JEZEBEL Pu239 Corrective Factors

The specifications of this experiment are provided on the "International Handbook of Evaluated Criticality Safety Benchmark Experiments" under the name "PU-MET-FAST-001" in the Plutonium Systems chapter.
JEZEBEL Pu239 is a 17,020 gram sphere of plutonium alloy with a density of 15.61 g/cm^3 and has a radius of 6.3849 cm.
The homogeneous compositions are given in Table I (taken from the benchmark DVD).

For the deterministic spherical model the following meshing has been used with equidistant points in the same region:

Axis			
R	Point	1	33
	Dimens.	0.0	6.3849

The following S_4 angular data have been used. Just a reminder that directions with zero weight are used only for improving convergence on the curvilinear derivative term and should not affect the final result if not used, as it is the case of some S_n codes (e. g. ONETRAN, ONEDANT).

Direc.	Weight	μ
1	0.0000000E+00	-0.9367418E+00
2	0.1666667E+00	-0.8688903E+00
3	0.3333333E+00	-0.3500212E+00
4	0.3333333E+00	0.3500212E+00
5	0.1666667E+00	0.8688903E+00

Corrective factors have been calculated with the ENDF/B-VII cross section data. In table II we provide the corrective factors for the homogenous R model for the deterministic S_4P_1 33 group calculations. Corrective factors are calculated as the ratio between the values obtained by the detailed Monte Carlo calculation and those obtained by the corresponding approximated calculation.

Table I. Homogeneous compositions.

Nuclide	Atom Density, atoms/barn-cm
Ga	1.3752×10^{-3}
^{239}Pu	3.7047×10^{-2}
^{240}Pu	1.7512×10^{-3}
^{241}Pu	1.1674×10^{-4}

Table II. Corrective factors for R homogeneous **deterministic** calculations.

Parameters	MC Detailed	S_4 R.	**Corr. Fact.**	Experiment
K_{eff}	0.99986 ±9pcm	1.00538	**0.99451**	1.00000
F28/F25	0.2084 ±0.0009	0.2032	**1.0256**	0.214
F37/F25	0.9707 ±0.0013	0.9620	**1.0090**	0.962
F49/F25	1.4248 ±0.0018	1.4220	**1.0020**	1.448

JEZEBEL Pu240 Corrective Factors

The specifications of this experiment are provided on the "International Handbook of Evaluated Criticality Safety Benchmark Experiments" under the name "PU-MET-FAST-002" in the Plutonium Systems chapter.
JEZEBEL Pu240 is a 19,460 g sphere of plutonium alloy with a density of 15.73 g/cm^3 has a radius of 6.6595 cm..
The homogeneous compositions are given in Table I (taken from the benchmark DVD).

For the deterministic spherical model the following meshing has been used with equidistant points in the same region:

Axis			
R	Point	1	33
	Dimens.	0.0	6.6595

The following S_4 angular data have been used. Just a reminder that directions with zero weight are used only for improving convergence on the curvilinear derivative term and should not affect the final result if not used, as it is the case of some S_n codes (e. g. ONETRAN, ONEDANT).

Direc.	Weight	μ
1	0.0000000E+00	-0.9367418E+00
2	0.1666667E+00	-0.8688903E+00
3	0.3333333E+00	-0.3500212E+00
4	0.3333333E+00	0.3500212E+00
5	0.1666667E+00	0.8688903E+00

Corrective factors have been calculated with the ENDF/B-VII cross section data. In table II we provide the corrective factors for the homogenous R model for the deterministic S_4P_1 33 group calculations. Corrective factors are calculated as the ratio between the values obtained by the detailed Monte Carlo calculation and those obtained by the corresponding approximated calculation.

Table I. Homogeneous compositions.

Nuclide	Atom Density, atoms/barn-cm
Ga	1.3722×10^{-3}
^{239}Pu	2.9934×10^{-2}
^{240}Pu	7.8754×10^{-3}
^{241}Pu	1.2146×10^{-3}
^{242}Pu	1.5672×10^{-4}

Table II. Corrective factors for R homogeneous **deterministic** calculations.

