Table 31. Differential Shim Rod Worths in the Oak Ridge Research Reactor

	Shim	R_i	R_f	Flow	X = % δk/k /in.	% Error in X from Error in			Total	
Core	Rod	in.	in.	gpm	Exp.	T'	$n(t_2)/n(t_1)$	ΔR	Err. %	C/E
179A	D4	12.00	12.38	1200	0.4002	0.59	4.80	1.86	5.18	1.089 ± 0.056
179A	D6	12.00	12.32	1200	0.4720	0.64	4.17	2.21	4.76	0.910 ± 0.043
179A	B4	12.01	12.64	1200	0.2330	0.67	6.38	1.12	6.51	1.082 ± 0.070
179A	B6	12.01	12.53	1200	0.2574	0.70	6.88	1.36	7.05	0.943 ± 0.066
179A	F4	12.01	12.80	1200	0.1500	0.85	9.10	0.90	9.18	1.084 ± 0.099
179A	F6	12.00	12.69	1200	0.1757	0.84	8.93	1.02	9.03	0.947 ± 0.085
179AX2	D4	12.00	12.37	1200	0.3856	0.58	4.34	1.91	4.77	1.063 ± 0.051
179AX2	D6	12.00	12.37	1200	0.4203	0.61	3.19	1.91	3.77	0.998 ± 0.038
179AX2	B4	12.00	12.54	1200	0.2853	0.58	3.50	1.31	3.78	0.931 ± 0.035
179AX2	B6	12.00	12.53	1200	0.2591	0.71	4.78	1.33	5.01	1.038 ± 0.052
179AX2	F4	12.00	12.86	1200	0.1392	0.80	6.05	0.82	6.16	1.077 ± 0.066
179AX2	F6	12.00	12.90	1200	0.1587	0.71	3.51	0.79	3.67	1.001 ± 0.037
179AX3	D4	12.00	12.34	1200	0.4718	0.56	3.70	2.08	4.28	0.894 ± 0.038
179AX3	D6	12.00	12.34	1200	0.4107	0.66	4.81	2.08	5.28	1.062 ± 0.056
179AX3	B4	12.00	12.56	1200	0.2671	0.67	4.71	1.26	4.92	1.050 ± 0.052
179AX3	B6	12.00	12.50	1200	0.2750	0.72	6.04	1.41	6.24	1.048 ± 0.065
179AX3	F4	12.00	12.74	1200	0.2118	0.62	3.94	0.96	4.10	1.071 ± 0.044
179AX3	F6	12.00	12.54	1200	0.2655	0.69	4.92	1.31	5.14	0.910 ± 0.047
179AX4	D4	12.00	12.27	1200	0.3717	0.71	8.42	2.62	8.85	1.033 ± 0.091
179AX4	D6	12.00	12.27	1200	0.3435	0.70	9.07	2.62	9.47	1.139 ± 0.108
179AX4	B4	12.01	12.33	1200	0.3197	0.64	8.99	2.21	9.28	0.960 ± 0.089
179AX4	B6	12.00	12.33	1200	0.3085	0.81	8.91	2.14	9.20	1.000 ± 0.092
179AX4	F4	12.01	12.75	1200	0.1310	0.42	9.61	0.96	9.67	1.070 ± 0.103
179AX4	F6	12.00	12.78	1200	0.1408	0.73	11.64	0.91	11.70	1.036 ± 0.121

Table 31. Differential Shim Rod Worths in the Oak Ridge Research Reactor (Cont.)

	Shim	R_i	R_f	Flow	X = %δk/k /in.	% Error in X from Error in Total				
Core	Rod	in.	in.	gpm	Exp. k	T'	$n(t_2)/n(t_1)$	ΔR	Err. %	C/E
179AX5	D4	12.00	12.23	1200	0.5836	0.36	3.90	3.07	4.98	1.045 ± 0.052
179AX5	D6	12.00	12.19	1200	0.5809	0.56	5.81	3.72	6.92	1.054 ± 0.073
179AX5	F4	12.00	12.29	1200	0.2517	0.63	8.05	1.81	8.12	1.060 ± 0.086
179AX5	F6	12.00	12.36	1200	0.3364	0.55	5.62	1.96	5.98	1.066 ± 0.064
179AX6	D4	12.00	12.31	1200	0.5690	0.29	0.98	2.28	2.50	1.014 ± 0.025
179AX6	D6	12.00	12.19	1200	0.5810	0.53	1.03	3.72	3.90	0.986 ± 0.038
179AX6	F4	12.00	12.31	1200	0.5438	0.32	1.18	2.28	2.59	1.044 ± 0.027
179AX6	F6	12.00	12.28	1200	0.5564	0.37	1.68	2.52	3.05	1.027 ± 0.031
179AX7	D4	12.00	12.39	1200	0.3934	0.58	3.36	1.81	3.86	1.006 ± 0.039
179AX7	D4	12.00	12.38	18,000	0.3648	0.69	4.81	1.86	5.20	1.085 ± 0.056
179AX7	D6	12.00	12.36	1200	0.4160	0.62	3.31	1.96	3.90	1.030 ± 0.040
179AX7	D6	12.00	12.33	18,000	0.4509	0.60	3.40	2.14	4.06	0.951 ± 0.039
179AX7	B4	12.00	12.52	1200	0.2511	0.61	5.10	1.36	5.31	0.978 ± 0.052
179AX7	B4	12.00	12.53	18,000	0.2543	0.79	4.90	1.33	5.14	0.966 ± 0.050
179AX7	B6	12.00	12.47	1200	0.2659	0.82	5.77	1.50	6.02	1.022 ± 0.062
179AX7	B6	12.00	12.34	18,000	0.2836	0.89	11.54	2.08	11.76	0.958 ± 0.113
179AX7	F4	12.00	12.81	1200	0.1288	0.90	8.42	0.87	8.54	1.146 ± 0.098
179AX7	F4	12.00	13.06	18,000	0.1449	0.66	3.31	0.67	3.50	1.018 ± 0.036
179AX7	F6	12.00	12.92	1200	0.1573	0.69	3.74	0.77	3.88	1.053 ± 0.041
179AX7	F6	12.00	12.80	18,000	0.1670	0.78	4.81	0.88	4.95	0.992 ± 0.049

shape of the curve becomes very important and this shape, unfortunately, was not measured as precisely as it might have been. Nevertheless, results from core 179AX6, where flux ratios were determined to a precision of about 1.5%, suggest that the method is potentially capable of measuring differential shim rod worths to an accuracy of a few percent. For the 179AX4 core small shim rod displacements resulted in unusually large asymptotic periods (in the 70-85 see range). Therefore, the total errors are very large (≈ 10%) because for long periods the results are extremely sensitive to flux ratio errors. Similar comments apply to core 179AX7 for the B6 and F4 shim rods.

The total or integral rod worth is obtained by integrating the differential worths from the lower limit (LL) to the upper limit (UL) of rod movement. To carry out these integrations the measured and calculated differential worths were fit to sixth degree polynomials by the least squares process. Results for the D6 shim rod in core 179AX5 are summarized in Table 32. Also shown in this table are the DIF3D and VIM-Monte Carlo evaluations of the total D6 rod worth based on eigenvalue calculations for the rod-in and rod-out configurations.

The VIM-Monte Carlo and the DIF3D-diffusion results are in very good agreement. They are also less than 1% larger than the integral worth obtained by integrating the calculated differential worths. However, these integral and total worths are not expected to be exactly the same because of differences in the rod bank positions.

7.4 Prompt Neutron Decay Constants

The prompt neutron decay constant α is the ratio of the effective delayed neutron fraction β, to the prompt neutron lifetime l_p. Thus, $\alpha = \beta_{eff}/l_p$. As discussed in Section 4.2.3, α was obtained from the break frequency of the measured cross power spectral density (CPSD) as a function of frequency. For these measurements the break frequency is the frequency at which the amplitude of the CPSD is one half of the asymptotic low-frequency value. Fig. 34 shows a measured CPSD frequency spectrum for the water-reflected fresh LEU core (LEU-1).

Methods for calculating β_{eff} and l_p are discussed in Section 6.3. Table 33 compares measured and calculated values of $\beta_{eff\_}/l_p$ for those cores for which successful measurements of this quantity were made. Core 179A was the last core to operate at full power (30 MW) in the ORR. When α measurements were made in this core, it had a relatively high photoneutron background associated with long-lived fission product gamma activity from the partially burned LEU fuel elements. Good agreement between the calculated and measured prompt neutron decay constant in this core is achieved only if β_{eff} includes contributions from delayed photoneutrons, as Table 33 indicates. These same photoneutron parameters were used in the analysis of the differential shim rod worths. For the fresh fuel cores, however, only delayed fission neutrons contribute to β_{eff}. Table 33 shows that the calculated and measured values for the prompt neutron decay constant are in excellent agreement.

7.5 Isothermal Temperature Coefficient

The isothermal temperature coefficient was measured in core 179AX7 (Fig. 14), which was identical to 179A except that the MFE's and the irradiation (Eu, Ir) experiments were removed. Using techniques describe in Section 4.2.5, the measurements were made under high flow rate conditions (18,000 gpm). Thus, the B4 critical rod position was measured as a function of coolant temperature in the range from 25 to 45 °C. The differential worth of the B4 shim rod was measured over this same rod displacement interval. Methods used to measure these differential worths were described in Sections 6.2 and 6.3.

Table 32. D6 Integral Rod Worth for ORR Core 179AX5

Integration Limits, In.[a]		Integral Worth, % δk/k		
LL = 0.0	UL = 26.56	Calc.	Exp.	C/E
		7.239	6.855	1.056

Code	R-out, In.	R-in, In.	R-bank, In.	k-out	k-in	% δk/k
VIM	26.56	0.0	17.72	1.0400±0.0018	0.966±0.0020	7.299±0.273
DIF3D	26.56	0.0	17.72	1.0371	0.9641	7.309

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[a] Integration of the differential rod worth from the lower to the upper limit gives the total rod worth.

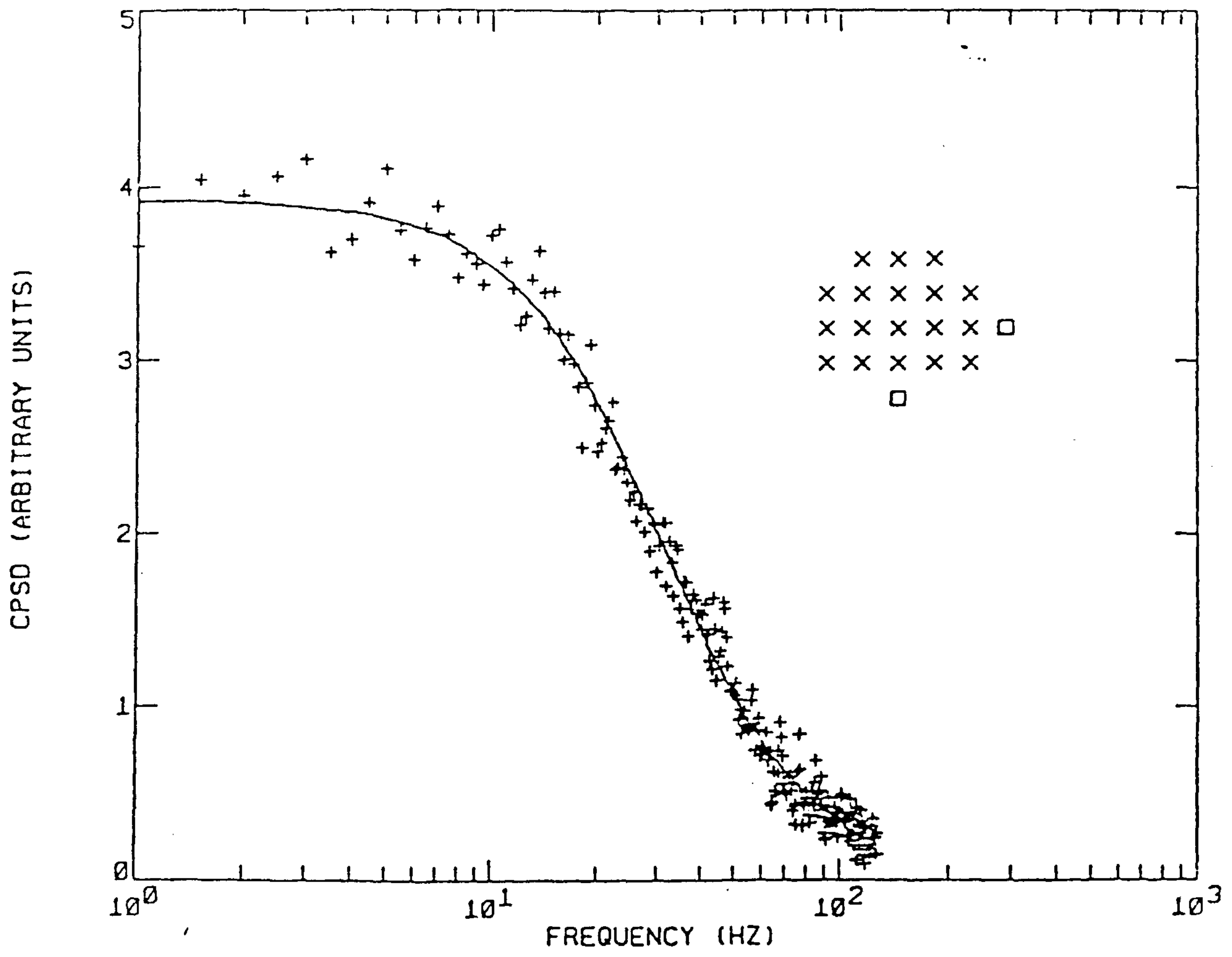

FIG. 34 Cross Power Spectral Density (CPSD) as function of frequency with least-squares fit and the LEU-1 Core Configuration (x = fuel elements or control rods; □ = detectors).

Table. 33. Prompt Neutron Decay Constant

	Delayed Neutron	Prompt Neutron	Prompt Neutron Decay Constant[a]		
Core	Fraction	Lifetime, sec	Calc.-sec.$^{-i}$	Exp.-sec.$^{-1}$	C/E
HEU-1	8.052E-3	47.87E-6	168.2	167.8tO.6	1.0024±0.0036
LEU-1	7.980E-3	41.55E-6	192.0	192.3tl.2	0.9984±0.0062
^{179}A	7.255E-3	55.54E-6	130.6	140.5±0.9	0.9297±0.0060
	7.915E-3[b]	55.54E-6	142.5	140.5±0.9	1.0143±0.0065

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[a] The prompt neutron decay constant is the ratio of the effective delayed neutron fraction to the prompt neutron lifetime.

[b] Includes estimate of delayed photoneutron contributions.

In this experiment temperature changes occur very slowly and most of the time the reactor is subcritical. Therefore, fuel, clad and coolant temperatures are essentially equal at any instant of time and so what is measured is truly an isothermal temperature coefficient, α_T. Thus,

$$\alpha_T = \frac{d\rho}{dT} = -(\frac{\delta k}{k} / \text{in.}) \frac{dL}{dT}$$

where

$\alpha_T \equiv$ isothermal temperature coefficient.

$\frac{\delta k}{k} / \text{in.} \equiv$ the differential worth of the B4 shim rod.

$\frac{dL}{dT} \equiv$ slope of the critical rod position versus temperature curve.

Table 34 shows calculated and measured differential worths, of the B4 shim rod and the observed B4 critical rod withdrawal positions at various coolant temperatures. These temperatures were obtained by averaging the digital readouts of the inlet and outlet coolant temperatures. A linear least squares analysis of the critical rod position versus temperature determined the value of dL/dT.

A calculated temperature coefficient for the 179AX7 core was obtained using EPRI-CELL cross sections generated at temperatures of 296K and 350K. These cross sections are based on the improved fast and thermal EPRI-CELL libraries[40]. The DIF3D eigenvalues obtained from these cross sections for core 179AX7 are k(296K) = 1.00516 and k(350K) = 0.99811. Thus, the calculated isothermal temperature coefficient, averaged over the 23-770C temperature range, is

$$\alpha_T(C) = - 1.\ 3008E-04 / °C.$$

Table 35 summarizes the isothermal temperature coefficient evaluations. The experimental temperature coefficient, $\alpha(E)$, is averaged over the 25-44°C temperature range. No attempt has been made to adjust $\alpha_T(C)$ and/or $\alpha_T(E)$ to correspond to the same temperature interval. Nevertheless, such an adjustment would be in the direction of increasing the C/E ratio given in Table 35. In any event, the calculated isothermal temperature coefficient is consistent with the measured one within experimental errors.

7.6 **Critical Configurations for the 30-MW Operating Cores Used in the Demonstration**

Some results based on preliminary REBUS-3 burnup calculations were presented in references 11, 27, 33, 35 and 41. For a final comparison of measured quantities with calculated ones, improved REBUS-3 burnup calculations were performed for each of the 22 operating cores used in the demonstration, These improved calculations:

1. made use of improved multigroup cross sections sets obtained from new EPRI-CELL libraries,[40]
2. explicitly modeled the voided beam tubes so that their perturbing effects on flux distributions within the core were included in the calculations,
3. included the effects of minor elements and impurities in the aluminum alloys,

Table 34. Components of the Isothermal Temperature Coefficient in Core 179AX7

Rod B4	Rod B4	Rods	Rods	Flow			% δk/k /in.		
Ri In.	Rf In.	F4 & F6 UL	D4,D6,B6 Banked	Rate gpm	k_i Calc.	k_f Ca1c.	k Ca1c.	Exp.	C/E
12.76	13.57	27.495	12.76	1,200	0.997722	0.999231	0.18687	0.18745	0.997 ± 0.040
12.84	13.58	27.495	12.76	18,000	0.997906	0.999321	0.19179	0.19799	0.969 ± 0.045

B4 Shim Rod Position at Criticality Versus Temperature

Position In.	Temperature °F
12.75	76.95 ± 0.59
12.82	78.55 ± 0.26
12.96	80.35 ± 0.26
13.19	85.28 ± 0.21
13.35	90.25 ± 0.17
13.53	95.72 ± 0.32
13.68	100.10 ± 0.16
13.89	105.18 ± 0.13
14.03	110.95 ± 0.98

Table 35. Isothermal Temperature Coefficient

ORR Core 179AX7

$$\alpha_T(E) = - \{\delta k/k \text{ /in.}\}\ dL/dT$$

$\delta k/k$ /in.	dL/dT in./°C	$\alpha_T(E)$ (°C^{-1})	$\alpha_T(C)$ (°C^{-1})	C/E
(1.9806±0.091)E-3	(6.78±0.21)E-2	-(1.341±0.075)E-4	-1.301E-4	0.970±0.054

4. provided a more detailed mesh structure than that used in the preliminary work so that more meaningful transverse gradient correction factors could be calculated,

5. included the isotopes ^{1}H, ^{2}H, ^{3}H, ^{3}He, ^{6}Li, ^{9}Be, ^{135}I, ^{135}Xe, ^{149}pm. ^{149}Sm, ^{234}U, ^{235}U, ^{236}U, ^{237}U, 238U, ^{237}Np, ^{238}Np ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{242}Am, ^{242m}Am, ^{243}Am, ^{242}Cm, ^{243}Cm, and ^{244}Cm in the burnup chains,

6. removed beryllium overlay errors which were present in some of the preliminary calculations,

7. made use of a more realistic model of the ORR core box, and

8. used improved ^{235}U mass estimates, based on the ^{137}CS gamma-scanning data, for those HEU fuel elements which were first irradiated in predemonstration cores.

After each burnup calculation a data set of the end-of-cycle (EOC) fuel element atom densities was copied from the REBUS-3 STACK file. This data set was used in a program written to prepare input for future REBUS-3 calculations allowing for atom density changes due to radioactive buildup and decay.

The non-equilibrium burnup calculations used the control rod movement capability of the REBUS-3 code. In most cases the cycle length (CL), expressed in full power days (FPD's), was divided into three equal time nodes (TN's). Shim rod positions at the boundaries of each time node were determined from the control rod position histories which were recorded throughout each operating cycle. For those cores with short cycle lengths the cycle was divided into only two equal time nodes.

Table 36 shows the calculated eigenvalues corresponding to the experimentally-determined critical configurations for each of the operating cores. These eigenvalues have been temperature-corrected to account for small temperature differences between the operating cores and the 296K used for cross section generation. Calculated temperature coefficients used for these corrections are -1.39E-04/°C (HEU Core 174C) and -1.30E-04/°C (LEU Core 179AX7). A measured isothermal temperature coefficient is discussed in Section 7.5. Most of the eigenvalues in Table 36 are within 0.5% of unity.

The configuration of each of these operating cores, fuel locations, and BOC ^{235}U masses are given in Appendix A. Critical shim rod elevations at each time node arc listed in Appendix B.

7.7 **Cycle-Averaged Fuel Element Powers**

After each bum cycle during the whole-core demonstration the fuel elements were removed from the ORR to allow for xenon decay while a second core was loaded into the assembly. During these intercycle periods the removed fuel elements were gamma-scanned axially along their center lines to measure the distribution of the 1.596 Mev ^{140}La fission product gamma ray activity. Because of the relatively short half lives of ^{140}Ba and ^{140}La, this information gives a measure of the fission rate densities and so the power densities that occurred during the previous bum cycle. Following the methods described in Section 6.4, the ^{140}La data were used to determine cycle-averaged fuel element powers. Analytical values for these fuel element powers were obtained from the REBUS-3 output at each time node.

