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NATIONAL NEUTRON CROSS SECTION CENTER

Brookhaven National Laboratory

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March 1976

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NATIONAL NEUTRON CROSS SECTION CENTER

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BENCHMARK TESTING OF ENDF/B-IV

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FOREWARD

The purpose of this report is fourfold:

1. To present the results of the benchmark testing of ENDF/B-IV in a clear and consistent fashion and to provide documentation of the testing results at this point in time.
2. To qualify the testing results recognizing that, in addition to the evolution in the evaluated data, the computational methods are also evolving.
3. To indicate those areas of basic nuclear data that require additional evaluations.
4. To indicate deficiencies in current benchmark tests.

Benchmark models for data testing have been identified by CSWEG for five areas of application: thermal reactors, fast reactors, shielding, dosimetry and fission products. The testing results for each of these areas are presented in Volume I, Sections II through VI. Each of these sections was prepared as a stand-alone report, i.e., page numbers, table and figure numbers sequence independently in each section. A brief summary of all testing results is given in Section I.

The testing results compiled in this report were computed over a period roughly defined by calendar year 1975. The results, especially those for thermal and fast reactors, are thus representative of the computational capabilities during this time. In Sections II and III, the computational methods used by the testers are briefly described.

Volume II of ENDF-203 is comprised of two appendices. Appendix A contains a more complete description of the reactor computational methods used in the thermal reactor data testing and detailed comparisons of broad group cross sections and reaction rates for the TRX-1 benchmark. Appendix B contains a description of the computational methods used by each tester and the results of fast reactor benchmark tests. Most of the important information contained in Volume II is summarized in Volume I. For this reason, and since Volume II is rather voluminous, Volume II will be available only on a very limited basis.

APPENDIX A

APPENDIX A

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I. INTRODUCTION

To help resolve the origin of the discrepancies among the calculated results for thermal systems, this Appendix gives descriptions of the various calculational methods, supplemental fewgroup information for benchmark TRX-1, and edits of the fast and thermal multigroup cross section libraries.

The fewgroup edits for TRX-1 (Section III) consist of zero-leakage and leakage-corrected 4-group reaction rates for $^{235,238}U$ captures and fissions; H, D, ^{16}O and ^{27}Al captures; and the slowing down source Q. For each energy group there are two columns in the tables: the left column is the reaction rate normalized to be consistent with a thermal ^{235}U fission rate of unity; the right column is the reaction rate divided by the corresponding SRL reaction rate. The upper energy boundaries for the 4-group structure are 10 MeV, 67.379 keV, 3.355 keV and 0.625 eV; these are compatable with the MUFT 54-group structure and were selected to closely match the boundaries of the fast cross sections, the unresolved and resolved resonance regions, and the thermal cross sections in the ENDF/B-IV ^{238}U evaluation.

In terms of the 4-group structure, the slowing down densities out of the groups are defined as follows:

$$Q_1 = (\Sigma_{1\to2} + \Sigma_{1\to3} + \Sigma_{1\to4})\, \phi_1$$

$$Q_2 = (\Sigma_{1\to3} + \Sigma_{1\to4})\, \phi_1 + (\Sigma_{2\to3} + \Sigma_{2\to4})\, \phi_2$$

$$Q_3 = \Sigma_{1\to4}\, \phi_1 + \Sigma_{2\to4}\, \phi_2 + \Sigma_{3\to4}\, \phi_3$$

To test the ENDF/B cross section processing codes, multigroup cross section edits for room temperature H as bound in H_2O, D as bound in D_2O, ^{16}O, ^{27}Al, ^{235}U and ^{238}U are also supplied for the MUFT group structure above 67.379 keV (Section IV). The following quantities are edited for each energy group:

Symbol	Cross Section Type
σ_{el}	elastic scattering, barns
σ_c	capture, barns
σ_f	fission, barns
σ_{in}	inelastic scattering, barns
$\sigma_{n,2n}$	(n,2n), barns
$\bar{\mu}$	cos. scattering angle (lab.)
$\bar{\nu}$	neutrons/fission
χ	fission spectrum*

Thermal $\bar{\nu}$, and the fission, capture and scattering cross sections for the THERMOS group structure are also supplied (Section V). The 4-group reaction rate compilation for TRX-1 provide the best test of the cross section processing in the resonance regions.

---

* $\sum_i \chi_i = 1$, where the energy group index i is summed over all groups.

II. CALCULATIONAL METHODS

Aerojet Nuclear Company (ANC)

ETOP was used to process the basic ENDF/B data into a fast library composed of 68 quarter lethargy groups below 10 MeV. This library is used by PHROG which computes the resonance self-shielding, slowing down spectrum, performs group averaging and outputs the scalar cross sections and the P_0 and P_1 scatter matrix in a form directly usable by the one-dimensional multigroup S_N transport code, SCAMP.[1],[2] In the case of the TRX-1 and TRX-2 calculations PHROG was essentially used as a data processing code to punch the first 65 quarter-lethargy groups onto cards for use in SCAMP input. No group averaging was performed and the resonance self-shielding calculation performed by PHROG was overridden by an independent calculation. PHROG was used, however, to calculate group dependent transport cross sections that are used by SCAMP to obtain the leakage correction.

The resonance self-shielding was performed using a modification of the RABBLE[3] code which includes the options available in RABBLE plus an unresolved treatment similar to that used by ETOG-1[4] with the inclusion of Doppler-broadening and a Dancoff correction factor based on the methods of Gelling and Sauer.[5]

In the thermal range (0 to 2.38 eV) FLANGE II[6] was used to process the ENDF data into a 101 group library usable by the INCITE[7] thermal spectrum code. INCITE was then used to generate 25-group cross sections below 0.876 eV and the full P_0 and P_1 scatter matrix using the Heywood scatter kernel for H_2O. INCITE data for H_2O was also used for the H_2O molecule from 0.876 to 2.38 eV* to provide the full scatter matrix for H_2O from 0 to 2.38 eV.

The 90-group libraries for TRX-1 and TRX-2 were used to obtain spatially-weighted cross sections for the homogenized fuel cell by the use of SCAMP in cylindrical geometry (assuming six angular intervals and four Gaussian quadrature points). The core buckling was used in the cell calculations to account for leakage in the fast groups; leakage was set to zero in the thermal groups. The coalescing options in SCAMP were used to flux weight the cross sections over all regions of the cell and the thermal groups collapsed in energy to provide 68 group (one thermal group) homogenized cross sections for use in the final full core SCAMP calculations (S_6, P_1).

---

* Nelkin kernel above 2 eV.

For the homogeneous spheres, cross sections for 16-energy groups (1 thermal) were obtained from 31 spectrum calculations using the PHROG 2 code in the fast groups and the INCITE code in the thermal. Initial cross sections were obtained using an extrapolation distance of 1.76 cm for the PNL spheres in all groups and in the case of the ORNL spheres an extrapolation length of 5.1 cm in the fast groups and -6.8 in the thermal. Fast and thermal bucklings were then computed with the SCAMP code and final cross sections obtained using these bucklings.

The difference between the first and final SCAMP calculations was less than 0.00014 in k for all cases. The SCAMP model for the spheres is given below.

Region	Mesh	Width (cm) PNL	Width (cm) ORNL
1	30	15.0	30.0
2	20	R-15.0	R-30.0

No. Intervals on the Angular Half-Space 6

Scattering Treatment P_1

Bettis Atomic Power Lab. (BAPL)

The TRX lattices were analyzed using the RCP Monte Carlo program with leakage corrections obtained from homogenized, multigroup full-core calculations. RCP described the lattice cell geometry explicitly and neutrons were followed over the full energy range below 10 MeV.

The ENDF/B cross sections were processed with ETOMX and FLAN2, which are Bettis versions of ETOG and FLANGE II, respectively.

Above 0.625 eV, smooth cross sections, including the inelastic scattering transfer matrix, were described in the 54-group MILC energy structure. Resonance profiles were described with 1000 equally spaced energy points in each RCP group. Smooth thermal cross sections were described at 25 energies. The hydrogen thermal scattering kernel was a 25-group P_3 Haywood kernel at a temperature of 296° K.

Neutrons were started uniformly in the fuel with the U-235 fission spectrum. A total-collision estimator and neutron weights were used so that every collision contributed to all possible absorptions at that point. The weight contributed at a collision to absorption of type-x was the weight carried by the incident neutron multiplied by Σ_x/Σ_t. The remainder of the neutron was allowed to undergo one type of scattering, selected from the appropriate cross sections, and to continue on its way.

Leakage corrections were obtained by means of the PAX program, with cross sections closely matching those of the Monte Carlo. For the two full lattices, the epithermal calculation used the MUFT option, which treated a homogenized, simply-buckled lattice in the B_1 approximation. An "L-factor" was used to force the U-238 capture in the zero-buckling MUFT calculation to match that of RCP above 0.625 eV. A single L-factor was applied to U-235 absorption (fission plus capture) in a similar manner.

Thermally, a DP1 calculation was done in 25 energy groups. Thermal disadvantage factors were used to force the zero-buckling thermal reaction rates to match those in the RCP calculation, and a fast advantage factor was applied similarly to obtain the proper U-238 fission rate.

Leakage corrections for the two-region lattices were obtained with the P7MG option in PAX, which performed one-dimensional, 54-multigroup calculations in cylinder geometry. The calculations were P3 epithermally and double-P1 thermally. There was one thermal group, with constants condensed from a 25-group calculation for each homogenized core region.

In all cases, leakage correction factors for the RCP-calculated reaction rates were obtained as the ratio of reaction rate in the leaking, homogenized lattice to that in the homogenized lattice with zero-buckling.

The analysis of the ORNL spheres employed P7MG with 57 epithermal groups and one thermal group (averaged over the asymptotic spectrum in 25 groups). The calculation was P_3 epithermally and double P_1 thermally with Marshak boundary conditions. Eigenvalues were converged to better than 5×10^{-6}.

Brookhaven National Laboratory (BNL)

The basic ENDF/B data were processed into multigroup cross sections for the integral transport theory code HAMMER[3], i.e., into the 30 group THERMOS structure at thermal energies below 0.625 eV, and into the epithermal 54 group MUFT structure above this energy. For the former the $S(\alpha,\beta,T)$ tapes containing the Haywood scattering law for Hydrogen in H_2O and Deuterium in D_2O were used. The P_0 and P_1 scattering kernels in the thermal group structure were calculated by FLANGE-II,[6] which also processed the ENDF/B-IV thermal absorption and fission cross sections into average group values. For nuclides other than Hydrogen, Oxygen, and Deuterium, FLANGE-II was used to evaluate the thermal group values of σ_s including resonance scattering wherever appropriate. The gas kernel for Oxygen was calculated by the code LITHE, which prepares the thermal library for the HAMMER code.[8]

At epithermal energies ETOG-3[4] was used to prepare the multigroup data. It was modified in accordance with the requirements of the lattice analysis code. The cut off between the resolved and unresolved resonance regions was fixed for each nuclide at the highest energy of the group belonging entirely to the resolved region. In the next group, the resonances were treated as unresolved, the average resonance parameters being extended to the entire group. Again, at the upper end of the unresolved resonance region, the resonances in the group belonging partially to the smooth cross section region were converted to equivalent smooth cross sections. Such conversions were also made for the resolved and unresolved p-wave resonances, and optionally for the s-wave resonances. Whenever resolved s-wave resonances parameters were included in the multigroup library, their 1/v tail contributions were added to the smooth cross sections throughout the resolved resonance region, since the effective resonance integrals, calculated in the HAMMER code, are reduced correspondingly. The (n,2n) cross section was added twice to the inelastic scattering cross section, and subtracted once from σ_a so that σ_t remains unchanged. This approximation is based on the assumption that the spectrum of the inelastically scattered neutrons is not very different from that of the neutrons produced in the (n,2n) reaction. The weighting spectrum for cross section averaging was taken to be 1/E joined to a fission spectrum at high energies. (The breakpoint was taken to be 67 KeV, and the temperature of the fission spectrum 1.27 MeV corresponding to thermal fissions in U-235). The parameter γ, which is half the mean square logarithmic energy increment per collision for elastic scattering divided by the corresponding mean increment, was replaced by half the group lethargy width for nuclides heavier than Deuterium, to prevent spurious oscillations in the slowing down density in the MUFT slowing down treatment. In group inelastic scattering was included in the inelastic matrix in the multigroup data.

In the lattices which were studied unresolved, s-wave average resonance parameters were included in the multigroup library for U-238 for resonance shielding calculations, the p-wave unresolved resonances being converted to equivalent smooth cross sections. For lattices of U metal rods, the p-wave shielding was calculated separately using an appropriately modified version of the TUZ program,(9) and a small correction was applied to the unresolved resonance region calculations. For U-235 all unresolved resonances were converted to equivalent smooth cross sections. In the resolved resonance regions of U-238 and U-235, which account for most of the resonance absorption in thermal reactor lattices, the resonance parameters and multigroup smooth absorption and fission cross sections, although available, were not used directly, Monte Carlo reaction rates being entered into the lattice analysis code with the input for each run. The U-235 fission spectrum for thermal fissions formed the source for the unit cell calculations.

HAMMER, which was used to calculate the lattices, is essentially an integral transport code for the unit cell of the lattice; collision probabilities for isotropic sources and transport corrected cross sections are used. In the HAMMER code effective resonance integrals are calculated for each resonance separately by the Nordheim procedure.(9) In the BNL analyses, however, the Nordheim procedure was replaced with a Monte Carlo resonance treatment. The method for doing this is described in reference (10). The Monte Carlo calculations covered the energy range from 50 keV to thermal cut off (0.625 eV), the reaction fractions being edited and transferred to the HAMMER analysis program in the MUFT groups covering the resolved resonance region of each nuclide.

Chalk River Nuclear Labs. (CRNL)

The TRX and MIT lattices were analyzed using the HAMMER integral transport code,[8] which utilizes the Nordheim integral treatment[9] to account for resonance absorption. Leakage was calculated using a homogenized lattice and a B_1 approximation. An annulus containing a heavy scatterer was used around the light water cells for the calculations in the thermal energy range.

The ETOG-2[4] code was used to process U-235 and U-238, which were the only cross sections taken from ENDF/B.

Electric Power Research Institute (EPRI)

The calculational procedure was similar to that used by CRNL, but resonance reaction rates for the HAMMER code were calculated by the RABBLE method[3], rather than the Nordheim treatment.

General Atomic Company (GA)

The GFE4 code was used to generate 99 group [GAM-II (Ref. 11) group structure] fast neutron data. The GFE4 code is an updated version of the GFE2 code described in Ref. 12 which will handle the new ENDF/B-4 data formats and also includes more general resolved resonance (including Adler-Adler capability) and nonelastic scattering energy transfer array computational algorithms.