Parameters	MC Detailed	S_4 R.	**Corr. Fact.**	Experiment
K_{eff}	0.99981 ±9pcm	1.00459	**0.99527**	1.00000

FLATTOP PU239 Corrective Factors

The specifications of this experiment are provided on the "International Handbook of Evaluated Criticality Safety Benchmark Experiments" under the name "PU-MET-FAST-006" in the Plutonium Systems chapter.
The radius of the core, a 6060-gram Pu sphere at a density of 15.53 g/cm3, was 4.5332 cm. The sphere was reflected by 19.6088 cm of normal uranium (outer radius of 24.1420 cm).
The homogeneous compositions are in Table I (taken from the benchmark DVD).

For the deterministic spherical model the following meshing has been used with equidistant points in the same region:

Axis				
R	Point	1	25	100
	Dimens.	0.0	4.5332	24.142

The following S_4 angular data have been used. Just a reminder that directions with zero weight are used only for improving convergence on the curvilinear derivative term and should not affect the final result if not used, as it is the case of some S_n codes (e. g. ONETRAN, ONEDANT).

Direc.	Weight	μ
1	0.0000000E+00	-0.9367418E+00
2	0.1666667E+00	-0.8688903E+00
3	0.3333333E+00	-0.3500212E+00
4	0.3333333E+00	0.3500212E+00
5	0.1666667E+00	0.8688903E+00

Corrective factors have been calculated with the ENDF/B-VII cross section data. In table II we provide the corrective factors for the homogenous R model for the deterministic S_4P_1 33 group calculations. Corrective factors are calculated as the ratio between the values obtained by the detailed Monte Carlo calculation and those obtained by the corresponding approximated calculation.

Table I. Homogeneous compositions.

Isotope	Atom Densities (atoms/barn-cm)
Core	
^{239}Pu	3.6697×10^{-2}
^{240}Pu	1.8700×10^{-3}
^{241}Pu	1.1639×10^{-4}
Ga	1.4755×10^{-3}
Reflector[(a)]	
^{234}U	2.6438×10^{-6}
^{235}U	3.4610×10^{-4}
^{238}U	4.7721×10^{-2}

Table II. Corrective factors for R homogeneous **deterministic** calculations.

Parameters	MC Detailed	S_4 R.	**Corr. Fact.**	Experiment
K_{eff}	1.00097 ±18pcm	0.99815	**1.00283**	1.00000
F28/F25	0.1767 ±0.0013	0.1715	**1.0303**	0.1799
F37/F25	0.8523 ±0.0013	0.8452	**1.0084**	0.8561

ZPR-6 Assembly 7 Corrective Factors

The specifications of this experiment are provided on the "International Handbook of Evaluated Reactor Physics Benchmark Experiments" under the name "ZPR-LMFR-EXP-001" in the Liquid Metal Fast Reactor chapter.
The homogeneous R-Z model and associated dimension are shown in Fig. 1 and homogeneous compositions are in Table I (both taken from the benchmark DVD).

For the deterministic model (one quarter only of the geometry was described) the following meshing has been used with equidistant points in the same region:

Axis							
R	Point	1	24	54	74	85	
	Dimens.	0.0	24.3435	80.7984	112.2504	140.2589	
Z	Point	1	51	64	69	74	80
	Dimens.	0.0	76.2813	101.7257	106.6800	110.5357	121.9200

The following S_4 angular data have been used. Just a reminder that directions with zero weight are used only for improving convergence on the curvilinear derivative term and should not affect the final result if not used, as it is the case of some S_n codes (e. g. TWOTRAN, TWODANT).