Table 36. Calculated Eigenvalues Corresponding to Measured Critical Configurations for ORR Demonstration Cores

CORE	Cycle Length, CL FPD's	Temperature-Adjusted Eigenvalue BOC	1/3 CL	MOC	2/3 CL	EOC
174C	16.8402	1.0024	0.9999		0.9985	0.9992
174D	12.8554	1.0006		0.9970		0.9960
174E	10.6228	1.0035		0.9966		0.9963
174F	15.4282	0.9918	0.9916		0.9935	0.9936
175A	18.5181	0.9963	0.9974		0.9970	0.9967
175B	20.3049	1.0058	1.0050		1.0040	1.0006
175C	17.3891	1.0001	1.0003		1.0009	1.0019
176A	17.2444	1.0041	1.0034		1.0032	1.0042
176B	21.8645	1.0000	0.9995		0.9992	0.9986
176C	19.4357	0.9952	0.9946		0.9950	0.9936
176D	19.4463	1.0042	1.0049		1.0048	1.0084
177A	14.7731	1.0018	1.0033		1.0030	1.0054
177B	18.5160	1.0018	1.0004		1.0006	0.9996
177C	18.4107	1.0038	1.0028		1.0038	1.0038
177D	15.3341	1.0065	1.0068		1.0070	1.0090
178A	12.1006	1.0006		1.0012		1.0053
178B[a]	0.6445	0.9946				0.9869
178C	11.1377	1.0062		0.9999		0.9996
178D	16.3556	1.0030	1.0006		0.9986	1.0002
178H	20.2765	1.0130[b]	0.9969		0.9975	0.9959
178J	16.5022	0.9981	0.9983		0.9982	0.9978
179A	20.1687	0.9969	0.9990		0.9995	0.9991

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[a] Insufficient excess reactivity. EOC control rod positions were not recorded, only estimated.

[b] Calculation neglects 135Xe buildup from the just previous experimental core, 178-EX 1.

Table 37 gives the cycle-averaged measured power P(E) and the corresponding C/E ratio for each fuel element in each of the operating cores used in the demonstration. However, no gamma-scanning data were taken for the fuel elements in the all-HEU reference core 174C. The mot -mean -square deviation (RMS DEV) of the departure of the C/E ratios from unity is shown at the bottom of Table 37 lb. each of the cores. Of the 524 C/E ratios given in this table about 75% differ from unity by 5% or less. In general, the LEU C/E fuel element power ratios cluster more tightly about unity than do those for the HEU fuel elements. This is probably due to the uncertainty in the ^{235}U mass of the HEU fuel elements at the beginning of the demonstration. Nearly all the HEU elements experienced some burnup prior to the beginning of the demonstration. Figures 35-54 show the C/E power ratios for each fuel element in each core configuration.

A careful examination of Table 37 reveals several anomalies. For cores 174D through 175C the C/E power ratios are unusually large in the A-row, especially at location A5. However, this trend tends to disappear for the remaining cores in the demonstration. The Heavy Section Steel Technology (HSST) Experiment (Section 2.5.3) was located just outside the core box on the west side of the core for 174D through 175C, but was removed for the remaining cores. The C/E data suggests that the HSST was not modeled very well in the diffusion calculations even though good eigenvalues (Table 36) were obtained. A number of core pairs with nearly identical configurations (176B-176C, 176D-177A, 177B-177C) show several low C/E ratios in column 5 for one member of the pair but not the other. In almost all these cases the low C/E ratio corresponds to an HEU fuel element which was not gamma-scanned for ^{137}Cs. As will be discussed in the next section, the ^{235}U mass for these fuel elements is quite uncertain, which may account for this strange behavior. Finally, all the cores beginning with 178C contained only LEU fuel and had the same configuration (see Figs. 50-54). For each of these cases a large C/E value was obtained at position B3 but very normal ratios at the symmetric position B7. The reason for this anomalous behavior is not understood.

The accuracy of the cycle-averaged fuel element powers obtained from the ^{140}La gamma-scanning data is limited by errors associated with the determination of the geometric efficiency factor $G_L(^{140}La)$. 'Me value obtained for this quantity, together with its standard error, is given in Section 6.4.2. For the seven cores containing all-LEU standard 19-plate fuel elements, the standard deviation in GL is about 2.0%. The RMS DEV's from unity for the C/E fuel element power ratios are larger than 2.0%, especially for cores 178C, 178D and 178H. This suggests the presence of systematic errors in the gamma-scanning data for the LEU cores and/or modeling deficiencies. Appendix F illustrates the evaluation of cycle-averaged fuel element powers from the ^{140}La gamma-scanning data for element C024.

7.8 Fuel -Element-Averaged ^{235}U Burnups

7.8.1 Results from ^{137}Cs Gamma-Scanning of Full-Sized Fuel Elements

During the demonstration fuel elements discharged from the ORR were gamma-scanned to determine the ^{137}Cs activity distribution. Because of the 30-year half life of ^{137}Cs' this measurement integrates the activity over all previous cycles of operation and so gives count rates proportional to the total fission density within the fuel element. The ^{235}U burnup is directly related to this total fission density. Mathematical details for analyzing the ^{137}Cs gamma-scanning data to determine final ^{235}U fuel element masses and burnups are given in Section 6.4. This is illustrated in Appendix F for C024.

Table 38 shows the experimental values for the ^{235}U masses and burnups for all 68 LEU fuel elements used in the demonstration and the corresponding C/E ratios. Similar information is provided at the end of this table for the LEU fuel followers. Of the 132 HEU fuel elements used in the demonstration only 3 were cycled into the reactor as fresh fuel. Table 39 summarizes the burnup results for these three HEU fuel elements.

Table 37. Summary of ORR Fuel Element Power C/E Ratios

CORE:	174D			174E			174F			175A			1758		
LOC	FE	P(E)-MW	C/E	FE	P(E)-HW	C/E	FE	P(E)-MW	C/E	FE	P(E)-MW	C/E	FE	P(E)-Mw	C/E
A2	T519	0.670	1.009	T527	0.630	1.096	T547	0.683	1.057	T521	0.589	1.104	T534	0.663	1.049
A3	T530	0.859	0.991	T521	0.766	1.086	T549	0.768	1.122	T531	0.798	1.055	T531	0.802	1.061
A4	T554	1.038	I.d06	T557	0.975	1.078	T544	1.014	1.056	T525	0.971	1.041	T552	0.976	1.051
A5	C021	1.055	1.097	C021	1.049	0.993	C024	1.065	1.121	C027	1.025	1.136	N001	1.022	1.151
A6	T555	0.995	1.029	T545	0.984	1.071	T541	0.996	1.065	T561	0.990	1.041	T556	0.967	1.063
A7	T540	0.823	0.990	T534	0.780	1.104	T515	0.759	1.103	T538	0.813	1.051	T546	0.787	1.067
A8	T503	0.644	0.984	T500	0.565	1.095	T519	0.564	1.137	T527	0.599	1.076	T547	0.608	1.061
B3	T501	0.980	1.003	T465	0.927	0.994	T503	0.996	1.006	T500	0.890	0.998	T491	0.944	0.984
B5	T455	1.007	1.046	T458	1.040	0.988	T416	1.043	0.983	T454	0.969	1.000	T417	1.004	1.006
B7	T497	0.889	0.962	T505	0.891	1.023	T522	0.945	0.965	T535	0.921	0.957	T484	0.901	0.979
C2	C022	1.170	1.038	C022	1.177	0.969	C025	1.194	1.033	C028	1.154	1.011	N002	1.211	0.986
C4	T526	1.225	0.987	T507	1.142	1.012	T508	1.150	1.016	T528	1.111	0.989	T530	1.154	0.978
C5	T419	1.161	0.956	T420	1.107	1.010	T453	1.049	1.055	T473	1.068	1.003	T456	1.128	1.003
C6	T535	1.214	0.945	T528	1.206	0.973	T530	1.129	1.041	T540	1.163	0.974	T515	1.167	0.974
C8	C023	1.135	0.915	C023	1.134	0.952	C026	1.127	0.999	C029	1.076	1.010	N003	1.113	0.976
D2	T319	0.771	0.993	T368	0.750	0.981	T408	0.769	0.979	T328	0.739	1.032	T439	0.709	1.020
D3	T548	1.262	0.984	T529	1.282	0.965	T533	1.249	0.991	c021	1.215	1.006	C024	1.294	0.973
D5	T434	1.073	0.965	T396	1.161	0.924	T426	1.049	0.988	T364	1.041	0.974	T460	1.186	0.955
D7	T539	1.214	0,921	T559	1.138	0.937	T560	1.219	0.970	C022	1.183	1.002	C025	1.231	0.976
D8	T469	0.764	0.920	T475	0.748	1.016	T430	0.755	0.992	T418	0.724	0.971	T523	0.742	0.986
E2	T515	0.883	0.989	T517	0.887	0.946	T532	0.909	0.986	c023	0.921	1.001	C026	0.949	0.992
E4	T537	1.174	0.980	T531	1.180	0.969	T518	1.164	0.993	T558	1.235	0.947	T553	1.251	0.929
E5	Ir			Ir			Ir			Ir			Ir		
E6	T549	1.200	0.950	T536	1.257	0.961	T542	1.182	0.992	T548	1.223	0.954	T554	1.205	0.953
E8	T556	1.037	0.924	T561	1.058	0.948	T562	0.996	0.977	C030	0.980	0.9ge	N004	0.983	0.985
F3	T516	0.771	0.939	T464	0.731	0.877	T479	0.732	0.968	T487	0.700	0.939	T445	0.705	0.962
F5	T459	0.848	0.967	T493	0.870	0.965	T443	0.813	0.984	T461	0.870	0.923	T489	0.815	0.932
F7	T514	0.791	0.910	T523	0.766	0.935	T492	0.776	0.986	T422	0.740	0.937	T495	0.678	0.984
RMS-DEV:			0:048			0.054			0.055			0.050			0.047

Note: IIEU fuel elements (FE) are identified with the letter T. LEU fuel elements are identified with the letters C (CERCA), N (NUKEM) and B (Babcock and Wilcox).

Table 37. Summary of ORR Fuel Element Power C/E Ratios (Continued)

CORE:	17 5C			176A			176B			176C			176D		
LOC	FE	P(E)-MW	C/E	FE	P(E)-MW	C/E	FE	P(E)-MW	C/E	FE	P(E)-MW	C/E	FE	P(E)-MW	C/E
A2	T538	0.694	1.036	T546	0.698	0.976	T507	0.523	0.996	T510	0.542	1.031	Be		
A3	T517	0.802	l.073	T536	0.841	0.997	T537	0.741	0.972	T520	0.692	1.001	T538	0.700	1.008
A4	T562	1.024	1.040	T541	1.004	0.986	T558	0.905	0.969	T542	0.784	0.982	C021	0.792	0.999
A5	N007	1.084	1.114	N005	1.305	1.045	T551	0.942	0.982	T559	0.843	0.993	C022	0.790	1.055
A6	T545	0.984	1.041	T557	1.002	0.984	T550	0.873	0.997	T532	0.773	0.989	C023	0.771	1.061
A7	T543	0.834	1.058	T539	0.815	1.022	T549	0.701	0.989	T554	0.662	0.993	T548	0.691	1.049
A8	T524	0.624	1.067	T534	0.656	0.984	T521	0.551	0.999	T514	0.502	0.998	Be		
B3	T497	0.908	1.004	T499	1.015	0.952	C021	1.057	1.002	C024	1.008	1.022	C027	1.114	1.007
B5	T470	1.029	0.984	T486	1.055	0.994	T425	0.941	0.957	T432	0.904	0.881	T442	1.085	0.857
B7	T482	0.910	0.947	T501	0.907	0.941	C030	1.069	0.971	14001	1.005	0.934	C028	1.019	0.989
C2	N008	1.132	1.046	N006	1.232	1.010	B041	1.254	0.975	B045	1.256	1.002	B048	1.292	1.015
C4	T519	1.155	0.990	T485	1.125	1.022	C027	1.357	1.019	N004	1.322	0.990	N008	1.484	0.979
C5	T496	1.137	1.074	T506	1.246	0.972	T484	1.013	0.985	T444	0.908	0.979	T429	1.196	0.875
C6	C023	1.323	1.029	C026	1.392	1.009	C028	1.267	1.007	N002	1.206	0.978	H007	1.393	0.911
C8	N009	1.116	0.964	N010	1.151	1.005	B042	1.138	0.978	B046	1.133	0.945	B049	1.183	0.996
D2	T451	0.715	0.993	T509	0.837	0.964	T480	0.824	0.963	T474	0.862	1.009	T483	0.840	0.995
D3	C030	1.274	1.011	N001	1.325	0.972	N008	1.286	1.003	N006	1.291	1.019	B041	1.414	0.985
D5	T400	1.080	0.991	T455	1.081	0.982	T410	1.028	0.954	T488	1.148	0.804	T447	1.133	0.901
D7	C028	1.152	0.974	N002	1.193	0.993	N007	1.168	0.980	N010	1.174	0.959	B042	1.285	0.964
D8	T464	0.724	0.892	T494	0.771	0.998	T349	0.751	0.974	T405	0.794	0.870	T481	0.849	0.933
E2	C029	0.942	1.015	N003	0.995	0.973	B043	1.064	0.991	B047	1.131	1.036	B043	1.128	1.017
E4	C021	1.161	0.996	C024	1.200	0.979	N009	1.286	0.968	N005	1.368	0.961	B044	1.288	1.029
E5	Ir		Ir			IR				T401	0.994	0.888	Al		
E6	C022	1.102	1.017	C025	1.144	1.022	C029	1.138	1.019	N003	1.231	0.976	N009	1.230	0.989
E8	C027	0.947	0.949	N004	0.970	1.019	B044	1.046	0.983	N011	1.096	0.979	B050	1.176	0.983
F3	T498	0.759	0.935	T465	0.705	0.922	C022	0.879	0.985	C025	1.001	0.989	C030	l.'005	0.999
F5	T504	0.197	0.949	T505	0.788	0.968	T495	0.826	0.892	T448	0.923	0.899	T477	0.910	0.910
F7	T511	0.734	0.935	T513	0.688	0.975	C023	0.858	0.997	C026	0.957	0.987	C029	0.985	0.997
RMS-DEV:		0.051				0.029			0.029			0.062			0.054

Note: HEU fuel elements (FE) are identified with the letter T. LEV fuel elements are identified with the letters C (CERCA) N (NUKEM) and B (Babcock and Wilcox).

Table 37. Summary of ORR Fuel Element Power C/E Ratios (Continued)

CORE:	17 7A			177B			171C			177D			178A		
LOC	FE	P(E)-MW	C/E	FE	P(E)-MW	C/E	FE	p (E)-MW	C/E	FE	P(E)-HW	C/E	FE	P(E)-MW	C/E
A2	Be			Be			Be			Be			Be		
A3	T553	0.759	1.025	T420	0.538	0.984	T443	0.564	1.001	Be			Be		
A4	C024	0.833	1.0~3	C027	0.723	1.019	N001	0.723	1.074	B048	0.877	0.975	B051	0.882	1.000
A5	C025	0.843	1.030	C028	0.755	1.018	N002	0.734	1.087	B050	0.839	1.014	B053	0.851	1.044
A6	C026	0.620	1.035	C029	0.717	1.041	N003	0.720	1.077	B095	0.901	1.002	C033	0.875	1.044
A7	T518	0.713	1.042	C030	0.629	1.080	N004	0.642	1.097	Be			Be		
A8	Be			Be			Be			Be			Be		
B3	N004	1.191	0.968	N008	1.015	0.998	N006	1.003	1.044	B043	1.126	0.953	B047	1.060	0.951
S5	T475	0.912	0.965	T390	0.924	0.896	T482	0.860	0.974	C028	1.031	0.975	N002	1.082	0.995
B7	N002	1.018	0.944	N007	0.958	0.963	N011	1.026	0.990	B044	0.979	1.019	N010	0.904	1.008
C2	B051	1.329	0.983	B095	1.308	0.957	C033	1.212	1.036	C036	1.249	0.958	C038	1.091	0.951
C4	N006	1.541	0.962	B041	1.487	0.907	B045	1.376	1.006	C027	1.188	0.989	N001	1.254	0.998
C5	T492	1.221	0.953	T393	1.089	0.879	T500	1.014	0.941	C021	1.068	1.011	C024	1.156	1.020
C6	N010	1.448	0.957	B042	1.336	0.950	B046	1.329	0.985	C029	1.153	0.991	N003	1.201	1.000
C8	B052	1.220	0.994	B096	1.127	1.006	C034	1.122	1.027	C037	1.118	1.015	C039	1.019	0.912
D2	T416	0.857	0.933	C021	0.977	0.979	C024	0.918	1.076	B041	1.017	0.979	B045	0.901	0.987
D3	B045	1.466	0.954	B048	1.520	0.901	B051	1.370	1.001	N008	1.171	0.967	N006	1.141	0.985
D5	T466	1.145	0.933	T419	1.115	0.850	T507	0.948	0.971	C022	1.167	0.996	C025	1.266	1.007
D7	B046	1.308	0.956	B049	1.268	0.961	B052	1.272	0.967	N009	1.116	0.966	N005	1.182	0.975
D8	T422	0.822	0.959	C023	0.917	1.015	C025	0.911	1.044	B042	1.011	1.012	B046	0.957	0.996
E2	B047	1.165	0.965	C032	1.221	0.985	N012	1.160	1.023	N013	1.176	0.939	N014	1.000	0,942
E4	N011	1.376	0.953	B050	1.499	0.891	B053	1.363	0.970	C030	1.244	0.951	N004	1.234	0.982
E5	Al			Al			Al			C023	1.095	1.015	C026	1.149	1.032
E6	N005	1.261	0.956	B043	1.271	0.961	B047	1.220	1.002	N007	1.203	0.985	N011	1.409	1.000
E8	B053	1.177	0.972	N013	1.157	0.994	N014	1.122	1.023	N015	1.213	0.978	N018	1.141	0.977
F3	N001	1.043	0.935	B044	1.163	0.929	N010	0.996	1.029	B096	1.284	0.886	C034	1.092	0.957
F5	T458	0.937	0.824	C022	1.041	0.967	C026	1.004	1.022	B049	1.329	0.934	B052	1.328	0.973
F7	N003	0.996	0.967	N009	1.014	0.972	N005	0.953	1.042	C032	1.224	0.948	N012	1.208	0.974
RMS-DEV:			0.0.52			0.064			0.045			0.039			0.033

Note: IIEU fuel elements (FE) are identified with the letter T. LEU fuel elements are identified with the letters C (CERCA), N (NUMEM) and B (Babcock and Wilcox).

