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Modification to ORIGEN2 for Generating N Reactor Source Terms

Volume 1 of 3

R. A. Schwarz

April 1997

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

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Volume 1

Modifications to ORIGEN2 for Generating N-Reactor Source Terms

1.0 Introduction

This report discusses work that has been done to upgrade the ORIGEN2 code cross sections to be compatible with the WIMS computer code data. Because of the changes in the ORIGEN2 cross sections, the Radnuc code has also been modified to reflect the new ORIGEN2 calculations. Details on changes made to the ORIGEN2 computer code and the Radnuc code will be discussed along with additional work that should be done in the future to upgrade both ORIGEN2 and Radnuc.

A detailed historical description^(a) of how source terms have been generated for N Reactor fuel stored in the K Basins has been generated. The neutron source discussed in this description was generated by the WIMS computer code (Gubbins et al. 1982) because of known shortcomings in the ORIGEN2 (Croff 1980) cross sections.^(b) Another document^(c) includes a discussion of the ORIGEN2 cross sections.

2.0 Comparison Between WIMS and Old ORIGEN2 Calculated Masses

The ORIGEN2 estimate for the production of ^{244}Cm is around a factor of 10 higher than that calculated by WIMS-E 6a.^(b) This isotope (^{244}Cm) is an important contributor to the neutron source generated by N Reactor fuel. Comparisons between the neutron source calculated by ORIGEN2 and WIMS-E 6a have been previously documented; however, these comparisons were between calculations that had different burnups. Table 1 includes a comparison between masses calculated by the WIMS-E 6a and ORIGEN2 codes for the same burnup.

As seen in Table 1, ORIGEN2 was overpredicting the ^{244}Cm content by a factor of 8.64. In investigating the difference in the ^{244}Cm values, it was discovered that there was an error in the ORIGEN2 cross section database. ^{244}Cm is produced by ^{243}Am capture which produces ^{244}Am which then beta decays to ^{244}Cm . The ORIGEN2 capture cross section for ^{243}Am leading to an excited state of ^{244}Am was high by a factor of approximately 18.

A number of other isotopes in Table 1 show up as having concentrations significantly different than those predicted by WIMS-E 6a. To fix the ^{244}Cm problem and address differences for these other isotopes, the ORIGEN2 actinide capture and neutron induce fission cross sections were updated so that they were equal to the cross sections calculated by WIMS-E 6a.

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- (a) Memo from R.A. Schwartz to A.T. Kee, "Shielding Source Term Generation for N Reactor." 8M730-RAS-95-012, Dated Nov. 29, 1995.
 - (b) Memo from K.N. Schwinkendorf to L.L. Carter, "WIMS-E Prediction of Transuranic Isotopic Production." 96003, Dated Feb. 16, 1996.
 - (c) DSI from F.A. Schmittroth to J.S. Lan, "A Review of ORIGEN2 Neutron Source Calculations." Dated Oct. 3, 1995.

3.0 Comparison Between WIMS and Old ORIGEN2 Cross Sections

ORIGEN2 has the capability of using both static and burnup dependent capture and fission cross sections. The static cross sections are contained in cross section files libraries requested by the ORIGEN2 LIB command. These cross sections are accessed by entering the cross section identifier as the 5th, 6th, and 7th entries on the ORIGEN2 LIB card. Table 2 lists the cross section identifiers corresponding to the different static N Reactor cross section files.

In addition to these static cross sections, there are a number of Fortran DATA statements internal to the ORIGEN2 code that contain burnup-dependent cross section information. These burnup-dependent cross sections are accessed by entering the burnup-dependent cross section identifier as the 12th entry on the ORIGEN2 LIB card. The burnup-dependent cross section identifiers are included in Table 2. All of the N Reactor calculations that have been made using ORIGEN2 have used the burnup-dependent cross sections when possible. Burnup-dependent cross sections only exist for ^{235}U capture and fission, ^{238}U capture and fission, ^{236}U capture and fission, ^{237}Np capture, ^{239}Np capture and fission, ^{240}Pu capture and fission, ^{241}Pu capture and fission, and ^{242}Pu capture.

Table 3 shows the difference between the average ORIGEN2 cross sections and those calculated by WIMS-E 6a. Notice in Table 3 that the differences in the ^{243}Am cross section shows up immediately as the largest cross section difference. Most of the other ORIGEN2 cross sections are within a factor of 2 of the WIMS-E 6a cross sections.

Appendix A includes a graph of each of the cross sections listed in Table 3. Each graph includes the burnup-dependent WIMS-E 6a cross section, the static ORIGEN2 cross section, and the burnup-dependent ORIGEN2 cross section if it exists. The burnup-dependent cross sections in ORIGEN2 are entered as a step function with five values, with each value corresponding to a burnup of 1,000 MWD/MTIHM (Metric Ton Initial Heavy Metal). When burnup-dependent cross sections exist, the cross section value for the first step is equal to the static cross section value.

4.0 Creation of New ORIGEN2 Cross Sections

New ORIGEN2 burnup dependent cross sections were created by fitting the burnup-dependent step function to the WIMS-E 6a cross section data. The step function for each of the 1000 MWD/MTU increments was set such that the value of the step function was set to the average value of the WIMS-E 6a cross section for the step being evaluated.

The ORIGEN2 static cross sections were set to the first cross section value from the burnup-dependent cross section set. If burnup-dependent cross sections did not exist then the static cross section was set to the WIMS-E 6a cross section at 500 MWD/MTU, to make the evaluation of the static cross sections the same as the static cross sections evaluated from the burnup-dependent cross sections.

The original ORIGEN2 cross sections set the static cross section to the case of no burnup. This could result in a significant error if the cross section changes significantly with burnup. Then new evaluation is not much better since it uses the cross section at 500 MWD/MTU. The static cross sections were not changed to be equal to the average burnup cross section from WIMS-E 6a because this would depart from the way other ORIGEN2 cross sections are evaluated.

The WIMS-E 6a cross sections do not directly correlate to the ORIGEN2 cross sections. Instead WIMS-E 6a will have an "effective" cross section that leads directly from a target to a product. For example, to produce ^{243}Am , the ^{242}Pu captures a neutron to produce ^{243}Pu which then beta decays to ^{243}Am . The WIMS-E 6a cross section set combines these two events into a single capture event for ^{242}Pu that produces ^{243}Am .

For capture cross sections, the ORIGEN2 computer code contains two capture cross sections: one for a capture that leads to the ground state of the daughter nuclide and one for a capture event that leads to the excited state of the daughter nuclide. The WIMS-E 6a code does not make this cross section distinction. For those atoms that have both capture cross sections, the WIMS-E 6a cross section will be divided between the two cross sections in the exact same ratio as currently exists in the ORIGEN2 cross section library.

It is because of these two types of capture cross sections that the ^{243}Am cross section was initially incorrectly set in the ORIGEN2 cross section library. When this cross section was created, the total capture cross section was used for the capture to the ground state of the daughter nuclide and capture to the excited state was set to the ratio of these two cross sections.^(a)

Table 4 lists the changes made in the ORIGEN2 static capture cross sections. Notice that Table 4 lists both the capture to ground state and the capture to an excited state of the daughter nuclide. Table 5 lists the changes made in the ORIGEN2 fission cross sections. Table 6 lists the changes made in the ORIGEN2 burnup dependent cross sections. Appendix B shows a plot of the new ORIGEN2 cross sections along with the WIMS cross sections.

5.0 New ORIGEN2 Runs for N Reactor Fuel

ORIGEN2 runs have been made for characterizing N Reactor fuel for many years. In 1985 Goldberg released a set of ORIGEN2 calculations (Hedengren 1985, 1986; Hedengren and Goldberg 1987) for N Reactor fuel that was used as the basis for characterizing N Reactor fuel. Another set was certified in 1991^(b) and another in 1992^(c); however, a new release of their ORIGEN2 output files was not made.

(a) Memo from F.A. Schmittroth to J.S. Lan, "A Review of ORIGEN2 Neutron Source Calculations." Dated Oct. 3, 1995.

(b) Memo from R.A. Schwartz to K.H. Bergsman, "Certification of ORIGEN2 Runs for N Reactor Fuel." RAS-91-0009, Dated Oct. 23, 1991.

(c) Memo from R.A. Schwartz to K.H. Bergsman, "New ORIGEN2 Runs for N Reactor Fuel." Dated Feb. 25, 1992.

Because of the major changes made in the cross sections a new release of these ORIGEN2 output files is include in this document as Volumes 2 and 3. These volumes contain 8 output files for 6%, 9%, 12%, and 16% ^{240}Pu for both Mark IV and Mark 1A N Reactor fuel.

The ORIGEN2 results in Volume 3 have been decayed for decay times of 1 year, 7.5 years, and then 10 year increments from 10 to 90 years.

6.0 Comparison Between WIMS and New ORIGEN2 Calculated Masses

Table 7 shows a comparison between actinide masses calculated by WIMS-E 6a and ORIGEN2 with the new cross section set. Notice that the ^{244}Cm values differ by only 6 % now. However, several isotopes still differ by more than 20 % including ^{231}Pa , ^{233}U , ^{237}Np , ^{238}Np , ^{238}Pu , $^{242\text{m}}\text{Am}$, ^{242}Am , and ^{242}Cm . Further work should be done to determine why these isotopes still do not match up. The best guess as to the reason for these differences is because of difference in the (n,2n) cross sections between WIMS-E 6a and ORIGEN2. It is recommended that the (n,2n) cross sections be changed in the same way that the capture cross sections were changed.

7.0 Upgrade to RADNUC for New ORIGEN2 Results

Because the ORIGEN2 output files for N Reactor fuel have changed, the Radnuc code (Gedeon 1995) must be changed to reflect the new ORIGEN2 results. The Radnuc code contains 8 sets of DATA statements for Mark IV and Mark 1A fuel at 6%, 9%, 12%, and 16% ^{240}Pu , decayed for 1 year. Table 8 shows a comparison of between the old and new DATA statements in the Radnuc code for 6% ^{240}Pu . Table 9 shows a comparison for 9% ^{240}Pu , Table 10 shows a comparison for 12 % ^{240}Pu , and Table 11 shows a comparison for 16% ^{240}Pu .

Most of the isotopic inventories do not change much at all. Only the actinides show significant changes in the DATA statements. The change in the ORIGEN2 values is burnup dependent, for example the ^{244}Cm ratio (Old/New) is 16 to 17 for 6 % ^{240}Pu , but is only 11 to 12 for 16 % ^{240}Pu . This means that ^{244}Cm for low burnup fuel was off more than that for high burnup fuel.

In addition to the change in the ORIGEN2 data files, the cobalt multiplication factor used by RADNUC was decreased by a factor of 25 to more accurately represent measured cobalt values.

8.0 Additional Work Required to Improve N Reactor ORIGEN2 Calculations

The following items should be considered to complete the upgrade of the N Reactor cross section libraries.

1. Upgrade the (n,2n) cross sections for actinides.
2. Upgrade the activation and fission product cross sections.
3. Certify a new version of Radnuc with the new cross sections.
4. Certify a new version of ORIGEN2 with the new cross sections.

Although this document lays the groundwork for certifying both Radnuc and ORIGEN2, additional work should be done to document and verify new versions of the code.

9.0 References

- Croff, A. G. 1980. *A User's Manual for the ORIGEN2 Computer Code*. ORNL/TM-7175, Oak Ridge National Laboratory, Oak Ridge, Tennessee.
- Gedeon, S. R. 1995. *Certification of Radnuc*. WHC-SD-HWV-SWD-001, Rev. 1, Westinghouse Hanford Corporation, Richland, Washington.
- Gubbins, M. E., M. J. Roth, and C. J. Taubman. 1982. *A General Introduction to the Use of the WIMS-E Modular Program*. AEEW-R 1329, Reactor Physics Division, AEE Winfrith, England.
- Hedengren, D. C. 1985. *ORIGEN2 Predictions of N Reactor Fuel Fission Product Composition*. SD-CP-TI-077, Rockwell Hanford Operations, Richland Washington.
- Hedengren, D. C. 1986. *ORIGEN2 Predictions of N Reactor Cladding and Fuel Activation Products Composition*. SD-CP-TI-094, Rockwell Hanford Operations, Richland Washington.
- Hedengren, D. C., and H. J. Goldberg. 1987. *ORIGEN2 Predictions of N Reactor Fuel Actinide Composition*. SD-CP-TI-105, Rockwell Hanford Operations, Richland Washington.