The GAND3 code was used to generate 13463 energy resonance data covering the 7102 to 2.38 eV energy range (point spacing of 85 meters/sec). The GAND3 code is an updated version of the GAND2 code described in Ref. 12, which will handle the new ENDF/B-4 formats as well as MLBW and Adler-Adler resolved resonance region representations. The GAND3 code was also used to generate 101 energy [GATHER-II (Ref. 13) grid] thermal neutron data for absorber nuclides by condensation from a 900 energy ultra-fine mesh grid (2.38 to 0.001 eV) with a Maxwellian joined to 1/E at 10 kT condensation spectrum.

The FLANGM code, a local modification of the FLANG-II code (Ref. 6) which properly distributes the ultra-fine mesh normalization integral over all fine groups rather than assigning it entirely to the self-scatter fine group, was used to prepare 101 energy thermal neutron scattering kernels (P_0 and P_1) for H in H_2O and D in D_2O from the 1969 ENDF/B scattering law data for these nuclides (materials 1002 and 1004). Effective temperatures for use in the "short collision time" approximation used in the FLANGM code for incident energies greater than 1 eV were obtained from the work of Koppel and Houston (Ref. 14). Free gas model thermal neutron scattering kernels for nitrogen, oxygen, and ^{238}U were prepared with the WTFG code (Ref. 15).

The cross section library was then used with the MICROX code (Ref. 16) to prepare 19 group cross sections for use in 48 interval P_1, S_4 calculations with the 1DFX code the GAC version of the DTF-IV code (Ref. 17).

The MICROX calculations for the uranium and plutonium spheres were one region modified B_0 spectrum calculations using energy-dependent bucklings determined by iteration between MICROX and 1DFX transport theory calculations. The P_1, S_4 transport theory leadages were used to determine bucklings according to the formula

$$B_g^2 = 3 \Sigma_{tr,g} L_g/\phi_g \ . \quad (1)$$

The MICROX calculations for the H_2O and D_2O moderated lattices were two space region modified B_0 calculations over the 15-MeV to 0.001-eV energy range using the bucklings given in the benchmark specifications. Dancoff correction factors for the H_2O and D_2O lattices were computed with the GADACO code (Ref. 18).

The aluminum clad was smeared into the H_2O or D_2O. The void region in the TRX-1/2 lattices was explicitly represented in the Dancoff correction factor calculations and smeared into the moderator region in the MICROX calculations.

In the case of the D_2O moderated lattices, the reported results were obtained directly from the MICROX calculations. The H_2O lattice results were obtained from 19 group P_1 S_4 1DEX calculations.

Savannah River Laboratory (SRL and SRL*)

Two sets of results (denoted SRL and SRL*) were reported by Savannah River Laboratory. For each of the calculations the module ETOJ of the JOSHUA system(19) was used to process 84-group (54-MUFT, 30-THERMOS groups) from the pointwise data. The 84-group cross sections contained P_3 scattering for hydrogen, deuterium and oxygen, and P_1 scattering for the remaining nuclides.

Both the SRL and SRL* calculations analyzed the TRX and MIT lattices using the integral transport theory routines employed in the RAHAB module of the JOSHUA system. However, resonance reaction rates in the SRL calculations utilized the standard Nordheim treatment (9), whereas the SRL* calculations utilized a new, more exact resonance treatment developed by D. R. Finch.[a] In each case the zero leakage integral transport results were leakage corrected by subsequent B_1 calculations for equivalent spatially homogeneous cells.

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[a] Resonance reaction rates are calculated by a coupled space-energy solution for the fluxes through the resonance region. Fluxes are computed at discrete energies using one-dimensional annular geometry. Reaction rates are obtained by numerically integrating the space and energy dependent fluxes with the resonance component of the cross sections to produce the reaction rates for fission and capture which are passed as normalized reaction rates per unit Q for each isotope, multigroup, and reaction.

Fluxes are computed by the integral transport equation

$$V_n \Sigma_n^T (E) \phi_n (E) = \sum_{n'} P_{nn'} (E) S_{n'} (E) V_{n'}$$

Slowing down sources (S) are computed via the integral slowing down equation in the P_0 approximation, and first flight collision probabilities (P) are computed in one-dimensional annular geometry in the cosine currents approximations.

The ANISN code[20] was used to analyze the ORNL and PNL spheres in the S_4 approximation. The multigroup cross sections for ANISN were corrected for resonance self-shielding using the Nordheim treatment.

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III. COMPARISON OF FEWGROUP REACTION RATES

FEWGROUP STRUCTURES

A. Four-Group Structure

Group	Upper Energy Boundary
1	10 MeV
2	67.379 keV
3	3.355 keV
4	0.625 eV

B. Two-Group Structure

Group	Upper Energy Boundary
1	10 MeV
2	0.625 eV

INFINITE LATTICE RESULTS

(TRX-1, $B^2 = 0$)

Pages 14 through 19

zero leakage 15

NORMALIZED REACTION RATES FOR FISSION

ISOTOPE/LAB	GROUP 1		GROUP 2		GROUP 3		GROUP 4	
U235								
ANC	0.008407	1.015761	0.004089	1.051836	0.086038	0.997339	1.000000	1.000000
BAPL	0.008284	1.001962	0.004062	1.044989	0.084102	0.974901	1.000000	1.000000
BNL	0.008195	0.991148	0.004100	1.054673	0.084337	0.977617	1.000000	1.000000
CRNL	0.008550	1.034077	0.004677	1.203155	0.096481	1.118396	1.000000	1.000000
EPRI								
SRL	0.008268	1.000000	0.003887	1.000000	0.086268	1.000000	1.000000	1.000000
SRL*	0.008001	0.967711	0.003828	0.984778	0.079936	0.926603	1.000000	1.000000
U238								
ANC	0.097791	0.991712	0.0	0.0	0.0		0.0	
BAPL	0.097215	0.985873	0.0	0.0	0.0		0.0	
BNL	0.096497	0.978588	0.000005	0.850937	0.0		0.0	
CRNL	0.100204	1.016186	0.000005	0.864339	0.0		0.0	
EPRI								
SRL	0.098608	1.000000	0.000006	1.000000	0.0		0.0	
SRL*	0.095517	0.968650	0.000005	0.844460	0.000005		0.0	

NORMALIZED REACTION RATES FOR NU*FISSION

ISOTOPE/LAB	GROUP 1		GROUP 2		GROUP 3		GROUP 4	
U235								
ANC								
BAPL	0.021604	1.003143	0.009837	1.044957	0.203424	0.974883	2.418789	0.999994
BNL	0.021327	0.990266	0.009927	1.054514	0.203994	0.977619	2.418797	0.999998
CRNL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EPRI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SRL	0.021537	1.000000	0.009413	1.000000	0.208665	1.000000	2.418802	1.000000
SRL*	0.020840	0.967646	0.009271	0.984852	0.193352	0.926616	2.418800	0.999999
U238								
ANC								
BAPL	0.274011	0.986593	0.0		0.0		0.0	
BNL	0.271819	0.978698	0.000012	1.063671	0.0		0.0	
CRNL								
EPRI								
SRL	0.277735	1.000000	0.000012	1.000000	0.000009	1.000000	0.0	
SRL*	0.269070	0.968802	0.000012	1.055574	0.000010	1.125946	0.0	

NORMALIZED REACTION RATES FOR CAPTURE

ISOTOPE/LAB	GROUP 1		GROUP 2		GROUP 3		GROUP 4	
H								
ANC								
BAPL	0.000067	0.997656	0.000157	1.070619	0.012160	1.158743	0.195114	0.996357
BNL	0.000067	0.998926	0.000157	1.072181	0.012325	1.174502	0.194485	0.993145
CRNL								
EPRI								
SRL	0.000068	1.000000	0.000147	1.000000	0.010494	1.000000	0.195828	1.000000
SRL*	0.000067	0.991323	0.000146	0.996463	0.010458	0.996623	0.190580	0.973202
O								
ANC								
BAPL	0.004329	0.990262	0.0		0.0		0.000052	
BNL								
CRNL								
EPRI								
SRL	0.004372	1.000000	0.0		0.0		0.000053	
SRL*	0.004359	0.997019	0.0		0.000002		0.000052	
AL								
ANC								
BAPL	0.000701	0.925619	0.000332	1.108146	0.001123	1.202627	0.014660	0.999581
BNL								
CRNL								
EPRI								
SRL	0.000758	1.000000	0.000299	1.000000	0.000934	1.000000	0.014666	1.000000
SRL*	0.000749	0.988477	0.000295	0.985203	0.000927	0.993170	0.014185	0.967198
U235								
ANC	0.001019	1.071145	0.001481	1.042147	0.041081	0.917828	0.172330	1.000804
BAPL	0.001003	1.054451	0.001472	1.035981	0.041540	0.928074	0.172654	1.002684
BNL	0.000954	1.003265	0.001437	1.046089	0.039851	0.890347	0.172603	1.002392
CRNL	0.001033	1.085759	0.001020	0.717901	0.041514	0.927504	0.172579	1.002247
EPRI								
SRL	0.000951	1.000000	0.001421	1.000000	0.044759	1.000000	0.172192	1.000000
SRL*	0.000922	0.969565	0.001398	0.984040	0.038779	0.866397	0.172222	1.000175
U238								
ANC	0.047698	1.190069	0.062500	1.134843	0.406480	1.003377	0.370550	1.001730
BAPL	0.046885	1.170756	0.060065	1.090989	0.382632	0.944511	0.371428	1.004105
BNL	0.040086	1.000984	0.058702	1.065883	0.392126	0.967946	0.371211	1.003517
CRNL	0.048369	1.207819	0.059535	1.081012	0.410646	1.013661	0.370995	1.002933
EPRI								
SRL	0.040046	1.000000	0.055074	1.000000	0.405112	1.000000	0.369910	1.000000
SRL*	0.033732	0.967176	0.060565	[illegible]	0.387463	0.956434	0.369893	[illegible]

NORMALIZED SLOWING DOWN SOURCE

LABORATORY	GROUP 1		GROUP 2		GROUP 3	
ANC					1.747300	0.996933
BAPL	2.320423	0.991792	2.275483	0.989371	1.753911	1.000699
BNL	2.305634	0.985471	2.282549	0.992443	1.753043	1.000203
CRNL	2.017815	0.862452	1.979646	0.860742	1.506363	0.859460
EPRI						
SRL	2.339626	1.000000	2.299529	1.000000	1.752686	1.000000
SRL*	2.310036	0.987352	2.264264	0.984493	1.747269	0.996909

TWO GROUP STRUCTURE
****

NORMALIZED REACTION RATES FOR FISSION

ISOTOPE/LAB	GROUP 1		GROUP 2	
U235				
ANC	0.098534	1.001124	1.000000	1.000000
BAPL	0.096449	0.979942	1.000000	1.000000
BNL	0.096632	0.981798	1.000000	1.000000
CRNL	0.109708	1.114660	1.000000	1.000000
EPRI				
SRL	0.098423	1.000000	1.000000	1.000000
SRL*	0.091765	0.932354	1.000000	1.000000
U238				
ANC	0.097791	0.991654	0.0	
BAPL	0.097215	0.985815	0.0	
BNL	0.096502	0.978580	0.0	
CRNL	0.100209	1.016177	0.0	
EPRI	0.0	0.0		
SRL	0.098614	1.000000	0.0	
SRL*	0.095527	0.968693	0.0	

NORMALIZED REACTION RATES FOR NU*FISSION

ISOTOPE/LAB	GROUP 1		GROUP 2	
U235				
ANC				
BAPL	0.234865	0.980176	2.418789	0.999994
BNL	0.235248	0.981777	2.418797	0.999998
CRNL				
EPRI				
SRL	0.239615	1.000000	2.418802	1.000000
SRL*	0.223463	0.932592	2.418800	0.999999
U238				
ANC				
BAPL	0.274011	0.986520	0.0	
BNL	0.271831	0.978670	0.0	
CRNL				
EPRI				
SRL	0.277755	1.000000	0.0	
SRL*	0.269092	0.968811	0.0	

NORMALIZED REACTION RATES FOR CAPTURE

ISOTOPE/LAB		GROUP 1		GROUP 2	
H					
	ANC				
	BAPL	0.012384	1.156522	0.195114	0.996357
	BNL	0.012550	1.171992	0.194485	0.993145
	CRNL				
	EPRI				
	SRL	0.010708	1.000000	0.195828	1.000000
	SRL*	0.010672	0.996587	0.190580	0.973202
O					
	ANC				
	BAPL	0.004329	0.990262	0.000052	
	BNL				
	CRNL				
	EPRI				
	SRL	0.004372	1.000000	0.000053	
	SRL*	0.004361	0.997585	0.000052	
AL					
	ANC				
	BAPL	0.002156	1.083003	0.014660	0.999581
	BNL				
	CRNL				
	EPRI				
	SRL	0.001991	1.000000	0.014666	1.000000
	SRL*	0.001971	0.990185	0.014185	0.967198
U235					
	ANC	0.043581	0.924671	0.172330	1.000804
	BAPL	0.044015	0.933878	0.172654	1.002684
	BNL	0.042292	0.897322	0.172603	1.002392
	CRNL	0.043567	0.924378	0.172579	1.002247
	EPRI				
	SRL	0.047131	1.000000	0.172192	1.000000
	SRL*	0.041100	0.872026	0.172222	1.000175
U238					
	ANC	0.516638	1.032797	0.370550	1.001730
	BAPL	0.489602	0.978750	0.371428	1.004105
	BNL	0.490914	0.981373	0.371211	1.003517
	CRNL	0.518550	1.036619	0.370995	1.002933
	EPRI				
	SRL	0.500232	1.000000	0.369910	1.000000
	SRL*	0.487160	0.973868	0.369893	0.999954

FINITE REACTOR RESULTS

(TRX-1, $B^2 = 57 \times 10^{-4}$ cm^{-2})

Pages 20 through 25

non zero leakage

NORMALIZED REACTION RATES FOR FISSION

ISOTOPE/LAB	GROUP 1		GROUP 2		GROUP 3		GROUP 4	
U235								
ANL	0.009033	1.019587	0.004296	1.054447	0.087160	0.984960	1.000000	1.000000
BAPL	0.008889	1.003343	0.004262	1.046105	0.086071	0.972656	1.000000	1.000000
BNL	0.008808	0.994238	0.004307	1.057165	0.086333	0.975611	1.000000	1.000000
CRNL	0.009201	1.038555	0.004944	1.213461	0.099268	1.121782	1.000000	1.000000
EPRI	0.008747	0.987351	0.004286	1.051983	0.083625	0.945016	1.000000	1.000000
SRL	0.008859	1.000000	0.004074	1.000000	0.088491	1.000000	1.000000	1.000000
SRL*	0.008571	0.967367	0.004011	0.984600	0.081975	0.926368	1.000000	1.000000
U238								
ANL	0.105300	0.996660	0.0		0.0		0.0	
BAPL	0.104407	0.988213	0.0		0.0		0.0	
BNL	0.103791	0.982379	0.000006	1.008745	0.0		0.0	
CRNL	0.107742	1.019776	0.000006	1.029943	0.0		0.0	
EPRI	0.103083	0.975678	0.000006	1.003801	0.0		0.0	
SRL	0.105653	1.000000	0.000006	1.000000	0.0		0.0	
SRL*	0.102293	0.968198	0.000006	0.999133	0.000003		0.0	