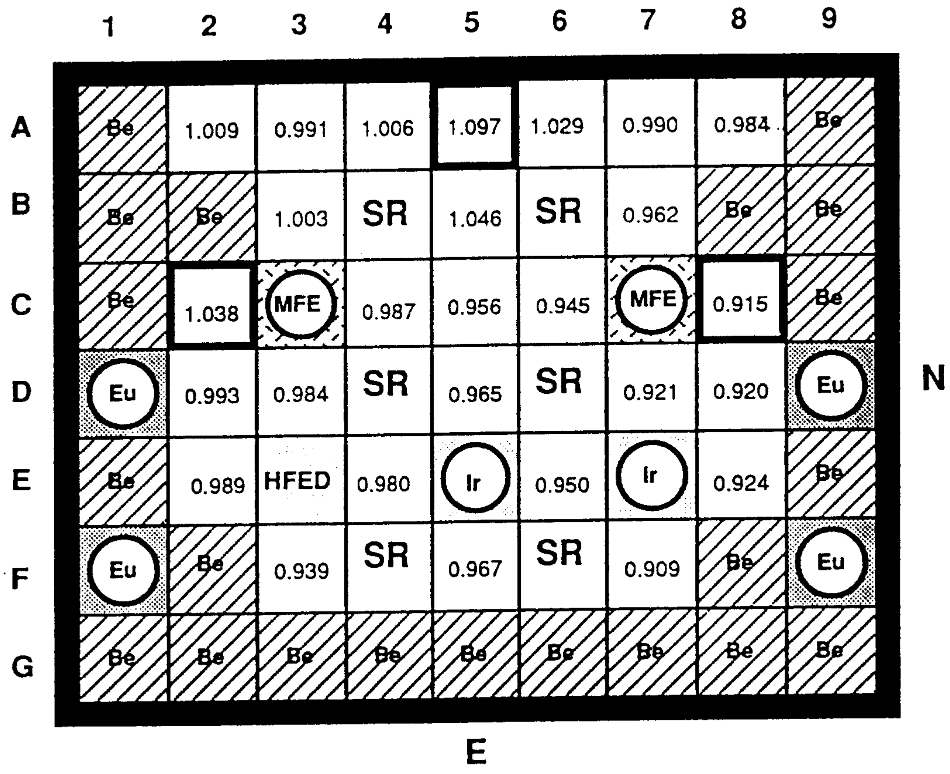
Table 37. Summary of ORR Fuel Element Power C/E Ratios (Continued)

CORE:	178C			178D			178H			178J			179A		
LOC	FE	P(E)-MW	C/E	FE	P(E)-MW	C/E	FE	P(E)-MW	C/E	FE	P(E)-MW	C/E	FE	P(E)-MW	C/E
A2	Be			Be			Be			Be			Be		
A3	C029	0.505	1.106	N003	0.539	1.067	B041	0.539	1.053	B045	0.573	1.027	N016	0.727	0.996
A4	N015	0.792	1.039	N018	0.818	1.014	N016	0.734	1.046	B054	0.826	1.010	B082	0.860	0.974
A5	N019	0.832	1.086	B098	0.806	1.042	B082	0.851	1.041	B086	0.872	1.030	N002	0.693	1.023
A6	B095	0.687	1.140	C033	0.717	1.092	N019	0.784	1.049	C040	0.792	1.044	B083	0.850	0.993
A7	C030	0.466	1.167	N004	0.505	1.096	N009	0.478	1.132	N010	0.528	1.064	B097	0.692	1.025
A8	Be			Be			Be			Be			Be		
B3	B048	0.765	1.162	B051	0.800	1.138	C032	0.794	1.153	C033	0.813	1.147	C036	0.854	1.103
B5	N009	0.837	1.116	N010	0.925	1.032	B042	0.872	1.071	B046	0.955	1.012	B041	0.930	0.986
B7	B050	0.771	1.057	B053	0.843	0.982	N013	0.825	1.008	C034	0.854	0.996	C037	0.895	0.981
C2	N016	0.987	0.973	B054	1.005	0.977	B083	1.007	0.968	B087	0.997	0.987	C035	1.023	0.977
C4	N007	0.981	1.101	N005	1.030	1.071	B043	1.003	1.092	B047	1.081	1.036	B048	1.102	1.026
C5	C027	0.971	1.066	N001	1.048	1.023	N007	0.971	1.060	N005	1.028	1.031	B042	1.062	1.005
C6	N008	0.953	1.040	N006	1.005	1.004	B044	1.018	1.015	N011	1.011	1.036	B049	1.065	0.995
C8	C031	0.940	0.944	C040	0.975	0.921	B084	0.930	0.973	B088	0.973	0.943	N017	0.988	0.937
D2	C032	0.920	0.995	N014	0.941	1.008	C037	0.923	1.021	C039	0.934	0.969	N020	0.962	0.983
D3	B041	0.957	1.088	B045	1.027	1.047	B048	1.010	1.081	B051	1.067	1.039	B095	1.029	1.041
D5	C028	1.053	1.016	C024	1.032	1.034	N008	0.994	1.095	N006	1.052	1.067	B043	1.110	1.011
D7	B042	1.065	0.969	B046	1.091	0.975	B049	1.074	0.988	B052	1.090	0.990	B096	1.094	0.989
DS	B096	0.942	0.916	C034	0.939	1.001	N015	0.962	1.000	N018	0.986	0.987	C031	0.932	1.024
E2	N020	1.016	0.962	B100	1.069	0.903	B097	0.967	0.979	B100	0.966	0.971	B084	0.974	0.952
E4	B049	1.198	1.030	B052	1.268	0.987	B096	1.249	1.020	N012	1.206	1.039	B050	1.080	0.999
E5	B043	1.173	1.038	B047	1.238	1.009	B050	1.226	1.034	B053	1.263	1.014	B044	1.060	1.023
E6	B044	1.275	0.962	N011	1.260	0.986	B095	1.348	1.001	N014	1.341	1.009	C032	1.248	1.011
E8	B097	1.119	0.939	B099	1.116	0.942	B085	1.074	0.994	B089	1.128	0.954	B085	1.007	0.994
F3	C036	1.099	0.938	C038	1.129	0.933	C031	1.078	0.978	B099	1.051	0.986	N015	0.943	0.996
F5	N013	1.251	0.987	N012	1.298	0.964	C036	1.226	1.040	C038	1.227	1.038	N013	1.119	1.005
F7	C037	1.202	0.932	C039	1.341	0.855	N020	1.195	0.975	B098	1.229	0.943	N019	1.095	0.996
RMS-DEV:			0.099			0.062			0.058			0.045			0.030

Note: HEU fuel elements (FE) are identified with the letter T. LEU fuel elements are identified with the letters C (CERCA), N (NUKEM) and B (Babcock and Wilcox).

ORR CORE 174D

Cycle-Averaged Power C/E Ratios



	1	2	3	4	5	6	7	8	9
A	Be	1.009	0.991	1.006	1.097	1.029	0.990	0.984	Be
B	Be	Be	1.003	SR	1.046	SR	0.962	Be	Be
C	Be	1.038	MFE	0.987	0.956	0.945	MFE	0.915	Be
D	Eu	0.993	0.984	SR	0.965	SR	0.921	0.920	Eu
E	Be	0.989	HFED	0.980	Ir	0.950	Ir	0.924	Be
F	Eu	Be	0.939	SR	0.967	SR	0.909	Be	Eu
G	Be	Be	Be	Be	Be	Be	Be	Be	Be

SR = Shim Rod Assemblies

MFE = Magnetic Fusion Experiment

Ir, Eu = Irradiation Facility for Activating Iridium or Europium Samples

HFED = High U-load Fuel Element Device for Mini-Plate Irradiations

Be = Beryllium Reflector Element

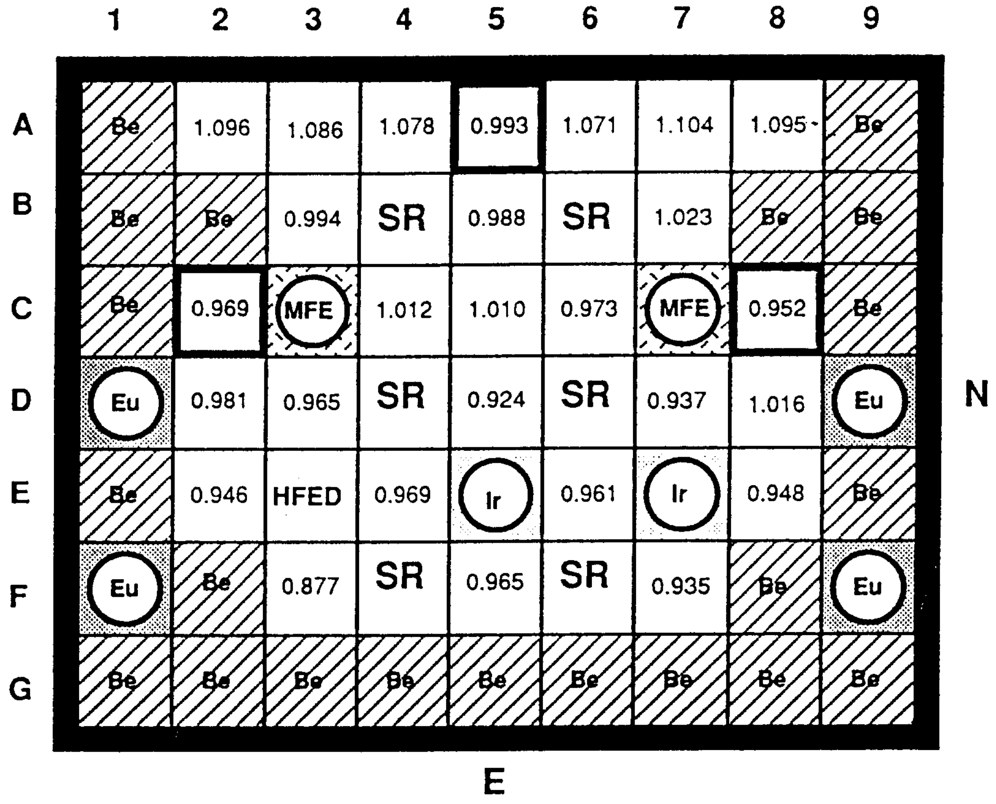
□ = LEU Fuel Element

RMS DEV = 0.048

Fig. 35

ORR CORE 174E

Cycle-Averaged Power C/E Ratios



	1	2	3	4	5	6	7	8	9
A	Be	1.096	1.086	1.078	0.993	1.071	1.104	1.095	Be
B	Be	Be	0.994	SR	0.988	SR	1.023	Be	Be
C	Be	0.969	MFE	1.012	1.010	0.973	MFE	0.952	Be
D	Eu	0.981	0.965	SR	0.924	SR	0.937	1.016	Eu
E	Be	0.946	HFED	0.969	Ir	0.961	Ir	0.948	Be
F	Eu	Be	0.877	SR	0.965	SR	0.935	Be	Eu
G	Be	Be	Be	Be	Be	Be	Be	Be	Be

SR = Shim Rod Assemblies

MFE = Magnetic Fusion Experiment

Ir, Eu = Irradiation Facility for Activating Iridium or Europium Samples

HFED = High U-load Fuel Element Device for Mini-Plate Irradiations

Be = Beryllium Reflector Element

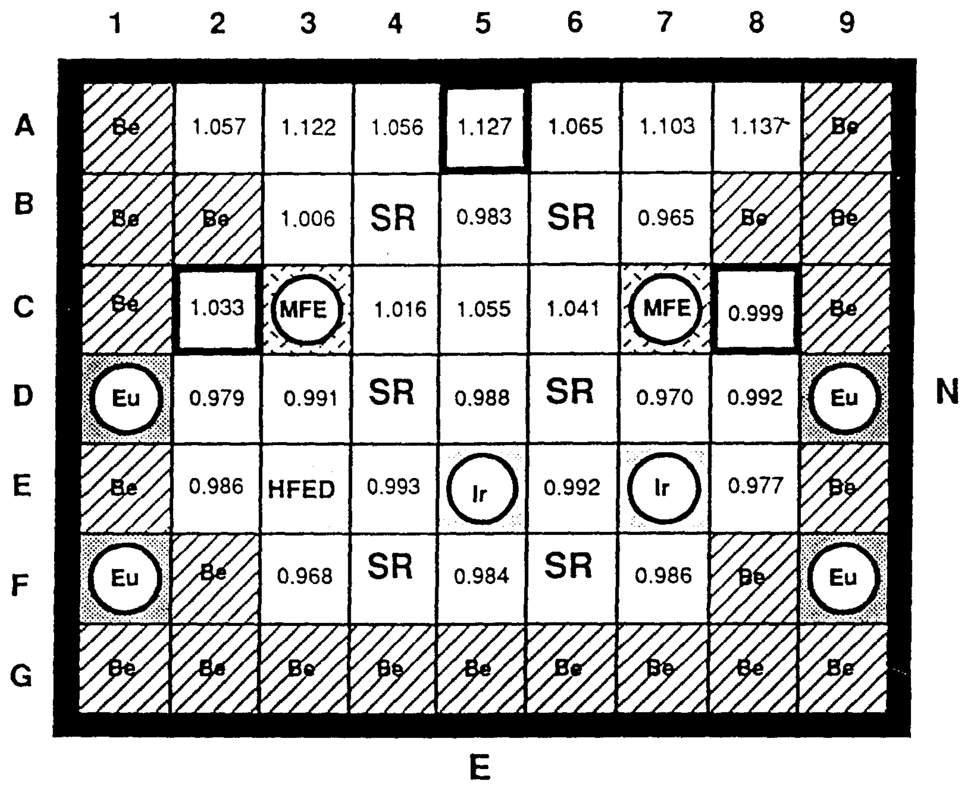
□ = LEU Fuel Element

RMS DEV = 0.054

Fig. 36

ORR CORE 174F

Cycle-Averaged Power C/E Ratios



	1	2	3	4	5	6	7	8	9
A	Be	1.057	1.122	1.056	1.127	1.065	1.103	1.137	Be
B	Be	Be	1.006	SR	0.983	SR	0.965	Be	Be
C	Be	1.033	MFE	1.016	1.055	1.041	MFE	0.999	Be
D	Eu	0.979	0.991	SR	0.988	SR	0.970	0.992	Eu
E	Be	0.986	HFED	0.993	Ir	0.992	Ir	0.977	Be
F	Eu	Be	0.968	SR	0.984	SR	0.986	Be	Eu
G	Be	Be	Be	Be	Be	Be	Be	Be	Be

SR = Shim Rod Assemblies

MFE = Magnetic Fusion Experiment

Ir, Eu = Irradiation Facility for Activating Iridium or Europium Samples

HFED = High U-load Fuel Element Device for Mini-Plate Irradiations

Be = Beryllium Reflector Element

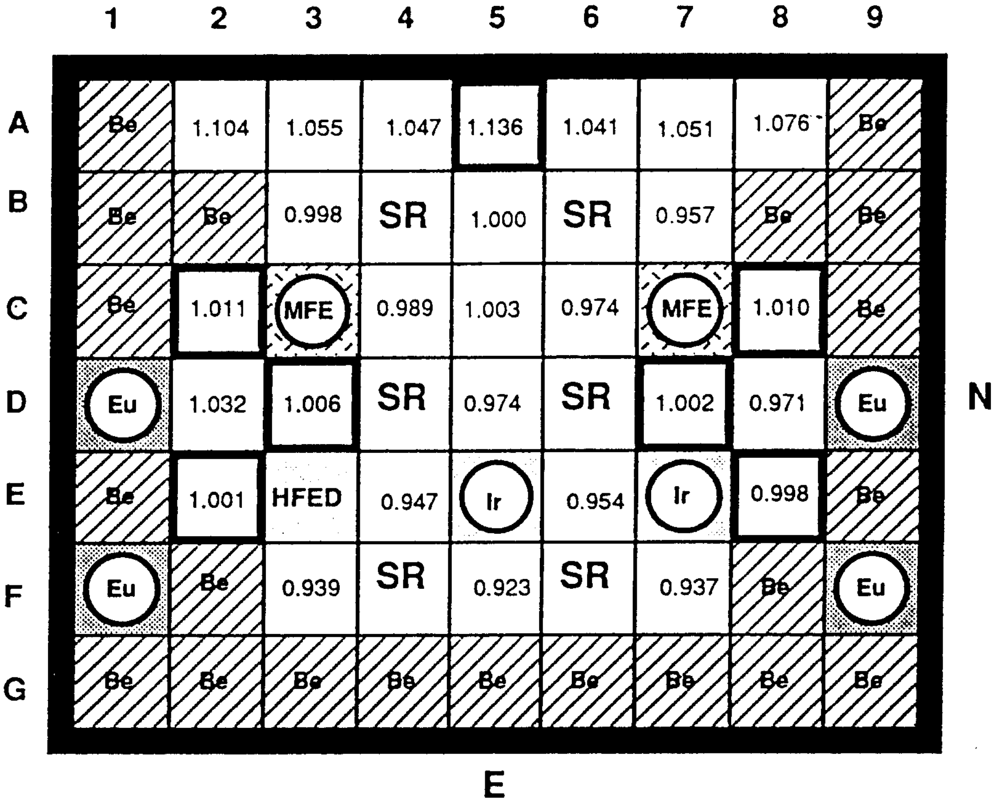
□ = LEU Fuel Element

RMS DEV = 0.055

Fig. 37

ORR CORE 175A

Cycle-Averaged Power C/E Ratios



	1	2	3	4	5	6	7	8	9
A	Be	1.104	1.055	1.047	1.136	1.041	1.051	1.076	Be
B	Be	Be	0.998	SR	1.000	SR	0.957	Be	Be
C	Be	1.011	MFE	0.989	1.003	0.974	MFE	1.010	Be
D	Eu	1.032	1.006	SR	0.974	SR	1.002	0.971	Eu
E	Be	1.001	HFED	0.947	Ir	0.954	Ir	0.998	Be
F	Eu	Be	0.939	SR	0.923	SR	0.937	Be	Eu
G	Be	Be	Be	Be	Be	Be	Be	Be	Be

SR = **Shim Rod Assemblies**

MFE = **Magnetic Fusion Experiment**

Ir, Eu = **Irradiation Facility for Activating Iridium or Europium Samples**

HFED = **High U-load Fuel Element Device for Mini-Plate Irradiations**

Be = **Beryllium Reflector Element**

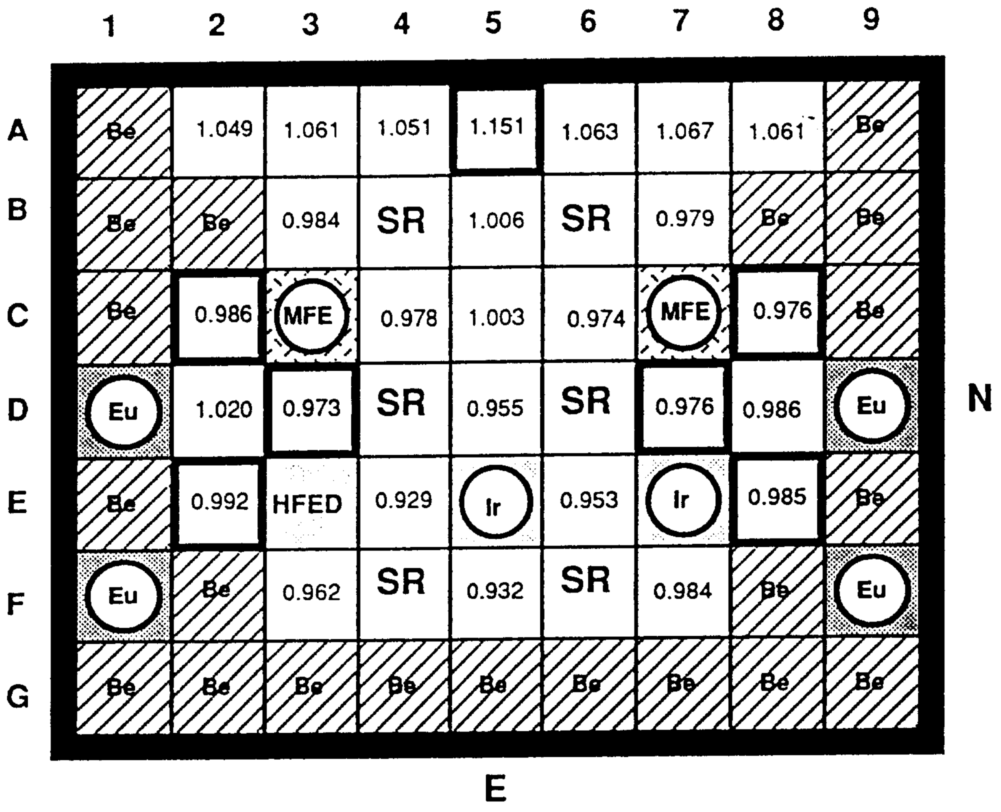
☐ = **LEU Fuel Element**

RMS DEV = 0.050

Fig. 38

ORR CORE 175B

Cycle-Averaged Power C/E Ratios



	1	2	3	4	5	6	7	8	9
A	Be	1.049	1.061	1.051	1.151	1.063	1.067	1.061	Be
B	Be	Be	0.984	SR	1.006	SR	0.979	Be	Be
C	Be	0.986	MFE	0.978	1.003	0.974	MFE	0.976	Be
D	Eu	1.020	0.973	SR	0.955	SR	0.976	0.986	Eu
E	Be	0.992	HFED	0.929	Ir	0.953	Ir	0.985	Be
F	Eu	Be	0.962	SR	0.932	SR	0.984	Be	Eu
G	Be	Be	Be	Be	Be	Be	Be	Be	Be