Table 1. Comparison of Old ORIGEN2 and WIMS Masses

Isotope	ORIGIN	WIMS	ORIGIN/WIMS
HE	6.28e-02	5.20e-02	1.21
TH230	2.48e-03	2.21e-03	1.12
TH232	4.23e-04	3.60e-04	1.18
PA231	9.82e-05	7.74e-05	1.27
U233	4.60e-04	2.76e-04	1.67
U234	6.33e+01	6.14e+01	1.03
U235	6.20e+03	6.14e+03	1.01
U236	1.05e+03	9.51e+02	1.10
U237	2.27e-06	2.31e-06	0.98
U238	9.86e+05	9.85e+05	1.00
NP237	6.58e+01	3.89e+01	1.69
NP238	7.92e-09	3.15e-09	2.52
NP239	2.69e-07	6.40e-07	0.42
PU238	6.84e+00	4.04e+00	1.70
PU239	2.26e+03	2.54e+03	0.89
PU240	4.32e+02	4.82e+02	0.90
PU241	7.33e+01	7.46e+01	0.98
PU242	1.59e+01	1.40e+01	1.14
AM241	6.48e+01	6.62e+01	0.98
AM242M	4.23e-02	1.68e-02	2.52
AM242	5.06e-07	2.01e-07	2.52
AM243	3.13e-01	7.45e-01	0.42
CM242	1.02e-04	4.07e-05	2.52
CM243	1.95e-03	1.35e-03	1.44
CM244	3.00e-01	3.47e-02	8.64
CM245	6.32e-03	8.54e-04	7.40
% PU 240	15.49	15.48	

Table 2. ORIGEN2 Cross Section Identifier

Cross Section	Activation	Fission	Actinide	Burnup Dependent actnide ^(a)
Mark IV inner	411	413	412	41
Mark IV outer	421	423	422	42
Mark 1A inner	431	433	432	43
Mark 1A outer	441	443	442	44
(a) Burnup dependent cross sections only exist for ^{235}U capture and fission, ^{238}U capture and fission, ^{236}U capture and fission, ^{237}Np capture, ^{239}Np capture and fission, ^{240}Pu capture and fission, ^{241}Pu capture and fission, and ^{242}Pu capture.				

Table 3. Comparison of ORIGEN2 and WIMS-E Cross Sections

Cross Section	ORIGEN2	WIMS-E 6a	ORIGEN2/ WIMS-E 6a
U235 mark IV inner capture	1.32e+01	1.29e+01	1.02
U235 mark IV outer capture	1.53e+01	1.51e+01	1.02
U235 mark 1A inner capture	1.38e+01	1.35e+01	1.02
U235 mark 1A outer capture	1.56e+01	1.51e+01	1.04
U236 mark IV inner capture	7.91e+00	6.37e+00	1.24
U236 mark IV outer capture	8.84e+00	6.80e+00	1.30
U236 mark 1A inner capture	8.07e+00	6.54e+00	1.23
U236 mark 1A outer capture	8.97e+00	6.89e+00	1.30
U237 mark IV inner capture	4.42e+01	5.43e+01	0.81
U237 mark IV outer capture	4.42e+01	6.44e+01	0.69
U237 mark 1A inner capture	4.42e+01	5.74e+01	0.77
U237 mark 1A outer capture	4.42e+01	6.47e+01	0.68
U238 mark IV inner capture	6.75e-01	7.08e-01	0.95
U238 mark IV outer capture	7.46e-01	8.07e-01	0.93
U238 mark 1A inner capture	6.98e-01	7.33e-01	0.95
U238 mark 1A outer capture	7.60e-01	8.27e-01	0.92
Np237 mark IV inner capture	4.13e+01	4.40e+01	0.94
Np237 mark IV outer capture	4.67e+01	4.92e+01	0.95
Np237 mark 1A inner capture	4.27e+01	4.55e+01	0.94
Np237 mark 1A outer capture	4.74e+01	4.92e+01	0.96
Np239 mark IV inner capture	1.42e+01	1.51e+01	0.94
Np239 mark IV outer capture	1.42e+01	1.63e+01	0.87
Np239 mark 1A inner capture	1.42e+01	1.55e+01	0.92
Np239 mark 1A outer capture	1.42e+01	1.64e+01	0.87
Pu238 mark IV inner capture	3.47e+01	4.78e+01	0.73
Pu238 mark IV outer capture	3.47e+01	5.72e+01	0.61
Pu238 mark 1A inner capture	3.47e+01	5.08e+01	0.68
Pu238 mark 1A outer capture	3.47e+01	5.74e+01	0.60
Pu239 mark IV inner capture	9.00e+01	8.95e+01	1.01
Pu239 mark IV outer capture	1.07e+02	1.07e+02	0.99
Pu239 mark 1A inner capture	9.34e+01	9.25e+01	1.01
Pu239 mark 1A outer capture	1.08e+02	1.08e+02	1.00

Table 3. Continued

Cross Section	ORIGEN2	WIMS-E 6a	ORIGEN2/ WIMS-E 6a
Pu240 mark IV inner capture	2.55e+02	2.67e+02	0.96
Pu240 mark IV outer capture	2.72e+02	2.82e+02	0.97
Pu240 mark 1A inner capture	2.60e+02	2.72e+02	0.95
Pu240 mark 1A outer capture	2.72e+02	2.81e+02	0.97
Pu241 mark IV inner capture	6.61e+01	5.66e+01	1.17
Pu241 mark IV outer capture	7.85e+01	6.80e+01	1.16
Pu241 mark 1A inner capture	6.93e+01	5.92e+01	1.17
Pu241 mark 1A outer capture	8.04e+01	6.84e+01	1.18
Pu242 mark IV inner capture	3.01e+01	3.32e+01	0.91
Pu242 mark IV outer capture	3.18e+01	3.42e+01	0.93
Pu242 mark 1A inner capture	3.05e+01	3.35e+01	0.91
Pu242 mark 1A outer capture	3.19e+01	3.41e+01	0.93
Am241 mark IV inner capture	2.03e+02	1.60e+02	1.27
Am241 mark IV outer capture	2.34e+02	1.86e+02	1.26
Am241 mark 1A inner capture	2.10e+02	1.65e+02	1.27
Am241 mark 1A outer capture	2.37e+02	1.86e+02	1.27
Am242m mark IV inner capture	9.80e+01	2.39e+02	0.41
Am242m mark IV outer capture	9.80e+01	2.89e+02	0.34
Am242m mark 1A inner capture	9.80e+01	2.53e+02	0.39
Am242m mark 1A outer capture	9.80e+01	2.91e+02	0.34
Am243 mark IV inner capture	1.10e+03	6.03e+01	18.22
Am243 mark IV outer capture	1.18e+03	6.29e+01	18.74
Am243 mark 1A inner capture	1.11e+03	6.14e+01	18.08
Am243 mark 1A outer capture	1.18e+03	6.29e+01	18.72
Cm243 mark IV inner capture	8.39e+00	1.78e+01	0.47
Cm243 mark IV outer capture	8.39e+00	2.02e+01	0.42
Cm243 mark 1A inner capture	8.39e+00	1.86e+01	0.45
Cm243 mark 1A outer capture	8.39e+00	2.03e+01	0.41
Cm244 mark IV inner capture	1.38e+01	1.49e+01	0.93
Cm244 mark IV outer capture	1.38e+01	1.61e+01	0.86
Cm244 mark 1A inner capture	1.38e+01	1.52e+01	0.91
Cm244 mark 1A outer capture	1.38e+01	1.63e+01	0.85
U235 mark IV inner fission	6.13e+01	6.33e+01	0.97

Table 3. Continued

Cross Section	ORIGEN2	WIMS-E 6a	ORIGEN2/ WIMS-E 6a
U235 mark IV outer fission	7.20e+01	7.54e+01	0.96
U235 mark 1A inner fission	6.50e+01	6.69e+01	0.97
U235 mark 1A outer fission	7.42e+01	7.56e+01	0.98
U236 mark IV inner fission	1.40e-01	2.37e-01	0.59
U236 mark IV outer fission	1.22e-01	2.28e-01	0.53
U236 mark 1A inner fission	1.40e-01	2.37e-01	0.59
U236 mark 1A outer fission	1.27e-01	2.31e-01	0.55
U237 mark IV inner fission	2.32e-01	6.35e-01	0.37
U237 mark IV outer fission	2.32e-01	6.48e-01	0.36
U237 mark 1A inner fission	2.32e-01	6.41e-01	0.36
U237 mark 1A outer fission	2.32e-01	6.50e-01	0.36
U238 mark IV inner fission	6.90e-02	7.80e-02	0.88
U238 mark IV outer fission	6.00e-02	7.20e-02	0.83
U238 mark 1A inner fission	6.90e-02	7.90e-02	0.88
U238 mark 1A outer fission	6.30e-02	7.40e-02	0.85
Np237 mark IV inner fission	5.24e-01	4.30e-01	1.22
Np237 mark IV outer fission	5.24e-01	3.95e-01	1.33
Np237 mark 1A inner fission	5.24e-01	4.29e-01	1.22
Np237 mark 1A outer fission	5.24e-01	4.00e-01	1.31
Np239 mark IV inner fission	4.26e-01	5.21e-01	0.82
Np239 mark IV outer fission	4.26e-01	4.77e-01	0.89
Np239 mark 1A inner fission	4.26e-01	5.18e-01	0.82
Np239 mark 1A outer fission	4.26e-01	4.79e-01	0.89
Pu238 mark IV inner fission	2.47e+00	2.83e+00	0.87
Pu238 mark IV outer fission	2.47e+00	3.07e+00	0.80
Pu238 mark 1A inner fission	2.47e+00	2.92e+00	0.85
Pu238 mark 1A outer fission	2.47e+00	3.08e+00	0.80
Pu239 mark IV inner fission	1.60e+02	1.60e+02	1.00
Pu239 mark IV outer fission	1.89e+02	1.92e+02	0.98
Pu239 mark 1A inner fission	1.67e+02	1.67e+02	1.00
Pu239 mark 1A outer fission	1.93e+02	1.93e+02	1.00
Pu240 mark IV inner fission	4.22e-01	5.35e-01	0.79
Pu240 mark IV outer fission	3.78e-01	5.02e-01	0.75

Table 3. Continued

Cross Section	ORIGEN2	WIMS-E 6a	ORIGEN2/ WIMS-E 6a
Pu240 mark 1A inner fission	4.22e-01	5.33e-01	0.79
Pu240 mark 1A outer fission	3.87e-01	5.10e-01	0.76
Pu241 mark IV inner fission	1.61e+02	1.68e+02	0.95
Pu241 mark IV outer fission	1.90e+02	2.02e+02	0.94
Pu241 mark 1A inner fission	1.69e+02	1.76e+02	0.96
Pu241 mark 1A outer fission	1.95e+02	2.03e+02	0.96
Pu242 mark IV inner fission	4.15e-01	3.90e-01	1.06
Pu242 mark IV outer fission	4.15e-01	3.62e-01	1.15
Pu242 mark 1A inner fission	4.15e-01	3.90e-01	1.06
Pu242 mark 1A outer fission	4.15e-01	3.66e-01	1.13
Am241 mark IV inner fission	1.12e+00	1.44e+00	0.78
Am241 mark IV outer fission	1.12e+00	1.58e+00	0.71
Am241 mark 1A inner fission	1.12e+00	1.47e+00	0.76
Am241 mark 1A outer fission	1.12e+00	1.60e+00	0.70
Am242m mark IV inner fission	4.66e+02	1.02e+03	0.46
Am242m mark IV outer fission	4.66e+02	1.23e+03	0.38
Am242m mark 1A inner fission	4.66e+02	1.08e+03	0.43
Am242m mark 1A outer fission	4.66e+02	1.24e+03	0.38
Am243 mark IV inner fission	3.96e-01	3.65e-01	1.09
Am243 mark IV outer fission	3.96e-01	3.41e-01	1.16
Am243 mark 1A inner fission	3.96e-01	3.66e-01	1.08
Am243 mark 1A outer fission	3.96e-01	3.46e-01	1.14
Cm243 mark IV inner fission	7.17e+01	9.54e+01	0.75
Cm243 mark IV outer fission	7.17e+01	1.07e+02	0.67
Cm243 mark 1A inner fission	7.17e+01	9.90e+01	0.72
Cm243 mark 1A outer fission	7.17e+01	1.07e+02	0.67
Cm244 mark IV inner fission	8.75e-01	8.74e-01	1.00
Cm244 mark IV outer fission	8.75e-01	8.70e-01	1.01
Cm244 mark 1A inner fission	8.75e-01	8.85e-01	0.99
Cm244 mark 1A outer fission	8.75e-01	8.82e-01	0.99