NORMALIZED REACTION RATES FOR NU*FISSION

ISOTOPE/LAB	GROUP 1		GROUP 2		GROUP 3		GROUP 4	
U235								
ANL								
BAPL	0.023180	1.004884	0.010317	1.045585	0.208188	0.972646	2.418811	1.000002
BNL	0.022919	0.993565	0.010428	1.056911	0.208820	0.975595	2.418798	0.999997
CRNL								
EPRI	0.022762	0.986781	0.010377	1.051730	0.202252	0.944911	2.418601	0.999998
SRL	0.023067	1.000000	0.009867	1.000000	0.214043	1.000000	2.418806	1.000000
SRL*	0.022316	0.967432	0.009713	0.984430	0.198286	0.926381	2.418601	0.999998
U238								
ANL								
BAPL	0.293927	0.988887	0.0		0.0			
BNL	0.292044	0.982530	0.000015	1.260931	0.0		0.0	
CRNL								
EPRI	0.290074	0.975903	0.000012	1.003801	0.0		0.0	
SRL	0.297237	1.000000	0.000012	1.000000	0.000009	1.000000	0.0	
SRL*	0.287822	0.968326	0.000012	0.999133	0.000009	0.999133	0.0	

NORMALIZED REACTION RATES FOR CAPTURE

ISOTOPE/LAB		GROUP 1		GROUP 2		GROUP 3		GROUP 4	
H									
	ANC								
	BAPL	0.000071	1.001668	0.000163	1.059457	0.012338	1.155684	0.195135	0.996440
	BNL	0.000075	1.050776	0.000164	1.066942	0.012548	1.175329	0.194494	0.993163
	CRNL								
	EPRI	0.000074	1.045626	0.000164	1.061713	0.012540	1.174582	0.195331	0.997438
	SRL	0.000071	1.000000	0.000154	1.000000	0.010676	1.000000	0.195833	1.000000
	SRL*	0.000071	0.999133	0.000151	0.979919	0.010637	0.996359	0.190589	0.973222
O									
	ANC								
	BAPL	0.004577	0.992656	0.0		0.0		0.000053	
	BNL								
	CRNL								
	EPRI								
	SRL	0.004610	1.000000	0.0	0.0	0.0	0.0	0.000053	
	SRL*	0.004595	0.996564	0.0	0.0	0.0	0.0	0.000050	
AL									
	ANC								
	BAPL	0.000736	0.926916	0.000347	1.105615	0.001140	1.202002	0.014662	0.999645
	BNL								
	CRNL								
	EPRI								
	SRL	0.000794	1.000000	0.000314	1.000000	0.000948	1.000000	0.014667	1.000000
	SRL*	0.000785	0.987948	0.000308	0.980281	0.000944	0.996010	0.014184	0.967039
U235									
	ANC	0.001091	1.073481	0.001554	1.044746	0.042070	0.915369	0.172560	1.002041
	BAPL	0.001071	1.054234	0.001543	1.037584	0.042573	0.926306	0.172671	1.002685
	BNL	0.001022	1.005804	0.001545	1.038887	0.040835	0.888497	0.172662	1.002635
	CRNL	0.001102	1.083954	0.001077	0.724244	0.042670	0.928417	0.172601	1.002280
	EPRI	0.001017	1.000875	0.001555	1.043793	0.041167	0.895727	0.172471	1.001521
	SRL	0.001016	1.000000	0.001487	1.000000	0.045960	1.000000	0.172208	1.000000
	SRL*	0.000986	0.970004	0.001465	0.985200	0.039821	0.866439	0.172240	1.000180
U238									
	ANC	0.051190	1.186879	0.065650	1.130656	0.412200	0.987698	0.371000	1.002848
	BAPL	0.050260	1.165792	0.063028	1.085498	0.393108	0.941951	0.371472	1.004123
	BNL	0.043283	1.003548	0.061799	1.064341	0.402530	0.964528	0.371227	1.003461
	CRNL	0.052045	1.206696	0.062560	1.076406	0.423703	1.015260	0.371051	1.002985
	EPRI	0.042987	0.996698	0.063463	1.092963	0.392301	0.940016	0.371079	1.003061
	SRL	0.043130	1.000000	0.058064	1.000000	0.417334	1.000000	0.369946	1.000000
	SRL*	0.041713	0.967146	0.064254	1.106611	0.399130	0.956379	0.369930	0.999957

NORMALIZED SLOWING DOWN SOURCE

LABORATORY	GROUP 1		GROUP 2		GROUP 3	
ANC					1.773600	0.997078
BAPL	2.467366	0.992227	2.365848	0.989253	1.773068	0.996779
BNL	2.455956	0.987639	2.394893	0.993836	1.778183	0.999655
CRNL						
EPRI	2.444544	0.983049	2.381786	0.986398	1.776011	0.998434
SRL	2.486695	1.000000	2.409745	1.000000	1.778797	1.000000
SRL*	2.455150	0.987314	2.372325	0.984471	1.773109	0.996802

TWO GROUP STRUCTURE

****

NORMALIZED REACTION RATES FOR FISSION

ISOTOPE/LAB	GROUP 1		GROUP 2	
U235				
ANC	0.100489	0.990776	1.000000	1.000000
BAPL	0.099222	0.978267	1.000000	1.000000
BNL	0.099448	0.980514	1.000000	1.000000
CRNL	0.113412	1.118195	1.000000	1.000000
EPRI	0.096659	0.953011	1.000000	1.000000
SRL	0.101425	1.000000	1.000000	1.000000
SRL*	0.094557	0.932290	1.000000	1.000000
U238				
ANC	0.105500	0.998605	0.0	
BAPL	0.104407	0.988157	0.0	
BNL	0.103797	0.982381	0.0	
CRNL	0.107748	1.019776	0.0	
EPRI	0.103029	0.975679	0.0	
SRL	0.105659	1.000000	0.0	
SRL*	0.102302	0.968227	0.0	

NORMALIZED REACTION RATES FOR NU*FISSION

ISOTOPE/LAB	GROUP 1		GROUP 2	
U235				
ANC				
BAPL	0.241685	0.978571	2.418811	1.000002
BNL	0.242167	0.980523	2.418798	0.999997
CRNL				
EPRI	0.235392	0.953089	2.418801	0.999998
SRL	0.246978	1.000000	2.418806	1.000000
SRL*	0.230315	0.932534	2.418801	0.999998
U238				
ANC				
BAPL	0.293927	0.988799	0.0	
BNL	0.292059	0.982512	0.0	
CRNL				
EPRI	0.290086	0.975875	0.0	
SRL	0.297257	1.000000	0.0	
SRL*	0.287843	0.968329	0.0	

NORMALIZED REACTION RATES FOR CAPTURE

ISOTOPE/LAB		GROUP 1		GROUP 2	
H					
	ANC				
	BAPL	0.012572	1.153319	0.195135	0.996440
	BNL	0.012787	1.172985	0.194494	0.993163
	CRNL				
	EPRI	0.012778	1.172146	0.195351	0.997438
	SRL	0.010901	1.000000	0.195833	1.000000
	SRL*	0.010859	0.996145	0.190589	0.973222
O					
	ANC				
	BAPL	0.004577	0.992656	0.000053	
	BNL				
	CRNL				
	EPRI				
	SRL	0.004610	1.000000	0.000053	
	SRL*	0.004595	0.996564	0.000050	
AL					
	ANC				
	BAPL	0.002223	1.081051	0.014662	0.999645
	BNL				
	CRNL				
	EPRI				
	SRL	0.002058	1.000000	0.014667	1.000000
	SRL*	0.002037	0.990495	0.014184	0.967039
U235					
	ANC	0.044715	0.922656	0.172560	1.002041
	BAPL	0.045137	0.932404	0.172671	1.002665
	BNL	0.043402	0.895573	0.172662	1.002635
	CRNL	0.044849	0.925413	0.172601	1.002280
	EPRI	0.043737	0.902476	0.172471	1.001521
	SRL	0.048453	1.000000	0.172208	1.000000
	SRL*	0.042272	0.872256	0.172240	1.000180
U238					
	ANC	0.529040	1.020273	0.371000	1.002848
	BAPL	0.506417	0.976644	0.371472	1.004123
	BNL	0.507613	0.978950	0.371227	1.003461
	CRNL	0.538247	1.038030	0.371051	1.002985
	EPRI	0.498751	0.961860	0.371079	1.003061
	SRL	0.518528	1.000000	0.369946	1.000000
	SRL*	0.505096	0.974097	0.369930	0.999957

IV. COMPARISON OF FAST MULTIGROUP CROSS SECTIONS

FAST GROUP STRUCTURE
(MUFT GROUPS 1-20)

Group	Upper Energy, Mev	Lower Lethargy
1	10.00000	0.25
2	7.78801	0.50
3	6.06531	0.75
4	4.72367	1.00
5	3.67879	1.25
6	2.86505	1.50
7	2.23130	1.75
8	1.73774	2.00
9	1.35335	2.25
10	1.05399	2.50
11	0.82085	2.75
12	0.63928	3.00
13	0.49787	3.25
14	0.38774	3.50
15	0.30194	3.75
16	0.23518	4.00
17	0.18316	4.25
18	0.14264	4.50
19	0.11109	4.75
20	0.08652	5.00

FAST MULTIGROUP EDITS

Pages 28 through 92

COMPARISON OF FAST CROSS SECTIONS FOR H-H2O ----- ELASTIC

GROUP	SRL	ANC	BAPL	ENL	CRNL
1	0.1046E 01	0.1073E 01	0.1075E 01	0.1072E 01	0.1073E 01
2	0.1284E 01	0.1307E 01	0.1313E 01	0.1306E 01	0.1306E 01
3	0.1552E 01	0.1570E 01	0.1573E 01	0.1570E 01	0.1570E 01
4	0.1849E 01	0.1864E 01	0.1861E 01	0.1863E 01	0.1863E 01
5	0.2177E 01	0.2188E 01	0.2196E 01	0.2187E 01	0.2187E 01
6	0.2537E 01	0.2543E 01	0.2547E 01	0.2543E 01	0.2542E 01
7	0.2935E 01	0.2939E 01	0.2943E 01	0.2939E 01	0.2939E 01
8	0.3380E 01	0.3381E 01	0.3387E 01	0.3381E 01	0.3379E 01
9	0.3869E 01	0.3869E 01	0.3871E 01	0.3866E 01	0.3869E 01
10	0.4419E 01	0.4415E 01	0.4446E 01	0.4415E 01	0.4416E 01
11	0.5046E 01	0.5039E 01	0.5044E 01	0.5039E 01	0.5039E 01
12	0.5755E 01	0.5746E 01	0.5759E 01	0.5746E 01	0.5745E 01
13	0.6556E 01	0.6544E 01	0.6569E 01	0.6544E 01	0.6542E 01
14	0.7459E 01	0.7444E 01	0.7476E 01	0.7444E 01	0.7442E 01
15	0.8443E 01	0.8425E 01	0.8451E 01	0.8425E 01	0.8422E 01
16	0.9490E 01	0.9472E 01	0.9501E 01	0.9473E 01	0.9471E 01
17	0.1060E 02	0.1058E 02	0.1062E 02	0.1058E 02	0.1058E 02
18	0.1173E 02	0.1170E 02	0.1174E 02	0.1170E 02	0.1170E 02
19	0.1284E 02	0.1281E 02	0.1285E 02	0.1281E 02	0.1280E 02
20	0.1391E 02	0.1389E 02	0.1392E 02	0.1389E 02	0.1387E 02

RELATIVE VALUES FOR H-H2O ----- ELASTIC

GROUP	SRL	ANC	BAFL	ENL	CRNL
1	1.000	1.026	1.028	1.025	1.026
2	1.000	1.018	1.023	1.017	1.017
3	1.000	1.012	1.014	1.012	1.012
4	1.000	1.008	1.007	1.008	1.008
5	1.000	1.005	1.009	1.005	1.005
6	1.000	1.002	1.004	1.002	1.002
7	1.000	1.001	1.003	1.001	1.001
8	1.000	1.000	1.002	1.000	1.000
9	1.000	1.000	1.000	1.000	1.000
10	1.000	0.999	1.006	0.999	0.999
11	1.000	0.999	1.000	0.999	0.999
12	1.000	0.998	1.001	0.998	0.998
13	1.000	0.998	1.002	0.998	0.998
14	1.000	0.998	1.002	0.998	0.998
15	1.000	0.998	1.001	0.998	0.998
16	1.000	0.998	1.001	0.998	0.998
17	1.000	0.998	1.002	0.998	0.998
18	1.000	0.997	1.001	0.997	0.997
19	1.000	0.998	1.001	0.998	0.997
20	1.000	0.999	1.001	0.999	0.997

COMPARISON OF FAST CROSS SECTIONS FOR H-H2O ----- CAPTURE

GROUP	SRL	ANC	BAPL	BNL	CRNL
1	0.3337E-04	0.3355E-04	0.3357E-04	0.3354E-04	0.3355E-04
2	0.3514E-04	0.3527E-04	0.3530E-04	0.3526E-04	0.3527E-04
3	0.3615E-04	0.3619E-04	0.3620E-04	0.3619E-04	0.3619E-04
4	0.3627E-04	0.3626E-04	0.3626E-04	0.3626E-04	0.3626E-04
5	0.3583E-04	0.3581E-04	0.3580E-04	0.3581E-04	0.3581E-04
6	0.3503E-04	0.3501E-04	0.3500E-04	0.3501E-04	0.3501E-04
7	0.3432E-04	0.3432E-04	0.3432E-04	0.3432E-04	0.3433E-04
8	0.3434E-04	0.3433E-04	0.3433E-04	0.3433E-04	0.3434E-04
9	0.3444E-04	0.3444E-04	0.3444E-04	0.3444E-04	0.3444E-04
10	0.3459E-04	0.3459E-04	0.3461E-04	0.3458E-04	0.3458E-04
11	0.3538E-04	0.3536E-04	0.3537E-04	0.3536E-04	0.3536E-04
12	0.3719E-04	0.3717E-04	0.3720E-04	0.3717E-04	0.3715E-04
13	0.3984E-04	0.3979E-04	0.3990E-04	0.3978E-04	0.3984E-04
14	0.4483E-04	0.4474E-04	0.4493E-04	0.4473E-04	0.4473E-04
15	0.5186E-04	0.5172E-04	0.5192E-04	0.5172E-04	0.5167E-04
16	0.6153E-04	0.6136E-04	0.6164E-04	0.6135E-04	0.6131E-04
17	0.7436E-04	0.7411E-04	0.7454E-04	0.7410E-04	0.7409E-04
18	0.9012E-04	0.8974E-04	0.9033E-04	0.8974E-04	0.8972E-04
19	0.1090E-03	0.1086E-03	0.1093E-03	0.1086E-03	0.1086E-03
20	0.1307E-03	0.1302E-03	0.1311E-03	0.1302E-03	0.1302E-03