SR = Shim Rod Assemblies

MFE = Magnetic Fusion Experiment

Ir, Eu = Irradiation Facility for Activating Iridium or Europium Samples

HFED = High U-load Fuel Element Device for Mini-Plate Irradiations

Be = Beryllium Reflector Element

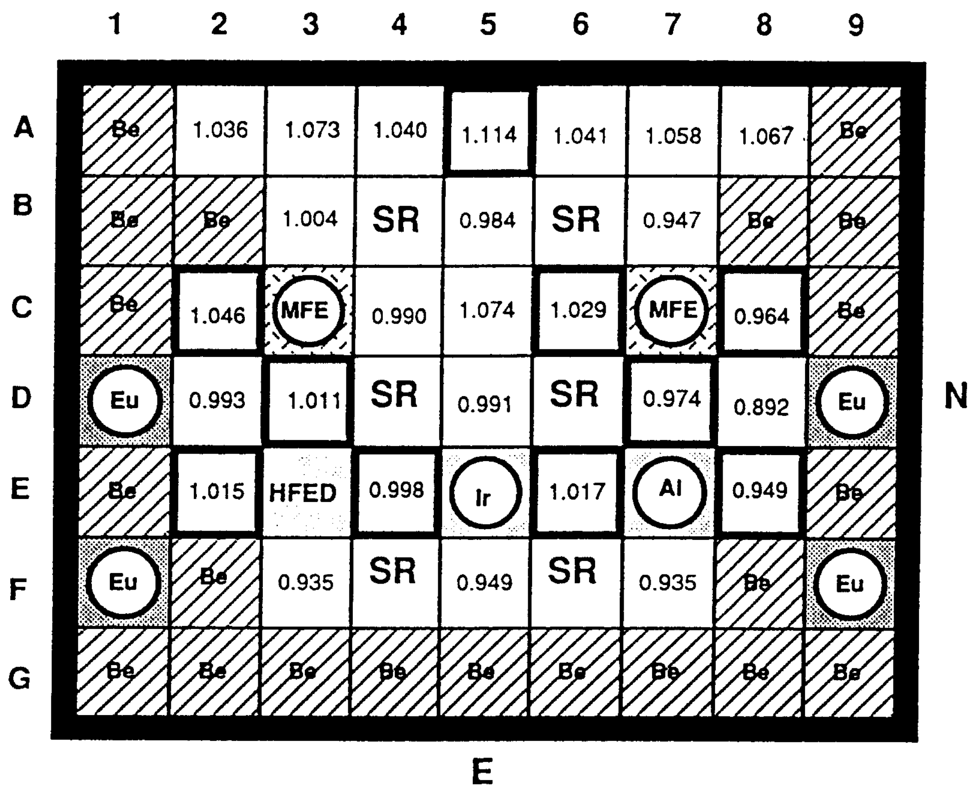
☐ = LEU Fuel Element

RMS DEV = 0.047

Fig. 39

ORR CORE 175C

Cycle-Averaged Power C/E Ratios



	1	2	3	4	5	6	7	8	9
A	Be	1.036	1.073	1.040	1.114	1.041	1.058	1.067	Be
B	Be	Be	1.004	SR	0.984	SR	0.947	Be	Be
C	Be	1.046	MFE	0.990	1.074	1.029	MFE	0.964	Be
D	Eu	0.993	1.011	SR	0.991	SR	0.974	0.892	Eu
E	Be	1.015	HFED	0.998	Ir	1.017	Al	0.949	Be
F	Eu	Be	0.935	SR	0.949	SR	0.935	Be	Eu
G	Be	Be	Be	Be	Be	Be	Be	Be	Be

SR = Shim Rod Assemblies

MFE = Magnetic Fusion Experiment

Ir, Eu = Irradiation Facility for Activating Iridium or Europium Samples

HFED = High U-load Fuel Element Device for Mini-Plate Irradiations

Be = Beryllium Reflector Element

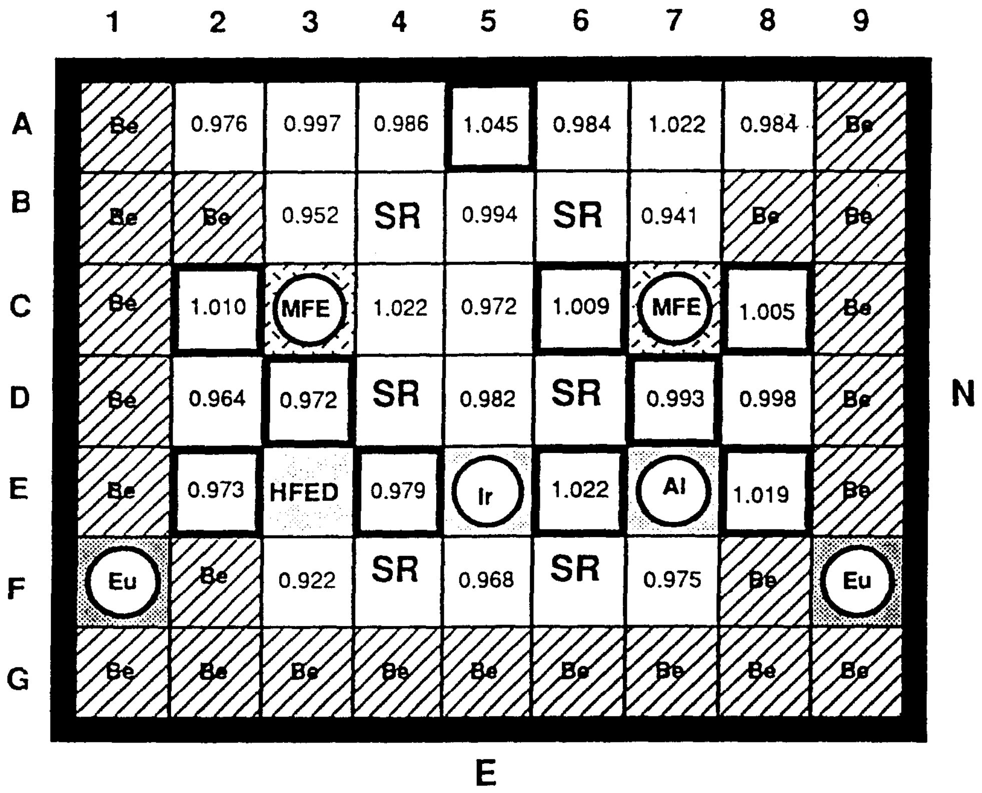
□ = LEU Fuel Element

RMS DEV = 0.051

Fig. 40

ORR CORE 176A

Cycle-Averaged Power C/E Ratios



	1	2	3	4	5	6	7	8	9
A	Be	0.976	0.997	0.986	1.045	0.984	1.022	0.984	Be
B	Be	Be	0.952	SR	0.994	SR	0.941	Be	Be
C	Be	1.010	MFE	1.022	0.972	1.009	MFE	1.005	Be
D	Be	0.964	0.972	SR	0.982	SR	0.993	0.998	Be
E	Be	0.973	HFED	0.979	Ir	1.022	Al	1.019	Be
F	Eu	Be	0.922	SR	0.968	SR	0.975	Be	Eu
G	Be	Be	Be	Be	Be	Be	Be	Be	Be

SR = Shim Rod Assemblies

MFE = Magnetic Fusion Experiment

Ir, Eu = Irradiation Facility for Activating Iridium or Europium Samples

HFED = High U-load Fuel Element Device for Mini-Plate Irradiations

Be = Beryllium Reflector Element

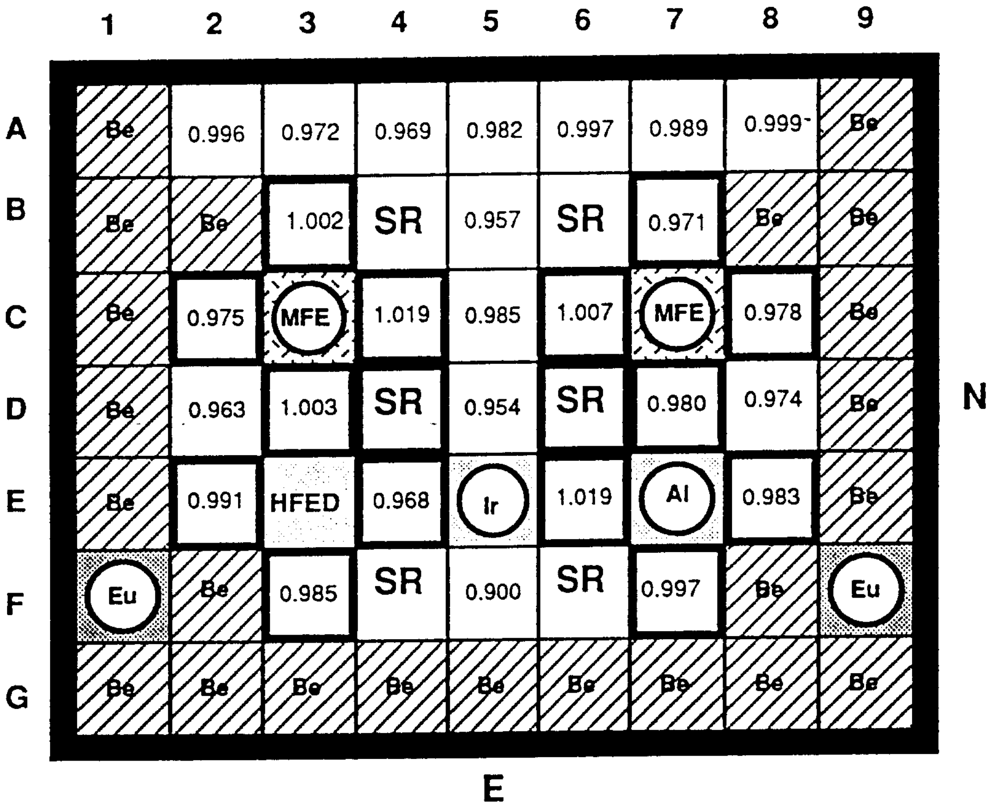
☐ = LEU Fuel Element

RMS DEV = 0.029

Fig. 41

ORR CORE 176B

Cycle-Averaged Power C/E Ratios



	1	2	3	4	5	6	7	8	9
A	Be	0.996	0.972	0.969	0.982	0.997	0.989	0.999	Be
B	Be	Be	1.002	SR	0.957	SR	0.971	Be	Be
C	Be	0.975	MFE	1.019	0.985	1.007	MFE	0.978	Be
D	Be	0.963	1.003	SR	0.954	SR	0.980	0.974	Be
E	Be	0.991	HFED	0.968	Ir	1.019	Al	0.983	Be
F	Eu	Be	0.985	SR	0.900	SR	0.997	Be	Eu
G	Be	Be	Be	Be	Be	Be	Be	Be	Be

SR = Shim Rod Assemblies

MFE = Magnetic Fusion Experiment

Ir, Eu = Irradiation Facility for Activating Iridium or Europium Samples

HFED = High U-load Fuel Element Device for Mini-Plate Irradiations

Be = Beryllium Reflector Element

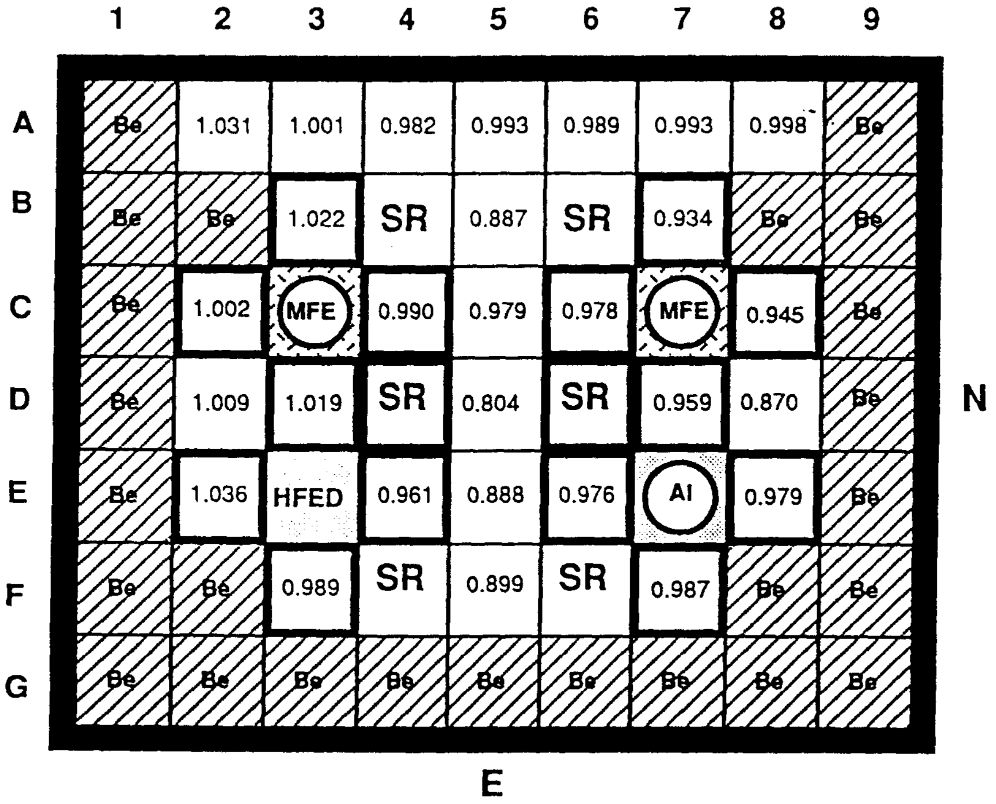
☐ = LEU Fuel Element

RMS DEV = 0.029

Fig. 42

ORR CORE 176C

Cycle-Averaged Power C/E Ratios



	1	2	3	4	5	6	7	8	9
A	Be	1.031	1.001	0.982	0.993	0.989	0.993	0.998	Be
B	Be	Be	1.022	SR	0.887	SR	0.934	Be	Be
C	Be	1.002	MFE	0.990	0.979	0.978	MFE	0.945	Be
D	Be	1.009	1.019	SR	0.804	SR	0.959	0.870	Be
E	Be	1.036	HFED	0.961	0.888	0.976	Al	0.979	Be
F	Be	Be	0.989	SR	0.899	SR	0.987	Be	Be
G	Be	Be	Be	Be	Be	Be	Be	Be	Be

SR = Shim Rod Assemblies

MFE = Magnetic Fusion Experiment

HFED = High U-load Fuel Element Device for Mini-Plate Irradiations

Be = Beryllium Reflector Element

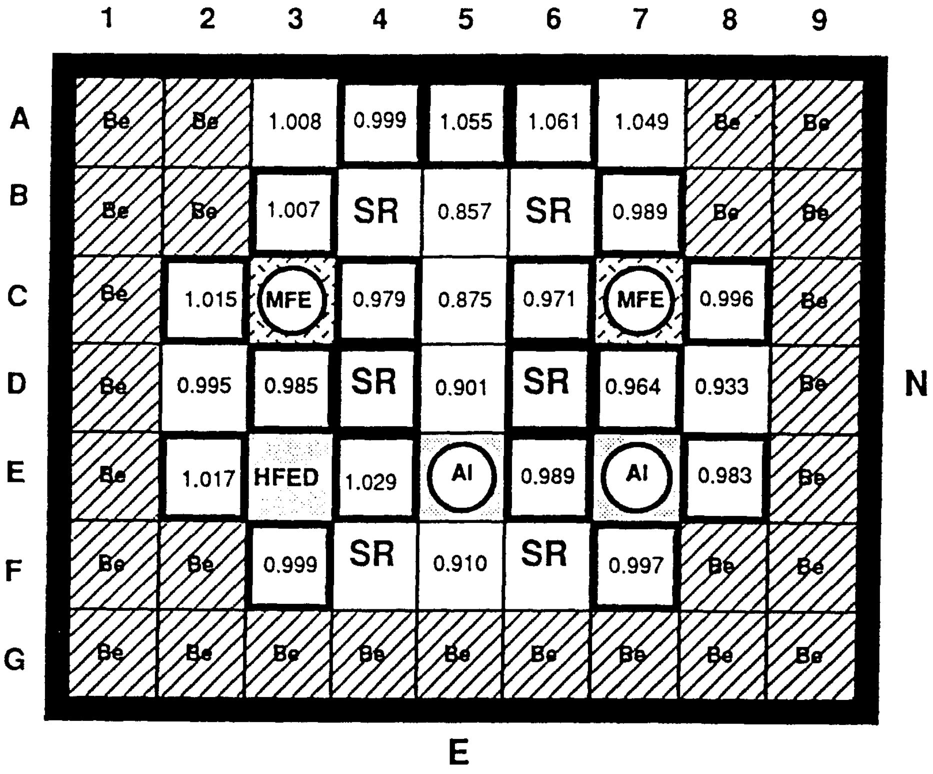
☐ = LEU Fuel Element

RMS DEV = 0.062

Fig. 43

ORR CORE 176D

Cycle-Averaged Power C/E Ratios



	1	2	3	4	5	6	7	8	9
A	Be	Be	1.008	0.999	1.055	1.061	1.049	Be	Be
B	Be	Be	1.007	SR	0.857	SR	0.989	Be	Be
C	Be	1.015	MFE	0.979	0.875	0.971	MFE	0.996	Be
D	Be	0.995	0.985	SR	0.901	SR	0.964	0.933	Be
E	Be	1.017	HFED	1.029	Al	0.989	Al	0.983	Be
F	Be	Be	0.999	SR	0.910	SR	0.997	Be	Be
G	Be	Be	Be	Be	Be	Be	Be	Be	Be

SR = Shim Rod Assemblies

MFE = Magnetic Fusion Experiment

HFED = High U-load Fuel Element Device for Mini-Plate Irradiations

Be = Beryllium Reflector Element

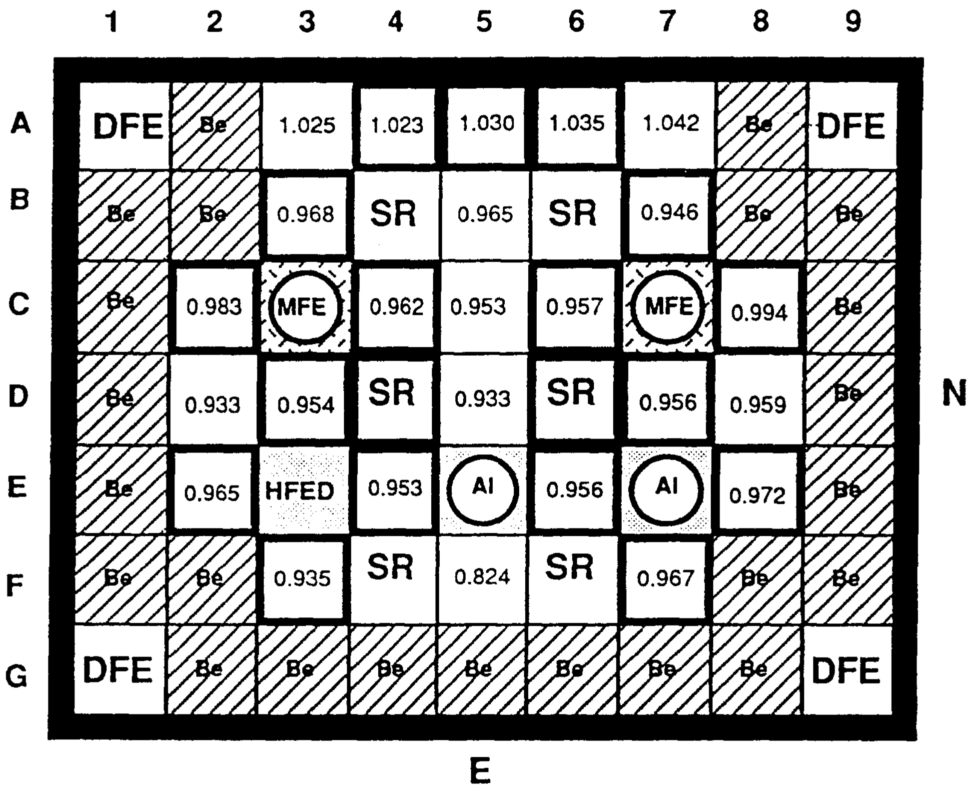
□ = LEU Fuel Element

RMS DEV = 0.054

Fig. 44

ORR CORE 177A

Cycle-Averaged Power C/E Ratios



	1	2	3	4	5	6	7	8	9
A	DFE	Be	1.025	1.023	1.030	1.035	1.042	Be	DFE
B	Be	Be	0.968	SR	0.965	SR	0.946	Be	Be
C	Be	0.983	MFE	0.962	0.953	0.957	MFE	0.994	Be
D	Be	0.933	0.954	SR	0.933	SR	0.956	0.959	Be
E	Be	0.965	HFED	0.953	Al	0.956	Al	0.972	Be
F	Be	Be	0.935	SR	0.824	SR	0.967	Be	Be
G	DFE	Be	Be	Be	Be	Be	Be	Be	DFE