Table 4. Changes Made in ORIGEN2 Capture Cross Sections

Cross Section	Old ORIGEN2		New ORIGEN2	
	Ground	Excited	Ground	Excited
U235 mark IV inner capture	1.32e+01	0.00	1.20e+01	0.00
U235 mark IV outer capture	1.53e+01	0.00	1.43e+01	0.00
U235 mark 1A inner capture	1.38e+01	0.00	1.27e+01	0.00
U235 mark 1A outer capture	1.56e+01	0.00	1.45e+01	0.00
U236 mark IV inner capture	7.91e+00	0.00	6.22e+00	0.00
U236 mark IV outer capture	8.84e+00	0.00	6.67e+00	0.00
U236 mark 1A inner capture	8.07e+00	0.00	6.35e+00	0.00
U236 mark 1A outer capture	8.97e+00	0.00	6.77e+00	0.00
U237 mark IV inner capture	4.42e+01	0.00	4.97e+01	0.00
U237 mark IV outer capture	4.42e+01	0.00	6.06e+01	0.00
U237 mark 1A inner capture	4.42e+01	0.00	5.30e+01	0.00
U237 mark 1A outer capture	4.42e+01	0.00	6.18e+01	0.00
U238 mark IV inner capture	6.76e-01	0.00	6.89e-01	0.00
U238 mark IV outer capture	7.46e-01	0.00	7.92e-01	0.00
U238 mark 1A inner capture	6.98e-01	0.00	7.15e-01	0.00
U238 mark 1A outer capture	7.60e-01	0.00	8.16e-01	0.00
Np237 mark IV inner capture	4.13e+01	0.00	4.24e+01	0.00
Np237 mark IV outer capture	4.67e+01	0.00	4.79e+01	0.00
Np237 mark 1A inner capture	4.27e+01	0.00	4.39e+01	0.00
Np237 mark 1A outer capture	4.74e+01	0.00	4.83e+01	0.00
Np239 mark IV inner capture	1.13e+01	2.85e+00	1.20e+01	3.02e+00
Np239 mark IV outer capture	1.13e+01	2.85e+00	1.30e+01	3.26e+00
Np239 mark 1A inner capture	1.13e+01	2.85e+00	1.23e+01	3.09e+00
Np239 mark 1A outer capture	1.13e+01	2.85e+00	1.30e+01	3.27e+00
Pu238 mark IV inner capture	3.47e+01	0.00	4.33e+01	0.00
Pu238 mark IV outer capture	3.47e+01	0.00	5.35e+01	0.00
Pu238 mark 1A inner capture	3.47e+01	0.00	4.66e+01	0.00
Pu238 mark 1A outer capture	3.47e+01	0.00	5.46e+01	0.00
Pu239 mark IV inner capture	9.00e+01	0.00	7.98e+01	0.00
Pu239 mark IV outer capture	1.07e+02	0.00	9.97e+01	0.00
Pu239 mark 1A inner capture	9.34e+01	0.00	8.37e+01	0.00
Pu239 mark 1A outer capture	1.08e+02	0.00	1.03e+02	0.00

Table 4. Continued

Cross Section	Old ORIGEN2		New ORIGEN2	
	Ground	Excited	Ground	Excited
Pu240 mark IV inner capture	2.55e+02	0.00	2.57e+02	0.00
Pu240 mark IV outer capture	2.72e+02	0.00	2.76e+02	0.00
Pu240 mark 1A inner capture	2.60e+02	0.00	2.64e+02	0.00
Pu240 mark 1A outer capture	2.72e+02	0.00	2.79e+02	0.00
Pu241 mark IV inner capture	6.61e+01	0.00	5.09e+01	0.00
Pu241 mark IV outer capture	7.85e+01	0.00	6.34e+01	0.00
Pu241 mark 1A inner capture	6.93e+01	0.00	5.40e+01	0.00
Pu241 mark 1A outer capture	8.04e+01	0.00	6.51e+01	0.00
Pu242 mark IV inner capture	3.01e+01	0.00	3.21e+01	0.00
Pu242 mark IV outer capture	3.18e+01	0.00	3.31e+01	0.00
Pu242 mark 1A inner capture	3.05e+01	0.00	3.26e+01	0.00
Pu242 mark 1A outer capture	3.19e+01	0.00	3.31e+01	0.00
Am241 mark IV inner capture	1.81e+02	2.24e+01	1.30e+02	1.61e+01
Am241 mark IV outer capture	2.08e+02	2.57e+01	1.56e+02	1.93e+01
Am241 mark 1A inner capture	1.87e+02	2.31e+01	1.36e+02	1.68e+01
Am241 mark 1A outer capture	2.11e+02	2.60e+01	1.59e+02	1.97e+01
Am242m mark IV inner capture	9.80e+01	0.00	2.15e+02	0.00
Am242 mark IV inner capture	1.87e+02	0.00	4.11e+02	0.00
Am242m mark IV outer capture	9.80e+01	0.00	2.69e+02	0.00
Am242 mark IV outer capture	2.21e+02	0.00	6.07e+02	0.00
Am242m mark 1A inner capture	9.80e+01	0.00	2.31e+02	0.00
Am242 mark 1A inner capture	1.99e+02	0.00	4.68e+02	0.00
Am242m mark 1A outer capture	9.80e+01	0.00	2.76e+02	0.00
Am242 mark 1A outer capture	2.28e+02	0.00	6.42e+02	0.00
Am243 mark IV inner capture	5.49e+01	1.04e+03	3.02e+00	5.73e+01
Am243 mark IV outer capture	5.89e+01	1.12e+03	3.14e+00	5.98e+01
Am243 mark 1A inner capture	5.55e+01	1.05e+03	3.07e+00	5.83e+01
Am243 mark 1A outer capture	5.88e+01	1.12e+03	3.14e+00	5.97e+01
Cm243 mark IV inner capture	8.39e+00	0.00	1.69e+01	0.00
Cm243 mark IV outer capture	8.39e+00	0.00	1.95e+01	0.00
Cm243 mark 1A inner capture	8.39e+00	0.00	1.77e+01	0.00
Cm243 mark 1A outer capture	8.39e+00	0.00	1.97e+01	0.00

Table 4. Continued

Cross Section	Old ORIGIN2		New ORIGIN2	
	Ground	Excited	Ground	Excited
Cm244 mark IV inner capture	1.38e+01	0.00	1.48e+01	0.00
Cm244 mark IV outer capture	1.38e+01	0.00	1.60e+01	0.00
Cm244 mark 1A inner capture	1.38e+01	0.00	1.52e+01	0.00
Cm244 mark 1A outer capture	1.38e+01	0.00	1.61e+01	0.00

Table 5. Changes Made in ORIGEN2 Fission Cross Sections

Cross Section	Old	New
U235 mark IV inner fission	6.13e+01	5.77e+01
U235 mark IV outer fission	7.20e+01	7.07e+01
U235 mark 1A inner fission	6.50e+01	6.17e+01
U235 mark 1A outer fission	7.42e+01	7.22e+01
U236 mark IV inner fission	1.40e-01	2.33e-01
U236 mark IV outer fission	1.22e-01	2.24e-01
U236 mark 1A inner fission	1.40e-01	2.34e-01
U236 mark 1A outer fission	1.27e-01	2.30e-01
U237 mark IV inner fission	2.32e-01	6.25e-01
U237 mark IV outer fission	2.32e-01	6.40e-01
U237 mark 1A inner fission	2.32e-01	6.32e-01
U237 mark 1A outer fission	2.32e-01	6.44e-01
U238 mark IV inner fission	6.86e-02	7.31e-02
U238 mark IV outer fission	5.98e-02	6.64e-02
U238 mark 1A inner fission	6.90e-02	7.29e-02
U238 mark 1A outer fission	6.27e-02	6.92e-02
Np237 mark IV inner fission	5.24e-01	4.03e-01
Np237 mark IV outer fission	5.24e-01	3.66e-01
Np237 mark 1A inner fission	5.24e-01	4.00e-01
Np237 mark 1A outer fission	5.24e-01	3.75e-01
Np239 mark IV inner fission	4.26e-01	4.87e-01
Np239 mark IV outer fission	4.26e-01	4.41e-01
Np239 mark 1A inner fission	4.26e-01	4.82e-01
Np239 mark 1A outer fission	4.26e-01	4.49e-01
Pu238 mark IV inner fission	2.47e+00	2.72e+00
Pu238 mark IV outer fission	2.47e+00	2.98e+00
Pu238 mark 1A inner fission	2.47e+00	2.81e+00
Pu238 mark 1A outer fission	2.47e+00	3.01e+00
Pu239 mark IV inner fission	1.60e+02	1.43e+02
Pu239 mark IV outer fission	1.89e+02	1.79e+02
Pu239 mark 1A inner fission	1.67e+02	1.51e+02
Pu239 mark 1A outer fission	1.93e+02	1.84e+02
Pu240 mark IV inner fission	4.22e-01	5.34e-01
Pu240 mark IV outer fission	3.78e-01	4.98e-01

Table 5. Continued

Cross Section	Old	New
Pu240 mark 1A inner fission	4.22e-01	5.31e-01
Pu240 mark 1A outer fission	3.87e-01	5.07e-01
Pu241 mark IV inner fission	1.61e+02	1.52e+02
Pu241 mark IV outer fission	1.90e+02	1.89e+02
Pu241 mark 1A inner fission	1.69e+02	1.61e+02
Pu241 mark 1A outer fission	1.95e+02	1.94e+02
Pu242 mark IV inner fission	4.15e-01	3.66e-01
Pu242 mark IV outer fission	4.15e-01	3.35e-01
Pu242 mark 1A inner fission	4.15e-01	3.64e-01
Pu242 mark 1A outer fission	4.15e-01	3.44e-01
Am241 mark IV inner fission	1.12e+00	1.36e+00
Am241 mark IV outer fission	1.12e+00	1.52e+00
Am241 mark 1A inner fission	1.12e+00	1.40e+00
Am241 mark 1A outer fission	1.12e+00	1.56e+00
Am242m mark IV inner fission	4.66e+02	9.23e+02
Am242 mark IV inner fission	7.49e+02	1.48e+03
Am242m mark IV outer fission	4.66e+02	1.15e+03
Am242 mark IV outer fission	8.84e+02	2.18e+03
Am242m mark 1A inner fission	4.66e+02	9.86e+02
Am242 mark 1A inner fission	7.97e+02	1.69e+03
Am242m mark 1A outer fission	4.66e+02	1.18e+03
Am242 mark 1A outer fission	9.13e+02	2.31e+03
Am243 mark IV inner fission	3.96e-01	3.46e-01
Am243 mark IV outer fission	3.96e-01	3.19e-01
Am243 mark 1A inner fission	3.96e-01	3.45e-01
Am243 mark 1A outer fission	3.96e-01	3.29e-01
Cm243 mark IV inner fission	7.17e+01	9.16e+01
Cm243 mark IV outer fission	7.17e+01	1.04e+02
Cm243 mark 1A inner fission	7.17e+01	9.53e+01
Cm243 mark 1A outer fission	7.17e+01	1.05e+02
Cm244 mark IV inner fission	8.75e-01	8.57e-01
Cm244 mark IV outer fission	8.75e-01	8.48e-01
Cm244 mark 1A inner fission	8.75e-01	8.64e-01
Cm244 mark 1A outer fission	8.75e-01	8.63e-01