RELATIVE VALUES FOR H-H2O ----- CAPTURE

GROUP	SRL	ANC	BAPL	BNL	CRNL
1	1.000	1.005	1.006	1.005	1.005
2	1.000	1.004	1.005	1.003	1.004
3	1.000	1.001	1.001	1.001	1.001
4	1.000	1.000	1.000	1.000	1.000
5	1.000	0.999	0.999	0.999	0.999
6	1.000	0.999	0.999	0.999	0.999
7	1.000	1.000	1.000	1.000	1.000
8	1.000	1.000	1.000	1.000	1.000
9	1.000	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000
11	1.000	0.999	1.000	0.999	0.999
12	1.000	0.999	1.000	0.999	0.999
13	1.000	0.999	1.002	0.998	1.000
14	1.000	0.998	1.002	0.998	0.998
15	1.000	0.997	1.001	0.997	0.996
16	1.000	0.997	1.002	0.997	0.996
17	1.000	0.997	1.002	0.997	0.996
18	1.000	0.996	1.002	0.996	0.996
19	1.000	0.996	1.003	0.996	0.996
20	1.000	0.996	1.003	0.996	0.996

COMPARISON OF FAST CROSS SECTIONS FOR H-H2O ----- MU-BAR

GROUP	SRL	ANC	BAPL	BNL	CRNL
1	0.6628E 00	0.6639E 00	0.6618E 00	0.6618E 00	0.6618E 00
2	0.6637E 00	0.6645E 00	0.6624E 00	0.6624E 00	0.6624E 00
3	0.6637E 00	0.6650E 00	0.6629E 00	0.6628E 00	0.6629E 00
4	0.6642E 00	0.6654E 00	0.6633E 00	0.6633E 00	0.6633E 00
5	0.6646E 00	0.6662E 00	0.6636E 00	0.6636E 00	0.6636E 00
6	0.6648E 00	0.6668E 00	0.6639E 00	0.6639E 00	0.6639E 00
7	0.6648E 00	0.6672E 00	0.6641E 00	0.6642E 00	0.6641E 00
8	0.6654E 00	0.6672E 00	0.6643E 00	0.6643E 00	0.6643E 00
9	0.6656E 00	0.6672E 00	0.6645E 00	0.6645E 00	0.6645E 00
10	0.6645E 00	0.6672E 00	0.6646E 00	0.6646E 00	0.6646E 00
11	0.6631E 00	0.6671E 00	0.6647E 00	0.6647E 00	0.6647E 00
12	0.6624E 00	0.6670E 00	0.6648E 00	0.6648E 00	0.6648E 00
13	0.6625E 00	0.6670E 00	0.6649E 00	0.6649E 00	0.6649E 00
14	0.6635E 00	0.6671E 00	0.6650E 00	0.6650E 00	0.6650E 00
15	0.6658E 00	0.6671E 00	0.6650E 00	0.6650E 00	0.6650E 00
16	0.6661E 00	0.6672E 00	0.6651E 00	0.6651E 00	0.6651E 00
17	0.6659E 00	0.6672E 00	0.6651E 00	0.6651E 00	0.6651E 00
18	0.6662E 00	0.6673E 00	0.6652E 00	0.6651E 00	0.6652E 00
19	0.6662E 00	0.6673E 00	0.6652E 00	0.6652E 00	0.6652E 00
20	0.6661E 00	0.6672E 00	0.6652E 00	0.6652E 00	0.6652E 00

RELATIVE VALUES FOR H-H2O ----- MU-BAR

GROUP	SRL	ANC	EAPL	BNL	CRNL
1	1.000	1.002	0.998	0.998	0.998
2	1.000	1.001	0.998	0.998	0.998
3	1.000	1.002	0.999	0.999	0.999
4	1.000	1.002	0.999	0.999	0.999
5	1.000	1.002	0.998	0.998	0.998
6	1.000	1.003	0.999	0.999	0.999
7	1.000	1.004	0.999	0.999	0.999
8	1.000	1.003	0.998	0.998	0.998
9	1.000	1.002	0.998	0.998	0.998
10	1.000	1.004	1.000	1.000	1.000
11	1.000	1.006	1.002	1.002	1.002
12	1.000	1.007	1.004	1.004	1.004
13	1.000	1.007	1.004	1.004	1.004
14	1.000	1.005	1.002	1.002	1.002
15	1.000	1.002	0.999	0.999	0.999
16	1.000	1.002	0.998	0.998	0.998
17	1.000	1.002	0.999	0.999	0.999
18	1.000	1.002	0.998	0.998	0.998
19	1.000	1.002	0.999	0.998	0.998
20	1.000	1.002	0.999	0.999	0.999

COMPARISON OF FAST CROSS SECTIONS FOR C-C20 ----- ELASTIC

GROUP	SRL	BNL	CRNL
1	0.1010E 01	0.1038E 01	0.1264E 01
2	0.1256E 01	0.1278E 01	0.1437E 01
3	0.1520E 01	0.1537E 01	0.1627E 01
4	0.1790E 01	0.1802E 01	0.1827E 01
5	0.2039E 01	0.2047E 01	0.2048E 01
6	0.2269E 01	0.2273E 01	0.2275E 01
7	0.2472E 01	0.2474E 01	0.2475E 01
8	0.2646E 01	0.2646E 01	0.2646E 01
9	0.2793E 01	0.2793E 01	0.2793E 01
10	0.2912E 01	0.2912E 01	0.2912E 01
11	0.2967E 01	0.2966E 01	0.2967E 01
12	0.3016E 01	0.3015E 01	0.3014E 01
13	0.3064E 01	0.3063E 01	0.3061E 01
14	0.3108E 01	0.3107E 01	0.3106E 01
15	0.3148E 01	0.3147E 01	0.3146E 01
16	0.3184E 01	0.3184E 01	0.3183E 01
17	0.3216E 01	0.3215E 01	0.3214E 01
18	0.3241E 01	0.3240E 01	0.3240E 01
19	0.3262E 01	0.3262E 01	0.3261E 01
20	0.3276E 01	0.3276E 01	0.3275E 01

RELATIVE VALUES FOR C-C20 ----- ELASTIC

GROUP	SRL	BNL	CRNL
1	1.000	1.028	1.251
2	1.000	1.018	1.144
3	1.000	1.011	1.070
4	1.000	1.007	1.021
5	1.000	1.004	1.004
6	1.000	1.002	1.003
7	1.000	1.001	1.001
8	1.000	1.000	1.000
9	1.000	1.000	1.000
10	1.000	1.000	1.000
11	1.000	1.000	1.000
12	1.000	1.000	0.999
13	1.000	1.000	0.999
14	1.000	1.000	0.999
15	1.000	1.000	0.999
16	1.000	1.000	1.000
17	1.000	1.000	0.999
18	1.000	1.000	1.000
19	1.000	1.000	1.000
20	1.000	1.000	1.000

COMPARISON OF FAST CROSS SECTIONS FOR C-D2O ------ CAPTURE

GROUP	SRL	BNL*	CRNL
1	0.9952E-05	-0.1128E 00	0.9964E-05
2	0.9893E-05	-0.7891E-01	0.9864E-05
3	0.9441E-05	-0.4447E-01	0.9395E-05
4	0.8737E-05	-0.1169E-01	0.8696E-05
5	0.7938E-05	-0.4573E-03	0.7913E-05
6	0.6990E-05	0.6971E-05	0.6966E-05
7	0.6044E-05	0.6035E-05	0.6032E-05
8	0.5236E-05	0.5231E-05	0.5230E-05
9	0.4603E-05	0.4604E-05	0.4603E-05
10	0.4037E-05	0.4040E-05	0.4040E-05
11	0.3481E-05	0.3486E-05	0.3486E-05
12	0.3035E-05	0.3039E-05	0.3038E-05
13	0.2732E-05	0.2735E-05	0.2734E-05
14	0.2503E-05	0.2506E-05	0.2505E-05
15	0.2313E-05	0.2316E-05	0.2315E-05
16	0.2131E-05	0.2134E-05	0.2134E-05
17	0.1978E-05	0.1981E-05	0.1980E-05
18	0.1841E-05	0.1844E-05	0.1843E-05
19	0.1716E-05	0.1718E-05	0.1718E-05
20	0.1616E-05	0.1617E-05	0.1617E-05

* Capture minus (n,2n)

RELATIVE VALUES FOR C-C20 ----- CAPTURE

GROUP	SRL	BNL	CRNL
1	1.000	*****	1.001
2	1.000	*****	0.997
3	1.000	*****	0.995
4	1.000	*****	0.995
5	1.000	*****	0.997
6	1.000	0.997	0.997
7	1.000	0.999	0.998
8	1.000	0.999	0.999
9	1.000	1.000	1.000
10	1.000	1.001	1.001
11	1.000	1.001	1.001
12	1.000	1.001	1.001
13	1.000	1.001	1.001
14	1.000	1.001	1.001
15	1.000	1.001	1.001
16	1.000	1.001	1.001
17	1.000	1.002	1.001
18	1.000	1.002	1.001
19	1.000	1.001	1.001
20	1.000	1.001	1.001

COMPARISON OF FAST CROSS SECTIONS FOR C-12C ----- MU-BAR

GROUP	SRL	BNL	CRNL
1	0.5364E 00	0.5333E 00	0.4383E 00
2	0.5166E 00	0.5132E 00	0.4568E 00
3	0.4687E 00	0.4639E 00	0.4381E 00
4	0.3984E 00	0.3937E 00	0.3866E 00
5	0.3213E 00	0.3166E 00	0.3165E 00
6	0.2484E 00	0.2445E 00	0.2443E 00
7	0.1857E 00	0.1823E 00	0.1821E 00
8	0.1343E 00	0.1311E 00	0.1310E 00
9	0.9743E-01	0.9422E-01	0.9421E-01
10	0.7423E-01	0.7094E-01	0.7093E-01
11	0.6028E-01	0.5690E-01	0.5690E-01
12	0.5504E-01	0.5150E-01	0.5150E-01
13	0.6388E-01	0.5889E-01	0.5887E-01
14	0.9391E-01	0.8763E-01	0.8761E-01
15	0.1474E 00	0.1429E 00	0.1428E 00
16	0.2112E 00	0.2070E 00	0.2069E 00
17	0.2486E 00	0.2445E 00	0.2444E 00
18	0.2737E 00	0.2690E 00	0.2689E 00
19	0.2888E 00	0.2770E 00	0.2770E 00
20	0.3000E 00	0.2827E 00	0.2827E 00

RELATIVE VALUES FOR D-D2O ----- MU-BAR

GROUP	SRL	BNL	CRNL
1	1.000	0.994	0.817
2	1.000	0.993	0.884
3	1.000	0.990	0.935
4	1.000	0.988	0.975
5	1.000	0.985	0.965
6	1.000	0.984	0.983
7	1.000	0.982	0.981
8	1.000	0.976	0.975
9	1.000	0.967	0.967
10	1.000	0.956	0.956
11	1.000	0.944	0.944
12	1.000	0.936	0.936
13	1.000	0.922	0.922
14	1.000	0.933	0.933
15	1.000	0.969	0.969
16	1.000	0.980	0.980
17	1.000	0.984	0.983
18	1.000	0.983	0.982
19	1.000	0.959	0.959
20	1.000	0.942	0.942

COMPARISON OF FAST CROSS SECTIONS FOR C-D2O ----- N2N

GROUP	SRL	CFNL
1	0.1169E 00	0.1126E 00
2	0.8193E-01	0.7879E-01
3	0.4670E-01	0.4435E-01
4	0.1295E-01	0.1162E-01
5	0.5343E-03	0.0
6	0.0	0.0
7	0.0	0.0
8	0.0	0.0
9	0.0	0.0
10	0.0	0.0
11	0.0	0.0
12	0.0	0.0
13	0.0	0.0
14	0.0	0.0
15	0.0	0.0
16	0.0	0.0
17	0.0	0.0
18	0.0	0.0
19	0.0	0.0
20	0.0	0.0

RELATIVE VALUES FOR C-C20 ----- N2N

GROUP	SRL	CRNL
1	1.000	0.963
2	1.000	0.962
3	1.000	0.950
4	1.000	0.897
5	1.000	0.0
6	0.0	0.0
7	0.0	0.0
8	0.0	0.0
9	0.0	0.0
10	0.0	0.0
11	0.0	0.0
12	0.0	0.0
13	0.0	0.0
14	0.0	0.0
15	0.0	0.0
16	0.0	0.0
17	0.0	0.0
18	0.0	0.0
19	0.0	0.0
20	0.0	0.0

COMPARISON OF FAST CROSS SECTIONS FOR D-D2O ----- INELAST

GROUP	SRL	BNL*	CRNL*
1	0.0	0.2255E 00	0.1126E 00
2	0.0	0.1578E 00	0.7879E-01
3	0.0	0.8896E-01	0.4435E-01
4	0.0	0.2339E-01	0.1162E-01
5	0.0	0.9304E-03	0.4607E-03
6	0.0	0.0	0.0
7	0.0	0.0	0.0
8	0.0	0.0	0.0
9	0.0	0.0	0.0
10	0.0	0.0	0.0
11	0.0	0.0	0.0
12	0.0	0.0	0.0
13	0.0	0.0	0.0
14	0.0	0.0	0.0
15	0.0	0.0	0.0
16	0.0	0.0	0.0
17	0.0	0.0	0.0
18	0.0	0.0	0.0
19	0.0	0.0	0.0
20	0.0	0.0	0.0

* BNL = 2x (n,2n) cross sections; CRNL = (n,2n) cross sections

RELATIVE VALUES FCR D-D2O ----- INELAST

GRCUP	SRL	BNL	CRNL
1	0.0	0.0	0.0
2	0.0	0.0	0.0
3	0.0	0.0	0.0
4	0.0	0.0	0.0
5	0.0	0.0	0.0
6	0.0	0.0	0.0
7	0.0	0.0	0.0
8	0.0	0.0	0.0
9	0.0	0.0	0.0
10	0.0	0.0	0.0
11	0.0	0.0	0.0
12	0.0	0.0	0.0
13	0.0	0.0	0.0
14	0.0	0.0	0.0
15	0.0	0.0	0.0
16	0.0	0.0	0.0
17	0.0	0.0	0.0
18	0.0	0.0	0.0
19	0.0	0.0	0.0
20	0.0	0.0	0.0