SR = Shim Rod Assemblies

MFE = Magnetic Fusion Experiment

DFE = Dummy Fuel Element

HFED = High U-load Fuel Element Device
for Mini-Plate Irradiations

Be = Beryllium Reflector Element

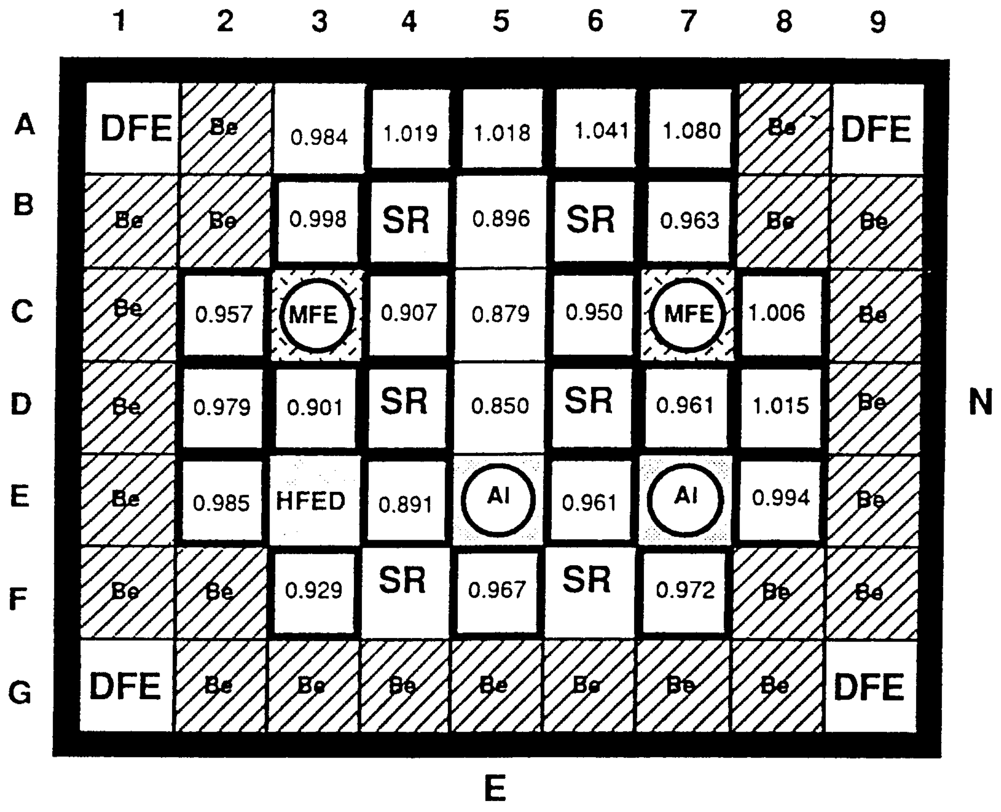
☐ = LEU Fuel Element

RMS DEV = 0.052

Fig. 45

ORR CORE 177B

Cycle-Averaged Power C/E Ratios



	1	2	3	4	5	6	7	8	9
A	DFE	Be	0.984	1.019	1.018	1.041	1.080	Be	DFE
B	Be	Be	0.998	SR	0.896	SR	0.963	Be	Be
C	Be	0.957	MFE	0.907	0.879	0.950	MFE	1.006	Be
D	Be	0.979	0.901	SR	0.850	SR	0.961	1.015	Be
E	Be	0.985	HFED	0.891	Al	0.961	Al	0.994	Be
F	Be	Be	0.929	SR	0.967	SR	0.972	Be	Be
G	DFE	Be	Be	Be	Be	Be	Be	Be	DFE

SR = Shim Rod Assemblies

MFE = Magnetic Fusion Experiment

DFE = Dummy Fuel Element

HFED = High U-load Fuel Element Device for Mini-Plate Irradiations

Be = Beryllium Reflector Element

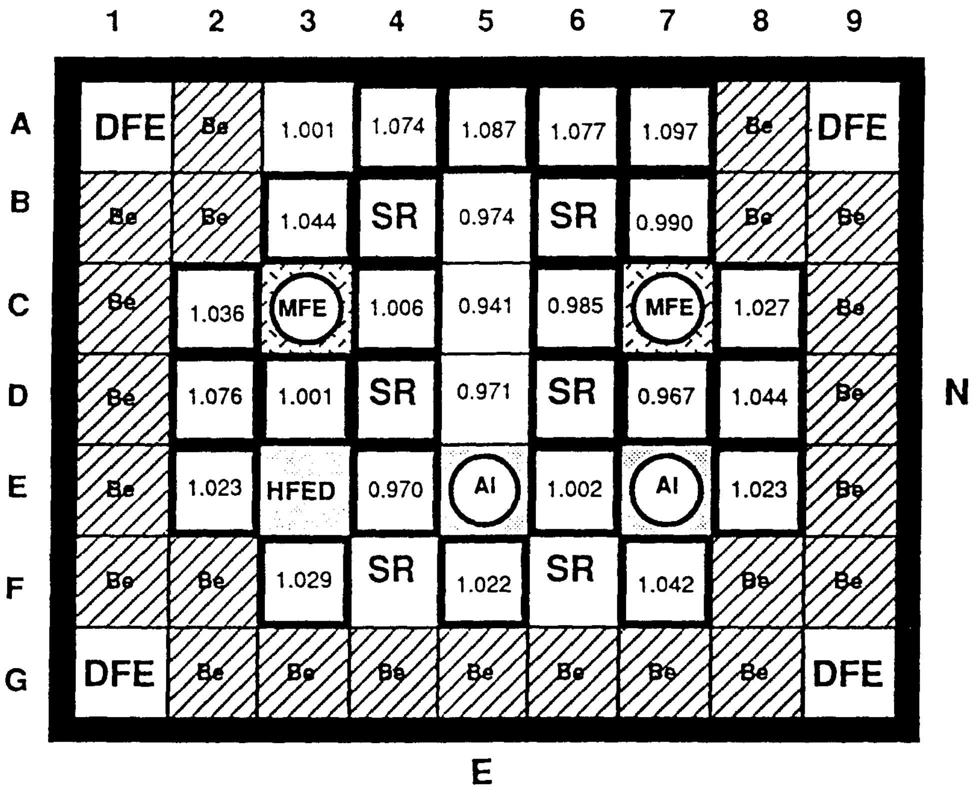
☐ = LEU Fuel Element

RMS DEV = 0.064

Fig. 46

ORR CORE 177C

Cycle-Averaged Power C/E Ratios



	1	2	3	4	5	6	7	8	9
A	DFE	Be	1.001	1.074	1.087	1.077	1.097	Be	DFE
B	Be	Be	1.044	SR	0.974	SR	0.990	Be	Be
C	Be	1.036	MFE	1.006	0.941	0.985	MFE	1.027	Be
D	Be	1.076	1.001	SR	0.971	SR	0.967	1.044	Be
E	Be	1.023	HFED	0.970	Al	1.002	Al	1.023	Be
F	Be	Be	1.029	SR	1.022	SR	1.042	Be	Be
G	DFE	Be	Be	Be	Be	Be	Be	Be	DFE

SR = Shim Rod Assemblies

MFE = Magnetic Fusion Experiment

DFE = Dummy Fuel Element

HFED = High U-load Fuel Element Device for Mini-Plate Irradiations

Be = Beryllium Reflector Element

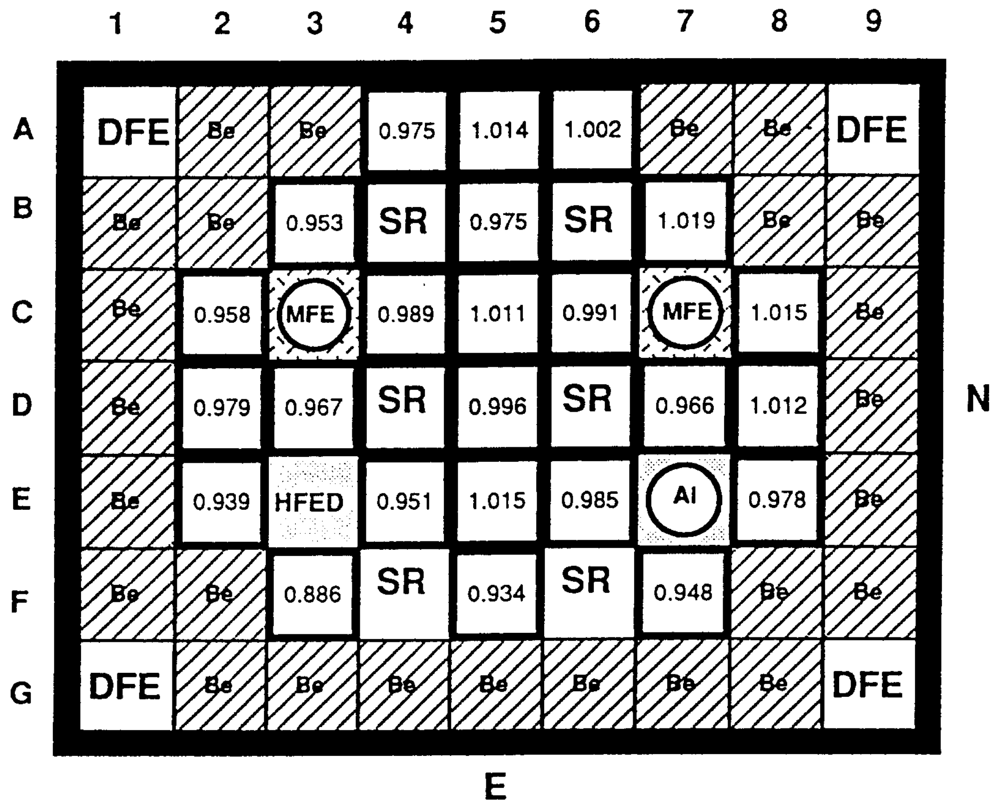
☐ = LEU Fuel Element

RMS DEV = 0.045

Fig. 47

ORR CORE 177D

Cycle-Averaged Power C/E Ratios



	1	2	3	4	5	6	7	8	9
A	DFE	Be	Be	0.975	1.014	1.002	Be	Be	DFE
B	Be	Be	0.953	SR	0.975	SR	1.019	Be	Be
C	Be	0.958	MFE	0.989	1.011	0.991	MFE	1.015	Be
D	Be	0.979	0.967	SR	0.996	SR	0.966	1.012	Be
E	Be	0.939	HFED	0.951	1.015	0.985	Al	0.978	Be
F	Be	Be	0.886	SR	0.934	SR	0.948	Be	Be
G	DFE	Be	Be	Be	Be	Be	Be	Be	DFE

SR = Shim Rod Assemblies

MFE = Magnetic Fusion Experiment

DFE = Dummy Fuel Element

HFED = High U-load Fuel Element Device for Mini-Plate Irradiations

Be = Beryllium Reflector Element

Al = Aluminum Reflector Element

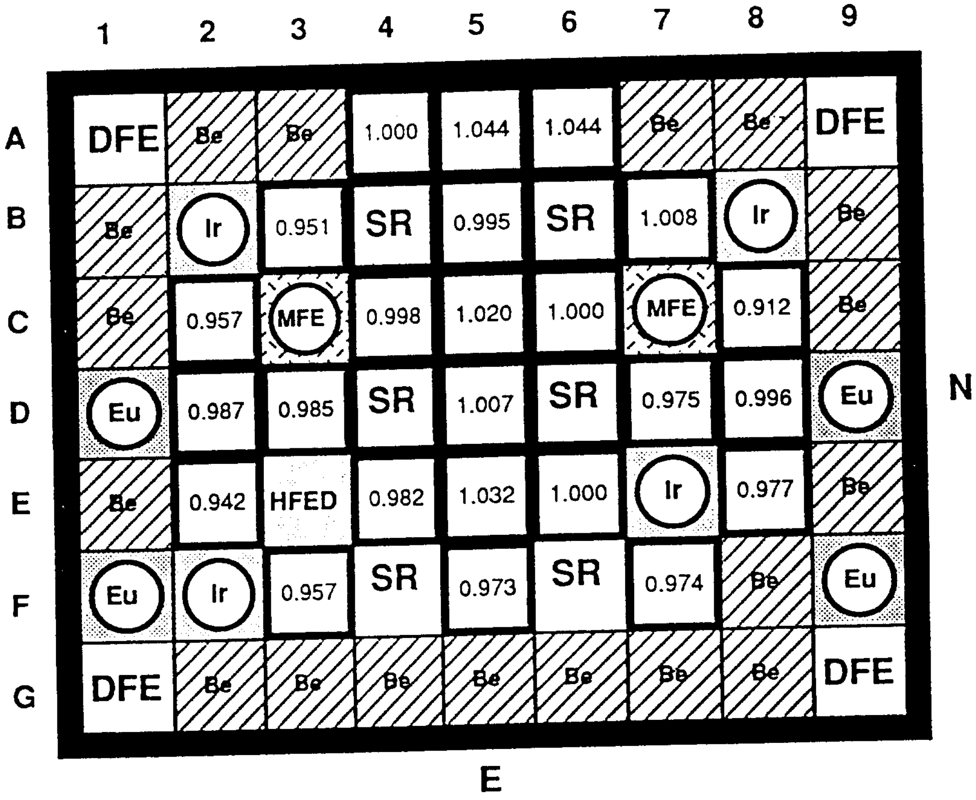
☐ = LEU Fuel Element

RMS DEV = 0.039

Fig. 48

ORR CORE 178A

Cycle-Averaged Power C/E Ratios



	1	2	3	4	5	6	7	8	9
A	DFE	Be	Be	1.000	1.044	1.044	Be	Be	DFE
B	Be	Ir	0.951	SR	0.995	SR	1.008	Ir	Be
C	Be	0.957	MFE	0.998	1.020	1.000	MFE	0.912	Be
D	Eu	0.987	0.985	SR	1.007	SR	0.975	0.996	Eu
E	Be	0.942	HFED	0.982	1.032	1.000	Ir	0.977	Be
F	Eu	Ir	0.957	SR	0.973	SR	0.974	Be	Eu
G	DFE	Be	Be	Be	Be	Be	Be	Be	DFE

SR = Shim Rod Assemblies

MFE = Magnetic Fusion Experiment

DFE = Dummy Fuel Element

HFED = High U-load Fuel Element Device for Mini-Plate Irradiations

Be = Beryllium Reflector Element

Ir, Eu = Irradiation Facility for Activating Iridium or Europium Samples

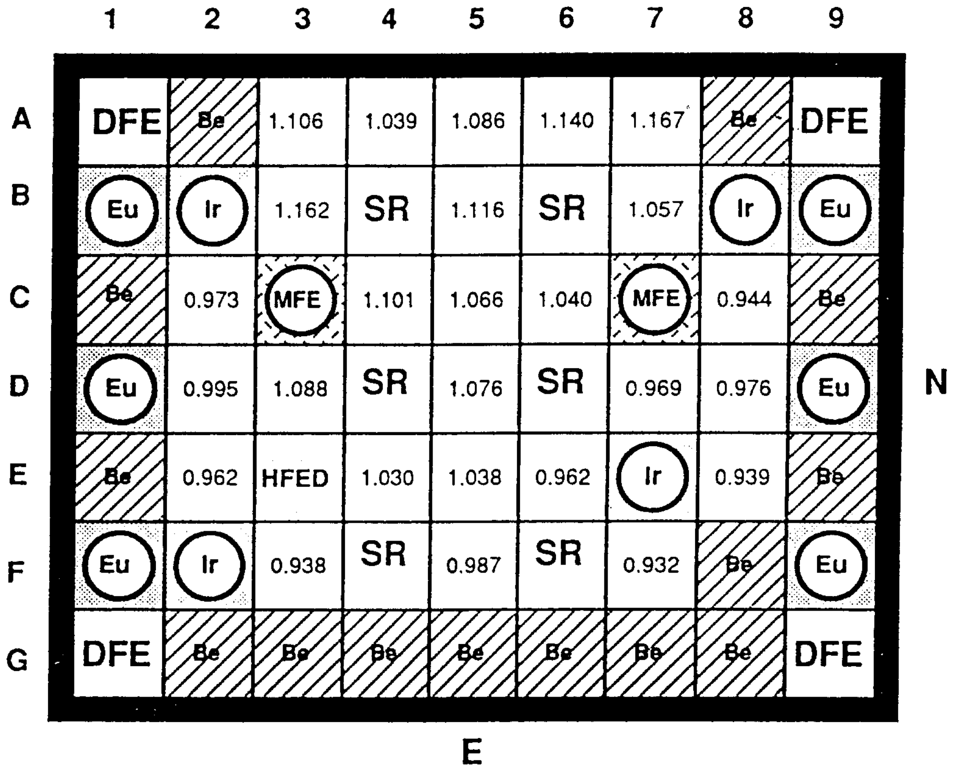
☐ = LEU Fuel Element

RMS DEV = 0.033

Fig. 49

ORR CORE 178C

Cycle-Averaged Power C/E Ratios



	1	2	3	4	5	6	7	8	9
A	DFE	Be	1.106	1.039	1.086	1.140	1.167	Be	DFE
B	Eu	Ir	1.162	SR	1.116	SR	1.057	Ir	Eu
C	Be	0.973	MFE	1.101	1.066	1.040	MFE	0.944	Be
D	Eu	0.995	1.088	SR	1.076	SR	0.969	0.976	Eu
E	Be	0.962	HFED	1.030	1.038	0.962	Ir	0.939	Be
F	Eu	Ir	0.938	SR	0.987	SR	0.932	Be	Eu
G	DFE	Be	Be	Be	Be	Be	Be	Be	DFE

All LEU Core

SR = Shim Rod Assemblies

MFE = Magnetic Fusion Experiment

DFE = Dummy Fuel Element

HFED = High U-load Fuel Element Device for Mini-Plate Irradiations

Be = Beryllium Reflector Element

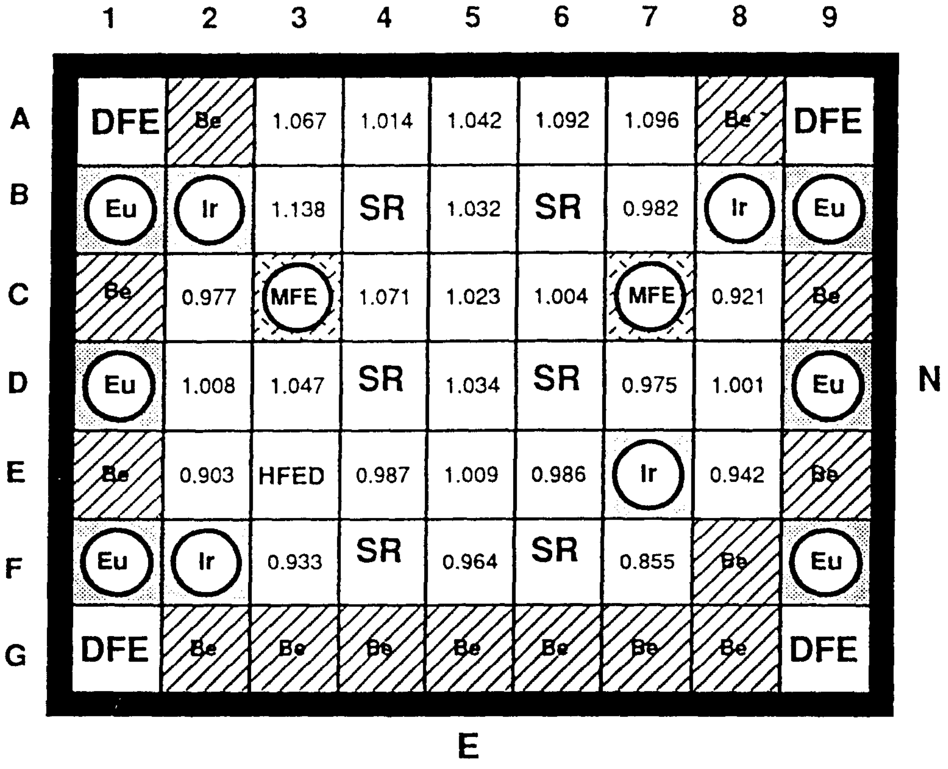
Ir, Eu = Irradiation Facility for Activating Iridium or Europium Samples

RMS DEV = 0.079

Fig. 50

ORR CORE 178D

Cycle-Averaged Power C/E Ratios



	1	2	3	4	5	6	7	8	9
A	DFE	Be	1.067	1.014	1.042	1.092	1.096	Be	DFE
B	Eu	Ir	1.138	SR	1.032	SR	0.982	Ir	Eu
C	Be	0.977	MFE	1.071	1.023	1.004	MFE	0.921	Be
D	Eu	1.008	1.047	SR	1.034	SR	0.975	1.001	Eu
E	Be	0.903	HFED	0.987	1.009	0.986	Ir	0.942	Be
F	Eu	Ir	0.933	SR	0.964	SR	0.855	Be	Eu
G	DFE	Be	Be	Be	Be	Be	Be	Be	DFE

All LEU Core

SR = Shim Rod Assemblies

MFE = Magnetic Fusion Experiment

DFE = Dummy Fuel Element

HFED = High U-load Fuel Element Device for Mini-Plate Irradiations

Be = Beryllium Reflector Element

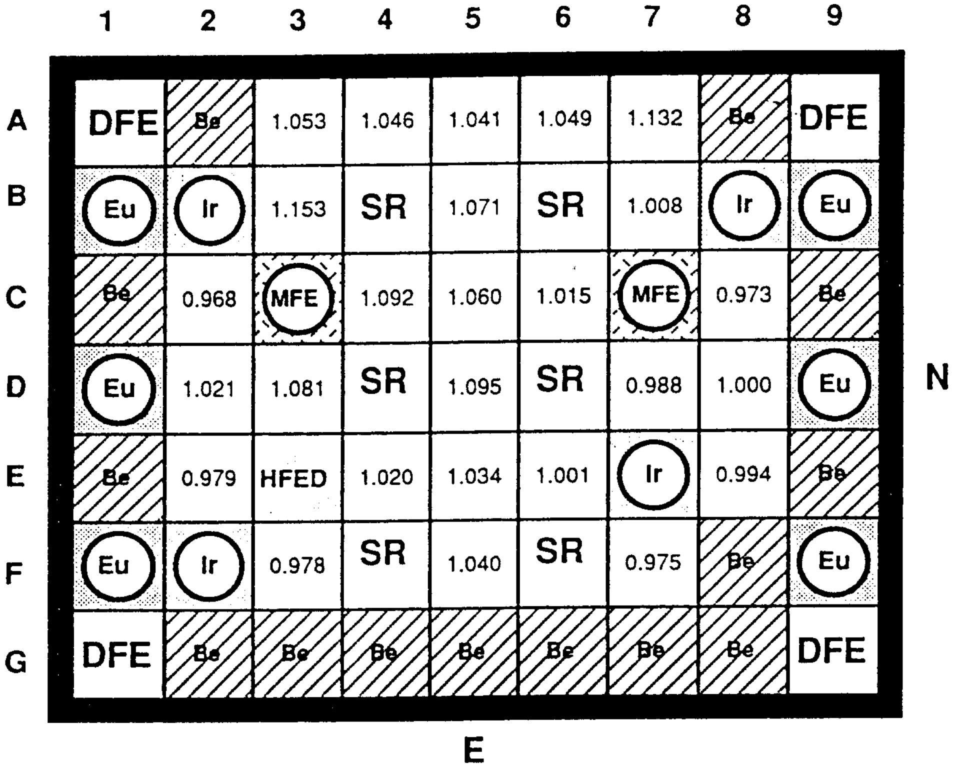
Ir, Eu = Irradiation Facility for Activating Iridium or Europium Samples

