to the axial blankets duplicates the core composition except that the fuel fraction will be UO_2 . The radial blanket portion of the combined blanket is determined from the constraints on the average combined blanket composition, axial blanket composition, and geometrical considerations. A 20-cm reflector surrounds the combined blanket, which is composed of 50% steel and 50% sodium.

The fuel and fertile material is oxide of 90% theoretical density. Startup plutonium isotopic fractions are 0.76 ^{239}Pu , 0.19 ^{240}Pu , 0.035 ^{241}Pu and 0.015 ^{242}Pu .

ENDF/B reaction cross sections and resonance parameters for Na, O, ^{238}U , ^{239}Pu , ^{240}Pu , ^{241}Pu , and lumped plutonium fission products were used to construct the basic 68-group cross-section library used by the BWIG (DRIP + DHRG3) portion of ZEUS. Data for other materials were taken from standard B&W libraries.

The two core zones simulate a reasonable degree of power flattening. Discharge fuel exposure never exceeds 10 atom % localized burnup. Fuel of at least two levels of exposure occupies each zone during operation except, of course, during the startup cycle. The incremental plutonium buildup is closely accounted for in the blanket.

Table 2-1 gives a general description of the two cores, along with a description of the two equivalent cylindrical reactors.

Table 2-1. General Description of Spherical Cores

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Average blanket</u>	<u>Reflector</u>
<u>Small Core</u>					
Volume, <i>l</i>	2000	1333	4492	5825	4465
Outer diam, cm	156.32	--	--	246.32	286.32
No. of regions	2	5	5	--	1
Steel, type	304 SS	304 SS	304 SS	--	304 SS
Fuel, % TD	90	90	90	--	--
Fuel temp, K	1644	1366	1366	--	--
Volume fraction:					
Fuel	0.37	0.37	0.47	0.45	--
Na	0.43	0.43	0.33	0.35	0.50
Steel	0.20	0.20	0.20	0.20	0.50
<u>Equivalent Cylindrical Reactor</u>					
Volume, <i>l</i>	2000	1333	4492	--	4465
Outer diam, cm	166.88	166.88	273.43	--	--
Height, cm	91.44	30.48 × 2	121.92	--	--
<u>Large Core</u>					
Volume, <i>l</i>	8000	5333	6910	12,243	8067
Outer diam, cm	248.14	--	--	338.14	378.14
No. of regions	2	5	5	--	1
Steel, type	304 SS	304 SS	304 SS	--	1
Fuel, % TD	90	90	90	--	--
Fuel temp, K	1644	1366	1366	--	--
Volume fraction:					
Fuel	0.37	0.37	0.51	0.45	--
Na	0.43	0.43	0.29	0.35	0.50
Steel	0.20	0.20	0.20	0.20	0.50
<u>Equivalent Cylindrical Reactor</u>					
Volume, <i>l</i>	8000	5333	6910	--	8067
Outer diam, cm	333.76	333.76	428.44	--	--
Height, cm	91.44	30.48 × 2	121.92	--	--

3. PROCEDURE

Equivalent cylindrical cores were produced for each of the two spherical cores by assuming a core height of 36 inches and an axial blanket thickness of 12 inches for both cores. This procedure was necessary to determine the average blanket composition. Since the calculations are limited to spherical geometry, the separate representation of the axial and radial blankets is restricted to a provision for alternate spherical shells surrounding the core. The selection of the thickness and the number of blanket regions was based on the ^{238}U absorption rate spatial distribution in the blankets.

In all cases the beginning-of-cycle feed enrichments were adjusted by zones to obtain the desired initial k_{eff} and a reasonably flat power distribution. The initial k_{eff} for a given fuel cycle was that which resulted in a maximum heavy atom burnup of 10% in the core. For the first cycle in a given case, the maximum local heavy atom burnup in the core was 5%. Half the volume of the core and the axial blanket fuel was removed at the end of each fuel cycle. Therefore, for each fuel cycle following the first, there were two levels of fuel exposure in the core and the axial blanket. Half the volume of the radial blanket fuel was removed on alternate fuel cycles. Therefore, there were two levels of fuel exposure in the radial blanket following cycle 2 for a given case. Within the limits of practicality, the refueling scheme for the radial blanket was designed to provide maximum fuel utilization without exceeding the limit of 10% maximum localized heavy atom burnup. Of course, the axial blanket was cycled with the core, which is necessary in a conventional cylindrical design regardless of burnup considerations.

The generalized refueling scheme is as follows:

	Cycle					
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
Core	0 + 0	0 + 1	0 + 1	0 + 1	0 + 1	0 + 1
Axial blanket	0 + 0	0 + 1	0 + 1	0 + 1	0 + 1	0 + 1
Radial blanket	0 + 0	1 + 1	0 + 2	1 + 3	0 + 2	1 + 3

Note: 0 = fresh fuel.

1 = fuel irradiated for one complete cycle.

2 = fuel irradiated for two complete cycles.

Equilibrium is manifested as alternate repeating cycles in discharge and feed enrichment. In other words, the feed and discharge enrichments for cycles i were identical for i equal to a positive integer greater than 2. The same is true for cycles $i + 1$. But

$$C_i \neq C_{i+1}$$

because of the radial blanket management procedure. The approach to equilibrium is illustrated in Figure 3-1 for the 2000-liter core (reference library). In all cases, the fourth fuel cycle was designated as the equilibrium fuel cycle.

Provision was made in the BWIG portion of the ZEUS package for multiplying the capture cross sections of all isotopes in the desired energy range by a designated factor FCAP. In addition, for all fissionable isotopes, provision was made for the fission cross section to be altered by a factor FFIS at all energies. This provision was used in the depletion calculations to form libraries with the fission product capture cross section increased by 50% at all energies, and, separately, with the ^{239}Pu capture cross section increased by 50% at all energies. The two modified libraries were used along with the reference libraries on both the 2000- and 8000-liter cores in the depletion calculations. Since this method allows the cross-section changes to affect the 68-group spectrum calculation, it correctly accounted for the effect of changes in the multigroup flux spectrum on the broad-group cross sections used in calculating reference, void, and Doppler core conditions in the 18-

Figure 3-1. Discharge and Feed Enrichments for
Small Core — Reference Library

group spatial calculation. In section 5 the influence of using these libraries is presented in terms of mass balances, breeding ratios, power peaking factors, enrichments, and discharge plutonium isotopic mix.

After equilibrium cycles had been determined for the six cases, perturbation worths were obtained for fuel isotopes, sodium, and fission products. Fuel temperature changes were incorporated in all cross-section libraries for use in end-of-equilibrium cycle criticality calculations. These results are also presented in section 5.

Depletion calculations were performed with the ZEUS (BWIG-GAMMIX-SIZZLE) package. Doppler coefficients resulted from SCRAMBLE criticality calculations. Isotopic worths were calculated using the one-dimensional worth compiler of the SCRAMBLE code.

The abbreviations used in this report are as follows:

<u>Designation</u>	<u>Item</u>
S, Small	2000-liter core.
L, Large	8000-liter core.
R, Ref	Reference cross section set for either 2000- or 8000-liter core.
FF	Reference cross section set with fission product capture cross sections increased 50% at all neutron energies.
Pu	Reference cross section set with ^{239}Pu capture cross sections increased 50% at all neutron energies.
BOC	Beginning of a fuel cycle.
EOC	End of a fuel cycle.
EC	Equilibrium cycle.
BOEC	Beginning of the equilibrium fuel cycle.
EOEC	End of the equilibrium fuel cycle.

4. PRELIMINARY INVESTIGATIONS

Before the depletion studies with the ZEUS (BWIG-GAMMIX-SIZZLE) fast reactor design package were begun, three preliminary investigations were carried out:

1. Determination of differences in the overall reactor characteristics resulting from using the new BWIG cross-section library instead of the old DHRG3 cross-section library.

2. Determination of the effects of using one 18-group cross-section set for the entire reactor (generated for the core composition) instead of using two cross-section libraries generated for the core and blanket compositions separately.

3. Determination of the effects on overall reactor characteristics of running reactor depletion calculations while maintaining small excess reactivity instead of maintaining the reactor critical by adding the burnable poison B_4C . The 2000-liter core and its reference library described in this report were used for all of these comparisons.

The first of the preliminary investigations was simply a check for gross inconsistencies in the results obtained using the newly formulated BWIG library (DHRG3 library data plus 68-group ENDF/B cross section and resonance parameters for Na, O, ^{238}U , ^{239}Pu , ^{240}Pu , ^{241}Pu , and fission products, all with the exception of elastic matrices) and the results of an identical case using the DHRG3 library. This served as a quick check of the BWIG set, so that the study could proceed expeditiously. In addition, the change from the DHRG3 library to the BWIG library is typical of the cross-section revisions that will be continually occurring. Thus, comparison of the core parameters calculated with these two libraries provides a realistic indication of the sensitivity of core performance to general cross-section revision.

Table 4-1 shows selected beginning- and end-of-cycle reactor physics parameters for the cases using the DHRG3 cross-section library and the new BWIG library. In both cases, separate cross-section sets were used in the core and the blankets. As can be seen from the table, agreement was quite good, and it was decided to proceed using the new BWIG library for all subsequent calculations.

Because of certain limitations in designating isotopic compositions in the current version of SIZZLE, it was necessary to use only one 18-group cross-section library in the depletion calculations in order to retain the identity of the two fuel exposures in each of the core and blanket zones (a stipulation of the contract). An investigation was carried out to ascertain the effects of this limitation. It was possible to do this on the first fuel cycle when only one level of fuel exposure was present in each core and blanket zone. Table 4-2 summarizes the calculated changes in physics parameters due to using a constant library (generated for the core composition) instead of using two libraries, one generated for the core composition and one for the blanket composition.

As indicated in Table 4-2, no significant sources of error were introduced by using the constant library. Thus, libraries generated for the core composition were used throughout the reactor in all subsequent cases.

The third comparison was made to establish the validity of performing the depletion calculations while maintaining small excess reactivity instead of forcing criticality with a B_4C search at each depletion cycle time step. The deletion of B_4C -maintained criticality greatly expedited the completion of the study owing to the computer time and the large number of cases involved. The available version of SIZZLE allowed an isotopic search in only those zones containing the first material. Power flattening requirements and the maintenance of fuel management procedures required the use of two materials in the core. Therefore, the calculation was limited to a B_4C search in the first core zone. For this comparison, the search was performed in core zone 1 with no control in zone 2. Table 4-3 shows the reactor physics parameters for the excess reactivity lifetime and those for the B_4C -maintained criticality lifetime.

The initial fissile loading (1032.2 kg) and enrichment were not changed in the case with no B₄C. Further, the comparison case was somewhat pessimistic, since further iteration determined that only 1.7% excess reactivity was required instead of 2.8%. This would reduce the observed differences even further.

The core breeding ratio and power fraction show good agreement at beginning of cycle (see Table 4-3). The small differences in the blanket and total breeding ratios shown in Table 4-3 are due to the change in flux and power shape as evidenced by the peaking factors in zones 1 and 2. Owing to the code limitation, the flux and power were depressed in zone 1 and peaked in zone 2. The slight increase in core leakage thus produced the higher blanket breeding ratio in the B₄C case. Again the results are pessimistic since the B₄C control had to be lumped in the center zone and could not be distributed uniformly throughout both core zones.

EOC isotopic densities (SR-cycle 1) for the two cases are given in Table 4-4. BOC and EOC core neutron balances are given in Tables 4-5, 4-6, and 4-7.

The burnup and depletion of the core were unaffected by substituting excess reactivity for boron control. The end-of-cycle neutron balance in Table 4-7, the physics parameters in Table 4-3, and the end-of-cycle number densities in Table 4-4 all indicate minimal differences in the final state of the core and blankets. Referring to Table 4-4 and considering only the larger differences, the fission product differences in zones 1 and 2 will tend to cancel so that no significant effect is observed for the core. In the blankets, the ²³⁸U and ²³⁹Pu differences are reasonable; the larger differences occur in isotopes having very small concentrations and consequently very little effect on the physics results. From the results of these comparisons, it was decided to maintain small excess reactivity in all depletion calculations.

Table 4-1. Comparison of Selected Parameters Obtained
Using DHRG3 and BWIG Cross-Section Sets

	DHRG3	BWIG	Change, %
<u>Beginning of Cycle</u>			
Core breeding ratio (BR_{core})	0.7723	0.7691	-0.42
Blanket breeding ratio (BR_{blkt})	0.6195	0.6226	+0.50
Total breeding ratio (BR_{total})	1.3918	1.3917	-0.01
Core zone 1 power peaking factor (PF_1)	1.2910	1.2839	-0.55
Core zone 2 power peaking factor (PF_2)	1.2740	1.2764	+0.19
Reactor fissile mass (M_f^R)	1032 kg	1032.2 kg	+0.02
Effective multiplication factor (λ)	1.0261	1.0282	+0.20
Average core power density ($\overline{\rho_P^C}$)	304.6 kW/l	305.3	+0.23
Core relative power (P_R^C)	0.9746	0.9754	+0.08
Blanket relative power (P_R^B)	0.0254	0.0246	-3.3
<u>End of Cycle</u>			
	(521 days)	(528.5 days)	
BR_{core}	0.7310	0.7243	-0.93
BR_{blkt}	0.6386	0.6414	+0.44
BR_{total}	1.3696	1.3657	-0.29
PF_1	1.3780	1.3736	-0.32
PF_2	1.164	1.2050	+3.4
$M_f^{R(a)}$	1163.0 kg	1165.43 kg	+0.21
λ	0.99948	1.0004	+0.09
$\overline{\rho_P^C}$	287.2 kW/l	286.46 kW/l	-0.26
P_R^C	0.9190	0.9163	-0.29
P_R^B	0.0810	0.0837	+3.2
Integrated breeding ratio (IBR) ^(b)	1.3832	1.3841	+0.07
$\Delta\lambda_{cycle}$	-0.02661	-0.02777	+0.42

(a) Includes ^{239}Np correction.