COMPARISON OF FAST CROSS SECTIONS FOR C16 ----- ELASTIC

GROUP	SRL	ANC	BAPL	BNL	CRNL
1	0.8632E 00	0.8726E 00	0.8714E 00	0.8704E 00	0.1090E 01
2	0.9384E 00	0.9246E 00	0.9219E 00	0.9257E 00	0.9882E 00
3	0.1295E 01	0.1294E 01	0.1297E 01	0.1294E 01	0.1291E 01
4	0.1980E 01	0.2085E 01	0.2048E 01	0.2063E 01	0.2065E 01
5	0.2438E 01	0.2324E 01	0.2286E 01	0.2358E 01	0.2366E 01
6	0.9165E 00	0.8949E 00	0.8912E 00	0.9038E 00	0.8959E 00
7	0.1745E 01	0.1768E 01	0.1762E 01	0.1757E 01	0.1767E 01
8	0.2222E 01	0.2231E 01	0.2231E 01	0.2224E 01	0.2217E 01
9	0.3667E 01	0.3657E 01	0.3638E 01	0.3668E 01	0.3655E 01
10	0.4871E 01	0.4844E 01	0.4597E 01	0.4906E 01	0.4917E 01
11	0.2709E 01	0.2709E 01	0.2708E 01	0.2707E 01	0.2815E 01
12	0.3339E 01	0.3337E 01	0.3346E 01	0.3319E 01	0.3511E 01
13	0.9680E 01	0.9685E 01	0.9406E 01	0.9686E 01	0.9650E 01
14	0.4056E 01	0.4062E 01	0.4026E 01	0.4078E 01	0.4129E 01
15	0.3494E 01	0.3494E 01	0.3492E 01	0.3495E 01	0.3567E 01
16	0.3462E 01	0.3462E 01	0.3462E 01	0.3462E 01	0.3525E 01
17	0.3495E 01	0.3495E 01	0.3496E 01	0.3495E 01	0.3547E 01
18	0.3537E 01	0.3536E 01	0.3537E 01	0.3536E 01	0.3573E 01
19	0.3575E 01	0.3574E 01	0.3576E 01	0.3575E 01	0.3596E 01
20	0.3610E 01	0.3609E 01	0.3611E 01	0.3610E 01	0.3618E 01

RELATIVE VALLES FCR C16 ----- ELASTIC

GROUP	SRL	ANC	BAFL	BNL	CRNL
1	1.000	1.011	1.010	1.008	1.263
2	1.000	0.985	0.982	0.986	1.053
3	1.000	0.999	1.002	0.999	0.997
4	1.000	1.055	1.034	1.042	1.043
5	1.000	0.953	0.938	0.967	0.970
6	1.000	0.976	0.972	0.986	0.978
7	1.000	1.013	1.010	1.007	1.013
8	1.000	1.004	1.004	1.001	0.998
9	1.000	0.997	0.992	1.000	0.997
10	1.000	0.994	0.944	1.007	1.009
11	1.000	1.000	1.000	0.999	1.039
12	1.000	0.999	1.002	0.994	1.052
13	1.000	1.001	0.972	1.001	0.997
14	1.000	1.001	0.993	1.005	1.018
15	1.000	1.000	1.000	1.000	1.021
16	1.000	1.000	1.000	1.000	1.018
17	1.000	1.000	1.000	1.000	1.015
18	1.000	1.000	1.000	1.000	1.010
19	1.000	1.000	1.000	1.000	1.006
20	1.000	1.000	1.000	1.000	1.002

COMPARISON OF FAST CROSS SECTIONS FOR O16 ----- CAPTURE

GROUP	SRL	ANC	EAPL	BNL	CRNL
1	0.1183E 00	0.1029E 00	0.1026E 00	0.1047E 00	0.1024E 00
2	0.8444E-01	0.8311E-01	0.8265E-01	0.8343E-01	0.8269E-01
3	0.5730E-01	0.6392E-01	0.6482E-01	0.6271E-01	0.4491E-01
4	0.6111E-01	0.5666E-01	0.5946E-01	0.5775E-01	0.5026E-01
5	0.9973E-03	0.8557E-03	0.8067E-03	0.8956E-03	0.1391E-02
6	0.2533E-07	0.2427E-07	0.2430E-07	0.2470E-07	0.3000E-03
7	0.2013E-07	0.2019E-07	0.2018E-07	0.2016E-07	0.2016E-07
8	0.2282E-07	0.2286E-07	0.2286E-07	0.2283E-07	0.2282E-07
9	0.2565E-07	0.2588E-07	0.2566E-07	0.2585E-07	0.2565E-07
10	0.2929E-07	0.2931E-07	0.2947E-07	0.2927E-07	0.2928E-07
11	0.3320E-07	0.3320E-07	0.3318E-07	0.3316E-07	0.3317E-07
12	0.3762E-07	0.3761E-07	0.3764E-07	0.3756E-07	0.3755E-07
13	0.4262E-07	0.4261E-07	0.4270E-07	0.4255E-07	0.4252E-07
14	0.4830E-07	0.4827E-07	0.4841E-07	0.4621E-07	0.4620E-07
15	0.5474E-07	0.5469E-07	0.5478E-07	0.5462E-07	0.5460E-07
16	0.6202E-07	0.6197E-07	0.6210E-07	0.6190E-07	0.6189E-07
17	0.7027E-07	0.7021E-07	0.7038E-07	0.7011E-07	0.7009E-07
18	0.7964E-07	0.7955E-07	0.7976E-07	0.7942E-07	0.7940E-07
19	0.9024E-07	0.9014E-07	0.9040E-07	0.9002E-07	0.9002E-07
20	0.1023E-06	0.1021E-06	0.1024E-06	0.1020E-06	0.1020E-06

RELATIVE VALUES FOR C16 ----- CAPTURE

GROUP	SRL	ANC	BAPL	BNL	CRNL
1	1.000	0.870	0.868	0.885	0.866
2	1.000	0.984	0.979	0.988	0.979
3	1.000	1.116	1.131	1.094	0.784
4	1.000	0.927	0.973	0.945	0.822
5	1.000	0.858	0.809	0.898	1.395
6	1.000	0.958	0.959	0.975	*****
7	1.000	1.003	1.003	1.001	1.001
8	1.000	1.002	1.002	1.000	1.000
9	1.000	1.001	1.000	1.000	1.000
10	1.000	1.001	1.006	0.999	1.000
11	1.000	1.000	1.000	0.999	0.999
12	1.000	1.000	1.000	0.998	0.998
13	1.000	1.000	1.002	0.998	0.998
14	1.000	0.999	1.002	0.998	0.998
15	1.000	0.999	1.001	0.998	0.997
16	1.000	0.999	1.001	0.998	0.998
17	1.000	0.999	1.002	0.998	0.997
18	1.000	0.999	1.002	0.997	0.997
19	1.000	0.999	1.002	0.998	0.998
20	1.000	0.998	1.001	0.997	0.997

COMPARISON OF FAST CROSS SECTIONS FOR C16 ----- MU-BAR

GROUP	SRL	ANC	BAPL	BNL	CRNL
1	0.1999E 00	0.2024E 00	0.2327E 00	0.2358E 00	0.1961E 00
2	0.1543E 00	0.1648E 00	0.1623E 00	0.1641E 00	0.1148E 00
3	0.2823E 00	0.2843E 00	0.2821E 00	0.2835E 00	0.2196E 00
4	0.3415E 00	0.3401E 00	0.3486E 00	0.3413E 00	0.3479E 00
5	0.2628E 00	0.2565E 00	0.2583E 00	0.2588E 00	0.2288E 00
6	0.1436E 00	0.1355E 00	0.1367E 00	0.1392E 00	0.6381E-01
7	0.7770E-01	0.7886E-01	0.7447E-01	0.7661E-01	0.1214E 00
8	0.4643E-01	0.4981E-01	0.5093E-01	0.4743E-01	0.1409E 00
9	0.8201E-01	0.7619E-01	0.7783E-01	0.8311E-01	0.1139E 00
10	0.1411E-01	0.1435E-01	0.1633E-01	0.1377E-01	0.5848E-01
11	0.7222E-01	0.7240E-01	0.7198E-01	0.7143E-01	0.1650E 00
12	0.2834E 00	0.2830E 00	0.2848E 00	0.2799E 00	0.3610E 00
13	0.2206E 00	0.2225E 00	0.2176E 00	0.2294E 00	0.2289E 00
14	-0.2051E 00	-0.2052E 00	-0.2049E 00	-0.2058E 00	-0.1856E 00
15	-0.1535E 00	-0.1538E 00	-0.1531E 00	-0.1546E 00	-0.1061E 00
16	-0.1068E 00	-0.1071E 00	-0.1063E 00	-0.1076E 00	-0.5349E-01
17	-0.7049E-01	-0.7079E-01	-0.7014E-01	-0.7122E-01	-0.2416E-01
18	-0.4218E-01	-0.4255E-01	-0.4200E-01	-0.4290E-01	-0.6821E-02
19	-0.2089E-01	-0.2110E-01	-0.2067E-01	-0.2124E-01	0.4032E-02
20	-0.6684E-02	-0.6838E-02	-0.6535E-02	-0.6904E-02	0.1246E-01

RELATIVE VALUES FOR O16 ----- MU-BAR

GROUP	SRL	ANC	EAPL	BNL	CRNL
1	1.000	1.013	1.164	1.180	0.981
2	1.000	1.068	1.056	1.064	0.744
3	1.000	1.008	1.000	1.005	0.779
4	1.000	0.996	1.021	0.999	1.019
5	1.000	0.984	0.983	0.985	0.871
6	1.000	0.944	0.952	0.969	0.444
7	1.000	1.015	0.998	1.012	1.562
8	1.000	1.073	1.097	1.022	3.035
9	1.000	0.929	0.949	1.013	1.389
10	1.000	1.017	1.158	0.976	4.145
11	1.000	1.002	0.997	0.989	2.562
12	1.000	0.999	1.005	0.988	1.274
13	1.000	1.009	0.941	1.040	1.038
14	1.000	1.000	0.999	1.003	0.905
15	1.000	1.002	0.997	1.007	0.691
16	1.000	1.003	0.995	1.007	0.501
17	1.000	1.004	0.995	1.010	0.343
18	1.000	1.009	0.996	1.017	0.162
19	1.000	1.011	0.990	1.017	-.193
20	1.000	1.023	0.978	1.033	*****

COMPARISON OF FAST CROSS SECTIONS FOR O16 ------ INELAST

GROUP	SRL	ANC	BAPL	BNL	CRNL
1	0.2470E 00	0.2446E 00	0.2448E 00	0.2450E 00	0.1984E 00
2	0.9940E-01	0.7099E-01	0.6675E-01	0.7484E-01	0.3892E-01
3	0.0	0.0	0.0	0.0	0.1836E-08
4	0.0	0.0	0.0	0.0	0.1195E-08
5	0.0	0.0	0.0	0.0	0.6917E-09
6	0.0	0.0	0.0	0.0	0.2973E-09
7	0.0	0.0	0.0	0.0	0.2856E-09
8	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0

RELATIVE VALUES FOR C16 ----- INELAST

GROUP	SRL	ANC	EAPL	BNL	CRNL
1	1.000	0.990	0.991	0.992	0.803
2	1.000	0.714	0.672	0.753	0.[illegible]92
3	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0

COMPARISON OF FAST CROSS SECTIONS FOR AL27 ----- ELASTIC

GROUP	SRL	ANC	BAFL	ENL	CRNL
1	0.7467E 00	0.7717E 00	0.7707E 00	0.7676E 00	0.7666E 00
2	0.1027E 01	0.1066E 01	0.1071E 01	0.1060E 01	0.1062E 01
3	0.1317E 01	0.1338E 01	0.1337E 01	0.1333E 01	0.1334E 01
4	0.1571E 01	0.1597E 01	0.1587E 01	0.1590E 01	0.1592E 01
5	0.1925E 01	0.1938E 01	0.1942E 01	0.1934E 01	0.1935E 01
6	0.2580E 01	0.2569E 01	0.2564E 01	0.2565E 01	0.2566E 01
7	0.2713E 01	0.2703E 01	0.2706E 01	0.2709E 01	0.2708E 01
8	0.2831E 01	0.2835E 01	0.2836E 01	0.2831E 01	0.2832E 01
9	0.3123E 01	0.3129E 01	0.3140E 01	0.3123E 01	0.3123E 01
10	0.3354E 01	0.3361E 01	0.3434E 01	0.3344E 01	0.3345E 01
11	0.4014E 01	0.4012E 01	0.4022E 01	0.4025E 01	0.4025E 01
12	0.3646E 01	0.3845E 01	0.3850E 01	0.3840E 01	0.3840E 01
13	0.4181E 01	0.4183E 01	0.4154E 01	0.4184E 01	0.4186E 01
14	0.3591E 01	0.3586E 01	0.3598E 01	0.3577E 01	0.3575E 01
15	0.3411E 01	0.3431E 01	0.3384E 01	0.3467E 01	0.3464E 01
16	0.4452E 01	0.4457E 01	0.4442E 01	0.4463E 01	0.4463E 01
17	0.7456E 01	0.7382E 01	0.7572E 01	0.7275E 01	0.7279E 01
18	0.4102E 01	0.4122E 01	0.4070E 01	0.4161E 01	0.4159E 01
19	0.8082E 01	0.7921E 01	0.8336E 01	0.7731E 01	0.7731E 01
20	0.6089E 01	0.6236E 01	0.5854E 01	0.6407E 01	0.6409E 01

RELATIVE VALUES FOR AL27 ----- ELASTIC

GROUP	SRL	ANC	BAPL	BNL	CRNL
1	1.000	1.033	1.032	1.028	1.029
2	1.000	1.038	1.043	1.032	1.034
3	1.000	1.016	1.015	1.012	1.013
4	1.000	1.017	1.010	1.012	1.013
5	1.000	1.007	1.009	1.005	1.005
6	1.000	1.003	1.002	1.002	1.002
7	1.000	0.996	0.997	0.999	0.998
8	1.000	1.001	1.002	1.000	1.000
9	1.000	1.002	1.006	1.000	1.000
10	1.000	1.002	1.024	0.997	0.997
11	1.000	1.000	1.002	1.003	1.003
12	1.000	1.000	1.001	0.998	0.998
13	1.000	1.000	0.994	1.001	1.001
14	1.000	0.999	1.002	0.996	0.996
15	1.000	1.006	0.992	1.016	1.016
16	1.000	1.001	0.998	1.002	1.002
17	1.000	0.990	1.016	0.976	0.976
18	1.000	1.005	0.992	1.014	1.014
19	1.000	0.980	1.031	0.957	0.957
20	1.000	1.024	0.961	1.052	1.053