Table 6. Changes Made in ORIGEN2 Burnup Dependent Cross Sections

Cross Section	0-1000 MWD/MTU	1000-2000 MWD/MTU	2000-3000 MWD/MTU	3000-4000 MWD/MTU	4000-5000 MWD/MTU	5000-MWD/MTU
OLD U235 mark IV inner capture	1.32e+01	1.16e+01	1.09e+01	1.04e+01	9.98e+00	9.69e+00
NEW U235 mark IV inner capture	1.20e+01	1.09e+01	1.03e+01	9.86e+00	9.53e+00	9.23e+00
OLD U235 mark IV outer capture	1.53e+01	1.38e+01	1.31e+01	1.26e+01	1.23e+01	1.20e+01
NEW U235 mark IV outer capture	1.43e+01	1.34e+01	1.29e+01	1.25e+01	1.22e+01	1.20e+01
OLD U235 mark IA inner capture	1.38e+01	1.25e+01	1.19e+01	1.14e+01	1.11e+01	1.08e+01
NEW U235 mark IA inner capture	1.27e+01	1.17e+01	1.12e+01	1.08e+01	1.05e+01	1.02e+01
OLD U235 mark IA outer capture	1.56e+01	1.45e+01	1.40e+01	1.37e+01	1.34e+01	1.32e+01
NEW U235 mark IA outer capture	1.45e+01	1.39e+01	1.35e+01	1.32e+01	1.30e+01	1.28e+01
OLD U236 mark IV inner capture	7.91e+00	8.04e+00	8.07e+00	8.08e+00	8.07e+00	8.05e+00
NEW U236 mark IV inner capture	6.22e+00	5.99e+00	5.84e+00	5.73e+00	5.64e+00	5.54e+00
OLD U236 mark IV outer capture	8.84e+00	9.00e+00	9.05e+00	9.07e+00	9.07e+00	9.07e+00
NEW U236 mark IV outer capture	6.67e+00	6.45e+00	6.30e+00	6.20e+00	6.12e+00	6.04e+00
OLD U236 mark IA inner capture	8.07e+00	8.17e+00	8.19e+00	8.19e+00	8.18e+00	8.17e+00
NEW U236 mark IA inner capture	6.35e+00	6.05e+00	5.88e+00	5.75e+00	5.64e+00	5.55e+00
OLD U236 mark IA outer capture	8.97e+00	9.09e+00	9.13e+00	9.16e+00	9.16e+00	9.16e+00
NEW U236 mark IA outer capture	6.77e+00	6.51e+00	6.35e+00	6.23e+00	6.14e+00	6.06e+00
OLD U238 mark IV inner capture	6.76e-01	6.45e-01	6.31e-01	6.21e-01	6.13e-01	6.07e-01
NEW U238 mark IV inner capture	6.89e-01	6.69e-01	6.56e-01	6.47e-01	6.39e-01	6.33e-01
OLD U238 mark IV outer capture	7.46e-01	7.17e-01	7.04e-01	6.95e-01	6.88e-01	7.49e-01
NEW U238 mark IV outer capture	7.92e-01	7.75e-01	7.64e-01	7.56e-01	7.51e-01	7.46e-01
OLD U238 mark IA inner capture	6.98e-01	6.71e-01	6.59e-01	6.50e-01	6.43e-01	6.38e-01
NEW U238 mark IA inner capture	7.15e-01	6.96e-01	6.84e-01	6.75e-01	6.69e-01	6.63e-01
OLD U238 mark IA outer capture	7.60e-01	7.39e-01	7.30e-01	7.23e-01	7.19e-01	7.15e-01
NEW U238 mark IA outer capture	8.16e-01	8.04e-01	7.97e-01	7.92e-01	7.88e-01	7.84e-01

Table 6. Continued

Cross Section	0-1000 MWD/MTU	1000-2000 MWD/MTU	2000-3000 MWD/MTU	3000-4000 MWD/MTU	4000-5000 MWD/MTU	5000-MWD/MTU
OLD Np237 mark IV inner capture	4.13e+01	3.93e+01	3.83e+01	3.76e+01	3.70e+01	3.66e+01
NEW Np237 mark IV inner capture	4.24e+01	4.03e+01	3.88e+01	3.77e+01	3.68e+01	3.60e+01
OLD Np237 mark IV outer capture	4.67e+01	4.48e+01	4.39e+01	4.33e+01	4.28e+01	4.24e+01
NEW Np237 mark IV outer capture	4.79e+01	4.61e+01	4.49e+01	4.40e+01	4.32e+01	4.26e+01
OLD Np237 mark 1A inner capture	4.27e+01	4.09e+01	4.01e+01	3.95e+01	3.90e+01	3.86e+01
NEW Np237 mark 1A inner capture	4.39e+01	4.20e+01	4.07e+01	3.97e+01	3.89e+01	3.82e+01
OLD Np237 mark 1A outer capture	4.74e+01	4.61e+01	4.55e+01	4.50e+01	4.47e+01	4.45e+01
NEW Np237 mark 1A outer capture	4.83e+01	4.71e+01	4.62e+01	4.55e+01	4.50e+01	4.45e+01
OLD Pu239 mark IV inner capture	9.00e+01	7.34e+01	6.51e+01	5.97e+01	5.59e+01	5.30e+01
NEW Pu239 mark IV inner capture	7.98e+01	6.68e+01	5.94e+01	5.45e+01	5.10e+01	4.79e+01
OLD Pu239 mark IV outer capture	1.07e+02	9.06e+01	8.27e+01	7.76e+01	7.40e+01	7.13e+01
NEW Pu239 mark IV outer capture	9.97e+01	8.84e+01	8.16e+01	7.71e+01	7.38e+01	7.12e+01
OLD Pu239 mark 1A inner capture	9.34e+01	7.99e+01	7.27e+01	6.78e+01	6.42e+01	6.15e+01
NEW Pu239 mark 1A inner capture	8.37e+01	7.19e+01	6.51e+01	6.05e+01	5.73e+01	5.46e+01
OLD Pu239 mark 1A outer capture	1.08e+02	9.66e+01	9.04e+01	8.62e+01	8.32e+01	8.10e+01
NEW Pu239 mark 1A outer capture	1.03e+02	9.41e+01	8.86e+01	8.46e+01	8.17e+01	7.94e+01
OLD Pu240 mark IV inner capture	2.55e+02	2.20e+02	1.75e+02	1.42e+02	1.21e+02	1.06e+02
NEW Pu240 mark IV inner capture	2.57e+02	1.96e+02	1.50e+02	1.23e+02	1.05e+02	9.07e+01
OLD Pu240 mark IV outer capture	2.72e+02	2.39e+02	1.96e+02	1.65e+02	1.44e+02	1.28e+02
NEW Pu240 mark IV outer capture	2.76e+02	2.30e+02	1.89e+02	1.61e+02	1.42e+02	1.28e+02
OLD Pu240 mark 1A inner capture	2.60e+02	2.35e+02	1.96e+02	1.63e+02	1.40e+02	1.23e+02
NEW Pu240 mark 1A inner capture	2.64e+02	2.06e+02	1.60e+02	1.32e+02	1.13e+02	9.96e+01
OLD Pu240 mark 1A outer capture	2.72e+02	2.52e+02	2.17e+02	1.88e+02	1.66e+02	1.50e+02
NEW Pu240 mark 1A outer capture	2.79e+02	2.49e+02	2.16e+02	1.88e+02	1.68e+02	1.52e+02

Table 6. Continued

Cross Section	0-1000 MWD/MTU	1000-2000 MWD/MTU	2000-3000 MWD/MTU	3000-4000 MWD/MTU	4000-5000 MWD/MTU	5000-MWD/MTU
OLD Pu241 mark IV inner capture	6.61e+01	5.50e+01	4.97e+01	4.62e+01	4.36e+01	4.16e+01
NEW Pu241 mark IV inner capture	5.09e+01	4.40e+01	4.00e+01	3.72e+01	3.52e+01	3.34e+01
OLD Pu241 mark IV outer capture	7.85e+01	6.78e+01	6.27e+01	5.93e+01	5.69e+01	5.51e+01
NEW Pu241 mark IV outer capture	6.34e+01	5.74e+01	5.38e+01	5.13e+01	4.94e+01	4.80e+01
OLD Pu241 mark IA inner capture	6.93e+01	6.03e+01	5.58e+01	5.26e+01	5.03e+01	4.85e+01
NEW Pu241 mark IA inner capture	5.40e+01	4.78e+01	4.41e+01	4.16e+01	3.98e+01	3.83e+01
OLD Pu241 mark IA outer capture	8.04e+01	7.25e+01	6.86e+01	6.60e+01	6.41e+01	6.27e+01
NEW Pu241 mark IA outer capture	6.51e+01	6.07e+01	5.78e+01	5.58e+01	5.43e+01	5.31e+01
OLD Pu242 mark IV inner capture	3.01e+01	3.09e+01	3.12e+01	3.14e+01	3.15e+01	3.15e+01
NEW Pu242 mark IV inner capture	3.21e+01	3.27e+01	3.30e+01	3.31e+01	3.32e+01	3.31e+01
OLD Pu242 mark IV outer capture	3.18e+01	3.26e+01	3.30e+01	3.32e+01	3.33e+01	3.33e+01
NEW Pu242 mark IV outer capture	3.31e+01	3.36e+01	3.39e+01	3.41e+01	3.42e+01	3.42e+01
OLD Pu242 mark IA inner capture	3.05e+01	3.11e+01	3.14e+01	3.16e+01	3.16e+01	3.17e+01
NEW Pu242 mark IA inner capture	3.26e+01	3.31e+01	3.34e+01	3.35e+01	3.35e+01	3.35e+01
OLD Pu242 mark IA outer capture	3.19e+01	3.25e+01	3.28e+01	3.30e+01	3.31e+01	3.31e+01
NEW Pu242 mark IA outer capture	3.31e+01	3.35e+01	3.38e+01	3.39e+01	3.41e+01	3.41e+01
OLD U235 mark IV inner fission	6.13e+01	5.26e+01	4.85e+01	4.57e+01	4.37e+01	4.21e+01
NEW U235 mark IV inner fission	5.77e+01	5.15e+01	4.76e+01	4.50e+01	4.30e+01	4.12e+01
OLD U235 mark IV outer fission	7.20e+01	6.35e+01	5.96e+01	5.71e+01	5.52e+01	5.38e+01
NEW U235 mark IV outer fission	7.07e+01	6.53e+01	6.19e+01	5.96e+01	5.78e+01	5.64e+01
OLD U235 mark IA inner fission	6.50e+01	5.77e+01	5.43e+01	5.19e+01	5.01e+01	4.87e+01
NEW U235 mark IA inner fission	6.17e+01	5.60e+01	5.26e+01	5.02e+01	4.85e+01	4.70e+01
OLD U235 mark IA outer fission	7.42e+01	6.78e+01	6.51e+01	6.32e+01	6.19e+01	6.09e+01
NEW U235 mark IA outer fission	7.22e+01	6.84e+01	6.59e+01	6.41e+01	6.27e+01	6.16e+01