(b) Based on burnup rate of 1.05 g/MWd.

Table 4-2. Comparison of Case Using Library Generated for Both Core and Blanket With That Using Core Library Only

	Case 1	Case 2	Change, %
<u>Beginning of Cycle</u>			
BR_{core}	0.7691	0.7704	+0.17
BR_{blanket}	0.6226	0.6220	-0.10
BR_{total}	1.3917	1.3924	+0.05
PF_1	1.2839	1.2861	+0.17
PF_2	1.2764	1.2772	+0.06
$M_f^{R(a)}$	1032.2 kg	1032.2 kg	--
λ	1.0282	1.0282	--
$\overline{\rho_P^c}$	305.3	305.4	+0.03
P_R^c	0.9754	0.9757	+0.03
P_R^B	0.0246	0.0243	-1.22
<u>End of Cycle (528.5 days)</u>			
BR_{core}	0.7243	0.7314	+0.98
BR_{blanket}	0.6414	0.6443	+0.45
BR_{total}	1.3657	1.3757	+0.73
PF_1	1.3736	1.3784	+0.35
PF_2	1.2050	1.2050	--
$M_f^{R(a)}$	1165.43	1167.23	+0.15
λ	1.0004	0.99971	-0.07
$\overline{\rho_P^c}$	286.46	288.15	+0.59
P_R^c	0.9163	0.9216	+0.58
P_R^B	0.0837	0.0784	-0.3
$IBR^{(b)}$	1.3841	1.3893	+0.38
$\Delta\lambda_{\text{cycle}}$	-0.02777	-0.02849	+0.26

(a) Includes ^{239}Np correction.

(b) Based on burnup rate of 1.05 g/MWd.

Table 4-3. Comparison of Excess Reactivity Lifetime
With B₄C-Maintained Criticality Lifetime

	Beginning of Cycle		
	B ₄ C	No B ₄ C	Change, %
BR _{core}	0.7596	0.7704	+1.42
BR _{blanket}	0.6504	0.6220	-4.37
BR _{total}	1.4100	1.3924	-1.25
PF ₁	1.2094	1.2861	+6.3
PF ₂	1.2946	1.2772	-0.01
M _f ^{R(a)}	1032.2	1032.2	--
λ	0.99995	1.0282	--
$\overline{\rho}_P^c$	303.5	304.0	+0.14
P _R ^c	0.9743	0.9757	+0.14
P _R ^B	0.0257	0.0243	-5.45
	End of Cycle (528.5 days)		
	B ₄ C	No B ₄ C	Change, %
BR _{core}	0.7317	0.7314	-0.04
BR _{blanket}	0.6473	0.6443	-0.46
BR _{total}	1.3790	1.3757	-0.24
PF ₁	1.3752	1.3854	+0.74
PF ₂	1.2064	1.2050	-0.12
M _f ^{R(a)}	1170.53	1167.23	-0.28
λ	0.99908	0.99971	--
$\overline{\rho}_P^c$	287.71	288.15	+0.15
P _R ^c	0.9202	0.9216	+0.15
P _R ^B	0.0798	0.0784	-1.75
IBR ^(b)	1.3988	1.3893	-0.68

(a) Includes ²³⁹Np correction.

(b) Based on a burnup rate of 1.05 g/MWd.

Table 4-4. Comparison of End-of-Cycle Isotopic Densities for B₄C-Maintained Criticality (Case 1) and Excess Reactivity (Case 2)

Isotope	Core zone 1			Core zone 2		
	Case 1	Case 2	Change, %	Case 1	Case 2	Change, %
²⁴¹ Pu	0.3979-4	0.4009-4	+ 0.75	0.6802-2	0.6815-4	+ 0.19
²⁴⁰ Pu	0.2657-3	0.2676-3	+ 0.71	0.4240-3	0.4243-3	+ 0.07
²³⁸ U	0.6521-2	0.6512-2	- 0.14	0.5896-2	0.5899-2	+ 0.05
²³⁹ Pu	0.9134-3	0.9132-3	- 0.02	0.1378-2	0.1380-2	+ 0.14
²⁴² Pu	0.1817-4	0.1824-4	+ 0.38	0.3072-4	0.3076-4	+ 0.13
²³⁹ Np	0.2520-5	0.2536-5	+ 0.63	0.1402-5	0.1399-5	- 0.21
B _{nat}	0.1030-3	--	x	--	--	x
C	0.3535-4	--	x	--	--	x
O	0.1637-1	0.1637-1	--	0.1644-1	0.1644-1	--
Na	0.9283-2	0.9283-2	--	0.9283-2	0.9283-1	--
304 SS	0.1723-1	0.1723-1	--	0.1723-1	0.1723-1	--
FF	0.7811-3	0.7950-3	+ 1.7	0.7849-3	0.7750-3	- 1.3

Isotope	Axial blanket zone 1			Radial blanket zone 1		
	Case 1	Case 2	Change, %	Case 1	Case 2	Change, %
²⁴¹ Pu	0.8674-7	0.8313-7	- 4.3	0.9976-7	0.9541-7	- 4.6
²⁴⁰ Pu	0.5246-5	0.5096-5	- 2.9	0.6197-5	0.6012-5	- 3.1
²³⁸ U	0.7870-2	0.7874-2	+ 0.05	0.1010-1	0.1010-1	--
²³⁹ Pu	0.2201-3	0.2170-3	- 1.4	0.2692-3	0.2652-3	- 1.5
²⁴² Pu	0.1050-8	0.9914-9	- 5.9	0.1162-8	0.1094-8	- 5.3
²³⁹ Np	0.1547-5	0.1539-5	- 0.52	0.1882-5	0.1872-5	- 0.53
B _{nat}	--	--	x	--	--	x
C	--	--	x	--	--	x
O	0.1628-1	0.1628-1	--	0.2084-1	0.2084-1	--
Na	0.9283-2	0.9283-2	--	0.7043-2	0.7043-2	--
304 SS	0.1723-1	0.1723-1	--	0.1723-1	0.1723-1	--
FF	0.6822-4	0.6602-4	- 3.3	0.7616-4	0.7364-4	- 3.4

Table 4-5. Core Neutron Balance With B₄C (Absorptions + Leakage)_{core} ≡ (Productions)_{core} ≡ 1.0

<u>BOC</u>				
(Leakage = 0.25785)				
<u>Isotope</u>	<u>Absorption</u>	<u>Capture</u>	<u>Fission</u>	<u>Production</u>
²³⁹ Pu	0.33217	0.06179	0.27038	0.79297
²⁴⁰ Pu	0.03043	0.01669	0.01374	0.04206
²⁴¹ Pu	0.02072	0.00292	0.01780	0.05361
²⁴² Pu	0.00266	0.00163	0.00103	0.00316
²³⁸ U	0.28955	0.25137	0.03818	0.10820
¹⁶ O	0.00188	0.00188	--	--
²³ Na	0.00214	0.00214	--	--
SS-304	0.03538	0.03538	--	--
Pu-FF	--	--	--	--
B _{nat}	0.02724	0.02724	--	--
¹² C	<u>0.53 × 10⁻⁶</u>	<u>0.53 × 10⁻⁶</u>	<u>--</u>	<u>--</u>
Total	0.74217	0.40104	0.34113	1.00000

<u>EOC</u>				
(Leakage = 0.24883)				
<u>Isotope</u>	<u>Absorption</u>	<u>Capture</u>	<u>Fission</u>	<u>Production</u>
²³⁹ Pu	0.33068	0.06196	0.26872	0.78822
²⁴⁰ Pu	0.03460	0.01915	0.01545	0.04730
²⁴¹ Pu	0.02075	0.00294	0.01781	0.05368
²⁴² Pu	0.00280	0.00174	0.00106	0.00327
²³⁸ U	0.29239	0.25446	0.03793	0.10753
¹⁶ O	0.00194	0.00194	--	--
²³ Na	0.00226	0.00226	--	--
SS-304	0.03724	0.03724	--	--
Pu-FF	0.02050	0.02050	--	--
B _{nat}	0.00804	0.00804	--	--
¹² C	<u>0.18 × 10⁻⁶</u>	<u>0.18 × 10⁻⁶</u>	<u>--</u>	<u>--</u>
Total	0.75120	0.41073	0.34097	1.00000

Table 4-6. Core Neutron Balance Without B₄C (Absorptions + Leakage)_{core} ≡ (Productions)_{core} ≡ 1.0

<u>BOC</u>				
(Leakage = 0.25635)				
<u>Isotope</u>	<u>Absorption</u>	<u>Capture</u>	<u>Fission</u>	<u>Production</u>
²³⁹ Pu	0.34417	0.06517	0.27900	0.79534
²⁴⁰ Pu	0.03149	0.01763	0.01386	0.04128
²⁴¹ Pu	0.02156	0.00306	0.01850	0.05416
²⁴² Pu	0.00274	0.00171	0.00103	0.00309
²³⁸ U	0.30264	0.26414	0.02850	0.10613
¹⁶ O	0.00189	0.00189	--	--
²³ Na	0.00227	0.00227	--	--
SS-304	0.03691	0.03691	--	--
Pu-FF	--	--	--	--
B _{nat}	--	--	--	--
¹² C	--	--	--	--
Total	0.74367	0.39278	0.35089	1.00000

<u>EOC</u>				
(Leakage = 0.24835)				
<u>Isotope</u>	<u>Absorption</u>	<u>Capture</u>	<u>Fission</u>	<u>Production</u>
²³⁹ Pu	0.33438	0.06315	0.27123	0.78914
²⁴⁰ Pu	0.03512	0.01961	0.01551	0.04710
²⁴¹ Pu	0.02107	0.00300	0.01807	0.05404
²⁴² Pu	0.00282	0.00175	0.00107	0.00326
²³⁸ U	0.29533	0.25749	0.03784	0.10646
¹⁶ O	0.00194	0.00194	--	--
²³ Na	0.00231	0.00231	--	--
SS-304	0.03760	0.03760	--	--
Pu-FF	0.02109	0.02109	--	--
B _{nat}	--	--	--	--
¹² C	--	--	--	--
Total	0.75166	0.40794	0.34372	1.00000

Table 4-7. Small Excess Reactivity Lifetime and
B₄C-Maintained Criticality Lifetime;
Comparison of Core Neutron Balance

$$(\text{Absorptions} + \text{Leakage})_{\text{core}} \equiv (\text{Productions})_{\text{core}} \equiv 1.0$$

$$\text{All Entries} = \frac{\text{No B}_4\text{C} - \text{B}_4\text{C}}{\text{B}_4\text{C}} \times 100$$

BOC

% Changes
($\lambda = 1.0282$)
Leakage = 0.58

Isotope	Absorption	Capture	Fission	Production
²³⁹ Pu	+3.6	+5.5	+3.2	+0.30
²⁴⁰ Pu	+3.5	+5.6	+0.87	-1.9
²⁴¹ Pu	+4.1	+4.8	+3.9	+1.0
²⁴² Pu	+3.0	+4.9	0.0	-2.2
²³⁸ U	+4.5	+5.1	+0.84	-1.9
¹⁶ O	+0.53	+0.53	--	--
²³ Na	+6.1	+6.1	--	--
SS-304	+4.3	+4.3	--	--
Pu-FF	--	--	--	--
B _{nat}	-100	-100	--	--
¹² C	-100	-100	--	--
Total	+0.20	-2.1	+2.9	0.0

EOC

% Changes
Leakage = 0.19

Isotope	Absorption	Capture	Fission	Production
²³⁹ Pu	+1.1	+1.9	+0.93	+0.12
²⁴⁰ Pu	+1.5	+2.4	+0.39	-0.42
²⁴¹ Pu	+1.5	+2.0	+1.5	+0.67
²⁴² Pu	+0.71	+0.57	+0.94	-0.31
²³⁸ U	+1.0	+1.2	-0.24	-1.0
¹⁶ O	0.0	0.0	--	--
²³ Na	+2.2	+2.2	--	--
SS-304	+0.97	+0.97	--	--
Pu-FF	+2.9	+2.9	--	--
B _{nat}	-100	-100	--	--
¹² C	-100	-100	--	--
Total	+0.06	-0.56	+0.81	0.0

5. RESULTS

5.1. Depletion Calculations

Tables 5-1 through 5-6 show total breeding ratios (BOC and EOC) for each fuel cycle in each case. For the small core, the use of the FF cross-section set reduced the total breeding ratio at EC-BOC by about 3%. At EC-EOC the reduction in the total breeding ratio is approximately 0.4%. Using the plutonium set, the reduction in the total breeding ratio for the 2000-liter core is approximately 14% at EC-BOC, and approximately 11.5% at EC-EOC.