Direc.	Weight	η	μ
1	0.0000000E+00	-0.8819200E+00	-0.4714000E+00
2	0.8333331E-01	-0.8819200E+00	-0.3333333E+00
3	0.8333331E-01	-0.8819200E+00	0.3333333E+00
4	0.0000000E+00	-0.3333333E+00	-0.9428100E+00
5	0.8333331E-01	-0.3333333E+00	-0.8819200E+00
6	0.8333331E-01	-0.3333333E+00	-0.3333333E+00
7	0.8333331E-01	-0.3333333E+00	0.3333333E+00
8	0.8333331E-01	-0.3333333E+00	0.8819200E+00
9	0.0000000E+00	0.8819200E+00	-0.4714000E+00
10	0.8333331E-01	0.8819200E+00	-0.3333333E+00
11	0.8333331E-01	0.8819200E+00	0.3333333E+00
12	0.0000000E+00	0.3333333E+00	-0.9428100E+00
13	0.8333331E-01	0.3333333E+00	-0.8819200E+00
14	0.8333331E-01	0.3333333E+00	-0.3333333E+00
15	0.8333331E-01	0.3333333E+00	0.3333333E+00
16	0.8333331E-01	0.3333333E+00	0.8819200E+00

Corrective factors have been calculated with the ENDF/B-VII cross section data. In tables II and III we provide the corrective factors for the homogenous R-Z model for Monte Carlo (MC) and deterministic S_4P_1 33 group calculations. Spectral indices have been calculated at the central location. Corrective factors are calculated as the ratio between the values obtained by the detailed Monte Carlo calculation and those obtained by the corresponding approximated calculation.