Table 6. Continued

Cross Section	0-1000 MWD/MTU	1000-2000 MWD/MTU	2000-3000 MWD/MTU	3000-4000 MWD/MTU	4000-5000 MWD/MTU	5000-MWD/MTU
OLD U236 mark IV inner fission	1.40e-01	1.45e-01	1.48e-01	1.50e-01	1.51e-01	1.52e-01
NEW U236 mark IV inner fission	2.33e-01	2.35e-01	2.36e-01	2.36e-01	2.37e-01	2.37e-01
OLD U236 mark IV outer fission	1.22e-01	1.27e-01	1.30e-01	1.32e-01	1.33e-01	1.34e-01
NEW U236 mark IV outer fission	2.24e-01	2.26e-01	2.27e-01	2.28e-01	2.28e-01	2.28e-01
OLD U236 mark 1A inner fission	1.40e-01	1.45e-01	1.48e-01	1.50e-01	1.52e-01	1.53e-01
NEW U236 mark 1A inner fission	2.34e-01	2.35e-01	2.36e-01	2.37e-01	2.37e-01	2.37e-01
OLD U236 mark 1A outer fission	1.27e-01	1.31e-01	1.33e-01	1.35e-01	1.36e-01	1.36e-01
NEW U236 mark 1A outer fission	2.30e-01	2.30e-01	2.30e-01	2.31e-01	2.31e-01	2.30e-01
OLD U238 mark IV inner fission	6.86e-02	7.11e-02	7.24e-02	7.33e-02	7.41e-02	7.47e-02
NEW U238 mark IV inner fission	7.31e-02	7.50e-02	7.62e-02	7.72e-02	7.79e-02	7.86e-02
OLD U238 mark IV outer fission	5.98e-02	6.24e-02	6.38e-02	6.47e-02	6.54e-02	1.66e-30
NEW U238 mark IV outer fission	6.64e-02	6.84e-02	6.96e-02	7.06e-02	7.13e-02	7.18e-02
OLD U238 mark 1A inner fission	6.90e-02	7.15e-02	7.29e-02	7.40e-02	7.48e-02	7.55e-02
NEW U238 mark 1A inner fission	7.29e-02	7.50e-02	7.64e-02	7.75e-02	7.83e-02	7.90e-02
OLD U238 mark 1A outer fission	6.27e-02	6.47e-02	6.56e-02	6.63e-02	6.68e-02	6.72e-02
NEW U238 mark 1A outer fission	6.92e-02	7.06e-02	7.16e-02	7.23e-02	7.28e-02	7.32e-02
OLD Pu239 mark IV inner fission	1.60e+02	1.31e+02	1.17e+02	1.08e+02	1.01e+02	9.62e+01
NEW Pu239 mark IV inner fission	1.43e+02	1.21e+02	1.09e+02	1.00e+02	9.41e+01	8.86e+01
OLD Pu239 mark IV outer fission	1.89e+02	1.61e+02	1.48e+02	1.39e+02	1.33e+02	1.29e+02
NEW Pu239 mark IV outer fission	1.79e+02	1.60e+02	1.48e+02	1.40e+02	1.35e+02	1.30e+02
OLD Pu239 mark 1A inner fission	1.67e+02	1.43e+02	1.31e+02	1.23e+02	1.17e+02	1.12e+02
NEW Pu239 mark 1A inner fission	1.51e+02	1.31e+02	1.20e+02	1.12e+02	1.06e+02	1.02e+02
OLD Pu239 mark 1A outer fission	1.93e+02	1.72e+02	1.62e+02	1.55e+02	1.50e+02	1.46e+02
NEW Pu239 mark 1A outer fission	1.84e+02	1.69e+02	1.60e+02	1.54e+02	1.49e+02	1.45e+02

Table 6. Continued

Cross Section	0-1000 MWD/MTU	1000-2000 MWD/MTU	2000-3000 MWD/MTU	3000-4000 MWD/MTU	4000-5000 MWD/MTU	5000-MWD/MTU
OLD Pu240 mark IV inner fission	4.22e-01	4.31e-01	4.31e-01	4.31e-01	4.32e-01	4.33e-01
NEW Pu240 mark IV inner fission	5.34e-01	5.34e-01	5.33e-01	5.33e-01	5.34e-01	5.36e-01
OLD Pu240 mark IV outer fission	3.78e-01	3.87e-01	3.88e-01	3.88e-01	3.88e-01	3.88e-01
NEW Pu240 mark IV outer fission	4.98e-01	5.02e-01	5.01e-01	5.00e-01	5.01e-01	5.01e-01
OLD Pu240 mark 1A inner fission	4.22e-01	4.32e-01	4.33e-01	4.33e-01	4.34e-01	4.34e-01
NEW Pu240 mark 1A inner fission	5.31e-01	5.33e-01	5.31e-01	5.31e-01	5.33e-01	5.34e-01
OLD Pu240 mark 1A outer fission	3.87e-01	3.94e-01	3.94e-01	3.93e-01	3.93e-01	3.92e-01
NEW Pu240 mark 1A outer fission	5.07e-01	5.10e-01	5.09e-01	5.07e-01	5.06e-01	5.06e-01
OLD Pu241 mark IV inner fission	1.61e+02	1.35e+02	1.23e+02	1.15e+02	1.09e+02	1.05e+02
NEW Pu241 mark IV inner fission	1.52e+02	1.33e+02	1.21e+02	1.13e+02	1.07e+02	1.02e+02
OLD Pu241 mark IV outer fission	1.90e+02	1.66e+02	1.54e+02	1.47e+02	1.41e+02	1.37e+02
NEW Pu241 mark IV outer fission	1.89e+02	1.72e+02	1.62e+02	1.54e+02	1.49e+02	1.45e+02
OLD Pu241 mark 1A inner fission	1.69e+02	1.48e+02	1.38e+02	1.31e+02	1.26e+02	1.22e+02
NEW Pu241 mark 1A inner fission	1.61e+02	1.44e+02	1.33e+02	1.26e+02	1.21e+02	1.17e+02
OLD Pu241 mark 1A outer fission	1.95e+02	1.77e+02	1.69e+02	1.63e+02	1.59e+02	1.56e+02
NEW Pu241 mark 1A outer fission	1.94e+02	1.81e+02	1.73e+02	1.68e+02	1.63e+02	1.60e+02

Table 7. Comparison of New ORIGEN2 and WIMS Masses

Isotope	ORIGEN	WIMS	ORIGEN/WIMS
HE	6.00e-02	5.20e-02	1.16
TH230	2.48e-03	2.21e-03	1.12
TH232	4.23e-04	3.60e-04	1.18
PA231	9.86e-05	7.74e-05	1.27
U233	4.21e-04	2.76e-04	1.53
U234	6.30e+01	6.14e+01	1.03
U235	6.16e+03	6.14e+03	1.00
U236	1.04e+03	9.51e+02	1.10
U237	2.33e-06	2.31e-06	1.01
U238	9.85e+05	9.85e+05	1.00
NP237	5.60e+01	3.89e+01	1.44
NP238	4.07e-09	3.15e-09	1.29
NP239	6.08e-07	6.40e-07	0.95
PU238	5.96e+00	4.04e+00	1.48
PU239	2.48e+03	2.54e+03	0.98
PU240	4.71e+02	4.82e+02	0.98
PU241	7.53e+01	7.46e+01	1.01
PU242	1.41e+01	1.40e+01	1.01
AM241	6.69e+01	6.62e+01	1.01
AM242M	2.17e-02	1.68e-02	1.29
AM242	2.60e-07	2.01e-07	1.29
AM243	7.08e-01	7.45e-01	0.95
CM242	5.26e-05	4.07e-05	1.29
CM243	1.60e-03	1.35e-03	1.19
CM244	3.27e-02	3.47e-02	0.94
CM245	7.35e-04	8.54e-04	0.86
% PU 240	15.45	15.48	

Table 8. Comparison Between RADNUC Data Statements for 6% ²⁴⁰Pu

Isotope	Mark 1A 6 % Pu 240 inventories (curies)			Mark IV 6 % Pu 240 inventories (curies)		
	Old	New	Old/New	Old	New	Old/New
H-3	1.96e+01	1.98e+01	0.99	1.67e+01	1.68e+01	0.99
C-14	4.72e-06	4.72e-06	1.00	3.93e-06	3.93e-06	1.00
Se-79	1.75e-02	1.75e-02	1.00	1.46e-02	1.47e-02	1.00
Kr-85	4.53e+02	4.51e+02	1.00	3.72e+02	3.70e+02	1.00
Sr-89	2.17e+03	2.16e+03	1.01	1.77e+03	1.76e+03	1.01
Sr-90	3.63e+03	3.61e+03	1.01	2.96e+03	2.95e+03	1.01
Y-90	3.63e+03	3.61e+03	1.01	2.97e+03	2.95e+03	1.01
Y-91	5.02e+03	4.99e+03	1.01	4.10e+03	4.09e+03	1.00
Zr-93	8.31e-02	8.28e-02	1.00	6.85e-02	6.82e-02	1.00
Nb-93m	4.59e-03	4.57e-03	1.00	3.78e-03	3.77e-03	1.00
Zr-95	7.99e+03	7.97e+03	1.00	6.61e+03	6.60e+03	1.00
Nb-95	1.73e+04	1.78e+04	0.97	1.43e+04	1.48e+04	0.97
Nb-95m	5.93e+01	5.92e+01	1.00	4.90e+01	4.89e+01	1.00
Tc-99	5.84e-01	5.84e-01	1.00	4.87e-01	4.86e-01	1.00
Ru-103	4.99e+02	5.06e+02	0.99	4.28e+02	4.31e+02	0.99
Rh-103m	4.50e+02	4.57e+02	0.99	3.86e+02	3.89e+02	0.99
Ru-106	8.70e+03	8.97e+03	0.97	8.01e+03	8.20e+03	0.98
Rh-106	8.70e+03	8.97e+03	0.97	8.01e+03	8.20e+03	0.98
Pd-107	1.79e-03	1.86e-03	0.97	1.68e-03	1.72e-03	0.98
Ag-110	4.37e-02	4.60e-02	0.95	4.09e-02	4.26e-02	0.96
Ag-110m	3.29e+00	3.46e+00	0.95	3.08e+00	3.20e+00	0.96
Cd-113m	1.35e+00	1.42e+00	0.95	1.25e+00	1.32e+00	0.94
Cd-115m	1.24e+00	1.32e+00	0.94	1.15e+00	1.23e+00	0.94
Sn-119m	5.87e+00	6.20e+00	0.95	5.39e+00	5.73e+00	0.94
Sn-121m	4.94e-03	4.99e-03	0.99	4.34e-03	4.35e-03	1.00
Sn-123	6.65e+01	6.94e+01	0.96	5.99e+01	6.28e+01	0.95
Te-123m	5.01e-04	5.37e-04	0.93	4.63e-04	5.01e-04	0.92
Sb-124	1.67e-01	1.76e-01	0.95	1.52e-01	1.62e-01	0.94
Sb-125	4.78e+02	5.00e+02	0.96	4.35e+02	4.57e+02	0.95
Te-125m	1.15e+02	1.21e+02	0.96	1.05e+02	1.11e+02	0.95
Sn-126	2.55e-02	2.63e-02	0.97	2.27e-02	2.36e-02	0.96
Sb-126	3.56e-03	3.69e-03	0.97	3.18e-03	3.31e-03	0.96