For the 8000-liter core, the use of the FF set reduced the total breeding ratio at EC-BOC by approximately 1.5%. At EC-EOC the reduction is about 1%. Using the plutonium set, the total breeding ratio is reduced about 12.5% at EC-BOC and about 9% at EC-EOC. Thus, the effect on breeding ratio is much more pronounced when using the plutonium set.

Tables 5-7 through 5-12 present power peaking factors for each cycle of each case at both BOC and EOC. Also, the ratio of these peaking factors in the two core zones is given for ease of comparison. Based on these tables, the introduction of the FF or plutonium sets does not seem to appreciably affect the power peaking, if all other conditions remain the same.

Tables 5-13 through 5-18 give feed, BOC average, EOC average, and discharge enrichments for each core zone and average for the core for each fuel cycle in each case. For the 2000-liter core, the FF set increases the average core enrichment by about 3.5% at EC-BOC and about 3% at EC-EOC. Using the plutonium set, the corresponding increases in average core enrichments are about 8% at EC-BOC and 5% at EC-EOC. For the 2000-liter core, the increase in average core enrichment at EC-BOC is about 2% when using the FF set. At EC-EOC, the increase is about 1%. Employing the plutonium set results in

increases of about 5% at EC-BOC and about 1.5% at EC-EOC. Thus, the required enrichment is increased more when using the plutonium set than the FF set.

Tables 5-19 through 5-68 show BOC and EOC total mass balances and EOC discharge mass balances by isotope and by core and blankets for each cycle of each case. Table 5-69 shows the average core discharge plutonium isotopic mixes for all cases. The feed plutonium mix in all cases was 76% ^{239}Pu , 19% ^{240}Pu , 3.5% ^{241}Pu , and 1.5% ^{242}Pu . Comparing the cases using the reference and the plutonium cross-section sets, there is as expected, a reduction in the ^{239}Pu fraction and a gain in the ^{240}Pu fraction due to the increased ^{239}Pu captures. Very small changes are seen when comparing the cases using the reference and the FF cross-section sets.

5.2. Worths and Coefficients

The following items were to be obtained at equilibrium fuel cycle conditions (except as noted) according to contract requirements:

1. Total fission product reactivity worth at the beginning and end of cycle, and the contribution to fission product worth resulting from capture.
2. For the two reference cases only: A comparison, at the beginning and end of cycle, of the fission product scattering contribution to worth with the worth of the scattering contribution of fissioned heavy atoms.
3. Worth, separately, of ^{238}U , ^{239}Pu , ^{240}Pu , and ^{241}Pu inventory changes between the beginning and end of cycle.
4. Worth of blanket plutonium inventory buildup from cycle beginning to end.
5. A representative sodium void decrement at cycle beginning and end. In addition, the effect of substituting the start-of-cycle fission product inventory and also the start-of-cycle blanket plutonium inventory on the end-of-cycle sodium void decrement will be determined.
6. Isothermal Doppler coefficients at cycle beginning and end.

7. In-core and total coefficients at cycle beginning and end.
8. Power peak-to-average values at cycle beginning and end.

All items except 2 and a portion of 7 were completed. Item 2 could not be obtained because the as-stipulated ENDF/B set used for lumped plutonium fission fragments contains no scattering matrix. As to item 7, both in-core and total worths were obtained in all instances, where applicable, except for the Doppler coefficients. In this case, only the in-core Doppler coefficients were calculated. This procedure was adopted for two reasons. First, owing to the nature of the axial and radial blanket representation in spherical geometry (alternating radial and axial spherical shell regions), difficulties were introduced in attempting to ascertain a meaningful average blanket fuel temperature change for a given core fuel temperature change. Second, past experience with standard B&W LMFBR calculations (oxide-fueled) has indicated that even when using larger average blanket fuel temperature changes (relative to a given core fuel temperature change) than are normally considered, the error introduced in the Doppler coefficient by considering only a change in the average core fuel temperature is at most very small.

All worth calculations were performed using the one-dimensional perturbation worth compiler of the multigroup, diffusion theory SCRAMBLE code.³ Doppler coefficients were determined using SCRAMBLE with Doppler-broadened cross-section sets from BWIG.⁴

All worths presented are indicative of reactivity associated with the addition of the particular isotope(s) or effect (Doppler) relative to an absence of the isotope (void) or effect. Each worth presented is determined based on the zonal concentration of the isotope(s) in question in the region designated, i.e., core and blankets. Thus, the worths presented are for 100% of the isotope(s) in question. They should therefore

- - - - -

³Scramble User's Manual; Digital Computer Group; Central Theory and Computing; AEE Winfrith, Dorchester, Dorset, Private Communication.

⁴ZEUS, A Fast Reactor Physics Design Package, Babcock & Wilcox (to be published).

be used only for comparison, since accuracy can only be expected for small changes using perturbation theory.

Tables 5-70 and 5-71 show the total fission product reactivity worth and the contribution to fission product worth resulting from capture for all cases at BOEC and EOEC, respectively, and also the percentage change observed when using the FF and plutonium libraries. As can be seen, for all cases the total fission product worth consists almost entirely of the capture component, since the leakage term is small and the scattering cross sections are missing. The use of the FF library increases the fission product worth from 40 to 50% for both core sizes at BOEC and EOEC. Use of the plutonium library decreases the core and core plus blanket fission product worth from 10 to 15% for both core sizes at BOEC and EOEC. The blanket fission product worth, however, increases for the small core at BOEC and EOEC, but decreases for the large core at BOEC and EOEC.

Tables 5-72 through 5-76 show isotopic worths at BOEC and EOEC for ^{238}U , ^{239}Pu , ^{241}Pu , and ^{242}Pu for all cases considered and the percentage change between BOEC and EOEC worths. Also given is the percentage change in worth relative to the reference cross-section set when using the FF or plutonium sets. From these tables, one could examine the effect of using the FF or plutonium sets on the worth of isotopic inventory changes for the isotopes in question. Also, the effect of using the altered sets on the BOEC and EOEC worths individually could easily be determined. Since the tables are self-explanatory, no attempt is made to discuss the various comparisons.

Table 5-77 shows the worth of the total blanket plutonium inventory at BOEC and EOEC for all cases and the difference in BOEC and EOEC values in terms of a percentage change. Also, the percentage change due to using the FF and plutonium sets is given. In general, the changes in blanket plutonium inventory buildup from BOEC to EOEC, and also BOEC and EOEC values individually, are affected more by the plutonium set than the FF set.

Table 5-78 gives sodium worths at BOEC and EOEC and the effect of using the FF and plutonium sets on the sodium worths in terms of a percentage difference. With no specifics being mentioned, it can be

seen from the table that the plutonium set affects the sodium worth at both BOEC and EOEC more than the FF set does.

Table 5-79 reflects the effect of substituting the BOEC fission product inventory and, separately, the BOEC blanket plutonium inventory, on the EOEC sodium worth. The percentage change due to each of the above-mentioned substitutions is also given. Substitution of the BOEC fission product inventory affects the EOEC sodium worth by decreasing the in-core and total worth from 4 to 10% and decreasing the blanket sodium worth from 1 to 3% for all cases. The substitution of blanket plutonium increases the in-core and total EOEC sodium worth, but only very slightly. The effect on the blanket sodium worth is a decrease from 4 to 12%.

Table 5-80 gives BOEC and EOEC in-core Doppler coefficients for all cases and the percentage changes from the reference cases. As would be expected with the plutonium set, the effect of the substitutions is greater than with the FF set.

Table 5-1. Total Breeding Ratios
(Small Core, Ref Library)

<u>Cycle</u>	<u>BOC</u>	<u>EOC</u>
1	1.4200	1.4001
2	1.3684	1.3607
3	1.3628	1.3562
4	1.3630	1.3540
5	1.3795	1.3680

Table 5-2. Total Breeding Ratios
(Small Core, FF Library)

<u>Cycle</u>	<u>BOC</u>	<u>EOC</u>
1	1.3975	1.3858
2	1.3304	1.3324
3	1.3481	1.3462
4	1.3259	1.3481

Table 5-3. Total Breeding Ratios
(Small Core, Pu Library)

<u>Cycle</u>	<u>BOC</u>	<u>EOC</u>
1	1.2099	1.2421
2	1.1890	1.2213
3	1.1839	1.2173
4	1.1683	1.2001

Table 5-4. Total Breeding Ratios
(Large Core, Ref Library)

<u>Cycle</u>	<u>BOC</u>	<u>EOC</u>
1	1.4554	1.3463
2	1.3923	1.3055
3	1.3916	1.3059
4	1.3792	1.2974

Table 5-5. Total Breeding Ratios
(Large Core, FF Library)

<u>Cycle</u>	<u>BOC</u>	<u>EOC</u>
1	1.4300	1.3324
2	1.3695	1.2933
3	1.3732	1.2962
4	1.3573	1.2852

Table 5-6. Total Breeding Ratios
(Large Core, Pu Library)

<u>Cycle</u>	<u>BOC</u>	<u>EOC</u>
1	1.2272	1.1981
2	1.2139	1.1868
3	1.2078	1.1829
4	1.2051	1.1792

Table 5-7. Power Peaking Factors
(Small Core, Ref Library)

	<u>BOC</u>	<u>EOC</u>
<u>Cycle 1</u>		
Core zone 1	1.2876	1.3637
Core zone 2	1.2781	1.2194
$(PF)_1/(PF)_2$	1.0074	1.1183
<u>Cycle 2</u>		
Core zone 1	1.3196	1.3752
Core zone 2	1.2454	1.1992
$(PF)_1/(PF)_2$	1.0590	1.1468
<u>Cycle 3</u>		
Core zone 1	1.3010	1.3597
Core zone 2	1.2547	1.2071
$(PF)_1/(PF)_2$	1.0369	1.1264
<u>Cycle 4</u>		
Core zone 1	1.3192	1.3714
Core zone 2	1.2367	1.1920
$(PF)_1/(PF)_2$	1.0667	1.1505
<u>Cycle 5</u>		
Core zone 1	1.2837	1.3493
Core zone 2	1.2623	1.2113
$(PF)_1/(PF)_2$	1.0170	1.1140

Table 5-8. Power Peaking Factors
(Small Core, FF Library)

	<u>BOC</u>	<u>EOC</u>
<u>Cycle 1</u>		
Core zone 1	1.2862	1.3521
Core zone 2	1.2772	1.2228
$(PF)_1/(PF)_2$	1.0071	1.1057
<u>Cycle 2</u>		
Core zone 1	1.2430	1.2953
Core zone 2	1.2886	1.2327
$(PF)_1/(PF)_2$	0.96464	1.0507
<u>Cycle 3</u>		
Core zone 1	1.2501	1.3047
Core zone 2	1.2859	1.2288
$(PF)_1/(PF)_2$	0.97216	1.0618
<u>Cycle 4</u>		
Core zone 1	1.2219	1.2787
Core zone 2	1.2891	1.2317
$(PF)_1/(PF)_2$	0.94788	1.0381

Table 5-9. Power Peaking Factors
(Small Core, Pu Library)

	<u>BOC</u>	<u>EOC</u>
<u>Cycle 1</u>		
Core zone 1	1.2847	1.3302
Core zone 2	1.2775	1.2362
$(PF)_1/(PF)_2$	1.0057	1.0760
<u>Cycle 2</u>		
Core zone 1	1.2865	1.2923
Core zone 2	1.2522	1.2389
$(PF)_1/(PF)_2$	0.97334	1.0431
<u>Cycle 3</u>		
Core zone 1	1.2568	1.2956
Core zone 2	1.2858	1.2388
$(PF)_1/(PF)_2$	0.97744	1.0459
<u>Cycle 4</u>		
Core zone 1	1.2344	1.2753
Core zone 2	1.2871	1.2396
$(PF)_1/(PF)_2$	0.95906	1.0288

Table 5-10. Power Peaking Factors
(Large Core, Ref Library)

	<u>BOC</u>	<u>EOC</u>
<u>Cycle 1</u>		
Core zone 1	1.0446	1.3248
Core zone 2	1.3612	1.2319
$(PF)_1/(PF)_2$	0.76737	1.0754
<u>Cycle 2</u>		
Core zone 1	1.1695	1.3904
Core zone 2	1.2988	1.1956
$(PF)_1/(PF)_2$	0.90046	1.1629
<u>Cycle 3</u>		
Core zone 1	1.1246	1.3540
Core zone 2	1.3160	1.2088
$(PF)_1/(PF)_2$	0.85459	1.1201
<u>Cycle 4</u>		
Core zone 1	1.0913	1.3196
Core zone 2	1.3168	1.2109
$(PF)_1/(PF)_2$	0.82878	1.0898

Table 5-11. Power Peaking Factors
(Large Core, FF Library)

	<u>BOC</u>	<u>EOC</u>
<u>Cycle 1</u>		
Core zone 1	1.0447	1.3002
Core zone 2	1.3614	1.2383
$(PF)_1/(PF)_2$	0.76736	1.0500
<u>Cycle 2</u>		
Core zone 1	1.1561	1.3547
Core zone 2	1.3028	1.2045
$(PF)_1/(PF)_2$	0.88741	1.1247
<u>Cycle 3</u>		
Core zone 1	1.1191	1.3269
Core zone 2	1.3168	1.2145
$(PF)_1/(PF)_2$	0.84987	1.0925
<u>Cycle 4</u>		
Core zone 1	1.0856	1.2919
Core zone 2	1.3182	1.2174
$(PF)_1/(PF)_2$	0.82352	1.0612