COMPARISON OF FAST CROSS SECTIONS FOR AL27 ----- CAPTURE

GROUP	SRL	ANC	EAPL	BNL	CRNL
1	0.1625E 00	0.1518E 00	0.1516E 00	0.1530E 00	0.1526E 00
2	0.8150E-01	0.7467E-01	0.7366E-01	0.7561E-01	0.7533E-01
3	0.3279E-01	0.3018E-01	0.3020E-01	0.3063E-01	0.3051E-01
4	0.1172E-01	0.1087E-01	0.1105E-01	0.1105E-01	0.1101E-01
5	0.4174E-02	0.3798E-02	0.3666E-02	0.3906E-02	0.3888E-02
6	0.2734E-03	0.2542E-03	0.2550E-03	0.2608E-03	0.2596E-03
7	0.1459E-03	0.1460E-03	0.1460E-03	0.1460E-03	0.1460E-03
8	0.1409E-03	0.1408E-03	0.1408E-03	0.1409E-03	0.1408E-03
9	0.1341E-03	0.1340E-03	0.1341E-03	0.1341E-03	0.1341E-03
10	0.1817E-03	0.1825E-03	0.1889E-03	0.1808E-03	0.1809E-03
11	0.3052E-03	0.3053E-03	0.3050E-03	0.3045E-03	0.3045E-03
12	0.3649E-03	0.3649E-03	0.3652E-03	0.3643E-03	0.3642E-03
13	0.7216E-03	0.7196E-03	0.7294E-03	0.7131E-03	0.7130E-03
14	0.8311E-03	0.8322E-03	0.8269E-03	0.8346E-03	0.8342E-03
15	0.7605E-03	0.7597E-03	0.7612E-03	0.7586E-03	0.7583E-03
16	0.8901E-03	0.8883E-03	0.8927E-03	0.8862E-03	0.8859E-03
17	0.1918E-02	0.1901E-02	0.1943E-02	0.1878E-02	0.1878E-02
18	0.2696E-02	0.2692E-02	0.2730E-02	0.2685E-02	0.2686E-02
19	0.2651E-02	0.2632E-02	0.2679E-02	0.2608E-02	0.2608E-02
20	0.1866E-02	0.1895E-02	0.1818E-02	0.1929E-02	0.1930E-02

RELATIVE VALUES FOR AL27 ----- CAPTURE

GROUP	SRL	ANC	BAPL	BNL	CRNL
1	1.000	0.934	0.933	0.942	0.939
2	1.000	0.916	0.904	0.928	0.924
3	1.000	0.920	0.921	0.934	0.930
4	1.000	0.927	0.942	0.943	0.939
5	1.000	0.910	0.878	0.936	0.931
6	1.000	0.940	0.943	0.964	0.960
7	1.000	1.001	1.000	1.001	1.001
8	1.000	0.999	0.999	1.000	0.999
9	1.000	0.999	1.000	1.000	1.000
10	1.000	1.004	1.040	0.995	0.996
11	1.000	1.000	0.999	0.998	0.998
12	1.000	1.000	1.001	0.998	0.998
13	1.000	0.997	1.011	0.988	0.988
14	1.000	1.001	0.995	1.004	1.004
15	1.000	0.999	1.001	0.998	0.997
16	1.000	0.998	1.003	0.996	0.995
17	1.000	0.991	1.013	0.979	0.979
18	1.000	0.999	1.001	0.956	0.996
19	1.000	0.993	1.011	0.984	0.984
20	1.000	1.016	0.974	1.034	1.034

COMPARISON OF FAST CROSS SECTIONS FOR AL27 ----- MU-EAR

GROUP	SRL	ANC	BAPL	BNL	CRNL
1	0.2866E 00	0.3249E 00	0.5978E 00	0.6000E 00	0.5996E 00
2	0.3072E 00	0.3395E 00	0.5519E 00	0.5532E 00	0.5531E 00
3	0.3474E 00	0.3760E 00	0.5531E 00	0.5537E 00	0.5538E 00
4	0.3663E 00	0.3924E 00	0.5342E 00	0.5346E 00	0.5345E 00
5	0.3559E 00	0.3691E 00	0.4610E 00	0.4639E 00	0.4637E 00
6	0.4281E 00	0.4356E 00	0.4884E 00	0.4893E 00	0.4894E 00
7	0.3458E 00	0.3478E 00	0.3830E 00	0.3839E 00	0.3837E 00
8	0.3330E 00	0.3364E 00	0.3623E 00	0.3628E 00	0.3628E 00
9	0.3338E 00	0.3367E 00	0.3495E 00	0.3501E 00	0.3501E 00
10	0.3148E 00	0.3147E 00	0.3128E 00	0.3158E 00	0.3157E 00
11	0.2695E 00	0.2694E 00	0.2696E 00	0.2704E 00	0.2704E 00
12	0.2130E 00	0.2130E 00	0.2127E 00	0.2140E 00	0.2139E 00
13	0.1566E 00	0.1567E 00	0.1559E 00	0.1575E 00	0.1573E 00
14	0.1138E 00	0.1139E 00	0.1132E 00	0.1145E 00	0.1145E 00
15	0.8635E-01	0.8652E-01	0.8621E-01	0.8694E-01	0.8694E-01
16	0.6086E-01	0.6092E-01	0.6069E-01	0.6120E-01	0.6119E-01
17	0.4355E-01	0.4360E-01	0.4343E-01	0.4383E-01	0.4381E-01
18	0.3404E-01	0.3411E-01	0.3389E-01	0.3435E-01	0.3435E-01
19	0.2522E-01	0.2492E-01	0.2523E-01	0.2530E-01	0.2530E-01
20	0.2492E-01	0.2492E-01	0.2492E-01	0.2496E-01	0.2496E-01

RELATIVE VALUES FOR AL27 ----- MU-BAR

GROUP	SRL	ANC	EAFL	ENL	CRNL
1	1.000	1.134	2.086	2.094	2.092
2	1.000	1.105	1.797	1.801	1.800
3	1.000	1.082	1.592	1.594	1.594
4	1.000	1.071	1.458	1.459	1.459
5	1.000	1.037	1.295	1.303	1.303
6	1.000	1.018	1.141	1.143	1.143
7	1.000	1.006	1.108	1.110	1.110
8	1.000	1.010	1.088	1.089	1.089
9	1.000	1.009	1.047	1.049	1.049
10	1.000	1.000	0.994	1.003	1.003
11	1.000	1.000	1.001	1.003	1.003
12	1.000	1.000	0.999	1.005	1.004
13	1.000	1.001	0.996	1.006	1.004
14	1.000	1.001	0.995	1.006	1.006
15	1.000	1.002	0.998	1.007	1.007
16	1.000	1.001	0.997	1.006	1.005
17	1.000	1.001	0.997	1.006	1.006
18	1.000	1.002	0.996	1.009	1.009
19	1.000	0.988	1.000	1.003	1.003
20	1.000	1.000	1.000	1.002	1.002

COMPARISON OF FAST CROSS SECTIONS FOR AL27 ----- INELAST

GROUP	SRL	ANC	EAPL	BNL	CRNL
1	0.8353E 00	0.8371E 00	0.8371E 00	0.8369E 00	0.8369E 00
2	0.8253E 00	0.8194E 00	0.8185E 00	0.8202E 00	0.8196E 00
3	0.7780E 00	0.7730E 00	0.7730E 00	0.7739E 00	0.7736E 00
4	0.7253E 00	0.7219E 00	0.7234E 00	0.7227E 00	0.7226E 00
5	0.5946E 00	0.5848E 00	0.5818E 00	0.5877E 00	0.5872E 00
6	0.3659E 00	0.3614E 00	0.3617E 00	0.3633E 00	0.3629E 00
7	0.3011E 00	0.3012E 00	0.3011E 00	0.3012E 00	0.3011E 00
8	0.2499E 00	0.2483E 00	0.2482E 00	0.2494E 00	0.2493E 00
9	0.1473E 00	0.1459E 00	0.1474E 00	0.1477E 00	0.1476E 00
10	0.2975E-02	0.2912E-02	0.2481E-02	0.3047E-02	0.3039E-02
11	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0

RELATIVE VALUES FOR AL27 ----- INELAST

GROUP	SRL	ANC	BAFL	BNL	CRNL
1	1.000	1.002	1.002	1.002	1.002
2	1.000	0.993	0.992	0.994	0.993
3	1.000	0.994	0.994	0.995	0.994
4	1.000	0.995	0.997	0.996	0.996
5	1.000	0.984	0.978	0.988	0.988
6	1.000	0.988	0.988	0.993	0.992
7	1.000	1.000	1.000	1.000	1.000
8	1.000	0.994	0.993	0.998	0.998
9	1.000	0.999	1.001	1.003	1.002
10	1.000	0.979	0.834	1.024	1.022
11	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0

COMPARISON OF FAST CROSS SECTIONS FOR U235 ------ ELASTIC

GROUP	SRL	ANC	BAPL	BNL	CRNL
1	0.3584E 01	0.3701E 01	0.3646E 01	0.3634E 01	0.4691E 01
2	0.4125E 01	0.4227E 01	0.4189E 01	0.4171E 01	0.5520E 01
3	0.4569E 01	0.4638E 01	0.4603E 01	0.4597E 01	0.6386E 01
4	0.4896E 01	0.4927E 01	0.4903E 01	0.4903E 01	0.6729E 01
5	0.4829E 01	0.4834E 01	0.4814E 01	0.4821E 01	0.6629E 01
6	0.4511E 01	0.4509E 01	0.4500E 01	0.4504E 01	0.6263E 01
7	0.4101E 01	0.4099E 01	0.4095E 01	0.4097E 01	0.5824E 01
8	0.3887E 01	0.3888E 01	0.3885E 01	0.3886E 01	0.5496E 01
9	0.3915E 01	0.3920E 01	0.3916E 01	0.3916E 01	0.5380E 01
10	0.4271E 01	0.4275E 01	0.4294E 01	0.4268E 01	0.5623E 01
11	0.4788E 01	0.4788E 01	0.4786E 01	0.4782E 01	0.6088E 01
12	0.5484E 01	0.5483E 01	0.5487E 01	0.5475E 01	0.6610E 01
13	0.6098E 01	0.6097E 01	0.6108E 01	0.6089E 01	0.7114E 01
14	0.6732E 01	0.6729E 01	0.6743E 01	0.6723E 01	0.7597E 01
15	0.7281E 01	0.7281E 01	0.7265E 01	0.7270E 01	0.8025E 01
16	0.7873E 01	0.7867E 01	0.7878E 01	0.7865E 01	0.8501E 01
17	0.8384E 01	0.8380E 01	0.8391E 01	0.8375E 01	0.8908E 01
18	0.8881E 01	0.8874E 01	0.8887E 01	0.8869E 01	0.9311E 01
19	0.9417E 01	0.9412E 01	0.9426E 01	0.9404E 01	0.9746E 01
20	0.9920E 01	0.9920E 01	0.9925E 01	0.9914E 01	0.1008E 02

RELATIVE VALUES FOR U235 ----- ELASTIC

GROUP	SRL	ANC	BAPL	BNL	CRNL
1	1.000	1.033	1.017	1.014	1.309
2	1.000	1.025	1.015	1.011	1.338
3	1.000	1.015	1.008	1.006	1.398
4	1.000	1.006	1.001	1.001	1.374
5	1.000	1.001	0.997	0.998	1.373
6	1.000	1.000	0.997	0.998	1.388
7	1.000	1.000	0.998	0.999	1.420
8	1.000	1.000	0.999	1.000	1.414
9	1.000	1.001	1.000	1.000	1.374
10	1.000	1.001	1.005	0.999	1.317
11	1.000	1.000	1.000	0.999	1.272
12	1.000	1.000	1.001	0.998	1.205
13	1.000	1.000	1.002	0.999	1.167
14	1.000	1.000	1.002	0.999	1.128
15	1.000	1.000	1.001	0.998	1.102
16	1.000	0.999	1.001	0.999	1.080
17	1.000	1.000	1.001	0.999	1.063
18	1.000	0.999	1.001	0.999	1.048
19	1.000	0.999	1.001	0.999	1.035
20	1.000	1.000	1.000	0.999	1.016

COMPARISON OF FAST CROSS SECTIONS FOR U235 ----- CAPTURE

GROUP	SRL	ANC	BAPL	BNL*	CRNL
1	0.7054E-02	0.7740E-02	0.7748E-02	-0.3939E 00	0.7685E-02
2	0.1285E-01	0.1347E-01	0.1356E-01	-0.2184E 00	0.1341E-01
3	0.1760E-01	0.1805E-01	0.1804E-01	-0.4115E-03	0.1798E-01
4	0.2410E-01	0.2450E-01	0.2437E-01	0.2441E-01	0.2443E-01
5	0.3197E-01	0.3236E-01	0.3249E-01	0.3225E-01	0.3226E-01
6	0.4197E-01	0.4231E-01	0.4230E-01	0.4217E-01	0.4219E-01
7	0.5427E-01	0.5459E-01	0.5455E-01	0.5442E-01	0.5442E-01
8	0.7200E-01	0.7231E-01	0.7233E-01	0.7207E-01	0.7207E-01
9	0.9777E-01	0.9804E-01	0.9784E-01	0.9773E-01	0.9775E-01
10	0.1211E 00	0.1212E 00	0.1218E 00	0.1210E 00	0.1210E 00
11	0.1378E 00	0.1378E 00	0.1377E 00	0.1376E 00	0.1376E 00
12	0.1623E 00	0.1623E 00	0.1624E 00	0.1620E 00	0.1620E 00
13	0.1901E 00	0.1900E 00	0.1904E 00	0.1897E 00	0.1896E 00
14	0.2162E 00	0.2161E 00	0.2168E 00	0.2157E 00	0.2157E 00
15	0.2621E 00	0.2618E 00	0.2624E 00	0.2614E 00	0.2613E 00
16	0.2961E 00	0.2959E 00	0.2965E 00	0.2956E 00	0.2956E 00
17	0.3402E 00	0.3399E 00	0.3408E 00	0.3393E 00	0.3392E 00
18	0.3908E 00	0.3904E 00	0.3915E 00	0.3857E 00	0.3857E 00
19	0.4367E 00	0.4364E 00	0.4371E 00	0.4361E 00	0.4361E 00
20	0.5059E 00	0.5050E 00	0.5072E 00	0.5041E 00	0.5041E 00

* Capture minus (n,2n)

RELATIVE VALUES FOR U235 ----- CAPTURE

GROUP	SRL	ANC	BAPL	BNL	CRNL
1	1.000	1.097	1.058	*****	1.089
2	1.000	1.048	1.055	*****	1.044
3	1.000	1.026	1.025	-.023	1.022
4	1.000	1.017	1.011	1.013	1.014
5	1.000	1.012	1.016	1.009	1.009
6	1.000	1.008	1.008	1.005	1.005
7	1.000	1.006	1.005	1.003	1.003
8	1.000	1.004	1.005	1.001	1.001
9	1.000	1.003	1.001	1.000	1.000
10	1.000	1.001	1.006	0.999	0.999
11	1.000	1.000	0.999	0.999	0.999
12	1.000	1.000	1.001	0.998	0.998
13	1.000	0.999	1.002	0.998	0.997
14	1.000	1.000	1.003	0.998	0.998
15	1.000	0.999	1.001	0.997	0.997
16	1.000	0.999	1.001	0.998	0.998
17	1.000	0.999	1.002	0.997	0.997
18	1.000	0.999	1.002	0.997	0.997
19	1.000	0.999	1.001	0.999	0.999
20	1.000	0.998	1.003	0.996	0.996