Figure 1. R-Z homogeneous model

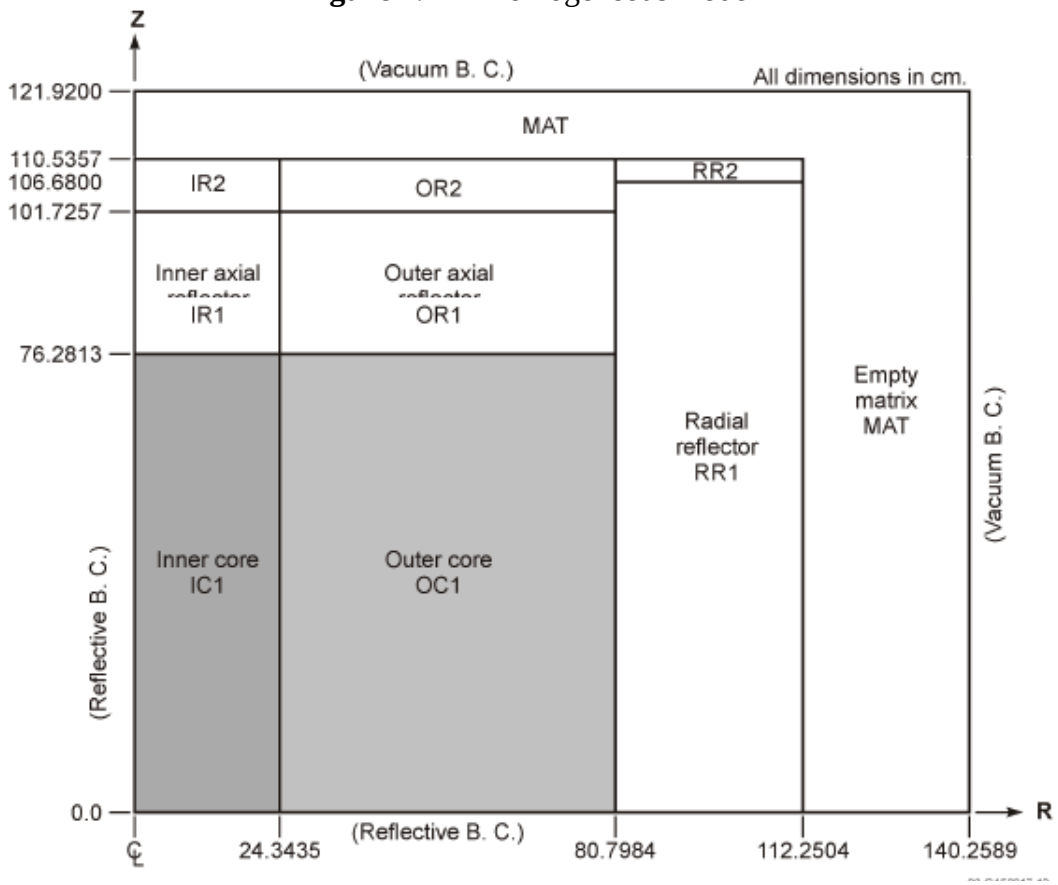

Table I. Homogeneous R-Z compositions.

Nuclide	Inner Core IC1	Outer Core OC1	Inner Axial Reflector 1 (IR1)	Inner Axial Reflector 2 (IR2)
^{240}Pu	1.17621E-04	1.17551E-04	0.00000E+00	0.00000E+00
^{241}Pu	1.32171E-05	1.50239E-05	0.00000E+00	0.00000E+00
^{235}U	1.26065E-05	1.26448E-05	8.29422E-05	8.65264E-05
^{238}U	5.79290E-03	5.81017E-03	3.71167E-02	3.87479E-02
^{239}Pu	8.86521E-04	8.86314E-04	0.00000E+00	0.00000E+00
^{238}Pu	3.33012E-07	4.68474E-07	0.00000E+00	0.00000E+00
^{242}Pu	1.40289E-06	1.76343E-06	0.00000E+00	0.00000E+00
^{241}Am	3.12449E-06	2.58715E-06	0.00000E+00	0.00000E+00
Cr	2.69312E-03	2.68787E-03	1.64641E-03	1.44970E-03
Ni	1.19777E-03	1.18818E-03	6.89374E-04	6.07516E-04
Fe	1.28729E-02	1.32415E-02	6.06025E-03	5.25530E-03
^{27}Al	4.02097E-06	1.63640E-05	0.00000E+00	0.00000E+00
^{23}Na	9.27911E-03	9.11269E-03	0.00000E+00	0.00000E+00
^{16}O	1.37692E-02	1.42601E-02	0.00000E+00	0.00000E+00
C	3.66420E-05	3.40451E-05	3.67281E-05	2.71677E-05
Mo	2.36058E-04	2.38695E-04	1.06205E-05	1.00416E-05
Mn	2.25629E-04	2.23933E-04	1.43193E-04	1.27167E-04
Cu	2.46769E-05	2.48245E-05	1.97417E-05	1.90679E-05
Si	1.62355E-04	1.54889E-04	1.06228E-04	9.52030E-05
Ca	2.13014E-06	2.09220E-06	0.00000E+00	0.00000E+00
Cl	2.98536E-07	2.96680E-07	0.00000E+00	0.00000E+00
^{59}Co	8.32422E-07	1.69933E-07	0.00000E+00	0.00000E+00
Nuclide	Outer Axial Reflector 1 (OR1)	Outer Axial Reflector 2 (OR2)	Radial Reflector (RR1)	Matrix (MAT and RR2)
^{240}Pu	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
^{241}Pu	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
^{235}U	8.26986E-05	8.54980E-05	8.66555E-05	0.00000E+00
^{238}U	3.70115E-02	3.82849E-02	3.88076E-02	0.00000E+00
^{239}Pu	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
^{238}Pu	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
^{242}Pu	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
^{241}Am	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
Cr	1.65503E-03	1.46815E-03	1.17821E-03	1.19186E-03
Ni	6.92826E-04	6.15041E-04	4.75780E-04	4.82129E-04
Fe	6.08806E-03	5.31944E-03	4.23998E-03	4.31040E-03
^{27}Al	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
^{23}Na	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
^{16}O	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
C	3.66408E-05	2.73038E-05	1.85721E-05	1.98538E-05
Mo	1.06734E-05	1.02040E-05	8.18136E-06	8.27768E-06
Mn	1.43786E-04	1.28519E-04	1.04936E-04	1.06060E-04
Cu	1.98177E-05	1.92138E-05	1.70748E-05	1.71923E-05
Si	1.06088E-04	9.54624E-05	6.76848E-05	6.88726E-05
Ca	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
Cl	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00
^{59}Co	0.00000E+00	0.00000E+00	0.00000E+00	0.00000E+00

Table II. Corrective factors for R-Z homogeneous **Monte Carlo** calculations.