Table 8. Continued

Isotope	Mark 1A 6 % Pu 240 inventories (curies)			Mark IV 6 % Pu 240 inventories (curies)		
	Old	New	Old/New	Old	New	Old/New
Sb-126m	2.55e-02	2.63e-02	0.97	2.27e-02	2.36e-02	0.96
Te-127	1.67e+02	1.71e+02	0.98	1.48e+02	1.52e+02	0.97
Te-127m	1.71e+02	1.75e+02	0.98	1.51e+02	1.55e+02	0.97
Te-129	3.81e+00	3.85e+00	0.99	3.28e+00	3.31e+00	0.99
Te-129m	5.85e+00	5.91e+00	0.99	5.03e+00	5.08e+00	0.99
I-129	1.12e-03	1.14e-03	0.99	9.64e-04	9.74e-04	0.99
Cs-134	4.56e+02	4.57e+02	1.00	3.69e+02	3.71e+02	1.00
Cs-135	1.53e-02	1.52e-02	1.01	1.32e-02	1.31e-02	1.01
Cs-137	4.13e+03	4.12e+03	1.00	3.44e+03	3.43e+03	1.00
Ba-137m	3.90e+03	3.90e+03	1.00	3.25e+03	3.25e+03	1.00
Ce-141	2.13e+02	2.12e+02	1.00	1.77e+02	1.76e+02	1.00
Pr-143	4.97e-03	4.95e-03	1.00	4.11e-03	4.10e-03	1.00
Ce-144	4.93e+04	4.92e+04	1.00	4.07e+04	4.06e+04	1.00
Pr-144	4.93e+04	4.92e+04	1.00	4.07e+04	4.06e+04	1.00
Pr-144m	5.92e+02	5.90e+02	1.00	4.89e+02	4.87e+02	1.00
Pm-147	1.22e+04	1.22e+04	1.00	1.02e+04	1.02e+04	1.00
Pm-148	3.24e-01	3.25e-01	1.00	2.68e-01	2.68e-01	1.00
Pm-148m	5.76e+00	5.76e+00	1.00	4.75e+00	4.76e+00	1.00
Sm-151	6.73e+01	6.78e+01	0.99	5.88e+01	5.92e+01	0.99
Eu-152	1.84e-01	1.85e-01	1.00	1.56e-01	1.57e-01	0.99
Gd-153	2.83e-02	2.85e-02	1.00	2.37e-02	2.40e-02	0.99
Eu-154	3.01e+01	3.05e+01	0.99	2.52e+01	2.56e+01	0.98
Eu-155	7.61e+01	7.76e+01	0.98	7.02e+01	7.12e+01	0.99
Tb-160	1.00e-01	1.05e-01	0.95	9.41e-02	9.81e-02	0.96
H-3	1.42e-01	1.45e-01	0.98	1.38e-01	1.40e-01	0.98
C-14	1.27e-01	1.28e-01	0.99	1.20e-01	1.21e-01	0.99
Fe-55	3.99e+01	4.04e+01	0.99	3.70e+01	3.74e+01	0.99
Ni-59	7.89e-03	7.98e-03	0.99	7.12e-03	7.18e-03	0.99
Co-60	8.22e+00	8.32e+00	0.99	6.59e+00	6.65e+00	0.99
Ni-63	9.85e-01	9.96e-01	0.99	8.90e-01	8.99e-01	0.99
Zr-93	2.68e-03	2.71e-03	0.99	2.17e-03	2.19e-03	0.99
Nb-93m	1.46e-04	1.48e-04	0.99	1.19e-04	1.20e-04	0.99

Table 8. Continued

Isotope	Mark 1A 6 % Pu 240 inventories (curies)			Mark IV 6 % Pu 240 inventories (curies)		
	Old	New	Old/New	Old	New	Old/New
Zr-95	7.82e+01	7.89e+01	0.99	6.40e+01	6.45e+01	0.99
Nb-95	1.69e+02	1.77e+02	0.96	1.38e+02	1.44e+02	0.96
Nb-95m	5.80e-01	5.85e-01	0.99	4.75e-01	4.79e-01	0.99
In-113m	1.12e+01	1.13e+01	0.99	9.29e+00	9.38e+00	0.99
Sn-113	1.12e+01	1.13e+01	0.99	9.28e+00	9.37e+00	0.99
Sn-119m	6.50e+01	6.58e+01	0.99	5.46e+01	5.52e+01	0.99
Sn-121m	1.37e-02	1.39e-02	0.99	1.14e-02	1.16e-02	0.99
Sb-125	2.14e+01	2.17e+01	0.99	1.79e+01	1.81e+01	0.99
Te-125m	5.17e+00	5.23e+00	0.99	4.33e+00	4.37e+00	0.99
U-234	4.66e-01	4.65e-01	1.00	4.25e-01	4.25e-01	1.00
U-235	2.18e-02	2.19e-02	1.00	1.81e-02	1.81e-02	1.00
U-236	4.76e-02	4.69e-02	1.02	4.46e-02	4.40e-02	1.01
U-238	3.32e-01	3.32e-01	1.00	3.33e-01	3.33e-01	1.00
Np-237	1.12e-02	9.84e-03	1.14	1.10e-02	9.76e-03	1.13
Pu-238	7.73e+00	7.02e+00	1.10	7.64e+00	6.99e+00	1.09
Pu-239	5.60e+01	6.07e+01	0.92	5.58e+01	5.99e+01	0.93
Pu-240	1.42e+01	1.47e+01	0.97	1.43e+01	1.43e+01	1.00
Pu-241	7.93e+02	8.32e+02	0.95	8.05e+02	8.18e+02	0.98
Pu-242	9.40e-04	8.13e-04	1.16	9.55e-04	7.87e-04	1.21
Am-241	1.40e+00	1.47e+00	0.95	1.43e+00	1.45e+00	0.98
Am-242m	2.26e-03	1.50e-03	1.51	2.31e-03	1.47e-03	1.58
Am-242	2.25e-03	1.49e-03	1.51	2.30e-03	1.46e-03	1.58
Am-243	3.95e-04	4.66e-04	0.85	4.00e-04	4.50e-04	0.89
Cm-242	1.20e+00	9.55e-01	1.26	1.22e+00	9.27e-01	1.32
Cm-244	4.99e-02	3.08e-03	16.23	5.09e-02	2.97e-03	17.13

Table 9. Comparison Between RADNUC Data Statements for 9% ²⁴⁰Pu

Isotope	Mark 1A 9 % Pu 240 inventories (curies)			Mark IV 9 % Pu 240 inventories (curies)		
	Old	New	Old/New	Old	New	Old/New
H-3	3.33e+01	3.36e+01	0.99	2.84e+01	2.86e+01	0.99
C-14	7.86e-06	7.86e-06	1.00	6.55e-06	6.54e-06	1.00
Se-79	2.89e-02	2.90e-02	1.00	2.42e-02	2.43e-02	1.00
Kr-85	7.29e+02	7.25e+02	1.01	5.96e+02	5.93e+02	1.00
Sr-89	2.46e+03	2.44e+03	1.01	1.99e+03	1.98e+03	1.00
Sr-90	5.83e+03	5.79e+03	1.01	4.74e+03	4.71e+03	1.01
Y-90	5.83e+03	5.79e+03	1.01	4.74e+03	4.71e+03	1.01
Y-91	5.87e+03	5.83e+03	1.01	4.78e+03	4.76e+03	1.00
Zr-93	1.36e-01	1.35e-01	1.00	1.11e-01	1.11e-01	1.00
Nb-93m	8.18e-03	8.15e-03	1.00	6.74e-03	6.72e-03	1.00
Zr-95	9.77e+03	9.74e+03	1.00	8.07e+03	8.05e+03	1.00
Nb-95	2.11e+04	2.19e+04	0.97	1.75e+04	1.81e+04	0.97
Nb-95m	7.24e+01	7.23e+01	1.00	5.98e+01	5.97e+01	1.00
Tc-99	9.69e-01	9.68e-01	1.00	8.08e-01	8.07e-01	1.00
Ru-103	6.17e+02	6.21e+02	0.99	5.34e+02	5.38e+02	0.99
Rh-103m	5.56e+02	5.61e+02	0.99	4.81e+02	4.85e+02	0.99
Ru-106	1.64e+04	1.69e+04	0.97	1.52e+04	1.55e+04	0.98
Rh-106	1.64e+04	1.69e+04	0.97	1.52e+04	1.55e+04	0.98
Pd-107	3.74e-03	3.86e-03	0.97	3.52e-03	3.58e-03	0.98
Ag-110	1.47e-01	1.52e-01	0.97	1.39e-01	1.40e-01	0.99
Ag-110m	1.11e+01	1.14e+01	0.97	1.05e+01	1.06e+01	0.99
Cd-113m	2.39e+00	2.51e+00	0.95	2.22e+00	2.33e+00	0.95
Cd-115m	1.55e+00	1.62e+00	0.96	1.46e+00	1.52e+00	0.96
Sn-119m	9.22e+00	9.65e+00	0.95	8.53e+00	8.94e+00	0.95
Sn-121m	9.42e-03	9.52e-03	0.99	8.35e-03	8.37e-03	1.00
Sn-123	9.68e+01	1.00e+02	0.97	8.78e+01	9.10e+01	0.97
Te-123m	2.25e-03	2.34e-03	0.96	2.11e-03	2.17e-03	0.97
Sb-124	3.88e-01	4.02e-01	0.97	3.59e-01	3.70e-01	0.97
Sb-125	8.21e+02	8.54e+02	0.96	7.53e+02	7.83e+02	0.96
Te-125m	1.99e+02	2.07e+02	0.96	1.82e+02	1.90e+02	0.96
Sn-126	4.47e-02	4.60e-02	0.97	4.02e-02	4.14e-02	0.97
Sb-126	6.25e-03	6.45e-03	0.97	5.62e-03	5.79e-03	0.97

Table 9. Continued

Isotope	Mark 1A 9 % Pu 240 inventories (curies)			Mark IV 9 % Pu 240 inventories (curies)		
	Old	New	Old/New	Old	New	Old/New
Sb-126m	4.47e-02	4.60e-02	0.97	4.02e-02	4.14e-02	0.97
Te-127	2.47e+02	2.52e+02	0.98	2.21e+02	2.25e+02	0.98
Te-127m	2.52e+02	2.58e+02	0.98	2.25e+02	2.29e+02	0.98
Te-129	4.59e+00	4.63e+00	0.99	3.98e+00	4.00e+00	0.99
Te-129m	7.05e+00	7.11e+00	0.99	6.11e+00	6.15e+00	0.99
I-129	1.95e-03	1.97e-03	0.99	1.68e-03	1.69e-03	0.99
Cs-134	1.38e+03	1.36e+03	1.01	1.13e+03	1.11e+03	1.02
Cs-135	2.51e-02	2.51e-02	1.00	2.16e-02	2.17e-02	1.00
Cs-137	6.88e+03	6.87e+03	1.00	5.73e+03	5.72e+03	1.00
Ba-137m	6.50e+03	6.50e+03	1.00	5.42e+03	5.42e+03	1.00
Ce-141	2.36e+02	2.36e+02	1.00	1.96e+02	1.96e+02	1.00
Pr-143	5.10e-03	5.09e-03	1.00	4.22e-03	4.22e-03	1.00
Ce-144	7.40e+04	7.37e+04	1.00	6.10e+04	6.08e+04	1.00
Pr-144	7.40e+04	7.37e+04	1.00	6.10e+04	6.08e+04	1.00
Pr-144m	8.88e+02	8.85e+02	1.00	7.32e+02	7.30e+02	1.00
Pm-147	1.84e+04	1.84e+04	1.00	1.53e+04	1.54e+04	1.00
Pm-148	5.94e-01	5.93e-01	1.00	4.94e-01	4.93e-01	1.00
Pm-148m	1.05e+01	1.05e+01	1.00	8.76e+00	8.75e+00	1.00
Sm-151	8.84e+01	8.98e+01	0.98	7.80e+01	7.94e+01	0.98
Eu-152	5.50e-01	5.49e-01	1.00	4.74e-01	4.73e-01	1.00
Gd-153	1.50e-01	1.48e-01	1.02	1.29e-01	1.26e-01	1.03
Eu-154	8.78e+01	8.78e+01	1.00	7.45e+01	7.38e+01	1.01
Eu-155	1.00e+02	1.03e+02	0.97	9.22e+01	9.46e+01	0.97
Tb-160	2.90e-01	2.97e-01	0.98	2.76e-01	2.77e-01	0.99
H-3	3.85e-01	3.86e-01	1.00	3.77e-01	3.73e-01	1.01
C-14	2.13e-01	2.13e-01	1.00	2.02e-01	2.01e-01	1.01
Fe-55	6.54e+01	6.54e+01	1.00	6.08e+01	6.04e+01	1.01
Ni-59	1.32e-02	1.32e-02	1.00	1.19e-02	1.19e-02	1.01
Co-60	1.36e+01	1.36e+01	1.00	1.09e+01	1.09e+01	1.01
Ni-63	1.65e+00	1.65e+00	1.00	1.50e+00	1.49e+00	1.01
Zr-93	4.51e-03	4.52e-03	1.00	3.66e-03	3.64e-03	1.01
Nb-93m	2.67e-04	2.68e-04	1.00	2.17e-04	2.17e-04	1.00