Table 5-12. Power Peaking Factors
(Large Core, Pu Library)

	<u>BOC</u>	<u>EOC</u>
<u>Cycle 1</u>		
Core zone 1	1.0358	1.2473
Core zone 2	1.3591	1.2611
$(PF)_1/(PF)_2$	0.76210	0.98909
<u>Cycle 2</u>		
Core zone 1	1.1331	1.3130
Core zone 2	1.3130	1.2231
$(PF)_1/(PF)_2$	0.86302	1.0735
<u>Cycle 3</u>		
Core zone 1	1.1084	1.2903
Core zone 2	1.3229	1.2317
$(PF)_1/(PF)_2$	0.83783	1.0476
<u>Cycle 4</u>		
Core zone 1	1.1054	1.2856
Core zone 2	1.3137	1.2243
$(PF)_1/(PF)_2$	0.84142	1.0501

Table 5-13. Enrichments^(a)
(Small Core, Ref Library)

	<u>Feed</u>	<u>BOC</u>	<u>EOC</u>	<u>Discharge</u>
<u>Cycle 1</u>				
Core zone 1	0.11564	0.11564	0.12063	0.12063
Core zone 2	0.19658	0.19658	0.18653	0.18653
Core average	0.15620	0.15620	0.15368	0.15368
<u>Cycle 2</u>				
Core zone 1	0.12050	0.12056	0.12414	0.12424
Core zone 2	0.20238	0.19461	0.18516	0.17832
Core average	0.16154	0.15768	0.15477	0.15141
<u>Cycle 3</u>				
Core zone 1	0.11705	0.12048	0.12406	0.12679
Core zone 2	0.20246	0.19721	0.18739	0.18279
Core average	0.15986	0.15895	0.15584	0.15492
<u>Cycle 4</u>				
Core zone 1	0.11505	0.12069	0.12431	0.12897
Core zone 2	0.20008	0.19175	0.18278	0.17523
Core average	0.15766	0.15634	0.15368	0.15227
<u>Cycle 5</u>				
Core zone 1	0.11705	0.11850	0.12263	0.12380
Core zone 2	0.20246	0.19625	0.18649	0.18104
Core average	0.15986	0.15747	0.15466	0.20288

(a) In Tables 5-13 through 5-18, enrichment = $\frac{\text{mass } ({}^{239}\text{Pu} + {}^{241}\text{Pu})}{\text{mass } (\text{Pu} + \text{U})}$
including ${}^{239}\text{Np}$ correction.

Table 5-14. Enrichments
(Small Core, FF Library)

	<u>Feed</u>	<u>BOC</u>	<u>EOC</u>	<u>Discharge</u>
<u>Cycle 1</u>				
Core zone 1	0.11736	0.11736	0.12179	0.12179
Core zone 2	0.19951	0.19951	0.18911	0.18911
Core average	0.15853	0.15853	0.15555	0.15555
<u>Cycle 2</u>				
Core zone 1	0.12085	0.12131	0.12450	0.12491
Core zone 2	0.22341	0.20660	0.19554	0.18058
Core average	0.17228	0.16408	0.16012	0.15283
<u>Cycle 3</u>				
Core zone 1	0.11607	0.12001	0.12357	0.12671
Core zone 2	0.19828	0.20403	0.19325	0.19845
Core average	0.15727	0.16210	0.15847	0.16263
<u>Cycle 4</u>				
Core zone 1	0.11818	0.11934	0.12300	0.12396
Core zone 2	0.21820	0.20352	0.19296	0.17990
Core average	0.16833	0.16154	0.15805	0.15202

Table 5-15. Enrichments
(Small Core, Pu Library)

	<u>Feed</u>	<u>BOC</u>	<u>EOC</u>	<u>Discharge</u>
<u>Cycle 1</u>				
Core zone 1	0.12492	0.12492	0.12417	0.12417
Core zone 2	0.21235	0.21235	0.19755	0.19755
Core average	0.16874	0.16874	0.16096	0.16096
<u>Cycle 2</u>				
Core zone 1	0.12625	0.12523	0.12379	0.12450
Core zone 2	0.22816	0.21316	0.18527	0.19848
Core average	0.17735	0.16932	0.15464	0.16159
<u>Cycle 3</u>				
Core zone 1	0.12634	0.12577	0.12453	0.12490
Core zone 2	0.21688	0.21411	0.19698	0.19935
Core average	0.17172	0.17004	0.16081	0.16220
<u>Cycle 4</u>				
Core zone 1	0.12483	0.12503	0.12437	0.12461
Core zone 2	0.22407	0.21307	0.19863	0.18893
Core average	0.17458	0.16916	0.16158	0.15686

Table 5-16. Enrichments
(Large Core, Ref Library)

	<u>Feed</u>	<u>BOC</u>	<u>EOC</u>	<u>Discharge</u>
<u>Cycle 1</u>				
Core zone 1	0.09229	0.09229	0.10485	0.10485
Core zone 2	0.15689	0.15689	0.15273	0.15273
Core average	0.12465	0.12465	0.12883	0.12883
<u>Cycle 2</u>				
Core zone 1	0.09229	0.09846	0.10908	0.11371
Core zone 2	0.15689	0.15485	0.15126	0.14955
Core average	0.12465	0.12671	0.13024	0.13171
<u>Cycle 3</u>				
Core zone 1	0.09127	0.09783	0.10854	0.11348
Core zone 2	0.16007	0.15677	0.15281	0.15003
Core average	0.12574	0.12737	0.13075	0.13184
<u>Cycle 4</u>				
Core zone 1	0.09142	0.09750	0.10808	0.11269
Core zone 2	0.15718	0.15635	0.15248	0.15182
Core average	0.12436	0.12698	0.13033	0.13232

Table 5-17. Enrichments
(Large Core, FF Library)

	<u>Feed</u>	<u>BOC</u>	<u>EOC</u>	<u>Discharge</u>
<u>Cycle 1</u>				
Core zone 1	0.09381	0.09381	0.10571	0.10571
Core zone 2	0.15948	0.15948	0.15487	0.15487
Core average	0.12671	0.12671	0.13033	0.13033
<u>Cycle 2</u>				
Core zone 1	0.09438	0.09995	0.10989	0.11411
Core zone 2	0.16044	0.15770	0.15362	0.15130
Core average	0.12747	0.12888	0.13182	0.13278
<u>Cycle 3</u>				
Core zone 1	0.09268	0.09914	0.10927	0.11417
Core zone 2	0.16175	0.15885	0.15453	0.15208
Core average	0.12728	0.12906	0.13197	0.13320
<u>Cycle 4</u>				
Core zone 1	0.09368	0.09902	0.10896	0.11305
Core zone 2	0.16073	0.15885	0.15454	0.15297
Core average	0.12726	0.12899	0.13180	0.13307

Table 5-18. Enrichments
(Large Core, Pu Library)

	<u>Feed</u>	<u>BOC</u>	<u>EOC</u>	<u>Discharge</u>
<u>Cycle 1</u>				
Core zone 1	0.10044	0.10044	0.10726	0.10726
Core zone 2	0.17074	0.17074	0.16158	0.16158
Core average	0.13566	0.13566	0.13446	0.13446
<u>Cycle 2</u>				
Core zone 1	0.09817	0.10264	0.10872	0.11208
Core zone 2	0.16711	0.16439	0.15652	0.15428
Core average	0.13271	0.13357	0.13268	0.13324
<u>Cycle 3</u>				
Core zone 1	0.10011	0.10275	0.10875	0.11076
Core zone 2	0.17370	0.16632	0.15809	0.15189
Core average	0.13698	0.13460	0.13348	0.13139
<u>Cycle 4</u>				
Core zone 1	0.09785	0.10225	0.10834	0.11167
Core zone 2	0.16332	0.16371	0.15598	0.15638
Core average	0.13065	0.13303	0.13221	0.13408

Table 5-19. Mass Balance, kg
(Small Core, Ref Library, Cycle 1)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>BOC</u>				
²³⁹ Pu ^(a)	968.81	0.00	0.00	968.81
²⁴⁰ Pu	242.20	0.00	0.00	242.20
²⁴¹ Pu	44.62	0.00	0.00	44.62
²⁴² Pu	19.12	0.00	0.00	19.12
Total Pu	1274.75	0.00	0.00	1,274.75
²³⁸ U	5213.21	4287.79	18,495.27	27,996.27
Total (U + Pu)	6487.96	4287.79	18,495.27	29,271.02
<u>EOC</u>				
²³⁹ Pu ^(a)	916.39	46.15	112.19	1,074.73
²⁴⁰ Pu	264.19	0.52	0.99	265.70
²⁴¹ Pu	42.82	0.00	0.01	42.83
²⁴² Pu	19.30	0.00	0.00	19.30
Total Pu	1242.70	46.67	113.19	1,402.56
²³⁸ U	4998.98	4236.98	18,374.18	27,610.14
Total (U + Pu)	6241.68	4283.65	18,487.37	29,012.70

(a) Includes ²³⁹Np correction in Tables 3-19 through 3-68.

Table 5-20. Discharge Mass Balance, kg
(Small Core, Ref Library, Cycle 1)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>EOC</u>				
²³⁹ Pu	458.20	23.08	0.00	481.28
²⁴⁰ Pu	132.10	0.26	0.00	132.36
²⁴¹ Pu	21.41	0.00	0.00	21.41
²⁴² Pu	9.65	0.00	0.00	9.65
Total Pu	621.35	23.34	0.00	644.69
²³⁸ U	2499.49	2118.49	0.00	4,617.98
Total (U + Pu)	3120.84	2141.83	0.00	5,262.67

Table 5-21. Mass Balance, kg
(Small Core, Ref Library, Cycle 2)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>BOC</u>				
²³⁹ Pu	959.28	23.22	112.19	1,094.69
²⁴⁰ Pu	267.37	0.26	0.99	258.62
²⁴¹ Pu	44.49	0.00	0.01	44.50
²⁴² Pu	19.54	0.00	0.00	19.54
Total Pu	1280.68	23.48	113.19	1,417.35
²³⁸ U	5085.12	4262.39	18,374.18	27,721.69
Total (U + Pu)	6365.80	4285.87	18,487.37	29,139.04
<u>EOC</u>				
²³⁹ Pu	905.09	66.76	216.40	1,188.25
²⁴⁰ Pu	276.81	1.23	3.73	281.77
²⁴¹ Pu	43.32	0.02	0.06	43.40
²⁴² Pu	19.67	0.00	0.00	19.67
Total Pu	1244.89	68.01	220.19	1,533.09
²³⁸ U	4883.00	4211.93	18,252.84	27,347.77
Total (U + Pu)	6127.89	4279.94	18,473.03	28,880.86

Table 5-22. Discharge Mass Balance, kg
(Small Core, Ref Library, Cycle 2)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>EOC</u>				
²³⁹ Pu	433.91	43.79	108.20	585.90
²⁴⁰ Pu	140.71	0.98	1.87	143.56
²⁴¹ Pu	21.20	0.00	0.03	21.23
²⁴² Pu	9.70	0.00	0.00	9.70
Total Pu	605.52	44.77	110.10	760.39
²³⁸ U	2400.27	2093.44	9,126.42	13,620.13
Total (U + Pu)	3005.79	2138.21	9,236.52	14,380.52

Table 5-23. Mass Balance, kg
(Small Core, Ref Library, Cycle 3)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>BOC</u>				
²³⁹ Pu	967.02	22.97	108.20	1,098.19
²⁴⁰ Pu	260.07	0.25	1.86	262.18
²⁴¹ Pu	44.96	0.00	0.03	44.99
²⁴² Pu	19.76	0.00	0.00	19.76
Total Pu	1291.81	23.22	110.09	1,425.12
²³⁸ U	5074.95	4262.38	18,374.05	27,711.38
Total (U + Pu)	6366.76	4285.60	18,594.23	29,246.59
<u>EOC</u>				
²³⁹ Pu	911.31	66.46	212.68	1,190.45
²⁴⁰ Pu	279.41	1.21	4.46	285.08
²⁴¹ Pu	43.77	0.02	0.10	43.89
²⁴² Pu	19.88	0.00	0.00	19.88
Total Pu	1254.37	67.69	217.24	1,539.30
²³⁸ U	4874.09	4212.01	18,252.96	27,339.06
Total (U + Pu)	6128.46	4279.70	18,470.20	28,878.36

Table 5-24. Discharge Mass Balance, kg
(Small Core, Ref Library, Cycle 3)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>EOC</u>				
²³⁹ Pu	443.64	43.54	0.00	487.18
²⁴⁰ Pu	144.80	0.96	0.00	145.76
²⁴¹ Pu	21.88	0.02	0.00	21.90
²⁴² Pu	10.02	0.00	0.00	10.02
Total Pu	620.34	44.52	0.00	664.86
²³⁸ U	2384.60	2093.48	0.00	4,478.08
Total (U + Pu)	3004.94	2138.00	0.00	5,142.94