Parameters	MC Detailed	MC R-Z Hom.	**Corr. Fact.**	Experiment
K_{eff}	1.00094 ±7 pcm	0.98680	**1.01433**	1.00051
F49/F25	0.9093 ±0.0065	0.9213	**0.9870**	0.9414
F28/F25	0.0224 ±0.0002	0.0214	**1.04673**	0.0233
C28/F25	0.1336 ±0.0008	0.1388	**0.9625**	0.1323

Table III. Corrective factors for R-Z homogeneous **deterministic** calculations.

Parameters	MC Detailed	S_4 R-Z Hom.	**Corr. Fact.**	Experiment
K_{eff}	1.00094 ±7 pcm	0.98915	**1.01192**	1.00051
F49/F25	0.9093 ±0.0065	0.9232	**0.9849**	0.9435
F28/F25	0.0224 ±0.0002	0.0218	**1.0275**	0.0233
C28/F25	0.1336 ±0.0008	0.1387	**0.9632**	0.1323

ZPR-6 Assembly 7 High Pu240 Corrective Factors

The specifications of this experiment are provided on the "International Handbook of Evaluated Reactor Physics Benchmark Experiments" under the name "ZPR-LMFR-EXP-002" in the Liquid Metal Fast Reactor chapter.
The homogeneous R-Z model and associated dimension are shown in Fig. 1 and homogeneous compositions are in Table I (both taken from the benchmark DVD).

For the deterministic model (one quarter only of the geometry was described) the following meshing has been used with equidistant points in the same region:

Axis							
R	Point	1	24	51	53	74	85
	Dimens.	0.0	24.3435	75.0028	78.0496	111.5583	140.2589
Z	Point	1	51	64	69	74	80
	Dimens.	0.0	76.2813	101.7257	106.6800	110.5357	121.9200

The following S_4 angular data have been used. Just a reminder that directions with zero weight are used only for improving convergence on the curvilinear derivative term and should not affect the final result if not used, as it is the case of some S_n codes (e. g. TWOTRAN, TWODANT).

Direc.	Weight	η	μ
1	0.0000000E+00	-0.8819200E+00	-0.4714000E+00
2	0.8333331E-01	-0.8819200E+00	-0.3333333E+00
3	0.8333331E-01	-0.8819200E+00	0.3333333E+00
4	0.0000000E+00	-0.3333333E+00	-0.9428100E+00
5	0.8333331E-01	-0.3333333E+00	-0.8819200E+00
6	0.8333331E-01	-0.3333333E+00	-0.3333333E+00
7	0.8333331E-01	-0.3333333E+00	0.3333333E+00
8	0.8333331E-01	-0.3333333E+00	0.8819200E+00
9	0.0000000E+00	0.8819200E+00	-0.4714000E+00
10	0.8333331E-01	0.8819200E+00	-0.3333333E+00
11	0.8333331E-01	0.8819200E+00	0.3333333E+00
12	0.0000000E+00	0.3333333E+00	-0.9428100E+00
13	0.8333331E-01	0.3333333E+00	-0.8819200E+00
14	0.8333331E-01	0.3333333E+00	-0.3333333E+00
15	0.8333331E-01	0.3333333E+00	0.3333333E+00
16	0.8333331E-01	0.3333333E+00	0.8819200E+00

Corrective factors have been calculated with the ENDF/B-VII cross section data. In tables II and III we provide the corrective factors for the homogenous R-Z model for Monte Carlo (MC) and deterministic S_4P_1 33 group calculations. Corrective factors are calculated as the ratio between the values obtained by the detailed Monte Carlo calculation and those obtained by the corresponding approximated calculation.