Table 9. Continued

Isotope	Mark 1A 9 % Pu 240 inventories (curies)			Mark IV 9 % Pu 240 inventories (curies)		
	Old	New	Old/New	Old	New	Old/New
Zr-95	9.94e+01	9.87e+01	1.01	8.18e+01	8.05e+01	1.02
Nb-95	2.15e+02	2.21e+02	0.97	1.77e+02	1.80e+02	0.98
Nb-95m	7.37e-01	7.32e-01	1.01	6.06e-01	5.97e-01	1.02
In-113m	1.56e+01	1.55e+01	1.00	1.30e+01	1.29e+01	1.01
Sn-113	1.56e+01	1.55e+01	1.00	1.30e+01	1.29e+01	1.01
Sn-119m	9.91e+01	9.92e+01	1.00	8.37e+01	8.31e+01	1.01
Sn-121m	2.30e-02	2.31e-02	1.00	1.93e-02	1.92e-02	1.00
Sb-125	3.51e+01	3.51e+01	1.00	2.95e+01	2.93e+01	1.01
Te-125m	8.49e+00	8.51e+00	1.00	7.14e+00	7.10e+00	1.01
U-234	4.56e-01	4.56e-01	1.00	4.16e-01	4.17e-01	1.00
U-235	2.01e-02	2.02e-02	0.99	1.67e-02	1.68e-02	1.00
U-236	5.63e-02	5.51e-02	1.02	5.14e-02	5.05e-02	1.02
U-238	3.32e-01	3.32e-01	1.00	3.32e-01	3.32e-01	1.00
Np-237	1.97e-02	1.68e-02	1.17	1.93e-02	1.65e-02	1.17
Pu-238	2.45e+01	2.13e+01	1.15	2.40e+01	2.08e+01	1.15
Pu-239	8.33e+01	9.02e+01	0.92	8.34e+01	8.91e+01	0.94
Pu-240	3.25e+01	3.36e+01	0.97	3.19e+01	3.23e+01	0.99
Pu-241	2.83e+03	2.86e+03	0.99	2.84e+03	2.72e+03	1.04
Pu-242	5.65e-03	4.73e-03	1.19	5.53e-03	4.37e-03	1.27
Am-241	5.24e+00	5.32e+00	0.98	5.26e+00	5.07e+00	1.04
Am-242m	2.16e-02	1.25e-02	1.73	2.20e-02	1.20e-02	1.83
Am-242	2.15e-02	1.25e-02	1.73	2.19e-02	1.20e-02	1.83
Am-243	3.56e-03	4.77e-03	0.75	3.52e-03	4.43e-03	0.80
Cm-242	1.20e+01	9.30e+00	1.29	1.22e+01	8.84e+00	1.38
Cm-244	8.12e-01	5.48e-02	14.81	8.22e-01	5.13e-02	16.01

Table 10. Comparison Between RADNUC Data Statements for 12% ²⁴⁰Pu

Isotope	Mark 1A 12 % Pu 240 inventories (curies)			Mark IV 12 % Pu 240 inventories (curies)		
	Old	New	Old/New	Old	New	Old/New
H-3	5.10e+01	5.14e+01	0.99	4.37e+01	4.39e+01	0.99
C-14	1.18e-05	1.18e-05	1.00	9.86e-06	9.86e-06	1.00
Se-79	4.32e-02	4.33e-02	1.00	3.62e-02	3.63e-02	1.00
Kr-85	1.05e+03	1.05e+03	1.01	8.61e+02	8.57e+02	1.00
Sr-89	2.51e+03	2.50e+03	1.01	2.03e+03	2.02e+03	1.00
Sr-90	8.42e+03	8.36e+03	1.01	6.84e+03	6.80e+03	1.01
Y-90	8.43e+03	8.36e+03	1.01	6.84e+03	6.80e+03	1.01
Y-91	6.16e+03	6.12e+03	1.01	4.99e+03	4.97e+03	1.00
Zr-93	1.99e-01	1.99e-01	1.00	1.64e-01	1.63e-01	1.00
Nb-93m	1.33e-02	1.33e-02	1.00	1.10e-02	1.09e-02	1.00
Zr-95	1.07e+04	1.07e+04	1.00	8.84e+03	8.83e+03	1.00
Nb-95	2.32e+04	2.40e+04	0.97	1.92e+04	1.98e+04	0.97
Nb-95m	7.93e+01	7.92e+01	1.00	6.56e+01	6.55e+01	1.00
Tc-99	1.45e+00	1.45e+00	1.00	1.21e+00	1.21e+00	1.00
Ru-103	7.08e+02	7.15e+02	0.99	6.16e+02	6.18e+02	1.00
Rh-103m	6.38e+02	6.44e+02	0.99	5.55e+02	5.57e+02	1.00
Ru-106	2.71e+04	2.78e+04	0.97	2.51e+04	2.54e+04	0.99
Rh-106	2.71e+04	2.78e+04	0.97	2.51e+04	2.54e+04	0.99
Pd-107	6.81e-03	7.01e-03	0.97	6.39e-03	6.48e-03	0.98
Ag-110	3.84e-01	3.91e-01	0.98	3.59e-01	3.56e-01	1.01
Ag-110m	2.89e+01	2.94e+01	0.98	2.70e+01	2.68e+01	1.01
Cd-113m	3.82e+00	3.99e+00	0.96	3.55e+00	3.70e+00	0.96
Cd-115m	1.78e+00	1.85e+00	0.96	1.67e+00	1.72e+00	0.97
Sn-119m	1.28e+01	1.34e+01	0.96	1.19e+01	1.23e+01	0.96
Sn-121m	1.59e-02	1.61e-02	0.99	1.42e-02	1.43e-02	1.00
Sn-123	1.24e+02	1.28e+02	0.97	1.13e+02	1.16e+02	0.97
Te-123m	7.20e-03	7.35e-03	0.98	6.68e-03	6.71e-03	0.99
Sb-124	7.39e-01	7.57e-01	0.98	6.80e-01	6.90e-01	0.99
Sb-125	1.27e+03	1.31e+03	0.96	1.16e+03	1.20e+03	0.97
Te-125m	3.07e+02	3.19e+02	0.96	2.82e+02	2.92e+02	0.97
Sn-126	7.05e-02	7.25e-02	0.97	6.35e-02	6.51e-02	0.97
Sb-126	9.87e-03	1.02e-02	0.97	8.88e-03	9.12e-03	0.97

Table 10. Continued

Isotope	Mark 1A 12 % Pu 240 inventories (curies)			Mark IV 12 % Pu 240 inventories (curies)		
	Old	New	Old/New	Old	New	Old/New
Sb-126m	7.05e-02	7.25e-02	0.97	6.35e-02	6.51e-02	0.97
Te-127	3.23e+02	3.29e+02	0.98	2.89e+02	2.93e+02	0.99
Te-127m	3.29e+02	3.36e+02	0.98	2.95e+02	2.99e+02	0.99
Te-129	5.17e+00	5.22e+00	0.99	4.50e+00	4.53e+00	0.99
Te-129m	7.94e+00	8.02e+00	0.99	6.92e+00	6.96e+00	0.99
I-129	3.04e-03	3.07e-03	0.99	2.63e-03	2.65e-03	0.99
Cs-134	3.07e+03	3.01e+03	1.02	2.51e+03	2.44e+03	1.03
Cs-135	3.76e-02	3.77e-02	1.00	3.26e-02	3.28e-02	0.99
Cs-137	1.03e+04	1.03e+04	1.00	8.64e+03	8.63e+03	1.00
Ba-137m	9.78e+03	9.77e+03	1.00	8.17e+03	8.16e+03	1.00
Ce-141	2.47e+02	2.47e+02	1.00	2.06e+02	2.06e+02	1.00
Pr-143	5.07e-03	5.07e-03	1.00	4.21e-03	4.21e-03	1.00
Ce-144	9.82e+04	9.79e+04	1.00	8.10e+04	8.07e+04	1.00
Pr-144	9.82e+04	9.79e+04	1.00	8.10e+04	8.07e+04	1.00
Pr-144m	1.18e+03	1.17e+03	1.00	9.71e+02	9.69e+02	1.00
Pm-147	2.41e+04	2.43e+04	1.00	2.03e+04	2.04e+04	0.99
Pm-148	8.27e-01	8.28e-01	1.00	6.94e-01	6.94e-01	1.00
Pm-148m	1.47e+01	1.47e+01	1.00	1.23e+01	1.23e+01	1.00
Sm-151	1.05e+02	1.07e+02	0.98	9.37e+01	9.61e+01	0.97
Eu-152	1.15e+00	1.15e+00	1.00	1.00e+00	1.01e+00	1.00
Gd-153	5.02e-01	4.90e-01	1.03	4.34e-01	4.18e-01	1.04
Eu-154	2.07e+02	2.06e+02	1.01	1.75e+02	1.72e+02	1.02
Eu-155	1.31e+02	1.35e+02	0.97	1.20e+02	1.24e+02	0.97
Tb-160	6.59e-01	6.68e-01	0.99	6.22e-01	6.16e-01	1.01
H-3	8.37e-01	8.31e-01	1.01	8.14e-01	7.94e-01	1.03
C-14	3.22e-01	3.20e-01	1.00	3.03e-01	3.00e-01	1.01
Fe-55	9.55e+01	9.50e+01	1.00	8.84e+01	8.71e+01	1.01
Ni-59	1.97e-02	1.96e-02	1.00	1.78e-02	1.75e-02	1.01
Co-60	2.01e+01	2.00e+01	1.00	1.61e+01	1.59e+01	1.01
Ni-63	2.48e+00	2.48e+00	1.00	2.25e+00	2.22e+00	1.01
Zr-93	6.80e-03	6.78e-03	1.00	5.50e-03	5.43e-03	1.01
Nb-93m	4.43e-04	4.43e-04	1.00	3.59e-04	3.56e-04	1.01

Table 10. Continued

Isotope	Mark 1A 12 % Pu 240 inventories (curies)			Mark IV 12 % Pu 240 inventories (curies)		
	Old	New	Old/New	Old	New	Old/New
Zr-95	1.13e+02	1.11e+02	1.02	9.26e+01	8.99e+01	1.03
Nb-95	2.46e+02	2.50e+02	0.98	2.01e+02	2.02e+02	0.99
Nb-95m	8.41e-01	8.26e-01	1.02	6.87e-01	6.67e-01	1.03
-113m	1.91e+01	1.89e+01	1.01	1.59e+01	1.56e+01	1.02
Sn-113	1.91e+01	1.89e+01	1.01	1.59e+01	1.56e+01	1.02
Sn-119m	1.33e+02	1.33e+02	1.01	1.12e+02	1.10e+02	1.02
Sn-121m	3.47e-02	3.46e-02	1.00	2.89e-02	2.86e-02	1.01
Sb-125	5.12e+01	5.10e+01	1.00	4.29e+01	4.23e+01	1.01
Te-125m	1.24e+01	1.24e+01	1.00	1.04e+01	1.03e+01	1.01
U-234	4.45e-01	4.45e-01	1.00	4.06e-01	4.07e-01	1.00
U-235	1.82e-02	1.83e-02	0.99	1.52e-02	1.53e-02	0.99
U-236	6.59e-02	6.43e-02	1.02	5.89e-02	5.77e-02	1.02
U-238	3.31e-01	3.31e-01	1.00	3.32e-01	3.32e-01	1.00
Np-237	3.10e-02	2.57e-02	1.20	2.98e-02	2.49e-02	1.20
Pu-238	5.81e+01	4.86e+01	1.19	5.55e+01	4.66e+01	1.19
Pu-239	1.10e+02	1.19e+02	0.92	1.10e+02	1.18e+02	0.93
Pu-240	5.98e+01	6.19e+01	0.97	5.78e+01	5.89e+01	0.98
Pu-241	6.90e+03	6.88e+03	1.00	6.83e+03	6.49e+03	1.05
Pu-242	2.13e-02	1.77e-02	1.20	2.03e-02	1.60e-02	1.27
Am-241	1.35e+01	1.36e+01	0.99	1.34e+01	1.29e+01	1.04
Am-242m	1.12e-01	5.81e-02	1.93	1.12e-01	5.56e-02	2.02
Am-242	1.12e-01	5.78e-02	1.93	1.12e-01	5.54e-02	2.02
Am-243	1.76e-02	2.82e-02	0.62	1.69e-02	2.55e-02	0.66
Cm-242	6.61e+01	5.15e+01	1.28	6.62e+01	4.82e+01	1.37
Cm-244	6.57e+00	5.14e-01	12.79	6.40e+00	4.63e-01	13.84