COMPARISON OF FAST CROSS SECTIONS FOR U235 ----- FISSION

GROUP	SRL	ANC	RAFL	ENL	CRNL
1	0.1785E 01	0.1781E 01	0.1781E 01	0.1782E 01	0.1780E 01
2	0.1499E 01	0.1441E 01	0.1432E 01	0.1449E 01	0.1447E 01
3	0.1091E 01	0.1050E 01	0.1090E 01	0.1090E 01	0.1089E 01
4	0.1138E 01	0.1142E 01	0.1140E 01	0.1141E 01	0.1141E 01
5	0.1205E 01	0.1209E 01	0.1210E 01	0.1208E 01	0.1208E 01
6	0.1269E 01	0.1270E 01	0.1269E 01	0.1269E 01	0.1269E 01
7	0.1273E 01	0.1273E 01	0.1273E 01	0.1273E 01	0.1273E 01
8	0.1255E 01	0.1255E 01	0.1255E 01	0.1255E 01	0.1255E 01
9	0.1253E 01	0.1254E 01	0.1254E 01	0.1254E 01	0.1253E 01
10	0.1193E 01	0.1192E 01	0.1188E 01	0.1193E 01	0.1194E 01
11	0.1134E 01	0.1134E 01	0.1134E 01	0.1134E 01	0.1134E 01
12	0.1156E 01	0.1156E 01	0.1156E 01	0.1156E 01	0.1157E 01
13	0.1198E 01	0.1198E 01	0.1199E 01	0.1197E 01	0.1197E 01
14	0.1234E 01	0.1234E 01	0.1235E 01	0.1233E 01	0.1233E 01
15	0.1299E 01	0.1298E 01	0.1299E 01	0.1298E 01	0.1298E 01
16	0.1340E 01	0.1339E 01	0.1341E 01	0.1339E 01	0.1339E 01
17	0.1431E 01	0.1430E 01	0.1432E 01	0.1429E 01	0.1429E 01
18	0.1515E 01	0.1514E 01	0.1516E 01	0.1513E 01	0.1513E 01
19	0.1583E 01	0.1583E 01	0.1583E 01	0.1583E 01	0.1583E 01
20	0.1715E 01	0.1713E 01	0.1718E 01	0.1711E 01	0.1711E 01

RELATIVE VALLES FOR U235 ----- FISSICN

GROUP	SRL	ANC	BAPL	ENL	CRNL
1	1.000	0.998	0.998	0.998	0.997
2	1.000	0.961	0.955	0.967	0.965
3	1.000	0.999	0.999	0.999	0.998
4	1.000	1.004	1.002	1.003	1.003
5	1.000	1.003	1.004	1.002	1.002
6	1.000	1.001	1.000	1.000	1.000
7	1.000	1.000	1.000	1.000	1.000
8	1.000	1.000	1.000	1.000	1.000
9	1.000	1.001	1.001	1.001	1.000
10	1.000	0.999	0.996	1.000	1.001
11	1.000	1.000	1.000	1.000	1.000
12	1.000	1.000	1.000	1.000	1.001
13	1.000	1.000	1.001	0.999	0.999
14	1.000	1.000	1.000	0.999	0.999
15	1.000	0.999	1.000	0.999	0.999
16	1.000	0.999	1.001	0.999	0.999
17	1.000	0.999	1.001	0.999	0.999
18	1.000	0.999	1.001	0.999	0.999
19	1.000	1.000	1.000	1.000	1.000
20	1.000	0.999	1.002	0.998	0.998

COMPARISON OF FAST CROSS SECTIONS FOR U235 ------ NU

GROUP	SRL	ANC	BAPL	BNL	CRNL
1	0.3769E 01	0.3671E 01	0.3670E 01	0.3675E 01	0.3673E 01
2	0.3418E 01	0.3399E 01	0.3395E 01	0.3403E 01	0.3401E 01
3	0.3170E 01	0.3153E 01	0.3153E 01	0.3156E 01	0.3156E 01
4	0.2977E 01	0.2966E 01	0.2969E 01	0.2968E 01	0.2968E 01
5	0.2825E 01	0.2819E 01	0.2817E 01	0.2821E 01	0.2824E 01
6	0.2728E 01	0.2725E 01	0.2725E 01	0.2726E 01	0.2725E 01
7	0.2662E 01	0.2661E 01	0.2661E 01	0.2662E 01	0.2662E 01
8	0.2612E 01	0.2611E 01	0.2611E 01	0.2611E 01	0.2611E 01
9	0.2571E 01	0.2571E 01	0.2571E 01	0.2571E 01	0.2571E 01
10	0.2538E 01	0.2538E 01	0.2537E 01	0.2538E 01	0.2538E 01
11	0.2512E 01	0.2512E 01	0.2512E 01	0.2512E 01	0.2512E 01
12	0.2491E 01	0.2491E 01	0.2491E 01	0.2491E 01	0.2490E 01
13	0.2475E 01	0.2475E 01	0.2475E 01	0.2475E 01	0.2475E 01
14	0.2463E 01	0.2463E 01	0.2462E 01	0.2463E 01	0.2462E 01
15	0.2453E 01	0.2453E 01	0.2453E 01	0.2453E 01	0.2452E 01
16	0.2445E 01	0.2445E 01	0.2445E 01	0.2445E 01	0.2445E 01
17	0.2439E 01	0.2440E 01	0.2439E 01	0.2440E 01	0.2439E 01
18	0.2435E 01	0.2435E 01	0.2435E 01	0.2435E 01	0.2435E 01
19	0.2431E 01	0.2431E 01	0.2431E 01	0.2431E 01	0.2432E 01
20	0.2429E 01	0.2429E 01	0.2428E 01	0.2429E 01	0.2429E 01

RELATIVE VALLES FOR U235 ----- NU

GROUP	SRL	ANC	BAPL	BNL	CRNL
1	1.000	0.990	0.990	0.991	0.990
2	1.000	0.994	0.993	0.996	0.995
3	1.000	0.995	0.995	0.996	0.996
4	1.000	0.996	0.997	0.997	0.997
5	1.000	0.998	0.997	0.999	1.000
6	1.000	0.999	0.999	0.999	0.999
7	1.000	1.000	1.000	1.000	1.000
8	1.000	1.000	1.000	1.000	1.000
9	1.000	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000
11	1.000	1.000	1.000	1.000	1.000
12	1.000	1.000	1.000	1.000	1.000
13	1.000	1.000	1.000	1.000	1.000
14	1.000	1.000	1.000	1.000	1.000
15	1.000	1.000	1.000	1.000	1.000
16	1.000	1.000	1.000	1.000	1.000
17	1.000	1.000	1.000	1.000	1.000
18	1.000	1.000	1.000	1.000	1.000
19	1.000	1.000	1.000	1.000	1.000
20	1.000	1.000	1.000	1.000	1.000

COMPARISON OF FAST CROSS SECTIONS FOR U235 ----- MU-BAR

GROUP	SRL	ANC	BAPL	BNL	CRNL
1	0.7862E 00	0.7215E 00	0.8336E 00	0.8353E 00	0.6476E 00
2	0.6927E 00	0.6568E 00	0.8241E 00	0.8252E 00	0.6240E 00
3	0.5912E 00	0.5934E 00	0.8132E 00	0.8141E 00	0.5864E 00
4	0.5757E 00	0.5769E 00	0.7894E 00	0.7896E 00	0.5754E 00
5	0.5468E 00	0.5468E 00	0.7494E 00	0.7509E 00	0.5458E 00
6	0.4929E 00	0.4925E 00	0.6835E 00	0.6845E 00	0.4919E 00
7	0.4322E 00	0.4323E 00	0.6130E 00	0.6138E 00	0.4316E 00
8	0.3824E 00	0.3829E 00	0.5396E 00	0.5405E 00	0.3823E 00
9	0.3468E 00	0.3476E 00	0.4762E 00	0.4765E 00	0.3468E 00
10	0.3231E 00	0.3240E 00	0.4234E 00	0.4257E 00	0.3232E 00
11	0.3023E 00	0.3032E 00	0.3847E 00	0.3850E 00	0.3024E 00
12	0.2906E 00	0.2913E 00	0.3505E 00	0.3510E 00	0.2907E 00
13	0.2716E 00	0.2722E 00	0.3166E 00	0.3177E 00	0.2718E 00
14	0.2519E 00	0.2525E 00	0.2842E 00	0.2851E 00	0.2522E 00
15	0.2350E 00	0.2355E 00	0.2592E 00	0.2597E 00	0.2352E 00
16	0.2193E 00	0.2198E 00	0.2368E 00	0.2376E 00	0.2197E 00
17	0.1794E 00	0.1799E 00	0.1902E 00	0.1917E 00	0.1801E 00
18	0.1395E 00	0.1400E 00	0.1460E 00	0.1474E 00	0.1402E 00
19	0.1081E 00	0.1084E 00	0.1115E 00	0.1126E 00	0.1086E 00
20	0.8330E-01	0.8405E-01	0.8484E-01	0.8565E-01	0.8424E-01

RELATIVE VALUES FOR U235 ----- MU-BAR

GROUP	SRL	ANC	EAPL	BNL	CRNL
1	1.000	0.918	1.060	1.062	0.824
2	1.000	0.948	1.190	1.191	0.901
3	1.000	0.999	1.375	1.377	0.992
4	1.000	1.002	1.371	1.372	0.999
5	1.000	1.000	1.371	1.373	0.998
6	1.000	0.999	1.387	1.389	0.998
7	1.000	1.000	1.418	1.420	0.999
8	1.000	1.001	1.411	1.413	1.000
9	1.000	1.002	1.373	1.374	1.000
10	1.000	1.003	1.310	1.318	1.000
11	1.000	1.003	1.273	1.274	1.000
12	1.000	1.002	1.206	1.208	1.000
13	1.000	1.002	1.166	1.170	1.001
14	1.000	1.002	1.128	1.132	1.001
15	1.000	1.002	1.103	1.105	1.001
16	1.000	1.002	1.080	1.083	1.002
17	1.000	1.003	1.060	1.069	1.004
18	1.000	1.004	1.047	1.057	1.005
19	1.000	1.003	1.032	1.042	1.005
20	1.000	1.003	1.012	1.022	1.005

COMPARISON OF FAST CROSS SECTIONS FOR U235 ----- N2N

GROUP	SRL	ANC	EAPL	CRNL
1	0.4124E 00	0.4001E 00	0.3999E 00	0.4010E 00
2	0.2533E 00	0.2283E 00	0.2244E 00	0.2307E 00
3	0.2436E-01	0.1723E-01	0.1729E-01	0.1809E-01
4	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0

RELATIVE VALUES FOR U235 ------ N2N

GROUP	SRL	ANC	BAFL	CRNL
1	1.000	0.970	0.970	0.972
2	1.000	0.901	0.886	0.911
3	1.000	0.707	0.710	0.743
4	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0

COMPARISON OF FAST CROSS SECTIONS FOR U235 ----- CHI

GROUP	SRL	ANC	EAPL	BNL	CRNL
1	0.6492E-02	0.6776E-02	C.8202E-C2	0.8200E-02	0.6492E-02
2	C.1895E-01	0.1957E-01	0.1893E-01	0.1892E-01	0.1896E-01
3	0.4048E-01	0.4147E-01	C.4C42E-01	0.4042E-01	0.4047E-01
4	0.6758E-01	0.6884E-01	0.6748E-01	C.6747E-01	0.6760E-01
5	C.9297E-01	0.9431E-01	0.9284E-01	0.9282E-01	0.9300E-01
6	0.1100E 00	0.1111E 00	C.1C97E 00	0.1097E 00	0.1099E 00
7	0.1155E CC	0.1163E 00	0.1152E 00	0.1152E 00	0.1154E C0
8	0.1103E 00	0.1110E 00	0.1102E 00	C.1101E 00	0.1103E 00
9	0.9811E-01	0.9863E-01	0.9796E-01	0.9797E-01	0.9812E-01
10	C.8243E-01	0.8275E-C1	0.8231E-01	0.8230E-01	0.8245E-01
11	0.6626E-01	0.6646E-01	C.6616E-01	C.6617E-01	0.6627E-01
12	0.5146E-C1	0.5157E-01	0.5138E-01	0.5137E-01	0.5147E-01
13	0.3889E-01	0.3896E-01	0.3883E-01	0.3882E-01	0.3890E-01
14	0.2879E-01	0.2882E-01	0.2874E-01	C.2875E-01	0.2880E-01
15	0.2096E-01	0.2098E-01	0.2093E-01	0.2093E-01	0.2096E-01
16	0.1507E-01	0.1508E-01	C.15C5E-C1	0.1505E-01	0.1507E-01
17	0.1073E-C1	0.1073E-01	0.1071E-01	0.1C71E-01	0.1073E-01
18	0.7582E-02	0.7579E-C2	C.7565E-02	C.7565E-02	0.7577E-02
19	0.5319E-02	0.5320E-02	C.5311E-02	0.5310E-02	0.5320E-02
20	0.3717E-02	0.3717E-02	0.3711E-02	0.3710E-02	0.3717E-02

RELATIVE VALLES FCR U235 ----- CHI

GROUP	SRL	ANC	BAPL	BNL	CRNL
1	1.000	1.044	1.263	1.263	1.000
2	1.000	1.033	0.999	0.999	1.000
3	1.000	1.024	0.998	0.999	1.000
4	1.000	1.019	0.998	0.998	1.000
5	1.000	1.014	0.999	0.998	1.000
6	1.000	1.010	0.998	0.998	0.999
7	1.000	1.007	0.997	0.997	0.999
8	1.000	1.006	0.999	0.999	1.000
9	1.000	1.005	0.999	0.999	1.000
10	1.000	1.004	0.999	0.998	1.000
11	1.000	1.003	0.999	0.999	1.000
12	1.000	1.002	0.998	0.998	1.000
13	1.000	1.002	0.999	0.998	1.000
14	1.000	1.001	0.998	0.999	1.000
15	1.000	1.001	0.999	0.999	1.000
16	1.000	1.001	0.998	0.999	1.000
17	1.000	1.000	0.998	0.998	1.000
18	1.000	1.000	0.998	0.998	0.999
19	1.000	1.000	0.998	0.998	1.000
20	1.000	1.000	0.998	0.998	1.000