Figure 1. R-Z homogeneous model

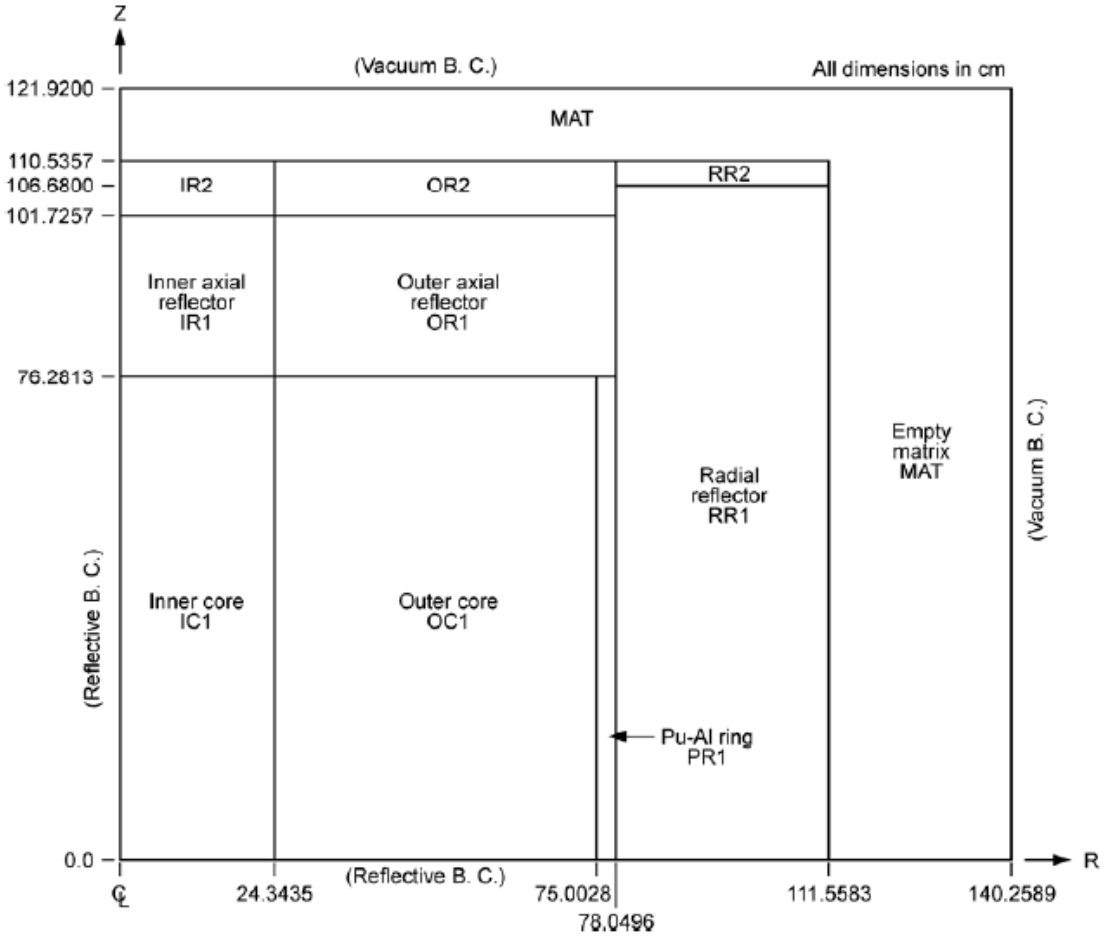

Table I. Homogeneous R-Z compositions.