Table 5-29. Mass Balance, kg
(Small Core, FF Library, Cycle 1)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>BOC</u>				
²³⁹ Pu	983.38	0.00	0.00	983.38
²⁴⁰ Pu	245.85	0.00	0.00	245.85
²⁴¹ Pu	45.30	0.00	0.00	45.30
²⁴² Pu	<u>19.41</u>	<u>0.00</u>	<u>0.00</u>	<u>19.41</u>
Total Pu	1293.94	0.00	0.00	1,293.94
²³⁸ U	<u>5194.88</u>	<u>4287.79</u>	<u>18,495.27</u>	<u>27,977.94</u>
Total (U + Pu)	6488.82	4287.79	18,495.27	29,271.88
<u>EOC</u>				
²³⁹ Pu	927.57	45.72	111.21	1,084.50
²⁴⁰ Pu	267.56	0.51	0.96	269.03
²⁴¹ Pu	43.43	0.00	0.01	43.44
²⁴² Pu	<u>19.57</u>	<u>0.00</u>	<u>0.00</u>	<u>19.57</u>
Total Pu	1258.13	46.23	112.18	1,416.54
²³⁸ U	<u>4984.36</u>	<u>4237.46</u>	<u>18,375.28</u>	<u>27,597.10</u>
Total (U + Pu)	6242.49	4283.69	18,487.46	29,013.64

Table 5-30. Discharge Mass Balance, kg
(Small Core, FF Library, Cycle 1)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>EOC</u>				
²³⁹ Pu	463.78	22.86	0.00	486.64
²⁴⁰ Pu	133.78	0.26	0.00	134.04
²⁴¹ Pu	21.72	0.00	0.00	21.72
²⁴² Pu	<u>9.79</u>	<u>0.00</u>	<u>0.00</u>	<u>9.79</u>
Total Pu	629.07	23.12	0.00	652.19
²³⁸ U	<u>2492.18</u>	<u>2118.73</u>	<u>0.00</u>	<u>4,610.91</u>
Total (U + Pu)	3121.25	2141.85	0.00	5,263.10

Table 5-31. Mass Balance, kg
(Small Core, FF Library, Cycle 2)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>BOC</u>				
²³⁹ Pu	998.52	22.86	111.21	1,132.59
²⁴⁰ Pu	267.47	0.26	0.96	268.69
²⁴¹ Pu	46.35	0.00	0.01	46.36
²⁴² Pu	20.34	0.00	0.00	20.34
Total Pu	1332.68	23.12	112.18	1,467.98
²³⁸ U	5035.48	4262.63	18,375.28	27,673.39
Total (U + Pu)	6368.16	4285.75	18,487.46	29,141.37
<u>EOC</u>				
²³⁹ Pu	936.58	66.08	214.90	1,217.56
²⁴⁰ Pu	286.27	1.20	3.64	291.11
²⁴¹ Pu	44.99	0.02	0.06	45.07
²⁴² Pu	20.44	0.00	0.00	20.44
Total Pu	1288.28	67.30	218.60	1,574.18
²³⁸ U	4842.03	4212.53	18,254.59	27,309.15
Total (U + Pu)	6130.31	4279.83	18,473.19	28,883.33

Table 5-32. Discharge Mass Balance, kg
(Small Core, FF Library, Cycle 2)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>EOC</u>				
²³⁹ Pu	438.41	43.30	107.45	589.16
²⁴⁰ Pu	141.92	0.95	1.82	144.69
²⁴¹ Pu	21.42	0.02	0.03	21.47
²⁴² Pu	9.82	0.00	0.00	9.82
Total Pu	611.57	44.27	109.30	765.14
²³⁸ U	2396.71	2093.86	9,127.29	13,617.86
Total (U + Pu)	3008.28	2138.13	9,236.59	14,383.00

Table 5-33. Mass Balance, kg
(Small Core, FF Library, Cycle 3)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>BOC</u>				
²³⁹ Pu	985.92	22.78	107.45	1,116.15
²⁴⁰ Pu	266.29	0.25	1.82	268.36
²⁴¹ Pu	46.03	0.00	0.03	46.06
²⁴² Pu	20.25	0.00	0.00	20.25
Total Pu	1318.49	23.03	109.30	1,450.82
²³⁸ U	5047.72	4262.56	18,374.93	27,685.21
Total (U + Pu)	6366.21	4285.59	18,484.23	29,136.03
<u>EOC</u>				
²³⁹ Pu	926.43	66.33	212.30	1,205.06
²⁴⁰ Pu	285.05	1.20	4.40	290.65
²⁴¹ Pu	44.72	0.02	0.09	44.83
²⁴² Pu	20.35	0.00	0.00	20.35
Total Pu	1276.55	67.55	216.79	1,560.89
²³⁸ U	4851.54	4212.10	18,253.42	27,317.06
Total (U + Pu)	6128.09	4279.65	18,470.21	28,877.95

Table 5-34. Discharge Mass Balance, kg
(Small Core, FF Library, Cycle 3)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>EOC</u>				
²³⁹ Pu	469.99	43.39	0.00	513.38
²⁴⁰ Pu	152.97	0.95	0.00	153.92
²⁴¹ Pu	23.22	0.02	0.00	23.24
²⁴² Pu	10.65	0.00	0.00	10.65
Total Pu	656.83	44.36	0.00	701.19
²³⁸ U	2350.19	2093.62	0.00	4,443.81
Total (U + Pu)	3007.02	2137.98	0.00	5,145.00

Table 5-35. Mass Balance, kg
(Small Core, FF Library, Cycle 4)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>BOC</u>				
²³⁹ Pu	983.81	22.94	212.30	1,219.05
²⁴⁰ Pu	262.68	0.25	4.40	267.33
²⁴¹ Pu	45.56	0.00	0.09	45.65
²⁴² Pu	20.00	0.00	0.00	20.00
Total Pu	1312.05	23.19	216.79	1,552.03
²³⁸ U	5060.21	4262.38	18,253.41	27,576.00
Total (U + Pu)	6372.26	4285.57	18,470.20	29,128.03
<u>EOC</u>				
²³⁹ Pu	926.21	66.53	310.24	1,302.98
²⁴⁰ Pu	281.26	1.15	8.46	290.87
²⁴¹ Pu	44.24	0.02	0.22	44.48
²⁴² Pu	20.10	0.00	0.01	20.11
Total Pu	1271.81	67.70	318.93	1,658.44
²³⁸ U	4868.37	4211.67	18,131.49	27,211.53
Total (U + Pu)	6140.18	4279.37	18,450.42	28,869.97

Table 5-36. Discharge Mass Balance, kg
(Small Core, FF Library, Cycle 4)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>EOC</u>				
²³⁹ Pu	437.14	43.56	200.82	681.52
²⁴⁰ Pu	140.25	0.94	6.64	147.83
²⁴¹ Pu	21.21	0.02	0.19	21.42
²⁴² Pu	9.72	0.00	0.00	9.72
Total Pu	608.32	44.52	207.65	860.49
²³⁸ U	2406.76	2093.31	9,006.90	13,506.97
Total (U + Pu)	3015.08	2137.83	9,214.55	14,367.46

Table 5-37. Mass Balance, kg
(Small Core, Pu Library, Cycle 1)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>BOC</u>				
²³⁹ Pu	1047.330	0.000	0.000	1,047.330
²⁴⁰ Pu	261.834	0.000	0.000	261.834
²⁴¹ Pu	48.240	0.000	0.000	48.240
²⁴² Pu	<u>20.670</u>	<u>0.000</u>	<u>0.000</u>	<u>20.670</u>
Total Pu	1378.074	0.000	0.000	1,378.074
²³⁸ U	<u>5114.458</u>	<u>4287.793</u>	<u>18,495.268</u>	<u>27,897.519</u>
Total (U + Pu)	6492.532	4287.793	18,495.268	29,275.593
<u>EOC</u>				
²³⁹ Pu	959.066	43.840	107.144	1,110.050
²⁴⁰ Pu	302.024	0.692	1.318	304.034
²⁴¹ Pu	46.390	0.008	0.011	46.409
²⁴² Pu	<u>20.762</u>	<u>0.000</u>	<u>0.000</u>	<u>20.762</u>
Total Pu	1328.242	44.540	108.473	1,481.255
²³⁸ U	<u>4918.204</u>	<u>4239.316</u>	<u>18,379.260</u>	<u>27,536.780</u>
Total (U + Pu)	6246.446	4283.856	18,487.733	29,018.035

Table 5-38. Discharge Mass Balance, kg
(Small Core, Pu Library, Cycle 1)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>EOC</u>				
²³⁹ Pu	479.533	21.920	0.000	501.453
²⁴⁰ Pu	151.012	0.346	0.000	151.358
²⁴¹ Pu	23.195	0.004	0.000	23.199
²⁴² Pu	<u>10.381</u>	<u>0.000</u>	<u>0.000</u>	<u>10.381</u>
Total Pu	664.121	22.270	0.000	686.391
²³⁸ U	<u>2459.102</u>	<u>2119.658</u>	<u>0.000</u>	<u>4,578.760</u>
Total (U + Pu)	3123.223	2141.928	0.000	5,265.151

Table 5-39. Mass Balance, kg
(Small Core, Pu Library, Cycle 2)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>BOC</u>				
²³⁹ Pu	1030.178	21.920	107.144	1,159.242
²⁴⁰ Pu	288.674	0.346	1.318	290.338
²⁴¹ Pu	48.558	0.003	0.011	48.572
²⁴² Pu	21.249	0.000	0.000	21.249
Total Pu	1388.659	22.269	108.473	1,519.401
²³⁸ U	4982.389	4263.554	18,379.264	27,625.207
Total (U + Pu)	6371.048	4285.823	18,487.737	29,144.608
<u>EOC</u>				
²³⁹ Pu	943.401	63.840	207.890	1,215.131
²⁴⁰ Pu	323.845	1.652	5.026	331.172
²⁴¹ Pu	47.592	0.024	0.076	47.692
²⁴² Pu	21.310	0.000	0.000	21.310
Total Pu	1336.148	65.516	212.992	1,614.656
²³⁸ U	4796.079	4214.598	18,261.080	27,271.757
Total (U + Pu)	6132.227	4280.114	18,474.072	28,886.413

Table 5-40. Discharge Mass Balance, kg
(Small Core, Pu Library, Cycle 2)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>EOC</u>				
²³⁹ Pu	442.205	41.689	103.945	587.839
²⁴⁰ Pu	166.573	1.308	2.513	170.394
²⁴¹ Pu	23.228	0.021	0.038	23.287
²⁴² Pu	10.402	0.000	0.000	10.402
Total Pu	642.408	43.018	106.496	791.922
²³⁸ U	2367.357	2095.348	9,130.540	13,593.245
Total (U + Pu)	3009.765	2138.366	9,237.036	14,385.167

Table 5-41. Mass Balance, kg
(Small Core, Pu Library, Cycle 3)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>BOC</u>				
²³⁹ Pu	1034.198	22.152	103.943	1,160.293
²⁴⁰ Pu	291.172	0.344	2.513	294.029
²⁴¹ Pu	48.914	0.003	0.038	48.955
²⁴² Pu	21.428	0.000	0.000	21.428
Total Pu	1395.712	22.499	106.494	1,524.705
²³⁸ U	4974.202	4263.146	18,378.175	27,615.523
Total (U + Pu)	6369.914	4285.645	18,484.669	29,140.228
<u>EOC</u>				
²³⁹ Pu	946.539	63.826	204.526	1,214.891
²⁴⁰ Pu	326.869	1.639	6.029	334.537
²⁴¹ Pu	47.933	0.024	0.132	48.089
²⁴² Pu	21.484	0.000	0.002	21.486
Total Pu	1342.825	65.489	210.689	1,619.003
²³⁸ U	4788.512	4214.487	18,260.703	27,263.702
Total (U + Pu)	6131.337	4279.976	18,471.392	28,882.705

Table 5-42. Discharge Mass Balance, kg
(Small Core, Pu Library, Cycle 3)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>EOC</u>				
²³⁹ Pu	459.108	41.797	0.000	500.905
²⁴⁰ Pu	173.905	1.301	0.000	175.206
²⁴¹ Pu	24.353	0.021	0.000	24.374
²⁴² Pu	10.926	0.000	0.000	10.926
Total Pu	668.292	43.119	0.000	711.411
²³⁸ U	2338.042	2095.091	0.000	4,433.133
Total (U + Pu)	3006.334	2138.210	0.000	5,144.544

Table 5-43. Mass Balance, kg
(Small Core, Pu Library, Cycle 4)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>BOC</u>				
²³⁹ Pu	1029.398	22.029	204.525	1,255.952
²⁴⁰ Pu	288.456	0.338	6.030	294.824
²⁴¹ Pu	48.543	0.003	0.120	48.666
²⁴² Pu	21.255	0.000	0.002	21.257
Total Pu	1387.652	22.370	210.677	1,620.699
²³⁸ U	4984.679	4263.293	18,260.706	27,508.678
Total (U + Pu)	6372.331	4285.663	18,471.383	29,129.377
<u>EOC</u>				
²³⁹ Pu	944.417	63.726	297.957	1,306.100
²⁴⁰ Pu	323.513	1.609	11.544	336.666
²⁴¹ Pu	47.553	0.023	0.287	47.863
²⁴² Pu	21.312	0.000	0.006	21.318
Total Pu	1336.795	65.358	309.794	1,711.947
²³⁸ U	4802.465	4214.427	18,143.018	27,159.910
Total (U + Pu)	6139.260	4279.785	18,452.812	28,871.857