RMS DEV = 0.062

Fig. 51

ORR CORE 178H

Cycle-Averaged Power C/E Ratios



	1	2	3	4	5	6	7	8	9
A	DFE	Be	1.053	1.046	1.041	1.049	1.132	Be	DFE
B	Eu	Ir	1.153	SR	1.071	SR	1.008	Ir	Eu
C	Be	0.968	MFE	1.092	1.060	1.015	MFE	0.973	Be
D	Eu	1.021	1.081	SR	1.095	SR	0.988	1.000	Eu
E	Be	0.979	HFED	1.020	1.034	1.001	Ir	0.994	Be
F	Eu	Ir	0.978	SR	1.040	SR	0.975	Be	Eu
G	DFE	Be	Be	Be	Be	Be	Be	Be	DFE

All LEU Core

SR = Shim Rod Assemblies

MFE = Magnetic Fusion Experiment

DFE = Dummy Fuel Element

HFED = High U-load Fuel Element Device for Mini-Plate Irradiations

Be = Beryllium Reflector Element

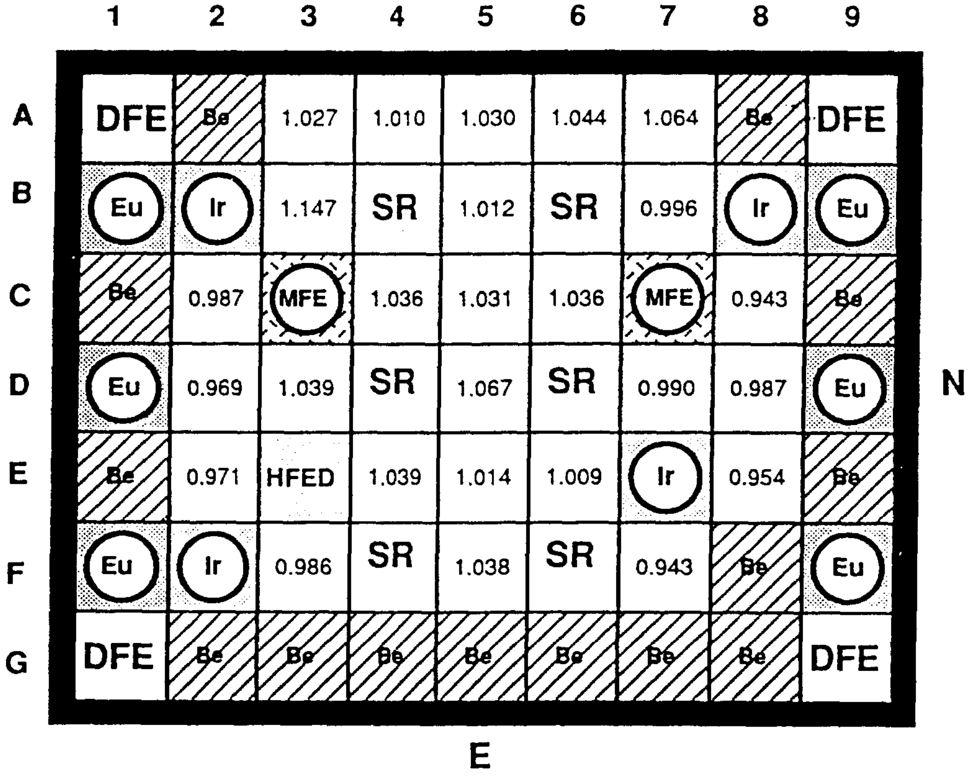
Ir, Eu = Irradiation Facility for Activating Iridium or Europium Samples

RMS DEV = 0.058

Fig. 52

ORR CORE 178J

Cycle-Averaged Power C/E Ratios



	1	2	3	4	5	6	7	8	9
A	DFE	Be	1.027	1.010	1.030	1.044	1.064	Be	DFE
B	Eu	Ir	1.147	SR	1.012	SR	0.996	Ir	Eu
C	Be	0.987	MFE	1.036	1.031	1.036	MFE	0.943	Be
D	Eu	0.969	1.039	SR	1.067	SR	0.990	0.987	Eu
E	Be	0.971	HFED	1.039	1.014	1.009	Ir	0.954	Be
F	Eu	Ir	0.986	SR	1.038	SR	0.943	Be	Eu
G	DFE	Be	Be	Be	Be	Be	Be	Be	DFE

All LEU Core

SR = Shim Rod Assemblies

MFE = Magnetic Fusion Experiment

DFE = Dummy Fuel Element

HFED = High U-load Fuel Element Device for Mini-Plate Irradiations

Be = Beryllium Reflector Element

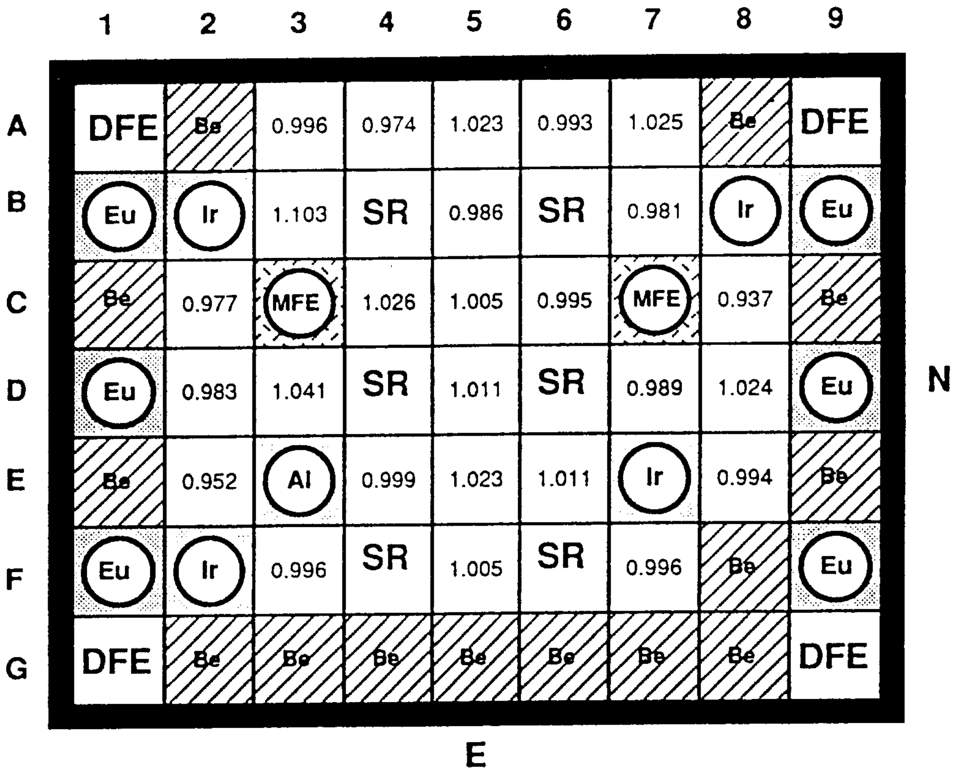
Ir, Eu = Irradiation Facility for Activating Iridium or Europium Samples

RMS DEV = 0.045

Fig. 53

ORR CORE 179A

Cycle-Averaged Power C/E Ratios



	1	2	3	4	5	6	7	8	9
A	DFE	Be	0.996	0.974	1.023	0.993	1.025	Be	DFE
B	Eu	Ir	1.103	SR	0.986	SR	0.981	Ir	Eu
C	Be	0.977	MFE	1.026	1.005	0.995	MFE	0.937	Be
D	Eu	0.983	1.041	SR	1.011	SR	0.989	1.024	Eu
E	Be	0.952	Al	0.999	1.023	1.011	Ir	0.994	Be
F	Eu	Ir	0.996	SR	1.005	SR	0.996	Be	Eu
G	DFE	Be	Be	Be	Be	Be	Be	Be	DFE

All LEU Core

SR = Shim Rod Assemblies

MFE = Magnetic Fusion Experiment

DFE = Dummy Fuel Element

Be = Beryllium Reflector Element

Al = Aluminum Reflector Element

Ir, Eu = Irradiation Facility for Activating Iridium or Europium Samples

RMS DEV = 0.030

Fig. 54

Table 38. Measured LEU Fuel Element 235U Masses and Burnups

CERCA Fuel Elements

	IRRADIATION HISTORY					FINAL MASS (G) & BURNUP (%)			
						MASS(E)	C/E	BU(E)	C/E
C021	177D-C5	177B-D2	176D-A4	176B-B3	175C-E4	168.0	0.996	50.58	1.004
	175A-D3	174E-A5	174D-A5						
C022	177D-D5	177B-F5	176D-A5	176B-F3	175C-E6	173.2	0.980	49.05	1.021
	175A-D7	174E-C2	174D-C2						
C023	177D-E5	177B-D8	176D-A6	176B-F7	175C-C6	177.2	0.995	47.87	1 .006
	175A-E2	174E-CS	174D-C8						
C024	178D-D5	178A-C5	177C-D2	177A-A4	176C-B3	165.9	0.983	51.20	1.016
	176A-E4	175B-D3	174F-A5						
C025	178A-D5	177C-D8	177A-A5	176C-F3	176A-E6	183.5	1.000	46.02	1.000
	175B-D7	174F-C2							
C-026	178A-E5	177C-F5	177A-A6	176C-F7	176A-C6	189.3	0.992	44.33	1.010
	175B-E2	174F-C8							
C027	178C-C5	178B-C5	177D-C4	177B-A4	176D-B3	180.0	0.992	47.07	1.009
	176B-C4	175C-E8	175A-A5						
C028	178C-D5	178B-D5	177D-B5	177B-A5	176D-B7	179.2	1.007	47.13	0.995
	176B-C6	175C-D7	175A-C2						
C029	178C-A3	178B-A3	177D-C6	177B-A6	176D-F7	192.7	1.009	43.16	0.992
	176B-E6	175C-E2	175A-C8						
C030	178C-A7	178B-A7	177D-E4	177B-A7	176D-F3	196.1	0.987	42.33	1.017
	176B-B7	175C-D3	175A-E8						
C031	179A-D8	178H-F3	178C-CB			273.9	1.007	19.22	0.982
C032	179A-E6	178H-B3	178C-D2	178B-D2	177D-F7	222.9	1.000	34.24	1.005
	177B-E2								
C033	178J-B3	178D-A6	178A-A6	177C-C2		262.4	0.999	22.83	1.005
C034	178J-B7	178D-D8	178A-F3	177C-C8		262.5	0.994	22.80	1.019
C035	179A-C2					313.9	1.002	7.42	1.015
C036	179A-B3	178H-F5	178C-F3	178B-F3	177D-C2	248.9	0.989	26.58	1.037
C037	179A-B7	178H-D2	178C-F7	178B-F7	177D-C8	254.6	1.005	24.90	0.992
C038	178J-F5	178D-F3	178A-C2			276.6	0.998	18.41	1.021
C039	178J-D2	178D-F7	178A-C8			282.9	0.996	16.80	1.022
C040	178J-A6	178D-C8				302.0	1.007	10.91	0.968

Table 38. Measured LEU Fuel Element 235U Masses and Burnups
(Continued)

NUKEM Fuel Elements

FE	IRRADIATION HISTORY					FINAL MASS (G) & BURNUP			
						MASS(E)	C/E	BU(E)	C/E
N001	178D-CS	178A-C4	177C-A4	177A-F3	176C-B7	188.4	0.994	44.42	1.012
	176A-D3	175B-A5							
N002	179A-A5	178A-B5	177C-A5	177A-B7	176C-C6	187.2	1.009	44.79	0.993
	176A-D7	175B-C2							
N003	178D-A3	17BA-C6	177C-A6	177A-F7	176C-E6	199.5	1.002	41.16	1.001
	176A-E2	175B-C8							
N004	178D-A7	178A-E4	177C-A7	177A-B3	176C-C4	201.1	0.986	40.69	1.024
	176A-E8	175B-E8							
N005	178J-C5	178D-C4	178A-D7	177C-F7	177A-E6	180.5	1.003	46.75	1.000
	176C-E4	176A-A5							
N006	178J-D5	178D-C6	178A-D3	177C-B3	177A-C4	172.8	1.009	49.02	0.994
	176C-D3	176A-C2							
N007	178H-C5	178C-C4	178B-C4	177D-E6	177B-B7	168.7	1.006	50.22	0.997
	176D-C6	176B-D7	175C-A5						
N008	178H-D5	178C-C6	178B-C6	177D-D3	177B-B3	161.6	1.005	52.32	0.999
	176D-C4	176B-D3	175C-C2						
N009	178H-A7	178C-B5	178B-B5	177D-D7	177B-F7	182.3	1.021	46.21	0.979
	176D-E6	176B-E4	175C-C8						
N010	178J-A7	178D-B5	178A-B7	177C-F3	177A-C6	191.4	1.029	43.55	0.966
	176C-D7	176A-C8							
N011	178J-C6	178D-E6	178A-E6	177C-B7	177A-E4	195.3	1.030	42.56	0.960
	176C-E8								
N012	178J-E4	178D-F5	178A-F7	177C-E2		242.0	1.008	28.60	0.987
N013	179A-F5	178H-B7	178C-F5	178B-F5	177D-E2	225.0	1.005	33.63	0.996
	177B-E8								
N014	178J-E6	178D-D2	17BA-E2	177C-E8		250.5	1.007	26.09	0.989
N015	179A-F3	178H-D8	178C-A4	178B-A4	177D-E8	254.7	1.009	24.88	0.980
N016	179A-A3	178H-A4	178C-C2	178B-C2		284.1	1.007	16.21	0.980
N017	179A-C8					313.8	1.008	7.44	0.941
N018	178J-D8	178D-A4	178A-E8			285.0	1.002	16.18	0 .987
N019	179A-F7	178H-A6	178C-A5			279.6	0.997	17.52	1.027
N020	179A-D2	178H-F7	178C-E2			274.8	0.993	19.17	1.031

Table 38. Measured LEU Fuel Element 235U Masses and Burnups
(Continued)

BABCOCK and WILCOX Fuel Elements

FE	IRRADIATION HISTORY					FINAL MASS (G) & BURNUP			
						MASS(E)	C/E	BU(E)	C/E
B041	179A-B5	178H-A3	178C-D3	178B-D3	177D-D2	174.6	1.002	48.50	1.001
	177B-C4	176D-D3	176B-C2						
B042	179A-C5	178H-B5	178C-D7	178B-D7	177D-DB	167.7	1.019	50.54	0.984
	177B-C6	176D-D7	176B-C8						
B043	179A-D5	178H-C4	178C-E5	178N-E4	177D-B3	165.1	1.011	51.44	0.990
	177B-E6	176D-E2	176B-E2						
B044	179A-E5	178H-C6	178C-E6	178B-E6	177D-B7	169.9	1.003	50.04	0.997
	177B-F3	176D-E4	176B-EB						
B045	178J-A3	178D-D3	178A-D2	177C-C4	177A-D3	208.9	0.990	38.38	1.021
	176C-C2								
B046	178J-B5	178D-D7	178A-D8	177C-C6	177A-D7	203.2	1.022	40.06	0.972
	176C-C8								
B047	178J-C4	178D-E5	178A-B3	177C-E6	177A-E2	203.4	0.991	40.16	1.014
	176C-E2								
B048	179A-C4	178H-D3	178C-B3	17BB-D8	177D-A4	196.1	0.992	42.16	1.016
	177B-D3	176D-C2							
B049	179A-C6	178H-D7	178C-E4	178B-B3	177D-F5	189.8	1.010	44.16	0.988
	177B-D7	176D-C8							
B050	179A-E4	178H-E5	178C-B7	178B-B7	177D-A5	196.0	1.004	42.37	0.993
	177B-E4	176D-EB							
B051	178J-D3	178D-B3	178A-A4	177C-D3	177A-C2	232.7	0.992	31.57	1.017
B052	178J-D7	178D-E4	178A-F5	177C-D7	177A-C8	222.3	1.009	34.42	0.990
B053	178J-E5	178D-B7	178A-AS	177C-E4	177A-E8	230.2	1.011	32.09	0.982
B054	178J-A4	178D-C2				299.6	1.009	11.63	0.953
B082	179A-A4	178H-A5				295.2	1.001	13.16	0.992
B083	179A-A6	178H-C2				292.3	1.004	13.77	0.991
B034	179A-E2	178H-C8				291.0	1.008	14.15	0.973
B085	179A-E8	178H-E8				287.7	0.998	15.37	1.010
B086	178J-A5					321.4	0.999	5.48	1.009
BO87	178J-C2					320.2	0.997	5.81	1.043
B088	178J-C8					319.8	1.003	5.94	0.956
D089	178J-E8					316.4	1.003	6.66	0.998
B095	179A-D3	178H-E6	178C-A6	178B-A6	177D-A6	224.7	0.990	33.71	1.025
	177B-C2								
B096	179A-D7	178H-E4	178C-D8	178B-A5	177D-F3	216.8	1.018	36.25	0.969
	177B-C8								
B097	179A-A7	178H-E2	178C-E8			281.5	1.006	17.19	0.974
B098	178J-F7	178D-AS				300.3	0.990	11.68	1.073
B099	178J-F3	178D-E8	178B-E8			297.5	0.994	12.49	1.041
B100	178J-E2	178D-E2	178B-E2			297.4	1.006	12.27	0.978

Table 38. Measured LEU Fuel Element 235U Masses and Burnups
(Continued)

BABCOCK and WILCOX Fuel Followers

FE	IRRADIATION HISTORY					FINAL MASS (G) & BURNUP			
						MASS(E)	C/E	BU(E)	C/E
UB001	178J-F4	178H-F4	178D-F4	178C-F4	178B-B4	50.57	1.039	74.72	0.987
	178A-B4	177D-B4	177C-B4	177B-B4	177A-D4				
	176D-D4	176C-D4	176B-D4						
UB002	178J-F6	178H-F6	178D-F6	178C-F6	178B-B6	50.32	1.042	74.84	0.986
	178A-B6	177D-B6	177C-B6	177B-B6	177A-D6				
	176D-D6	176C-D6	176B-D6						
UB003	179A-F4	178J-B4	178H-B4	178D-B4	178C-B4	80.56	1.010	59.72	0 . 993
	178B-D4	178A-D4	177D-D4	177C-D4	177B-D4				
UB004	179A-F6	178J-B6	178H-B6	178D-B6	178C-B6	81.08	1.009	59.46	0.994
	178B-D6	178A-D6	177D-D6	177C-D6	177B-D6				
UB005	179A-B4	178J-D4	178H-D4	178D-D4	178C-D4	119.9	1.013	40.04	0.982
UB006	179A-B6	178J-D6	178H-D6	178D-D6	178C-D6	120.5	1.006	39.76	0.991
UB007	179A-D4					175.9	1.006	12.07	0.957
UB008	179A-D6					175.0	1.009	12.51	0.939

Note: FF's UB001, UB002, UB003, and UB004 were gamma-3canned with the Ge(Li) detector. Results for the UB005, UB006, UB007, and UB008 FF's are based on gamma scans obtained with the NaI detector.

Table 39. Measured HEU Fuel Element 235U Masses and Burnups
for Initially Fresh Fuel

Fuel Element	Irradiation History		Final Mass (g) and Burnup			
			Mass(g)	C/E	BU(E)	C/E
T556	175B-A6	174D-E8	242.0	1.002	15.10	0.988
T561	175A-A6	174E-E8	247.4	0.998	13.18	1.014
T562	175C-A4	174F-E8	241.6	1.001	15.22	0.998

Except for the three mentioned above, all the HEU fuel elements used in the demonstration were partially burned in various cores before the beginning of the demonstration. Thus, their ^{235}U masses at the start of the demonstration were uncertain. For those HEU fuel elements which were gamma-scanned for both ^{140}La. and ^{137}Cs activities, the data were combined to determine the ^{235}U content at the beginning of the demonstration. These initial mass values for the HEU fuel elements were used in the REBUS-3 burnup calculations.

Measured HEU fuel element ^{235}U masses and burnups for those elements for which the activity distribution of the 0.662 MeV ^{137}Cs gamma ray was determined are given in Table 40. Of the 132 HEU elements used in the demonstration, ^{137}CS gamma-scanning data exist for 83. For these 83 fuel elements the measured initial masses together with the ORR estimates are given in the last two columns of Table 40. For those elements for which no ^{137}Cs data exists, the ORR initial ^{235}U mass estimates were used in the burnup calculations. The evaluation of the initial mass and final ^{235}U burnup for HEU fuel element T507 is illustrated in Appendix F.