Table 11. Comparison Between RADNUC Data Statements for 16% ²⁴⁰Pu

Isotope	Mark 1A 16 % Pu 240 inventories (curies)			Mark IV 16 % Pu 240 inventories (curies)		
	Old	New	Old/New	Old	New	Old/New
H-3	7.44e+01	7.50e+01	0.99	6.37e+01	6.41e+01	0.99
C-14	1.69e-05	1.69e-05	1.00	1.41e-05	1.41e-05	1.00
Se-79	6.15e-02	6.16e-02	1.00	5.14e-02	5.16e-02	1.00
Kr-85	1.45e+03	1.44e+03	1.01	1.18e+03	1.17e+03	1.00
Sr-89	2.36e+03	2.35e+03	1.01	1.90e+03	1.89e+03	1.00
Sr-90	1.15e+04	1.15e+04	1.01	9.32e+03	9.28e+03	1.00
Y-90	1.16e+04	1.15e+04	1.01	9.33e+03	9.28e+03	1.01
Y-91	5.90e+03	5.87e+03	1.01	4.76e+03	4.75e+03	1.00
Zr-93	2.79e-01	2.78e-01	1.00	2.28e-01	2.28e-01	1.00
Nb-93m	2.10e-02	2.09e-02	1.00	1.73e-02	1.72e-02	1.00
Zr-95	1.08e+04	1.07e+04	1.00	8.87e+03	8.86e+03	1.00
Nb-95	2.33e+04	2.41e+04	0.97	1.92e+04	1.99e+04	0.97
Nb-95m	7.98e+01	7.97e+01	1.00	6.58e+01	6.58e+01	1.00
Tc-99	2.06e+00	2.06e+00	1.00	1.72e+00	1.72e+00	1.00
Ru-103	7.61e+02	7.66e+02	0.99	6.60e+02	6.64e+02	0.99
Rh-103m	6.86e+02	6.92e+02	0.99	5.95e+02	5.98e+02	0.99
Ru-106	4.15e+04	4.24e+04	0.98	3.80e+04	3.84e+04	0.99
Rh-106	4.15e+04	4.24e+04	0.98	3.80e+04	3.84e+04	0.99
Pd-107	1.17e-02	1.20e-02	0.98	1.08e-02	1.09e-02	0.99
Ag-110	8.82e-01	8.85e-01	1.00	8.12e-01	7.92e-01	1.02
Ag-110m	6.63e+01	6.65e+01	1.00	6.11e+01	5.96e+01	1.03
Cd-113m	5.93e+00	6.14e+00	0.96	5.50e+00	5.67e+00	0.97
Cd-115m	1.93e+00	1.99e+00	0.97	1.80e+00	1.84e+00	0.98
Sn-119m	1.67e+01	1.73e+01	0.97	1.55e+01	1.59e+01	0.97
Sn-121m	2.55e-02	2.58e-02	0.99	2.27e-02	2.28e-02	1.00
Sn-123	1.47e+02	1.51e+02	0.97	1.34e+02	1.36e+02	0.98
Te-123m	2.02e-02	2.01e-02	1.00	1.86e-02	1.81e-02	1.03
Sb-124	1.27e+00	1.28e+00	0.99	1.16e+00	1.16e+00	1.00
Sb-125	1.85e+03	1.91e+03	0.97	1.70e+03	1.74e+03	0.97
Te-125m	4.50e+02	4.64e+02	0.97	4.12e+02	4.23e+02	0.97
Sn-126	1.07e-01	1.09e-01	0.98	9.60e-02	9.81e-02	0.98
Sb-126	1.50e-02	1.53e-02	0.98	1.34e-02	1.37e-02	0.98

Table 11. Continued

Isotope	Mark 1A 16 % Pu 240 inventories (curies)			Mark IV 16 % Pu 240 inventories (curies)		
	Old	New	Old/New	Old	New	Old/New
Sb-126m	1.07e-01	1.09e-01	0.98	9.60e-02	9.81e-02	0.98
Te-127	3.88e+02	3.94e+02	0.98	3.46e+02	3.49e+02	0.99
Te-127m	3.96e+02	4.02e+02	0.98	3.53e+02	3.57e+02	0.99
Te-129	5.47e+00	5.52e+00	0.99	4.76e+00	4.78e+00	1.00
Te-129m	8.41e+00	8.49e+00	0.99	7.31e+00	7.34e+00	1.00
I-129	4.52e-03	4.56e-03	0.99	3.91e-03	3.94e-03	0.99
Cs-134	6.19e+03	6.03e+03	1.03	5.04e+03	4.85e+03	1.04
Cs-135	5.36e-02	5.41e-02	0.99	4.65e-02	4.72e-02	0.98
Cs-137	1.48e+04	1.48e+04	1.00	1.24e+04	1.24e+04	1.00
Ba-137m	1.40e+04	1.40e+04	1.00	1.17e+04	1.17e+04	1.00
Ce-141	2.44e+02	2.43e+02	1.00	2.02e+02	2.02e+02	1.00
Pr-143	4.90e-03	4.90e-03	1.00	4.06e-03	4.06e-03	1.00
Ce-144	1.20e+05	1.20e+05	1.00	9.89e+04	9.87e+04	1.00
Pr-144	1.20e+05	1.20e+05	1.00	9.89e+04	9.87e+04	1.00
Pr-144m	1.44e+03	1.44e+03	1.00	1.19e+03	1.18e+03	1.00
Pm-147	2.93e+04	2.96e+04	0.99	2.47e+04	2.50e+04	0.99
Pm-148	1.03e+00	1.04e+00	0.99	8.69e-01	8.76e-01	0.99
Pm-148m	1.83e+01	1.84e+01	0.99	1.54e+01	1.56e+01	0.99
Sm-151	1.18e+02	1.21e+02	0.97	1.06e+02	1.10e+02	0.97
Eu-152	1.91e+00	1.94e+00	0.98	1.68e+00	1.72e+00	0.98
Gd-153	1.25e+00	1.23e+00	1.02	1.09e+00	1.05e+00	1.03
Eu-154	4.49e+02	4.42e+02	1.02	3.79e+02	3.68e+02	1.03
Eu-155	1.81e+02	1.84e+02	0.98	1.62e+02	1.65e+02	0.98
Tb-160	1.33e+00	1.32e+00	1.00	1.23e+00	1.20e+00	1.03
H-3	1.69e+00	1.65e+00	1.02	1.63e+00	1.56e+00	1.04
C-14	4.71e-01	4.65e-01	1.01	4.43e-01	4.33e-01	1.02
Fe-55	1.34e+02	1.32e+02	1.01	1.23e+02	1.20e+02	1.03
Ni-59	2.84e-02	2.81e-02	1.01	2.56e-02	2.50e-02	1.02
Co-60	2.87e+01	2.83e+01	1.01	2.29e+01	2.24e+01	1.02
Ni-63	3.62e+00	3.58e+00	1.01	3.26e+00	3.19e+00	1.02
Zr-93	9.96e-03	9.84e-03	1.01	8.02e-03	7.84e-03	1.02
Nb-93m	7.26e-04	7.20e-04	1.01	5.86e-04	5.75e-04	1.02

Table 11. Continued

Isotope	Mark 1A 16 % Pu 240 inventories (curies)			Mark IV 16 % Pu 240 inventories (curies)		
	Old	New	Old/New	Old	New	Old/New
Zr-95	1.21e+02	1.17e+02	1.03	9.81e+01	9.41e+01	1.04
Nb-95	2.61e+02	2.64e+02	0.99	2.13e+02	2.12e+02	1.01
Nb-95m	8.94e-01	8.71e-01	1.03	7.28e-01	6.98e-01	1.04
In-113m	2.18e+01	2.13e+01	1.02	1.81e+01	1.74e+01	1.04
Sn-113	2.18e+01	2.13e+01	1.02	1.81e+01	1.74e+01	1.04
Sn-119m	1.69e+02	1.66e+02	1.02	1.41e+02	1.37e+02	1.03
Sn-121m	5.07e-02	5.01e-02	1.01	4.22e-02	4.13e-02	1.02
Sb-125	7.19e+01	7.10e+01	1.01	6.00e+01	5.86e+01	1.02
Te-125m	1.75e+01	1.72e+01	1.01	1.46e+01	1.42e+01	1.02
U-234	4.30e-01	4.31e-01	1.00	3.93e-01	3.94e-01	1.00
U-235	1.60e-02	1.62e-02	0.99	1.35e-02	1.37e-02	0.99
U-236	7.66e-02	7.47e-02	1.02	6.71e-02	6.57e-02	1.02
U-238	3.31e-01	3.31e-01	1.00	3.32e-01	3.32e-01	1.00
Np-237	4.72e-02	3.79e-02	1.25	4.46e-02	3.62e-02	1.23
Pu-238	1.30e+02	1.03e+02	1.26	1.21e+02	9.61e+01	1.26
Pu-239	1.37e+02	1.49e+02	0.92	1.39e+02	1.48e+02	0.93
Pu-240	1.00e+02	1.04e+02	0.97	9.53e+01	9.76e+01	0.98
Pu-241	1.35e+04	1.33e+04	1.01	1.29e+04	1.22e+04	1.06
Pu-242	6.24e-02	5.08e-02	1.23	5.66e-02	4.39e-02	1.29
Am-241	2.82e+01	2.85e+01	0.99	2.73e+01	2.64e+01	1.03
Am-242m	4.19e-01	1.94e-01	2.16	4.10e-01	1.83e-01	2.24
Am-242	4.17e-01	1.93e-01	2.16	4.08e-01	1.82e-01	2.24
Am-243	6.29e-02	1.23e-01	0.51	5.76e-02	1.06e-01	0.54
Cm-242	2.61e+02	2.00e+02	1.31	2.55e+02	1.82e+02	1.40
Cm-244	3.69e+01	3.37e+00	10.96	3.44e+01	2.89e+00	11.89

Appendix A

Comparison Between Old ORIGEN2 Cross Sections and WIMS Cross Sections

Np239 MARK IV INNER CAPTURE

Np239 MARK IV OUTER CAPTURE

Np239 MARK 1A INNER CAPTURE

Np239 MARK 1A OUTER CAPTURE

Pu238 MARK IV INNER CAPTURE

Pu238 MARK IV OUTER CAPTURE

Pu238 MARK 1A INNER CAPTURE

Pu238 MARK 1A OUTER CAPTURE

Am241 MARK IV INNER CAPTURE

Am241 MARK IV OUTER CAPTURE

Am241 MARK 1A INNER CAPTURE

Am241 MARK 1A OUTER CAPTURE

Pu242 MARK IV INNER FISSION

Pu242 MARK 1A INNER FISSION

Pu242 MARK IV OUTER FISSION

Pu242 MARK 1A OUTER FISSION

Appendix B

Comparison Between New ORIGEN2 Cross Sections and WIMS Cross Sections

U238 MARK IV INNER CAPTURE

U238 MARK IV OUTER CAPTURE

U238 MARK 1A INNER CAPTURE

U238 MARK 1A OUTER CAPTURE

Pu238 MARK IV INNER CAPTURE

Pu238 MARK 1A INNER CAPTURE

Pu238 MARK IV OUTER CAPTURE

Pu238 MARK 1A OUTER CAPTURE

Cm244 MARK IV INNER CAPTURE

Cm244 MARK 1A INNER CAPTURE

Cm244 MARK IV OUTER CAPTURE

Cm244 MARK 1A OUTER CAPTURE

U235 MARK IV INNER FISSION

U235 MARK IV OUTER FISSION

U235 MARK 1A INNER FISSION

U235 MARK 1A OUTER FISSION

Pu238 MARK IV INNER FISSION

Pu238 MARK IV OUTER FISSION

Pu238 MARK 1A INNER FISSION

Pu238 MARK 1A OUTER FISSION

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