Table 5-44. Discharge Mass Balance, kg
(Small Core, Pu Library, Cycle 4)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>EOC</u>				
²³⁹ Pu	448.975	41.704	192.840	683.519
²⁴⁰ Pu	168.437	1.279	9.071	178.787
²⁴¹ Pu	23.572	0.020	0.251	23.843
²⁴² Pu	10.577	0.000	0.006	10.583
Total Pu	651.561	43.003	202.168	896.732
²³⁸ U	2361.042	2095.132	9,014.207	13,470.381
Total (U + Pu)	3012.603	2138.135	9,216.375	14,367.113

Table 5-45. Mass Balance, kg
(Large Core, Ref Library, Cycle 1)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>BOC</u>				
²³⁹ Pu	3087.07	0.00	0.00	3,087.07
²⁴⁰ Pu	771.77	0.00	0.00	771.77
²⁴¹ Pu	142.19	0.00	0.00	142.19
²⁴² Pu	60.93	0.00	0.00	60.93
Total Pu	4,061.96	0.00	0.00	4,061.96
²³⁸ U	21,844.02	17,151.24	30,733.28	69,728.54
Total (U + Pu)	25,905.98	17,151.24	30,733.28	73,790.50
<u>EOC</u>				
²³⁹ Pu	3,085.43	141.63	225.36	3,452.42
²⁴⁰ Pu	864.58	1.46	2.49	868.53
²⁴¹ Pu	138.86	0.01	0.02	138.89
²⁴² Pu	62.09	0.00	0.00	62.09
Total Pu	4,150.96	143.10	227.87	4,521.93
²³⁸ U	20,875.73	16,997.75	30,487.76	68,361.24
Total (U + Pu)	25,026.69	17,140.85	30,715.63	72,883.17

Table 5-46. Discharge Mass Balance, kg
(Large Core, Ref Library, Cycle 1)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>EOC</u>				
²³⁹ Pu	1,542.72	70.82	0.00	1,613.54
²⁴⁰ Pu	432.29	0.73	0.00	433.02
²⁴¹ Pu	69.43	0.01	0.00	69.44
²⁴² Pu	31.05	0.00	0.00	31.05
Total Pu	2,075.49	71.56	0.00	2,147.05
²³⁸ U	10,437.87	8498.88	0.00	18,936.75
Total (U + Pu)	12,513.36	8570.44	0.00	21,083.80

Table 5-47. Mass Balance, kg
(Large Core, Ref Library, Cycle 2)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>BOC</u>				
²³⁹ Pu	3,086.25	70.82	225.36	3,382.43
²⁴⁰ Pu	818.18	0.73	2.49	821.40
²⁴¹ Pu	140.52	0.01	0.02	140.55
²⁴² Pu	61.51	0.00	0.00	61.51
Total Pu	4,106.46	71.56	227.87	4,405.89
²³⁸ U	21,359.88	17,074.50	30,487.76	68,922.14
Total (U + Pu)	25,466.34	17,146.06	30,715.63	73,328.03
<u>EOC</u>				
²³⁹ Pu	3,065.24	205.11	427.14	3,697.49
²⁴⁰ Pu	903.70	3.40	9.15	916.25
²⁴¹ Pu	139.71	0.06	0.17	139.94
²⁴² Pu	62.55	0.00	0.00	62.55
Total Pu	4,171.20	208.57	436.46	4,816.23
²³⁸ U	20,436.28	16,922.47	30,246.90	67,605.65
Total (U + Pu)	24,607.48	17,131.04	30,683.36	72,421.88

Table 5-48. Discharge Mass Balance, kg
(Large Core, Ref Library, Cycle 2)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>EOC</u>				
²³⁹ Pu	1,521.04	134.83	213.57	1,869.44
²⁴⁰ Pu	473.04	2.71	4.57	480.32
²⁴¹ Pu	70.44	0.05	0.08	70.57
²⁴² Pu	31.54	0.00	0.00	31.54
Total Pu	2,096.06	137.59	218.22	2,451.87
²³⁸ U	9,987.04	8,423.34	15,123.45	33,533.83
Total (U + Pu)	12,083.10	8,560.93	15,341.67	35,985.70

Table 5-49. Mass Balance, kg
(Large Core, Ref Library, Cycle 3)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>BOC</u>				
²³⁹ Pu	3,104.49	70.28	213.57	3,388.34
²⁴⁰ Pu	819.92	0.69	4.57	825.18
²⁴¹ Pu	140.99	0.01	0.08	141.08
²⁴² Pu	61.74	0.00	0.00	61.74
Total Pu	4,127.14	70.98	218.22	4,416.34
²³⁸ U	21,354.28	17,074.75	30,490.10	68,919.13
Total (U + Pu)	25,481.42	17,145.73	30,708.32	73,335.47
<u>EOC</u>				
²³⁹ Pu	3,079.26	205.75	418.31	3,703.32
²⁴⁰ Pu	905.49	3.19	10.92	919.60
²⁴¹ Pu	140.09	0.06	0.27	140.42
²⁴² Pu	62.76	0.00	0.01	62.77
Total Pu	4,187.60	209.00	429.51	4,826.11
²³⁸ U	20,434.46	16,921.45	30,247.20	67,603.11
Total (U + Pu)	24,622.06	17,130.45	30,676.71	72,429.22

Table 5-50. Discharge Mass Balance, kg
(Large Core, Ref Library, Cycle 3)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>EOC</u>				
²³⁹ Pu	1,524.78	134.91	0.00	1,659.69
²⁴⁰ Pu	471.51	2.67	0.00	474.18
²⁴¹ Pu	70.24	0.05	0.00	70.29
²⁴² Pu	31.49	0.00	0.00	31.49
Total Pu	2,098.02	137.63	0.00	2,235.65
²³⁸ U	9,999.80	8,422.95	0.00	18,422.75
Total (U + Pu)	12,097.82	8,560.58	0.00	20,658.40

Table 5-51. Mass Balance, kg
(Large Core, Ref Library, Cycle 4)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>BOC</u>				
²³⁹ Pu	3,094.33	70.84	418.31	3,583.48
²⁴⁰ Pu	818.94	0.70	10.92	830.56
²⁴¹ Pu	140.77	0.01	0.27	141.05
²⁴² Pu	61.66	0.00	0.01	61.67
Total Pu	4,115.70	71.55	429.51	4,616.76
²³⁸ U	21,361.32	17,074.11	30,247.20	68,682.63
Total (U + Pu)	25,477.02	17,145.66	30,676.71	73,299.39
<u>EOC</u>				
²³⁹ Pu	3,070.75	209.87	608.64	3,889.26
²⁴⁰ Pu	902.88	3.43	20.99	927.30
²⁴¹ Pu	139.81	0.06	0.64	140.51
²⁴² Pu	62.66	0.00	0.02	62.68
Total Pu	4,176.10	213.36	630.29	5,019.75
²³⁸ U	20,457.08	16,916.10	30,000.58	67,373.76
Total (U + Pu)	24,633.18	17,129.46	30,630.87	72,393.51

Table 5-52. Discharge Mass Balance, kg
(Large Core, Ref Library, Cycle 4)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>EOC</u>				
²³⁹ Pu	1,530.39	137.17	391.84	2,059.40
²⁴⁰ Pu	474.17	2.71	16.45	493.33
²⁴¹ Pu	70.74	0.05	0.56	71.35
²⁴² Pu	31.74	0.00	0.02	31.76
Total Pu	2,107.04	139.93	408.87	2,655.84
²³⁸ U	9,993.30	8,419.97	14,881.90	33,295.17
Total (U + Pu)	12,100.34	8,559.90	15,290.77	35,951.01

Table 5-53. Mass Balance, kg
(Large Core, FF Library, Cycle 1)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>BOC</u>				
²³⁹ Pu	3,138.28	0.00	0.00	3,138.28
²⁴⁰ Pu	784.58	0.00	0.00	784.58
²⁴¹ Pu	144.55	0.00	0.00	144.55
²⁴² Pu	61.94	0.00	0.00	61.94
Total Pu	4,129.35	0.00	0.00	4,129.35
²³⁸ U	21,779.64	8,575.62	39,308.90	69,664.16
Total (U + Pu)	25,908.99	8,575.62	39,308.90	73,793.51
<u>EOC</u>				
²³⁹ Pu	3,121.34	140.56	223.62	3,485.52
²⁴⁰ Pu	876.28	1.44	2.44	880.16
²⁴¹ Pu	140.94	0.02	0.01	140.97
²⁴² Pu	63.06	0.00	0.00	63.06
Total Pu	4,201.62	142.02	226.07	4,569.71
²³⁸ U	20,828.37	16,998.94	30,489.70	68,317.01
Total (U + Pu)	25,029.99	17,140.96	30,715.77	72,886.72

Table 5-54. Discharge Mass Balance, kg
(Large Core, FF Library, Cycle 1)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>EOC</u>				
²³⁹ Pu	1,560.67	70.28	0.00	1,630.95
²⁴⁰ Pu	438.14	0.72	0.00	438.86
²⁴¹ Pu	70.47	0.01	0.00	70.48
²⁴² Pu	31.53	0.00	0.00	31.53
Total Pu	2,100.81	71.01	0.00	2,171.82
²³⁸ U	10,414.18	8,499.47	0.00	18,913.65
Total (U + Pu)	12,514.99	8,570.48	0.00	21,085.47

Table 5-55. Mass Balance, kg
(Large Core, FF Library, Cycle 2)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>BOC</u>				
²³⁹ Pu	3,139.32	70.28	223.62	3,433.22
²⁴⁰ Pu	832.80	0.72	2.44	835.96
²⁴¹ Pu	143.18	0.01	0.01	143.20
²⁴² Pu	<u>62.69</u>	<u>0.00</u>	<u>0.00</u>	<u>62.69</u>
Total Pu	4,177.99	71.01	226.07	4,475.07
²³⁸ U	<u>21,292.03</u>	<u>17,075.08</u>	<u>30,489.70</u>	<u>68,856.81</u>
Total (U + Pu)	25,470.02	17,146.09	30,715.77	73,331.88
<u>EOC</u>				
²³⁹ Pu	3,102.48	204.29	425.05	3,731.82
²⁴⁰ Pu	916.36	3.36	9.02	928.74
²⁴¹ Pu	141.87	0.05	0.16	142.08
²⁴² Pu	<u>63.65</u>	<u>0.00</u>	<u>0.00</u>	<u>63.65</u>
Total Pu	4,224.36	207.70	434.23	4,866.29
²³⁸ U	<u>20,387.14</u>	<u>16,923.39</u>	<u>30,249.42</u>	<u>67,559.95</u>
Total (U + Pu)	24,611.50	17,131.09	30,683.65	72,426.24

Table 5-56. Discharge Mass Balance, kg
(Large Core, FF Library, Cycle 2)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>EOC</u>				
²³⁹ Pu	1,533.71	134.19	212.53	1,880.43
²⁴⁰ Pu	477.69	2.67	4.51	484.87
²⁴¹ Pu	71.21	0.05	0.08	71.34
²⁴² Pu	<u>31.98</u>	<u>0.00</u>	<u>0.00</u>	<u>31.98</u>
Total Pu	2,114.59	136.91	217.12	2,468.62
²³⁸ U	<u>9,972.07</u>	<u>8,424.08</u>	<u>15,124.71</u>	<u>33,520.86</u>
Total (U + Pu)	12,086.66	8,560.99	15,341.83	35,989.48

Table 5-57. Mass Balance, kg
(Large Core, FF Library, Cycle 3)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>BOC</u>				
²³⁹ Pu	3,145.10	70.10	212.53	3,427.73
²⁴⁰ Pu	832.75	0.68	4.51	837.94
²⁴¹ Pu	143.26	0.01	0.08	143.35
²⁴² Pu	62.78	0.00	0.00	62.78
Total Pu	4,183.89	70.79	217.12	4,471.80
²³⁸ U	21,295.84	17,074.93	30,491.35	68,862.12
Total (U + Pu)	25,479.73	17,145.72	30,708.47	73,333.92
<u>EOC</u>				
²³⁹ Pu	3,107.19	205.28	416.85	3,729.32
²⁴⁰ Pu	916.37	3.34	10.80	930.51
²⁴¹ Pu	141.91	0.05	0.27	142.23
²⁴² Pu	63.72	0.00	0.01	63.73
Total Pu	4,229.19	208.67	427.93	4,865.79
²³⁸ U	20,391.47	16,922.05	30,249.03	67,562.55
Total (U + Pu)	24,620.66	17,130.72	30,676.96	72,428.34

Table 5-58. Discharge Mass Balance, kg
(Large Core, FF Library, Cycle 3)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>EOC</u>				
²³⁹ Pu	1,539.70	134.61	0.00	1,674.31
²⁴⁰ Pu	478.45	2.64	0.00	481.09
²⁴¹ Pu	71.37	0.04	0.00	71.41
²⁴² Pu	32.11	0.00	0.00	32.11
Total Pu	2,121.63	137.29	0.00	2,258.92
²³⁸ U	9,973.35	8,423.30	0.00	18,396.65
Total (U + Pu)	12,094.98	8,560.59	0.00	20,655.57