For a number of HEU fuel elements the ^{137}Cs activity was measured at only one point (15.3 inches from the top of the fuel column). Because of the need to send these elements to Savannah River for reprocessing, time was not available to obtain complete ^{137}Cs gamma scans. However, this one-point data was normalized to an average ^{137}Cs axial shape obtained from 10 HEU fuel elements having similar burnups. It was also necessary to take into account that the one-point data was taken with the 1/16-inch diameter collimator normally used for the ^{140}La gamma scans and not the larger collimator used for the other ^{137}Cs measurements. Results based on the analysis of these one-point ^{137}Cs measurements are given in Table 41. At the bottom of this table are the ^{235}U mass and burnup at discharge for HEU fuel element T490. For this particular fuel element, data for two complete ^{137}Cs gamma scans were taken. However, no ^{140}La measurements were made.

The accuracy of fuel-element-averaged burnups obtained from the ^{137}Cs gamma-scanning data is limited by errors associated with the determination of GC(^{137}Cs). For the LEU elements the standard deviation in GC ranges from about 1.9% to 2.6%, with the larger error applying to those fuel elements irradiated in only one core. The observed C/E burnup ratios are consistent with these error estimates, as Table 38 shows.

Table 42 gives the average burnup status for each of the LEU fuel elements at the end of the demonstration. Seven of the standard 19-plate fuel elements achieved average burnups in excess of 50% while two of the 15-plate fuel followers had average burnups of nearly 75%. Because of the early shutdown of the ORR, however, 32 Babcock and Wilcox fuel elements and 4 fuel followers remained unirradiated.

Calculated and measured axial distributions of ^{235}U burnups were obtained by dividing the fuel column into six segments of equal height (10.0 cm). Table 43 shows these axial distributions for those LEU fuel elements and fuel followers having average burnups of 50% or greater, Segment A is at the bottom of the fuel column and segment F at the top. For the 19-plate standard elements the maximum burnup is about 65% and occurs in segment C. The maximum burnup for the fuel followers is somewhat greater than 90% and occurs in segment F. Since there are only a few data points available in each axial segment, errors in the numerical integrations are relatively large and contribute to an appreciable scatter in the C/E ratios. This is especially true for the end segments (A and F) of the standard fuel elements because of the uncertainty associated with the extrapolation of the point values to the core-reflector interfaces. Segment A in the fuel followers is normally located deep in the axial reflector below the core where both cross sections and neutron fluxes are quite uncertain. This contributes to the large C/E ratios in this region. The evaluation of the burnup distribution from the ^{137}Cs data is illustrated in Appendix F for the LEU fuel follower UB002.

Table 40. Measured HEU Fuel Element ^{235}U Masses and Burnups

FE	IRRADIATION HISTORY	FINAL M235, G				INITIAL M235, G	
		ORR Est.	M(E)	C/E	BU(E),%	M(E)	ORR Est.
T519	175C-C4 174F-A8 174D-A2 174B-A7 173E-E2 173C-A6 173A-C2 172B-A5	153	150.9	0.992	47.07	198.6	194
T530	1753-C4 174F-C6 174D-A3 174B-E6 173E-A4 172G-C2	154	154.4	0.999	45.84	220.4	212
T554	176C-A7 175B-E6 174D-A4 174B-C8	194	200.7	1.001	29.58	264.4	258
T555	174D-A6 174B-E8	251	248.0	0.997	12.98	264.2	264
T540	175A-C6 174D-A7 174B-E4 173E-D7	177	177.6	1.004	37.67	218.4	213
T503	174F-B3 174D-A8 172C-C6 171C-E2 170D-F5	161	164.2	1.001	42.40	194.4	185
T501	176A-B7 1740-B3 173E-A8 173C-A7 173A-E2 172C-03 171A-E2 170D-C2	154	144.2	1.010	49.42	180.4	183
T497	17~C-B3 1740-B7 173E-A2 173C-A3 173A-A3 1723-D3 171E-D3 171A-A5 170C-A5	154	139.2	1.007	51.15	174.3	183
T526	1740-C4 174B-A2 173E-A3 173C-E4 173A-D3 172F-C2 172D-C2	165	175.1	1.001	38.56	195.1	183
T535	175A-B7 174D-C6 174B-A3 173E-E4 173C-D3 172H-C8	159	163.6	1.013	42.58	205.2	192
T548	1760-A7 175A-E6 174D-D3 173D-E8	194	202.4	0.999	28.99	268.4	266
T539	176A-A7 174D-D7 174B-A6 173B-C8	217	209.3	1.009	26.58	247.9	249
T515	175B-C6 174F-A7 174D-E2 173D-A6 173A-E8 171F-A5	177	172.3	1.003	39.55	233.1	239
T537	1766-A3 175A-A3 174D-E4 173D-C2 173B-A5	191	190.2	1.002	33.25	249.5	245
T549	176B-47 174F-A3 174D-E6 174B-D3 173E-A5	188	183.7	0.997	35.54	238.3	237
T556	175B-A6 174D-E8	249	242.0	1.002	15.10	284.8	285
T516	1740-F3 174B-A8 173D-A8 1738-A7 172H-A3 172F-D3 172D-03 172B-C8 171F-E8	162	165.3	1.004	42.00	177.8	177
T514	176C-A8 174D-F7 173C-B3 173A-E4 172G-A6 172E-D3 172A-C2 171E-E8	154	156.3	1.010	45.14	181.9	177
T527	175A-A8 174E-A2 174C-A7 173D-E4 173B-03 172F-C8 172D-C8	177	183.6	0.993	35.56	206.9	197
T521	175A-A2 174E-A3 174C-E4 173B-D7 172E-A5 172C-A5	187	185.4	0.991	34.94	210.3	210
T557	176A-A6 174E-A4 174C-A5	239	225.6	1.003	20.84	262.3	266
T545	175C-A6 174E-A6 173D-A5	244	230.2	0.997	19.21	266.8	270
T534	176A-A3 175B-A2 174E-A7 174B-E2 173D-A4 172H-C2	179	184.7	0.995	35.19	227.8	215
T500	177C-C5 175A-B3 174E-A8 174C-A2 1730-A3 173B-A6 172G-A4 171C-C3 170D-A5	134	123.8	1.016	56.56	177.1	183
T453	177A-F5 174E-B5 173D-F7 173A-A8 170A-08 169H-08 169F-E8 169A-A4 168F-D5 168B-A5	140	140.8	1.021	50.61	171.8	170
T507	177C-05 176B-A2 174E-C4 174C-A6 1730-A7 172H-A6 172F-A6 1720-A6 172A-D7 171E-07 171A-E3	131	123.0	1.007	56.83	175.2	183
T420	177B-A3 174E-C5 173D-F3 173A-A2 171B-A3 163H-B3 168E-A7 167D-D8 166F-A4 165G-C2	142	135.9	1.001	52.33	163.4	166
T528	175A-C4 174E-C6 174C-A3 173D-E2 173B-A4 172H-D7 172F-E8 172D-E3	158	154.6	1.006	45.75	197.2	196

Table 40. Measured HEU Fuel Element ^{235}U Masses and Burnups
(Continued)

FE	IRRADIATION HISTORY					FINAL M235, G			INITIAL M235, G		
						ORR Est.	M(E)	C/E	BU(E)%	M(E)	ORR Est.
T529	174E-D3	172G-A5				250	251.8	1.001	11.66	268.8	270
T559	176C-A5	174E-D7	174C-CS			221	223.0	1.005	21.76	261.4	255
T517	175C-A3	174E-E2	173E-A6	173A-A5	172A-A5	211	202.5	1.000	28.94	232.9	242
T531	1758-A3	174E-E4	173C-D7	172G-C8		207	208.9	0.998	26.71	246.2	244
T536	176A-A3	174E-E6	173D-D3	172H-EB		207	210.1	1.003	26.30	245.7	240
T561	175A-A6	174E-E8				253	247.4	0.998	13.18	235.7	285
T464	175C-D3	174E-F3	173B-B3	171C-A3	170C-D8	150	145.6	1.023	48.90	171.5	175
	170A-A6	169H-A6	169F-A4	1690-A4	169A-C2						
T493	1742-F5	173E-E6	173B-E6	172B-E2	171E-E2	162	172.3	1.000	39.53	183.6	176
	170E-F5	170B-A5									
T523	175B-D8	174E-F7	173E-C6	173B-E4	172H-D3	150	156.3	1.004	45.17	186.0	175
	1722-CS	172C-CS									
T547	175B-A8	174F-A2	174C-E6	173E-D3	173D-C8	176	183.0	0.995	35.79	212.9	201
T5~4	174F-A4	173C-E8				250	246.8	0.998	13.42	267.6	268
T541	176A-A4	174F-A6	173C-A5			238	225.7	1.002	20-82	269.1	271
T522	174F-87	174C-A8	173D-E6	1738-A3	172G-D3	162	167.6	1.003	41.19	186.0	177
	172E-C2	172C-C2									
T508	174F-C4	173D-C6	173B-E2	172C-A6	172A-D3	161	159.4	0.999	44.06	182.1	182
	171E-C2	171A-C2									
T533	174F-D3	172H-A5				241	243.4	0.998	14.60	267.4	269
T560	174F-D7	174C-E8				240	238.4	1.002	16.34	262.4	262
T430	174F-D8	173A-F7	1720-A8	169C-A3	168H-A3	153	147.1	1.002	48.38	162.1	165
	168E-D7	167D-E8	166G-A4	166D-A5							
T532	176C-A6	174F-E2	173D-D7	1726-E8		203	208.7	1.004	26.78	246.2	247
T518	177A-A7	174F-E4	173A-C8	172A-E8		203	217.3	0.997	23.77	253.6	248
T542	176C-A4	174F-E6	174C-A4	173C-C2		196	202.1	1.002	29.09	244.8	240
T562	175C-A4	174F-E8				245	241.6	1.001	15.22	284.4	285
T479	174F-F3	172C-F5	171F-C6	171B-A4	170C-E3	156	161.5	1.001	43.45	175.5	173
	170A-F5	169H-F5	169F-A5	169D-A5							
T443	177C-A3	174F-F5	173B-F5	171F-A7	169C-D8	143	145.3	0.997	49.00	173.7	173
	167C-E8	166H-C8									
T492	177A-C5	174F-F7	172F-E4	172D-E4	171E-A3	139	157.3	1.009	44.82	195.6	173
	170D-E8	170A-CS	169H-CZ								
T525	175A-A4	172F-A5	172D-A5			248	242.7	0.998	14.84	266.4	268
T538	176D-A3	175C-A2	175A-A7	174C-A6	173B-C2	181	184.5	0.994	35.27	237.1	228
T454	175A-B5	174B-B7	173C-A8	173A-A7	172G-E2	151	143.4	1.001	49.69	166.4	170
	172C-A3	1706-E6	169F-A6	169D-A6	168H-F5						
	168F-F5	168A-A5									
T558	176B-A4	175A-E4	174C-C2			198	209.4	1.012	26.52	264.0	250
T487	175A-F3	173B-C4	172A-C4	1718-A6	170D-E4	153	145.5	1.005	43.94	161.7	172
	170B-A6	169G-C2									
T552	175B-A4	1748-A5				246	238.2	0.998	16.43	264.4	268
T546	176A-A2	175B-A7	174C-D7	173E-C8		199	196.0	0.999	31.21	232.6	231
T491	175B-63	172E-E6	171C-D3	170E-A7	170C-A4	154	151.1	1.005	46.97	175.8	174
	170A-C2	169H-C2									
T553	177A-A3	175B-E4	174B-C2			201	215.5	1.007	24.40	262.0	253

Table 40. Measured HEU Fuel Element 235U Masses and Burnups
(Continued)

FE	IRRADIATICN HISTORY	FINAL M235, G			INITIAL M235, G		
		ORR Est.	M(E)	C/E	BU(E)%	M(E)	ORR Est.
T543	175C-A7 174C-D3 173C-C8	217	223.6	0.997	21.54	242.5	232
T524	175C-Ag 173E-A7 173C-E2 173A-A4 172G-D7 172E-E8 172C-E8	180	177.8	1.000	37.60	191.9	190
T470	175C-B5 172F-B3 172D-B3 170B-F3 169G-D2 169E-E8 169A-D5 168G-D5 168E-C2	151	140.1	1.002	50.85	162.7	168
T482	177C-B5 175C-B7 174B-C6 172H-C6 172F-A4 172D-A4 171F-D7 170E-D5 169F-F5 169D-F5	136	130.2	1.012	54.31	170.3	171
T457	175C-D2 174B-F7 1726-E6 170C-A3 169A-D8 168G-D8 168E-E4 16BA-F5	150	154.5	1.000	45.79	171.6	162
T498	175C-F3 172H-F5 172E-C6 172B-A4 171C-C2 170C-C2	151	165.4	1.004	41.96	181.7	169
T511	175C-F7 173D-F5 172H-A7 172E-E2 172C-E2 171F-C2 171C-A5	154	164.7	1.004	42.22	180.5	169
T499	176A-B3 173C-E5 172E-C4 172B-A3 1718-E2 170E-E4 170C-C8 170B-C8	135	155.7	1.007	45.38	178.0	171
T506	176A-C5 174B-B3 172H-E6 172F-E2 172D-E2 171B-C8 170E-CS	148	165.3	1.006	42.00	192.8	168
T509	176A-D2 174C-C4 173C-A2 173A-C6 172F-A3 172D-A3 172A-E2 171A-C8	149	157.3	1.004	44.80	175.6	162
T494	176A-08 174B-C4 173C-C6 172H-E2 172B-D7 171B-C2 170E-A6 170B-C2	149	150.7	1.001	47.11	167.7	162
T513	176A-F7 174C-B3 173D-A2 173B-C6 172H-A4 172F-D7 172D-D7 172B-C2 171E-A5	151	149.6	1.001	47.50	164.3	166
T551	176B-A5 174B-A4 173E-E8	225	216.2	1.003	24.16	242.6	243
T350	176B-A6 174B-D7 173E-C2	213	210.4	1.002	26.18	235.1	228
T512	1768-A3 174C-B7 172H-E4 172E-A4 172C-A4 171F-22 171C-E8	168	160.9	1.001	43.54	176.4	168
T480	176B-D2 174C-F7 172F-C4 172D-C4 172A-A4 171B-D7 170E-A4 170C-F5 169F-C2 169D-C2	148	146.1	1.005	48.74	168.8	163
T510	176C-A2 173D-C4 172G-C6 172E-D7 172C-D7 174F-C3 171B-E8	156	165.4	0.999	41.97	179.0	167
T520	176C-A3 174C-E2 173C-A4 173A-D7 172B-E8	192	198.1	0.999	30.51	215.0	208
T474	176C-D2 174C-F3 172G-A8 171A-A7 170A-D7 169H-D7 169C-F5 168H-C8 163F-C3	139	155.1	0.997	45.58	176.2	159
T466	177A-D5 174C-F5 172E-A7 172C-A7 169G-D7 169C-A6 168H-A6 168F-A6 168D-C2	138	146.7	1.009	48.53	168.1	159
T390	177B-B5 173B-85 169C-F3 167A-E2 166C-E2 165F-E4 165C-A6 165A-D3 164G-D7	136	132.2	1.018	53.60	154.0	157
T397	177B-C5 173A-B5 167C-E2 166F-E6 166A-F5 165F-E4 165B-A5 1641-E4	132	130.1	1.029	54.37	156.1	156

Table 41. Measured HEU Fuel Element ^{235}U Masses and Burnups

Results Based on ^{137}Cs Measurement at 15.3" from Top of Fuel Column

FE	IRRADIATION HISTORY					FINAL M235, G				INITIAL M235, G	
						ORR Est.	M(E)	C/E	BU(E),%	M(E)	ORR Est.
T455	176A-D5	174D-B5	172H-B3	170A-D2	169H-D2	139	136.7	1.001	52.04	177.2	174
	169F-E6	169C-E4	168H-E4	168F-E4	168A-C2						
T465	176A-F3	174E-B3	173A-B3	171E-C6	169G-E6	148	148.6	1.003	47.87	176.3	177
	169D-E8	169A-F5	168G-F5	168D-A5							
T505	176A-F5	174E-B7	173D-B3	173A-E6	172G-A3	147	151.5	0.997	46.83	180.0	177
	172E-A6	172A-C3	171E-C8	17DE-C2							
T417	175B-B5	173A-B7	171F-C4	168H-D7	168F-D7	148	145.9	0.999	48.82	171.8	169
	168D-D5	166G-E4	166C-E8	165F-A6							
T484	176B-C5	175B-B7	173A-F5	171E-C4	170C-D7	135	132.1	1.009	53.64	183.7	174
	170A-E4	169H-E4	169E-C8								
T456	175B-C5	173E-B7	169G-B3	168F-B3	168D-E8	145	150.8	1.000	47.09	179.9	168
	168A-C8										
T460	175B-D5	173E-F3	172C-E4	171E-A4	170B-D2	139	156.0	1.008	45.27	186.4	163
	169F-D2	169D-D2	168H-D8	168F-D8	168B-C8						
T445	175B-F3	173C-B7	172H-A8	170D-A3	169E-D2	149	152.9	1.002	46.36	170.7	170
	167D-E4	167A-A6									
T489	175B-F5	1730-B7	173B-A2	172A-A7	171C-A6	146	147.7	1.003	48.19	167.8	170
	170D-A7	170B-E4	169G-F5								
T496	175C-C5	173C-F3	172F-C6	172D-C6	172B-A6	148	169.6	0.990	40.50	194.9	163
	171A-D7	170D-A6	170B-F5								
T400	175C-D5	171E-B3	169E-F3	166H-135	166E-D2	142	143.8	1.001	49.55	167.6	163
	166A-E6	165F-D7	165C-E8	165A-E4							
T504	175C-F5	173E-B3	173C-E6	173A-A6	172E-A3	149	149.6	1.001	47.52	166.5	169
	171F-D3	171B-A5	170E-A5								
T486	176A-65	173E-F5	172B-C4	171C-D7	170E-E6	145	148.0	0.999	48.07	170.9	162
	170C-A6	169G-A5									
T485	176A-C4	173E-F7	173B-A8	172C-C4	172A-A3	147	148.0	1.003	48.06	172.7	167
	171A-A4	1700-A4	170B-D5	169E-F5							
T490	174C-B5	173A-C4	171F-A4	171B-03	170E-E8	156	147.1	1.012	48.40		175
	170C-D5	17CA-A5	169H-A5								

[*] Full element T490 was not gamma-scanned for the La-140 activity. However, complete Cs-137 gamma scans were taken from which this data was obtained.

Table 42. Average ^{235}U Burnup Status of ORR LEU Fuel Elements[a]

Range	19-Plate Standard Fuel Elements				15-Plate B&W
%	CERCA	NUKEM	B&W	Total	Fuel Followers
70-75	0	0	0	0	2
50-60	2	2	3	7	2
45-50	5	3	1	9	0
40-45	3	6	5	14	1
35-40	0	0	2	2	1
30-35	1	1	4	6	0
25-30	1	2	0	3	0
20-25	3	1	0	4	0
15-20	3	4	2	9	0
10-15	1	0	7	8	2
5-10	1	1	4	6	0
0	0	0	32	32	4
Total:	20	20	60	100	12

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[a] Based on results from the gamma-scanning of full-sized fuel elements.

Table 43. Axial Distribution of ^{235}U Burnups

Fuel Element	Last Core-Position	Quantity	Axial Segment[a]						
			A	B	C	D	E	F	Total[b]
C021	177D-C5	BU(E)-%:	48.28	59.26	62.94	58.46	45.62	29.25	50.58
		C/E:	1.040	1.031	1.016	0.996	0.960	0.942	1.004
C024	178D-D5	BU(E)-%:	49.98	60.57	63.56	59.24	44.93	29.20	51.20
		C/E:	1.036	1.037	1.030	1.000	0.991	0.973	1.016
N007	178H-C5	BU(E)-%:	48.55,	59.82	64.33	58.13	43.40	27.22	50.22
		C/E:	1.021	1.011	0.985	0.993	0.989	0.968	0.997
N008	178H-D5	BU(E)-%:	50.87	62.77	66.48	60.14	45.20	28.50	52.322
		C/E:	1.006	1.005	0.994	1.004	0.994	0.977	0.999
B042	179A-C5	BU(E)-%:	47.98	61.43	64.84	59.14	44.73	24.88	50.54
		C/E:	1.031	0.979	0.969	0.963	0.949	1.068	0.984
B043	179A-D5	BU(E)-%:	48.35	63.35	65.77	59.52	44.97	26.31	51.44
		C/E:	1.048	0.966	0.970	0.976	0.976	1.056	0.990
B044	179A-E5	BU(E)-%:	47.00	59.95	63.21	58.37	45.03	26.67	50.04
		C/E:	1.055	0.990	0.979	0.972	0.962	1.067	0.997
		Ave C/E:	1.034	1.003	0.992	0.986	0.974	1.007	
		Std Dev:	0.017	0.026	0.023	0.016	0.018	0.054	
UB001[C]	178J-F4	BU(E)-%:	40.10	67.74	82.87	88.86	90.41	78.31	74.72
		C/E:	1.097	0.956	0.954	0.963	0.958	1.052	0.987
UB002[c]	178J-F6	BU(E)-%:	37.20	65.18	82.78	90.44	91.98	81.46	74.84
		C/E:	1.215	1.004	0.955	0.943	0.935	1.002	0.986
UB003[c]	179A-F4	BU(E)-%:	23.57	47.81	66.89	77.42	80.99	61.63	59.72
		C/E:	1.103	0.974	0.936	0.936	0.937	1.173	0.993
UB004[c]	179A-F6	BU(E)-%:	21.77	46.33	65.33	76.79	80.99	65.56	59.46
		C/E:	1.224	1.015	0.956	0.936	0.927	1.089	0.994
		Ave C/E:	1.160	0.987	0.950	0.945	0.939	1.079	
		Std Dev:	0.069	0.027	0.010	0.013	0.013	0.072	

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[a] Each Fuel segment is 10.0 cm in height. Segment A is located at the bottom of the core.