Nuclide	Inner Core	Outer Core	Pu-Al Ring
^{240}Pu	3.2178E-04	1.1749E-04	5.0694E-05
^{241}Pu [a]	5.3569E-05	1.4641E-05	2.8433E-06
^{235}U	1.1872E-05	1.2575E-05	1.2151E-05
^{238}U	5.5620E-03	5.7820E-03	5.7042E-03
^{239}Pu	8.3844E-04	8.8583E-04	1.0697E-03
^{238}Pu	1.1083E-06	4.6444E-07	1.6248E-09
^{242}Pu	1.7447E-05	1.7620E-06	1.1005E-07
^{241}Am (a(	1.4681E-05	2.9643E-06	1.9758E-06
Cr	2.6792E-03	2.6909E-03	2.6230E-03
Ni	1.1908E-03	1.1885E-03	1.1648E-03
Fe	1.2805E-02	1.3230E-02	1.3160E-02
Al	4.1057E-06	1.8593E-05	1.1477E-04
Na	9.1676E-03	9.0718E-03	9.3420E-03
O	1.3684E-02	1.4192E-02	1.4386E-02
C	3.6621E-05	3.3605E-05	4.0021E-05
Mo	2.3662E-04	2.3875E-04	1.3306E-05
Mn	2.2447E-04	2.2395E-04	2.2020E-04
Cu	2.4580E-05	2.4882E-05	2.5731E-05
Si	1.6182E-04	1.5377E-04	1.5879E-04
Ca	2.1044E-06	2.0828E-06	2.1452E-06
Cl	2.9484E-07	2.9546E-07	3.0352E-07
Co	8.2889E-07	5.4095E-08	8.2412E-07

Nuclide	Inner Reflector 1	Inner Reflector 2	Outer Reflector 1	Outer Reflector 2
^{235}U	8.1353E-05	8.5866E-05	8.1048E-05	8.4740E-05
^{238}U	3.7936E-02	4.0055E-02	3.7795E-02	3.9527E-02
Cr	1.6464E-03	1.4497E-03	1.6557E-03	1.4696E-03
Ni	6.8937E-04	6.0752E-04	6.9310E-04	6.1564E-04
Fe	6.0603E-03	5.2553E-03	6.0903E-03	5.3245E-03
C	3.6728E-05	2.7168E-05	3.6634E-05	2.7315E-05
Mo	1.0620E-05	1.0042E-05	1.0678E-05	1.0217E-05
Mn	1.4319E-04	1.2717E-04	1.4383E-04	1.2863E-04
Cu	1.9742E-05	1.9068E-05	1.9824E-05	1.9225E-05
Si	1.0623E-04	9.5203E-05	1.0608E-04	9.5483E-05

Nuclide	Radial Reflector 1	Radial Reflector 2	Matrix
^{235}U	8.5846E-05	0.0000E+00	0.0000E+00
^{238}U	4.0046E-02	0.0000E+00	0.0000E+00
Cr	1.1782E-03	1.1910E-03	1.1910E-03
Ni	4.7578E-04	4.8172E-04	4.8172E-04
Fe	4.2400E-03	4.3056E-03	4.3056E-03
C	1.8572E-05	1.9752E-05	1.9752E-05
Mo	8.1814E-06	8.2719E-06	8.2719E-06
Mn	1.0494E-04	1.0599E-04	1.0599E-04
Cu	1.7075E-05	1.7186E-05	1.7186E-05
Si	6.7685E-05	6.8789E-05	6.8789E-05

Table II. Corrective factors for R-Z homogeneous **Monte Carlo** calculations.

Parameters	MC Detailed	MC R-Z Hom.	**Corr. Fact.**	Experiment
K_{eff}	1.00017 ±11pcm	0.98589	**1.01448**	1.00080

Table III. Corrective factors for R-Z homogeneous **deterministic** calculations.

Parameters	MC Detailed	S_4 R-Z Hom.	**Corr. Fact.**	Experiment
K_{eff}	1.00017 ±11pcm	0.98781	**1.01251**	1.00080