Table 5-59. Mass Balance, kg
(Large Core, FF Library, Cycle 4)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>BOC</u>				
²³⁹ Pu	3,143.59	70.67	416.85	3,631.11
²⁴⁰ Pu	831.94	0.70	10.79	843.43
²⁴¹ Pu	143.14	0.01	0.27	143.42
²⁴² Pu	62.72	--	0.01	62.73
Total Pu	4,181.39	71.38	427.92	4,680.69
²³⁸ U	21,299.16	17,074.29	30,249.03	68,622.48
Total (U + Pu)	25,480.55	17,145.67	30,676.95	73,303.17
<u>EOC</u>				
²³⁹ Pu	3,105.46	209.02	606.36	3,920.84
²⁴⁰ Pu	914.11	3.38	20.74	938.23
²⁴¹ Pu	141.70	0.05	0.63	142.38
²⁴² Pu	63.64	0.00	0.02	63.66
Total Pu	4,224.91	212.45	627.75	5,065.11
²³⁸ U	20,411.87	16,917.07	30,003.68	67,332.62
Total (U + Pu)	24,636.78	17,129.52	30,631.43	72,397.73

Table 5-60. Discharge Mass Balance, kg
(Large Core, FF Library, Cycle 4)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>EOC</u>				
²³⁹ Pu	1,539.47	136.69	390.37	2,066.53
²⁴⁰ Pu	476.97	2.68	16.25	495.90
²⁴¹ Pu	71.18	0.05	0.55	71.78
²⁴² Pu	32.04	0.00	0.02	32.06
Total Pu	2,119.66	139.42	407.19	2,666.27
²³⁸ U	9,984.47	8,420.54	14,884.04	33,289.05
Total (U + Pu)	12,104.13	8,559.96	15,291.23	35,955.32

Table 5-61. Mass Balance, kg
(Large Core, Pu Library, Cycle 1)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>BOC</u>				
²³⁹ Pu	3,361.62	0.00	0.00	3,361.62
²⁴⁰ Pu	840.41	0.00	0.00	840.41
²⁴¹ Pu	154.84	0.00	0.00	154.84
²⁴² Pu	66.35	0.00	0.00	66.35
Total Pu	4,423.22	0.00	0.00	4,423.22
²³⁸ U	21,498.73	17,151.24	30,733.28	69,383.25
Total (U + Pu)	25,921.95	17,151.24	30,733.28	73,806.47
<u>EOC</u>				
²³⁹ Pu	3,215.94	136.84	217.60	3,570.38
²⁴⁰ Pu	1,007.69	2.02	3.42	1,013.13
²⁴¹ Pu	151.68	0.02	0.03	151.73
²⁴² Pu	67.42	0.00	0.00	67.42
Total Pu	4,442.73	138.88	221.05	4,802.66
²³⁸ U	20,603.36	17,002.17	30,494.89	68,100.42
Total (U + Pu)	25,046.09	17,141.05	30,715.94	72,903.08

Table 5-62. Discharge Mass Balance, kg
(Large Core, Pu Library, Cycle 1)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>EOC</u>				
²³⁹ Pu	1,607.97	68.42	0.00	1,676.39
²⁴⁰ Pu	503.85	1.01	0.00	504.86
²⁴¹ Pu	75.84	0.01	0.00	75.85
²⁴² Pu	33.71	0.00	0.00	33.71
Total Pu	2,221.37	69.44	0.00	2,290.81
²³⁸ U	10,301.68	8,501.08	0.00	18,802.76
Total (U + Pu)	12,523.05	8,570.52	0.00	21,093.57

Table 5-63. Mass Balance, kg
(Large Core, Pu Library, Cycle 2)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>BOC</u>				
²³⁹ Pu	3,251.95	68.42	217.60	3,537.97
²⁴⁰ Pu	914.84	1.01	3.42	919.27
²⁴¹ Pu	151.57	0.01	0.03	151.61
²⁴² Pu	66.16	0.00	0.00	66.16
Total Pu	4,384.52	69.44	221.05	4,675.01
²³⁸ U	21,097.33	17,076.70	30,494.89	68,668.92
Total (U + Pu)	25,481.85	17,146.14	30,715.94	73,343.93
<u>EOC</u>				
²³⁹ Pu	3,114.89	199.83	414.20	3,728.92
²⁴⁰ Pu	1,063.80	4.74	12.70	1,081.24
²⁴¹ Pu	152.25	0.07	0.22	152.54
²⁴² Pu	67.03	0.00	0.01	67.04
Total Pu	4,339.97	204.64	427.13	5,029.74
²³⁸ U	20,226.66	16,926.81	30,257.52	67,410.99
Total (U + Pu)	24,624.63	17,131.45	30,684.65	72,440.73

Table 5-64. Discharge Mass Balance, kg
(Large Core, Pu Library, Cycle 2)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>EOC</u>				
²³⁹ Pu	1,533.46	132.36	207.10	1,872.92
²⁴⁰ Pu	573.19	3.77	6.35	583.31
²⁴¹ Pu	78.24	0.06	0.11	78.41
²⁴² Pu	34.15	0.00	0.00	34.15
Total Pu	2,219.04	136.19	213.56	2,568.79
²³⁸ U	9,876.88	8,426.58	15,128.76	33,432.22
Total (U + Pu)	12,095.92	8,562.77	15,342.32	36,001.01

Table 5-65. Mass Balance, kg
(Large Core, Pu Library, Cycle 3)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>BOC</u>				
²³⁹ Pu	3,278.80	68.95	207.10	3,554.85
²⁴⁰ Pu	914.96	0.97	6.35	922.28
²⁴¹ Pu	152.19	0.01	0.11	152.31
²⁴² Pu	<u>66.38</u>	<u>0.00</u>	<u>0.00</u>	<u>66.38</u>
Total Pu	4,412.33	69.93	213.56	4,695.82
²³⁸ U	<u>21,078.31</u>	<u>17,075.84</u>	<u>30,495.41</u>	<u>68,649.56</u>
Total (U + Pu)	25,490.64	17,145.77	30,708.97	73,345.38
<u>EOC</u>				
²³⁹ Pu	3,135.35	200.50	406.19	3,742.04
²⁴⁰ Pu	1,064.39	4.71	15.13	1,084.23
²⁴¹ Pu	152.65	0.07	0.35	153.07
²⁴² Pu	<u>67.23</u>	<u>0.00</u>	<u>0.01</u>	<u>67.24</u>
Total Pu	4,419.62	205.28	421.68	5,046.58
²³⁸ U	<u>20,213.11</u>	<u>16,925.81</u>	<u>30,257.79</u>	<u>67,396.71</u>
Total (U + Pu)	24,632.73	17,131.09	30,679.47	72,443.29

Table 5-66. Discharge Mass Balance, kg
(Large Core, Pu Library, Cycle 3)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>EOC</u>				
²³⁹ Pu	1,514.75	131.49	0.00	1,646.24
²⁴⁰ Pu	559.07	3.73	0.00	562.80
²⁴¹ Pu	76.29	0.06	0.00	76.35
²⁴² Pu	<u>33.30</u>	<u>0.00</u>	<u>0.00</u>	<u>33.30</u>
Total Pu	2,183.41	135.28	0.00	2,318.69
²³⁸ U	<u>9,925.53</u>	<u>8,425.66</u>	<u>0.00</u>	<u>18,351.19</u>
Total (U + Pu)	12,108.94	8,560.94	0.00	20,669.88

Table 5-67. Mass Balance, kg
(Large Core, Pu Library, Cycle 4)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>BOC</u>				
²³⁹ Pu	3,238.89	69.01	406.19	3,714.09
²⁴⁰ Pu	909.90	0.98	15.13	926.01
²⁴¹ Pu	150.90	0.01	0.35	151.26
²⁴² Pu	65.87	0.00	0.01	65.88
Total Pu	4,365.56	70.00	421.68	4,857.24
²³⁸ U	21,115.56	17,075.78	30,257.79	68,449.13
Total (U + Pu)	25,481.12	17,145.78	39,679.47	73,306.37
<u>EOC</u>				
²³⁹ Pu	3,105.83	203.23	588.06	3,897.12
²⁴⁰ Pu	1,056.88	4.74	28.99	1,090.61
²⁴¹ Pu	151.46	0.07	0.84	152.37
²⁴² Pu	66.73	0.00	0.02	66.75
Total Pu	4,380.90	208.04	617.91	5,206.85
²³⁸ U	20,256.27	16,922.15	30,018.04	67,196.46
Total (U + Pu)	24,637.17	17,130.19	30,635.95	72,403.31

Table 5-68. Discharge Mass Balance, kg
(Large Core, Pu Library, Cycle 4)

	<u>Core</u>	<u>Axial blanket</u>	<u>Radial blanket</u>	<u>Total</u>
<u>EOC</u>				
²³⁹ Pu	1,543.79	132.84	378.30	2,054.93
²⁴⁰ Pu	574.42	3.75	22.72	600.89
²⁴¹ Pu	78.62	0.06	0.73	79.41
²⁴² Pu	34.36	0.00	0.02	34.38
Total Pu	2,231.19	136.65	401.77	2,769.61
²³⁸ U	9,869.05	8,423.80	14,893.12	33,185.97
Total (U + Pu)	12,100.24	8,560.45	15,294.89	35,955.58

Table 5-69. EC-EOC Discharge Pu Isotopic Mixes
(Core Average, atom %)

Small Core			
Isotope	Library		
	Ref	FF	Pu
239	69.5	71.9	68.9
240	25.2	23.0	25.9
241	3.6	3.5	3.6
242	1.7	1.6	1.6
Large Core			
Isotope	Library		
	Ref	FF	Pu
239	72.6	72.6	69.2
240	22.5	22.5	25.8
241	3.4	3.4	3.5
242	1.5	1.5	1.5

Table 5-70. Total Fission Product Reactivity Worth^(a) and Contribution to Fission Product Worth Resulting From Capture at BOEC

		Capture	Total	Change, %
SR	Core	-0.00850	-0.00850	--
	Blkt	-0.00022	-0.00022	--
	Total	-0.00872	-0.00872	--
SFF	Core	-0.01194	-0.01195	+41
	Blkt	-0.00033	-0.00033	+50
	Total	-0.01228	-0.01228	+41
SPU	Core	-0.00711	-0.00711	-16
	Blkt	-0.00049	-0.00050	+127
	Total	-0.00760	-0.00760	-13
LR	Core	-0.00931	-0.00931	--
	Blkt	-0.00016	-0.00016	--
	Total	-0.00947	-0.00947	--
LFF	Core	-0.01360	-0.01360	+46
	Blkt	-0.00022	-0.00022	+38
	Total	-0.01383	-0.01383	+46
LPU	Core	-0.00810	-0.00810	-13
	Blkt	-0.00013	-0.00013	-19
	Total	-0.00823	-0.00823	-13

^(a) $\Delta k/k$ relative to a void.

Table 5-71. Total Fission Product Reactivity Worth^(a) and Contribution to Fission Product Worth Resulting From Capture at EOEC

		<u>Capture</u>	<u>Total</u>	<u>Change, %</u>
SR	Core	-0.02414	-0.02415	--
	Blkt	-0.00045	-0.00045	--
	Total	-0.02459	-0.02460	--
SFF	Core	-0.03300	-0.03301	+37
	Blkt	-0.00067	-0.00067	+49
	Total	-0.03368	-0.03369	+37
SPU	Core	0.02060	-0.02060	-15
	Blkt	-0.00070	-0.00071	+58
	Total	-0.02130	-0.02131	-13
LR	Core	-0.02644	-0.02644	--
	Blkt	-0.00028	-0.00029	--
	Total	-0.02672	0.02673	--
LFF	Core	-0.03740	-0.03741	+41
	Blkt	-0.00041	-0.00041	+41
	Total	-0.03781	-0.03782	+41
LPU	Core	-0.02343	-0.02343	-11
	Blkt	-0.00025	-0.00025	-14
	Total	-0.02368	-0.02368	-11

(a) $\Delta k/k$ relative to a void.

Table 5-72. Worth^(a) of ²³⁸U Inventory Change Between Beginning and End of Equilibrium Cycle

		<u>BOEC</u>	<u>Library change, %</u>	<u>EOEC</u>	<u>Library change, %</u>	<u>BOEC & EOEC change, %</u>
SR	Core	-0.19810	--	-0.18436	--	-6.9
	Blkt	-0.04139	--	-0.04383	--	+5.9
	Total	-0.23948	--	-0.22819	--	-4.7
SFF	Core	-0.19371	-2.2	-0.17766	-3.6	-8.3
	Blkt	-0.04287	+3.6	-0.04455	+1.6	+3.9
	Total	-0.23658	-1.2	-0.22221	-2.6	-6.1
SPU	Core	-0.17851	-9.9	-0.16889	-8.4	-5.4
	Blkt	-0.03971	-4.1	-0.04206	-4.0	+5.9
	Total	-0.21822	-8.9	-0.21095	-7.6	-3.3
LR	Core	-0.24988	--	-0.23696	--	-5.2
	Blkt	-0.02879	--	-0.03125	--	+8.5
	Total	-0.27867	--	-0.26821	--	-3.7
LFF	Core	-0.24553	-1.7	-0.22729	-4.1	-7.4
	Blkt	-0.02860	-0.7	-0.02639	-15.6	-7.7
	Total	-0.27413	-1.6	-0.25368	-5.4	-7.5
LPU	Core	-0.22870	-8.5	-0.21800	-8.0	-4.7
	Blkt	-0.02653	-7.8	-0.02525	-19.2	-4.8
	Total	-0.25523	-8.4	-0.24325	-9.3	-4.7

(a) $\Delta k/k$ relative to a void.