[b] Fuel-element-averaged burnup (from Table 38).

[c] LEU 15-plate fuel follower element.

7.8.2 Results from Post-Irradiation Mass Spectrometry Measurements

At the conclusion of the whole-core demonstration a number of plates were removed from selected fuel elements and fuel followers and gamma-scanned to measure ^{137}Cs activity distributions. In addition, small samples for mass spectrometry analyses were cut from a number of these plates. Methods used to analyze this postirradiation data to determine fuel-element-averaged 235U burnups which are independent of those obtained from the gamma-scanning of full-sized fuel elements (see Table 38) are discussed in Section 6.5. Table 44 summarizes the results of these burnup analyses and compares them with REBUS-3 calculations and with results obtained from the ^{137}CS gamma-scanning of full-sized fuel elements.

Generally speaking, ^{235}U burnups for the 19-plate LEU fuel elements obtained by these two independent experimental methods are self-consistent and agree reasonably well with the REBUS-3 burnup calculations. For the fuel followers, however, the results based on mass spectrometry are somewhat smaller than those obtained from the earlier evaluations. Uncertainties (la) in the experimental values are in the 2-3% range.

7.9 Uranium and Plutonium Isotopic Mass Ratios Versus ^{235}U Burnup

From the mass spectrometry measurements values for the uranium and plutonium isotopic mass ratios were obtained for various ^{235}U burnups. These results are compared with REBUS-3 depletion calculations in Table 45 and in Figs. 55-57. Obtained from Ref. 1, Appendix G, the ORNL data refer to the U_3Si_2-A1 test elements irradiated in the ORR prior to the whole-core demonstration. The ANL-W data were obtained from mass spectrometry measurements made at the Argonne National Laboratory in Idaho using samples taken from LEU elements used in the whole-core demonstration. Isotopic dilution methods were used to measure the mg Pu/g U for samples with varying degrees of burnup. For computational purposes the height of the fuel column was divided into six equal segments each 10.0 cm in length. The calculated mass spectra (Table 45) were obtained from the REBUS-3 output for those fuel segments from which the mass spectrometer samples were removed. No attempt was made to interpolate the calculated spectra to the plate and elevation corresponding to the exact location of the mass spectrometer samples.

Table 45 and Figs. 55-57 show that the REBUS-3 calculations follow the measurements remarkably well. However, it does appear that the ^{240}Pu/^{239}Pu ratio is over-calculated by about 10% in the 30%-70% ^{235}U burnup range. These calculations are based on ENDF/B-IV data. Changes in the resonance capture data for the plutonium isotopes in ENDF/B-VI are in the direction of improving the ^{240}Pu/^{239}Pu ratio without significantly changing the other plutonium mass ratios.

7.10 Use of Revised EPRI-CELL Libraries

In Section 7.1 major changes between the old and new EPRI-CELL libraries are discussed. Except for the VIM-Monte Carlo calculations, most of the analytical results given in this chapter are based on EPRI-CELL broad group cross sections generated from the revised libraries.40 However, the old libraries were used in the analytical analyses of the gold and cobalt wire activations (Section 7.2), the differential shim rod worths (Section 7.3), and the prompt neutron decay constants (Section 7.4). Spot checks indicated that the new libraries produced negligible changes in the calculated differential rod worths and in the prompt neutron decay constants. The wire data, however, were not re-evaluated when the new cross section libraries became available.

Table 44. Summary of Mass Spectrometry - ^{137}Cs Gamma Scan Bumup Analyses for ORR Fuel Elements and Fuel Followers

Fuel Element	Plate	Mass Spec. Sample Loc. from Top of Plate, In.	^{235}U Burnup (%), Method		
			Calc.	Mass Spec.	Scanning[a]
B043	2	16.05	50.93	51.79±1.29	51.44±1.03
	2	4.05		46.82±1.17	
	10	16.05		51.97±1.30	
C024	2	16.05	52.02	53.62±1.34	51.20±1.02
	2	4.05		53.47±1.34	
	10	16.05		50.87±1.27	
N007	2	16.05	50.07	50.67±1.27	50.22±1.00
	2	4.05		48.81±1.22	
	10	16.05		50.60±1.26	
B041	2	16.05	48.55	49.22±1.23	48.50±0.97
C025	2	16.05	46.02	46.55±1.16	46.02±0.92
N006	2	16.05	48.73	51.02±1.28	49.02±0.98
T490	2	4.05	45.3[b]	48.86±1.22	48.40±0.97
	2	9.05		49.36±1.23	
	2	16.05		50.40±1.26	
	2	21.05		48.97±1.22	
U13002[c]	2	6.55	73.79	70.72±1.77	74.84±1.50
	2	20.55		76.89±1.92	
	8	6.55		68.21±1.71	
U13005[c]	2	5.05	39.32	37.12±1.30	40.04±0.80
	8	5.05		37.01±1.30	

[a] Based on gamma-scanning of full-sized fuel elements (see Table 38).

[b] This result is an ORR estimate. It depends on bumups in predemonstration cores for which no calculations are available.

[c] This is a 15-plate fuel follower.

Table 45. Mass Spectra (wt %) for ORR Fuel Elements[a]

Fuel Element	Last Core	Sect. Or Plate	Source	235BU[b] %	Uranium Mass Spectrum				Plutonium Mass Spectnun					
					234	235	236	238	238	239	240	241	242	mg Pu/g U
B043	179A	C	Calc.	63.77	0.11	8.18	2.38	89.32	1.02	68.13	19.41	9.31	2.13	9.62
	D5	2	Meas.	64.50	0.09	8.05	2.46	89.39		71.25	18.05	8.52	2.18	9.99
		10	Meas.	60.61	0.09	8.85	2.34	88.71		71.85	17.82	8.33	2.00	10.15
C024	178D	C	Cale.	65.49	0.11	7.82	2.44	89.63	1.10	67.91	19.30	9.44	2.24	9.75
	D5	2	Meas.	67.37	0.11	7.43	2.50	89.96		69.95	18.54	9.02	2.49	10.11
		10	Meas.	62.35	0.11	8.47	2.34	89.08		71.48	18.03	8.37	2.13	10.07
N007	178H	C	Calc.	63.39	0.11	8.26	2.37	89.26	1.03	68.44	19.22	9.23	2.08	9.66
	C5	2	Meas.	66.49	0.10	7.65	2.51	89.74		69.78	18.96	8.79	2.48	9.94
		10	Meas.	61.52	0.10	8.68	2.34	88.87		71.65	18.07	8.24	2.04	9.99
B041	179A	C	Calc.	61.42	0.11	8.66	2.29	88.93	0.95	69.57	18.94	8.70	1.83	9.21
	B5	2	Meas.	61.50	0.09	8.67	2.35	88.88		72.13	17.77	8.15	1.95	10.30
C025	178A	C	Calc.	56.81	0.12	9.60	2.11	88.17	0.74	72.30	17.70	7.87	1.39	8.64
	D5	2	Meas.	58.27	0.12	9.30	2.14	88.44		74.84	16.65	7.08	1.44	8.76
N006	178J	C	Cale.	62.41	0.12	8.46	2.32	89.11	0.94	69.37	18.90	8.89	1.90	9.27
	D5	2	Meas.	64.09	0.11	8.15	2.40	89.34		72.01	17.68	8.28	2.03	9.91
UB002	178J	E	Cale.	86.04	0.10	3.34	3.21	93.35	2.63	55.59	23.05	12.06	6.66	12.41
	F6	2	Meas.	87.20	0.09	3.09	3.30	93.52		56.65	23.79	11.56	8.00	12.05
		8	Meas.	86.77	0.09	3.19	3.29	93.43		56.76	23.64	11.75	7.85	11.96
UB005	179A	E	Calc.	55.79	0.12	9.80	2.06	88.02	0.56	73.34	17.66	7.20	1.23	8.52
	B4	2	Meas.	55.32	0.11	9.92	2.07	87.90		75.80	16.41	6.52	1.26	9.00
		8	Meas.	53.04	0.11	10.37	1.98	87.53		76.75	15.93	6.23	1.09	8.75

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[a] For standard fuel elements and the UB002 and UB005 fuel fol-lowers the centers of the mass spectrometer samples were located 16.05, 6.55, and 5.05 inches from the top of the fuel plate, respectively (see Table 26).

[b] The measured burnup is at the location of the mass spectrometer sample. The calculated burnup is averaged over the 10.0 cm axial section (C or E) of tile fuel element.

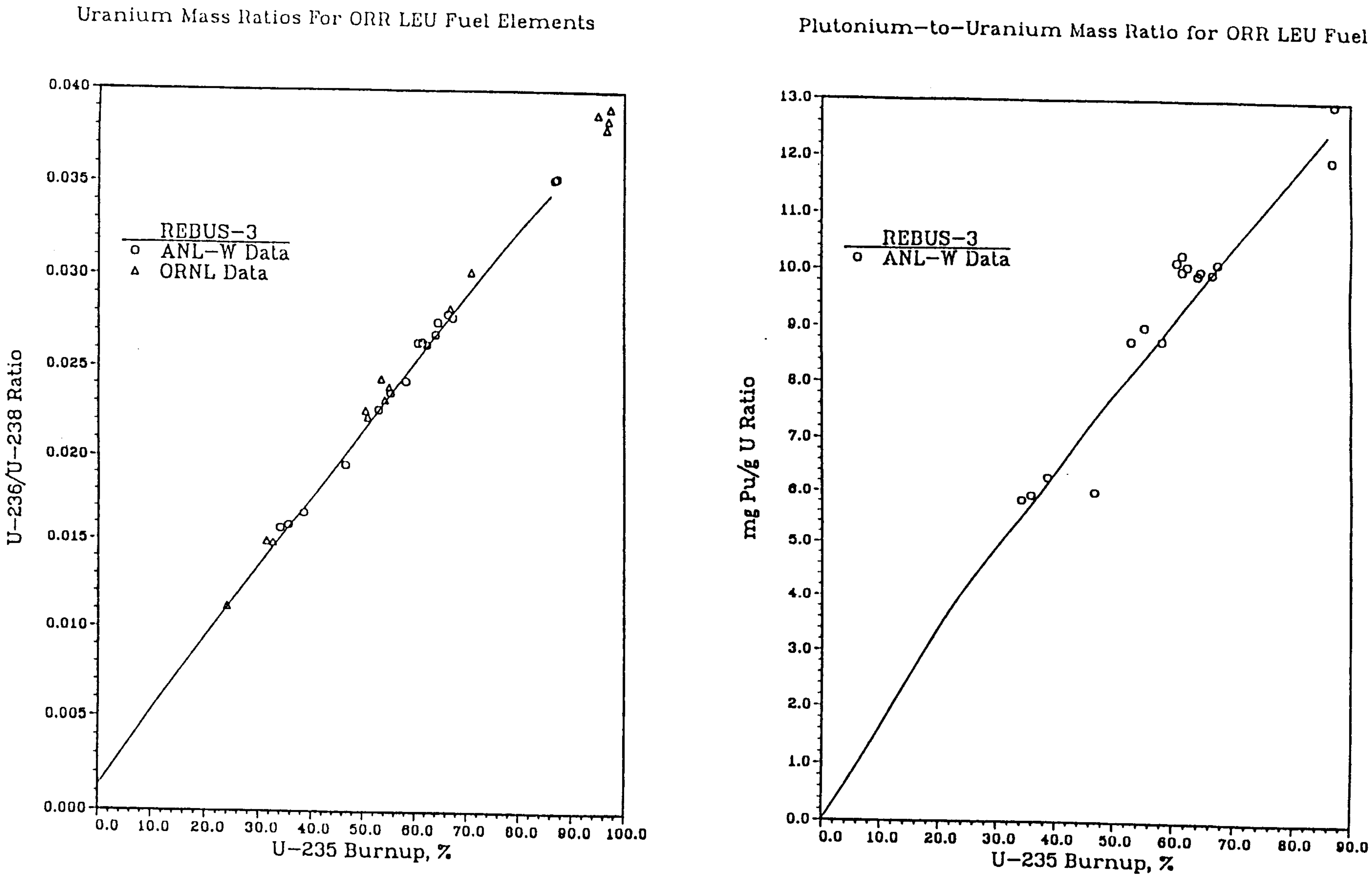

Fig. 55 Uranium and Plutonium Mass Ratios for ORR Fuel Elements

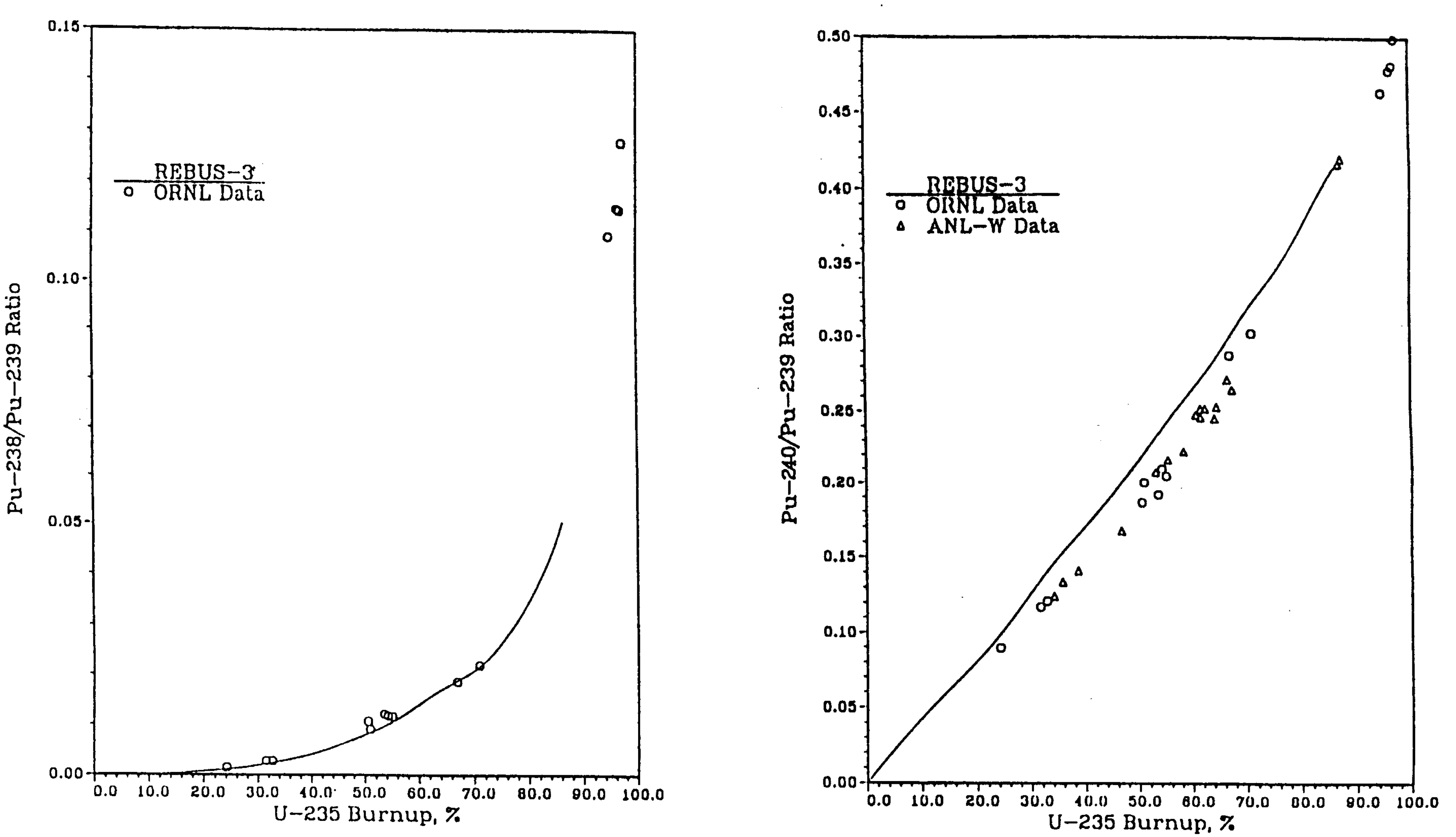

Fig. 56 Plutonium Mass Ratios for ORR Fuel Elements

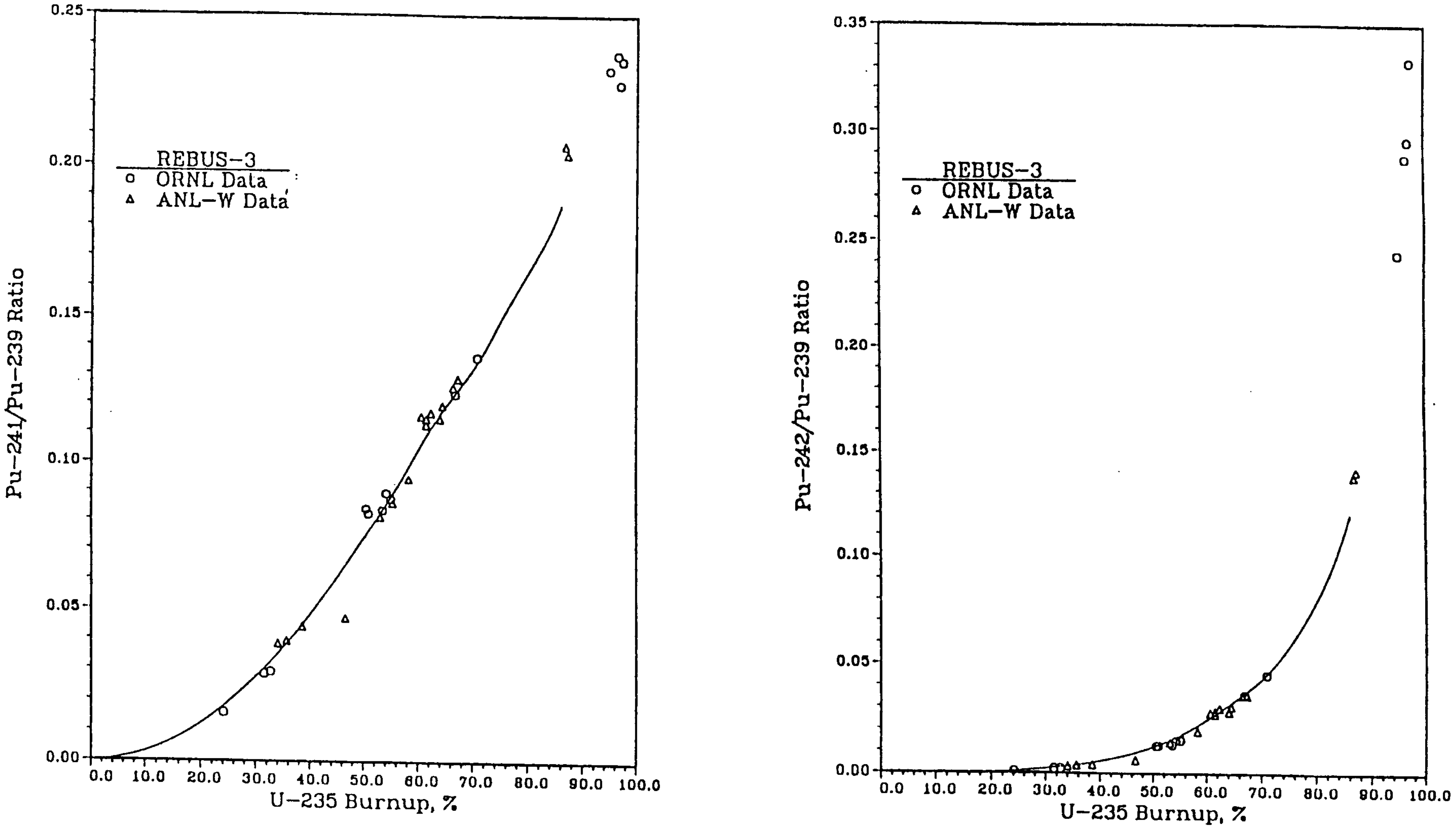

Fig. 57 Plutonium Mass Ratios for ORR Fuel Elements