Table 5-73. Worth^(a) of ²³⁹Pu Inventory Change Between Beginning and End of Equilibrium Cycle

		BOEC	Library change, %	EOEC	Library change, %	BOEC & EOEC change, %
SR	Core	+0.48747	--	+0.48524	--	-0.5
	Blkt	+0.01225	--	+0.02135	--	+75.6
	Total	+0.49972	--	+0.50677	--	+1.4
SFF	Core	+0.48821	+0.2	+0.48971	+0.9	+0.3
	Blkt	+0.01242	+1.4	+0.02180	+1.2	+75.5
	Total	+0.50063	+0.2	+0.51150	+0.9	+2.2
SPU	Core	+0.47072	-3.4	+0.46907	-3.3	-0.4
	Blkt	+0.01078	-1.2	+0.01928	-10.4	+78.8
	Total	+0.48150	-3.6	+0.48835	-3.6	+1.4
LR	Core	+0.49611	--	+0.49636	--	+0.1
	Blkt	+0.00910	--	+0.01315	--	+44.5
	Total	+0.50521	--	+0.50950	--	+8.5
LFF	Core	+0.49717	+0.2	+0.50068	+0.9	+7.1
	Blkt	+0.00897	-1.4	+0.01336	+1.6	+48.9
	Total	+0.50614	+0.2	+0.51404	+0.9	+1.6
LPU	Core	+0.47922	-3.4	+0.47847	-3.6	-0.2
	Blkt	+0.00797	-12.4	+0.01223	-7.0	+53.5
	Total	+0.48719	-3.6	+0.49070	-3.7	+0.7

(a) $\Delta k/k$ relative to a void.

Table 5-74. Worth^(a) of ²⁴⁰Pu Inventory Change Between Beginning and End of Equilibrium Cycle

		<u>BOEC</u>	<u>Library change, %</u>	<u>EOEC</u>	<u>Library change, %</u>	<u>BOEC & EOEC change, %</u>
SR	Core	+0.01344	--	+0.01606	--	+19.5
	Blkt	+0.00002	--	+0.00004	--	+100
	Total	+0.01346	--	+0.01610	--	+19.6
SFF	Core	+0.01310	-2.5	+0.01633	+1.7	+24.7
	Blkt	+0.00002	--	+0.00005	+25	+150
	Total	+0.01312	-2.5	+0.01637	+1.7	+24.8
SPU	Core	+0.01571	+17	+0.01991	+24	+26.7
	Blkt	+0.00003	+50	+0.00007	+75	+133
	Total	+0.01573	+17	+0.01997	+24	+27.0
LR	Core	+0.00999	--	+0.01150	--	+15.1
	Blkt	+0.00001	--	+0.00002	--	+100
	Total	+0.01000	--	+0.01152	--	+15.2
LFF	Core	+0.01033	+3.4	+0.01272	+11	+23.1
	Blkt	+0.00001	--	+0.00002	--	+100
	Total	+0.01034	+3.4	+0.01274	+11	+23.2
LPU	Core	+0.01297	+30	+0.01621	+41	+25.0
	Blkt	+0.00002	+100	+0.00004	+100	+100
	Total	+0.01299	+30	+0.01625	+41	+25.1

(a) $\Delta k/k$ relative to a void.

Table 5-75. Worth^(a) of ²⁴¹Pu Inventory Change Between Beginning and End of Equilibrium Cycle

		<u>BOEC</u>	<u>Library change, %</u>	<u>EOEC</u>	<u>Library change, %</u>	<u>BOEC & EOEC change, %</u>
SR	Core	+0.03561	--	+0.03629	--	+1.9
	Blkt	+0.00002	--	+0.00004	--	+100
	Total	+0.03562	--	+0.03633	--	+2.0
SFF	Core	+0.03463	-2.8	+0.03499	-3.6	+1.0
	Blkt	+0.00002	--	+0.00004	--	+100
	Total	+0.03464	-2.8	+0.03503	-3.6	+1.1
SPU	Core	+0.03520	-1.2	+0.03689	+1.7	+4.8
	Blkt	+0.00002	--	+0.00005	+25	+150
	Total	+0.03522	-1.1	+0.03694	+1.7	+4.9
LR	Core	+0.03560	--	+0.03468	--	-2.6
	Blkt	+0.00001	--	+0.00003	--	+200
	Total	+0.03561	--	+0.03471	--	-2.5
LFF	Core	+0.03562	+0.1	+0.03487	+0.5	-2.1
	Blkt	+0.00001	--	+0.00003	--	+200
	Total	+0.03563	+0.1	+0.03490	+0.5	-2.0
LPU	Core	+0.03646	+2.4	+0.03738	+7.8	+2.5
	Blkt	+0.00002	+100	+0.00004	+33	+100
	Total	+0.03648	+2.4	+0.03742	+7.8	+2.6

(a) $\Delta k/k$ relative to a void.

Table 5-76. Worth^(a) of ²⁴²Pu Inventory Change Between Beginning and End of Equilibrium Cycle

		<u>BOEC</u>	<u>Library change, %</u>	<u>EOEC</u>	<u>Library change, %</u>	<u>BOEC & EOEC change, %</u>
SR	Core	+0.00056	--	+0.00066	--	+17.9
	Blkt	~0	--	~0	--	--
	Total	+0.00056	--	+0.00066	--	+17.9
SFF	Core	+0.00057	+1.8	+0.00072	+9.1	+26.3
	Blkt	~0	--	~0	--	--
	Total	+0.00057	+1.8	+0.00072	+9.1	+26.3
SPU	Core	+0.00070	+25	+0.00082	+24	+17.1
	Blkt	~0	--	~0	--	--
	Total	+0.00070	+25	+0.00082	+24	+17.1
LR	Core	+0.00038	--	+0.00040	--	5.3
	Blkt	~0	--	~0	--	--
	Total	+0.00038	--	+0.00040	--	5.3
LFF	Core	+0.00040	5.3	+0.00048	+20	+20
	Blkt	~0	--	~0	--	--
	Total	+0.00040	5.3	+0.00048	+20	+20
LPU	Core	+0.00052	+37	+0.00058	+45	+11.5
	Blkt	~0	--	~0	--	--
	Total	+0.00052	+37	+0.00058	+45	+11.5

(a) $\Delta k/k$ relative to a void.

Table 5-77. Worth^(a) of Blanket Plutonium Inventory Buildup
From Cycle Beginning to End

	<u>BOEC</u>	<u>Library change, %</u>	<u>EOEC</u>	<u>Library change, %</u>	<u>BOEC & EOEC change %</u>
SR	+0.01229	--	+0.02161	--	+75.8
SFF	+0.01246	+1.4	+0.02189	+1.3	+75.7
SPU	+0.01083	-12	+0.01940	-10	+79.1
LR	+0.00912	--	+0.01320	--	+44.7
LFF	+0.00899	-1.4	+0.01341	+1.6	+49.2
LPU	+0.00801	-12	+0.01231	-6.7	+53.7

^(a) $\Delta k/k$ relative to a void.

Table 5-78. Sodium Worth^(a) at Cycle Beginning and End

		<u>BOEC</u>	<u>Library change, %</u>	<u>EOEC</u>	<u>Library change, %</u>
SR	Core	-0.02226	--	-0.02424	--
	Blkt	-0.00588	--	-0.00599	--
	Total	-0.02814	--	-0.03022	--
SFF	Core	-0.02243	+0.8	-0.02514	+3.7
	Blkt	-0.00615	+4.6	-0.00623	+4.0
	Total	-0.02858	+1.6	-0.03137	+3.8
SPU	Core	-0.02531	+14	-0.02700	+11
	Blkt	-0.00610	+3.7	-0.00626	+4.5
	Total	-0.03141	+12	-0.03326	+10
LR	Core	-0.02569	--	-0.02886	--
	Blkt	-0.00367	--	-0.00324	--
	Total	-0.02936	--	-0.03210	--
LFF	Core	-0.02621	+2.0	-0.03027	+4.9
	Blkt	-0.00368	+0.3	-0.00330	+1.9
	Total	-0.02989	+1.8	-0.03357	+4.6
LPU	Core	-0.02955	+15	-0.03231	+12
	Blkt	-0.00363	+1.1	-0.00334	+3.1
	Total	-0.03318	+13	-0.03565	+11

(a) $\Delta k/k$ relative to a void.

Table 5-79. Effect of Substitution of BOEC Fission Product Inventory and
BOEC Blanket Plutonium Inventory on EOEC Sodium Worth^(a)

		<u>Standard</u>	<u>BOEC FF subst</u>	<u>Change, %</u>	<u>BOEC blkt Pu subst</u>	<u>Change, %</u>
SR	Core	-0.02424	-0.02227	-8.1	-0.02452	+1.2
	Blkt	-0.00599	-0.00592	-1.2	-0.00571	-4.7
	Total	-0.03022	-0.02819	-6.7	-0.03023	+0.03
SFF	Core	-0.02514	-0.02256	-10.3	-0.02596	+3.2
	Blkt	-0.00623	-0.00614	-1.4	-0.00546	-12.4
	Total	-0.03138	-0.02870	-8.5	-0.03141	+0.1
SPU	Core	-0.02700	-0.02558	-5.3	-0.02730	+1.1
	Blkt	-0.00626	-0.00621	-0.8	-0.00599	-4.3
	Total	-0.03326	-0.03179	-4.4	-0.03328	+0.1
LR	Core	-0.02886	-0.02667	-7.6	-0.02918	+1.1
	Blkt	-0.00324	-0.00316	-2.4	-0.00300	-7.4
	Total	-0.03210	-0.02983	-7.1	-0.03218	+0.2
LFF	Core	-0.03027	-0.02725	-10	-0.03062	+1.2
	Blkt	-0.00330	-0.00319	-3.3	-0.00306	-7.3
	Total	-0.03357	-0.03044	-9.3	-0.03368	+0.3
LPU	Core	-0.03231	-0.03062	-5.2	-0.03264	+1.0
	Blkt	-0.00334	-0.00327	-2.1	-0.00309	-7.5
	Total	-0.03565	-0.03389	-4.9	-0.03573	+0.2

(a) $\Delta k/k$ relative to a void.

Table 5-80. In-Core Doppler Coefficient
 $(-T \frac{dk}{dT} \times 10^2)$

	<u>BOEC</u>	<u>Change, %</u>	<u>EOEC</u>	<u>Change, %</u>
SR	0.6760	--	0.5739	--
SFF	0.6315	-6.6	0.5091	-11
SPU	0.5197	-23	0.4572	-20
LR	0.9667	--	0.8503	--
LFF	0.9283	-4.0	0.7573	-11
LPU	0.7799	-19	0.6937	-18

DISTRIBUTION

1. U.S. Atomic Energy Commission (3)
Division of Reactor Development and Technology
Washington, D.C. 20545
Attn: J. W. Lewellen
2. U.S. Atomic Energy Commission
Division of Technical Information Extension
Post Office Box 62
Oak Ridge, Tennessee 37830
3. U.S. Atomic Energy Commission (2)
New York Operations Office
376 Hudson Street
New York, New York 10014
Attn: L. S. Hartman
Reports Library
4. Argonne National Laboratory (11)
9700 South Cass Avenue
Argonne, Illinois 60439
Attn: Dr. Robert Avery (5)
Fred Thalgott (3)
A. Amorosi, LMFBR Program Office (3)
5. Atomic Power Development Association, Inc.
1911 First Street
Detroit, Michigan 48226
Attn: John Nims
6. Atomics International
Post Office Box 309
Canoga Park, California 91304
Attn: Harry Morewitz
7. Brookhaven National Laboratory (2)
Upton, Long Island, N. Y. 11973
Attn: Jack Chernick
Herbert Kouts

8. Combustion Engineering, Inc.
Windsor, Connecticut 06095
Attn: Sidney Visner
9. General Electric Company
Atomic Power Division
175 Curtner Avenue
San Jose, California 95125
Attn: Mr. Paul Greebler
10. Los Alamos Scientific Laboratory
Post Office Box 1663
Los Alamos, New Mexico 87544
Attn: David Hall
11. Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830
Attn: Fred Maienschein
12. Pacific Northwest Laboratory
Post Office Box 999
Richland, Washington 99352
Attn: Peter Hofmann
13. Rensselaer Polytechnic Institute
Troy, New York 12181
Attn: Erwin Gaerttner
14. Westinghouse Electric Corporation
Post Office Box 355
Pittsburgh, Pennsylvania 15230
Attn: Lee Strawbridge
15. The Babcock & Wilcox Company (36)

Barringer, HS	Livolsi, AZ
Bhatnagar, SK	Neuhold, RJ
Carmichael, CD	Poor, HH/Alliance
Central Files (6)	Probert, PB/Barberton
Colpo, PN	Rowand, WH
Engelder, TC	Roy, DH (2)
Green, ID	Stewart, JE (5)
Holt, CD	Tilford, JM
Hostetler, DR	Travis, CC/TRG
Jacobsen, JA	Webb, RA
Library (2)	Whitaker, BW
Littrell, LW (2)	Wolfe, GE