COMPARISON OF FAST CROSS SECTIONS FOR U235 ----- INELAST

GROUP	SRL	ANC	BAPL	BNL*	CFNL
1	0.2269E 00	0.2493E 00	0.2493E 00	0.1049E 01	0.2472E 00
2	0.7816E 00	0.8923E 00	0.9093E 00	0.1340E 01	0.8807E 00
3	0.1727E 01	0.1752E 01	0.1751E 01	0.1784E 01	0.1748E 01
4	0.1824E 01	0.1823E 01	0.1823E 01	0.1823E 01	0.1823E 01
5	0.1809E 01	0.1808E 01	0.1808E 01	0.1808E 01	0.1809E 01
6	0.1753E 01	0.1761E 01	0.1761E 01	0.1762E 01	0.1761E 01
7	0.1729E 01	0.1727E 01	0.1727E 01	0.1728E 01	0.1728E 01
8	0.1610E 01	0.1607E 01	0.1607E 01	0.1609E 01	0.1608E 01
9	0.1464E 01	0.1462E 01	0.1463E 01	0.1464E 01	0.1464E 01
10	0.1353E 01	0.1353E 01	0.1351E 01	0.1354E 01	0.1354E 01
11	0.1304E 01	0.1304E 01	0.1304E 01	0.1305E 01	0.1305E 01
12	0.1135E 01	0.1135E 01	0.1134E 01	0.1136E 01	0.1136E 01
13	0.1023E 01	0.1024E 01	0.1021E 01	0.1026E 01	0.1026E 01
14	0.8756E 00	0.8762E 00	0.8735E 00	0.8775E 00	0.8778E 00
15	0.7554E 00	0.7561E 00	0.7543E 00	0.7574E 00	0.7571E 00
16	0.6379E 00	0.6385E 00	0.6370E 00	0.6391E 00	0.6389E 00
17	0.5337E 00	0.5346E 00	0.5326E 00	0.5358E 00	0.5359E 00
18	0.4459E 00	0.4465E 00	0.4449E 00	0.4475E 00	0.4476E 00
19	0.3405E 00	0.3422E 00	0.3377E 00	0.3442E 00	0.3444E 00
20	0.1639E 00	0.1648E 00	0.1625E 00	0.1657E 00	0.1657E 00

* Inelastic plus 2x (n,2n)

RELATIVE VALUES FOR U235 ----- INELAST

GROUP	SRL	ANC	BAPL	BNL	CRNL
1	1.000	1.097	1.099	4.623	1.089
2	1.000	1.142	1.163	1.714	1.127
3	1.000	1.014	1.014	1.033	1.012
4	1.000	0.999	1.000	0.999	0.999
5	1.000	0.999	1.000	0.999	1.000
6	1.000	0.999	0.999	0.999	0.999
7	1.000	0.999	0.999	0.999	0.999
8	1.000	0.998	0.998	0.999	0.999
9	1.000	0.999	1.000	1.000	1.000
10	1.000	1.000	0.998	1.001	1.001
11	1.000	1.000	1.000	1.001	1.001
12	1.000	1.000	0.999	1.001	1.001
13	1.000	1.001	0.998	1.003	1.003
14	1.000	1.001	0.998	1.002	1.003
15	1.000	1.001	0.999	1.003	1.002
16	1.000	1.001	0.999	1.002	1.002
17	1.000	1.002	0.998	1.004	1.004
18	1.000	1.001	0.998	1.004	1.004
19	1.000	1.005	0.992	1.011	1.011
20	1.000	1.005	0.992	1.011	1.011

COMPARISON OF FAST CROSS SECTIONS FOR U238 ----- ELASTIC

GROUP	SRL	ANC	EAPL	BNL	CRNL
1	0.3121E 01	0.3226E 01	0.3179E 01	0.3165E 01	0.6519E 01
2	0.3704E 01	0.3821E 01	0.3792E 01	0.3767E 01	0.6326E 01
3	0.4408E 01	0.4481E 01	0.4452E 01	0.4444E 01	0.6936E 01
4	0.4801E 01	0.4823E 01	0.4806E 01	0.4811E 01	0.7308E 01
5	0.4822E 01	0.4820E 01	0.4810E 01	0.4817E 01	0.7321E 01
6	0.4524E 01	0.4515E 01	0.4509E 01	0.4515E 01	0.7006E 01
7	0.4137E 01	0.4135E 01	0.4131E 01	0.4134E 01	0.6634E 01
8	0.4032E 01	0.4037E 01	0.4034E 01	0.4032E 01	0.6616E 01
9	0.4427E 01	0.4435E 01	0.4428E 01	0.4426E 01	0.6869E 01
10	0.5013E 01	0.5017E 01	0.5039E 01	0.5009E 01	0.7152E 01
11	0.5677E 01	0.5679E 01	0.5674E 01	0.5668E 01	0.7621E 01
12	0.6474E 01	0.6474E 01	0.6477E 01	0.6465E 01	0.8213E 01
13	0.7229E 01	0.7226E 01	0.7240E 01	0.7218E 01	0.8775E 01
14	0.8063E 01	0.8059E 01	0.8078E 01	0.8049E 01	0.9397E 01
15	0.8871E 01	0.8868E 01	0.8877E 01	0.8859E 01	0.1003E 02
16	0.9567E 01	0.9561E 01	0.9574E 01	0.9557E 01	0.1059E 02
17	0.1018E 02	0.1018E 02	0.1019E 02	0.1017E 02	0.1107E 02
18	0.1087E 02	0.1087E 02	0.1088E 02	0.1086E 02	0.1156E 02
19	0.1157E 02	0.1156E 02	0.1157E 02	0.1155E 02	0.1202E 02
20	0.1238E 02	0.1207E 02	0.1208E 02	0.1207E 02	0.1234E 02

RELATIVE VALUES FOR U238 ----- ELASTIC

GROUP	SRL	ANC	EAPL	BNL	CRNL
1	1.000	1.034	1.019	1.014	2.089
2	1.000	1.032	1.024	1.017	1.708
3	1.000	1.017	1.010	1.008	1.574
4	1.000	1.005	1.001	1.002	1.522
5	1.000	1.000	0.997	0.999	1.518
6	1.000	0.998	0.997	0.998	1.549
7	1.000	1.000	0.999	0.999	1.604
8	1.000	1.001	1.001	1.000	1.641
9	1.000	1.002	1.000	1.000	1.552
10	1.000	1.001	1.005	0.999	1.427
11	1.000	1.000	1.000	0.998	1.342
12	1.000	1.000	1.001	0.999	1.269
13	1.000	1.000	1.001	0.998	1.214
14	1.000	1.000	1.002	0.998	1.165
15	1.000	1.000	1.001	0.999	1.131
16	1.000	0.999	1.001	0.999	1.107
17	1.000	1.000	1.001	0.999	1.087
18	1.000	1.000	1.001	0.999	1.063
19	1.000	0.999	1.000	0.998	1.039
20	1.000	0.999	1.000	0.999	1.022

COMPARISON OF FAST CROSS SECTIONS FOR U238 ----- CAPTURE

GROUP	SRL	ANC	BAPL	BNL *	CRNL
1	0.2592E-02	0.2767E-02	0.2769E-02	-0.1364E 01	0.2755E-02
2	0.4341E-02	0.4567E-02	0.4602E-02	-0.3737E 00	0.4545E-02
3	0.7272E-02	0.7563E-02	0.7558E-02	0.7511E-02	0.7525E-02
4	0.1221E-01	0.1257E-01	0.1244E-01	0.1249E-01	0.1250E-01
5	0.2040E-01	0.2085E-01	0.2099E-01	0.2072E-01	0.2073E-01
6	0.3348E-01	0.3397E-01	0.3393E-01	0.3376E-01	0.3378E-01
7	0.5186E-01	0.5233E-01	0.5226E-01	0.5207E-01	0.5211E-01
8	0.7663E-01	0.7704E-01	0.7707E-01	0.7674E-01	0.7673E-01
9	0.1038E 00	0.1040E 00	0.1038E 00	0.1037E 00	0.1037E 00
10	0.1206E 00	0.1206E 00	0.1208E 00	0.1205E 00	0.1205E 00
11	0.1196E 00	0.1195E 00	0.1196E 00	0.1196E 00	0.1196E 00
12	0.1113E 00	0.1113E 00	0.1113E 00	0.1114E 00	0.1114E 00
13	0.1076E 00	0.1076E 00	0.1077E 00	0.1077E 00	0.1077E 00
14	0.1105E 00	0.1104E 00	0.1106E 00	0.1104E 00	0.1104E 00
15	0.1209E 00	0.1208E 00	0.1210E 00	0.1207E 00	0.1207E 00
16	0.1383E 00	0.1382E 00	0.1385E 00	0.1380E 00	0.1380E 00
17	0.1532E 00	0.1531E 00	0.1534E 00	0.1529E 00	0.1529E 00
18	0.1711E 00	0.1709E 00	0.1713E 00	0.1706E 00	0.1736E 00
19	0.1906E 00	0.1905E 00	0.1909E 00	0.1903E 00	0.1903E 00
20	0.2243E 00	0.2243E 00	0.2257E 00	0.2238E 00	0.2238E 00

* Capture minus (n,2n)

RELATIVE VALUES FOR U238 ----- CAPTURE

GROUP	SRL	ANC	BAPL	BNL	CRNL
1	1.000	1.068	1.068	*****	1.063
2	1.000	1.052	1.060	*****	1.047
3	1.000	1.043	1.039	1.033	1.035
4	1.000	1.029	1.019	1.023	1.024
5	1.000	1.022	1.029	1.016	1.016
6	1.000	1.015	1.014	1.008	1.009
7	1.000	1.009	1.008	1.004	1.005
8	1.000	1.005	1.006	1.001	1.001
9	1.000	1.002	1.000	0.999	0.999
10	1.000	1.000	1.002	0.999	0.999
11	1.000	0.999	1.000	1.000	1.000
12	1.000	1.000	1.000	1.001	1.001
13	1.000	1.000	1.001	1.001	1.001
14	1.000	0.999	1.001	0.999	0.999
15	1.000	0.999	1.001	0.998	0.998
16	1.000	0.999	1.002	0.998	0.998
17	1.000	0.999	1.001	0.998	0.998
18	1.000	0.999	1.001	0.997	0.997
19	1.000	0.999	1.002	0.998	0.998
20	1.000	0.998	1.004	0.996	0.996

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COMPARISON OF FAST CROSS SECTIONS FOR U238 ----- FISSION

GROUP	SRL	ANC	BAPL	BNL	CRNL
1	0.9990E 00	0.9910E 00	0.9911E 00	0.9908E 00	0.9907E 00
2	0.8896E 00	0.8585E 00	0.8535E 00	0.8630E 00	0.8617E 00
3	0.5811E 00	0.5740E 00	0.5741E 00	0.5752E 00	0.5748E 00
4	0.5632E 00	0.5632E 00	0.5632E 00	0.5632E 00	0.5631E 00
5	0.5485E 00	0.5478E 00	0.5475E 00	0.5483E 00	0.5479E 00
6	0.5512E 00	0.5513E 00	0.5513E 00	0.5513E 00	0.5512E 00
7	0.5209E 00	0.5189E 00	0.5190E 00	0.5200E 00	0.5198E 00
8	0.3120E 00	0.3067E 00	0.3062E 00	0.3105E 00	0.3103E 00
9	0.4340E-01	0.4284E-01	0.4316E-01	0.4350E-01	0.4347E-01
10	0.1263E-01	0.1252E-01	0.1186E-01	0.1269E-01	0.1268E-01
11	0.2021E-02	0.2017E-02	0.2029E-02	0.2044E-02	0.2044E-02
12	0.6993E-03	0.7006E-03	0.6931E-03	0.7139E-03	0.7137E-03
13	0.1704E-03	0.1707E-03	0.1687E-03	0.1720E-03	0.1721E-03
14	0.9333E-04	0.9354E-04	0.9252E-04	0.9401E-04	0.9403E-04
15	0.6530E-04	0.6536E-04	0.6522E-04	0.6546E-04	0.6547E-04
16	0.5633E-04	0.5643E-04	0.5629E-04	0.5650E-04	0.5651E-04
17	0.4943E-04	0.4948E-04	0.4936E-04	0.4954E-04	0.4954E-04
18	0.4403E-04	0.4407E-04	0.4397E-04	0.4413E-04	0.4413E-04
19	0.4038E-04	0.4039E-04	0.4035E-04	0.4041E-04	0.4040E-04
20	0.4005E-04	0.4000E-04	0.4000E-04	0.4000E-04	0.4000E-04

RELATIVE VALUES FOR U238 ----- FISSION

GROUP	SRL	ANC	BAFL	ENL	CRNL
1	1.000	1.002	1.002	1.002	1.002
2	1.000	0.965	0.959	0.970	0.969
3	1.000	0.988	0.988	0.990	0.989
4	1.000	1.000	1.000	1.000	1.000
5	1.000	0.999	0.998	0.999	0.999
6	1.000	1.000	1.000	1.000	1.000
7	1.000	0.996	0.996	0.998	0.998
8	1.000	0.983	0.982	0.995	0.995
9	1.000	0.987	0.994	1.002	1.002
10	1.000	0.994	0.941	1.007	1.006
11	1.000	0.998	1.004	1.011	1.011
12	1.000	1.002	0.991	1.021	1.021
13	1.000	1.002	0.990	1.009	1.010
14	1.000	1.002	0.991	1.007	1.007
15	1.000	1.001	0.999	1.002	1.003
16	1.000	1.001	0.998	1.002	1.002
17	1.000	1.001	0.999	1.002	1.002
18	1.000	1.001	0.999	1.002	1.002
19	1.000	1.000	0.999	1.001	1.000
20	1.000	1.000	1.000	1.000	1.000

COMPARISON OF FAST CROSS SECTIONS FOR U238 ------ NU

GROUP	SRL	ANC	EAPL	BNL	CRNL
1	0.3685E 01	0.3643E 01	0.3642E 01	0.3647E 01	0.3646E 01
2	0.3393E 01	0.3375E 01	0.3371E 01	0.3379E 01	0.3378E 01
3	0.3151E 01	0.3137E 01	0.3138E 01	0.3140E 01	0.3140E 01
4	0.2966E 01	0.2957E 01	0.2960E 01	0.2959E 01	0.2959E 01
5	0.2823E 01	0.2818E 01	0.2817E 01	0.2820E 01	0.2820E 01
6	0.2712E 01	0.2709E 01	0.2709E 01	0.2710E 01	0.2711E 01
7	0.2625E 01	0.2625E 01	0.2625E 01	0.2625E 01	0.2625E 01
8	0.2558E 01	0.2563E 01	0.2563E 01	0.2563E 01	0.2563E 01
9	0.2505E 01	0.2510E 01	0.2510E 01	0.2510E 01	0.2511E 01
10	0.2464E 01	0.2467E 01	0.2466E 01	0.2468E 01	0.2468E 01
11	0.2432E 01	0.2435E 01	0.2435E 01	0.2435E 01	0.2436E 01
12	0.2437E 01	0.2410E 01	0.2410E 01	0.2411E 01	0.2411E 01
13	0.2388E 01	0.2389E 01	0.2389E 01	0.2389E 01	0.2389E 01
14	0.2373E 01	0.2373E 01	0.2373E 01	0.2373E 01	0.2375E 01
15	0.2361E 01	0.2361E 01	0.2361E 01	0.2361E 01	0.2362E 01
16	0.2352E 01	0.2352E 01	0.2352E 01	0.2352E 01	0.2352E 01
17	0.2345E 01	0.2345E 01	0.2345E 01	0.2345E 01	0.2346E 01
18	0.2339E 01	0.2339E 01	0.2339E 01	0.2339E 01	0.2340E 01
19	0.2335E 01	0.2335E 01	0.2335E 01	0.2335E 01	0.2335E 01
20	0.2331E 01	0.2331E 01	0.2331E 01	0.2331E 01	0.2331E 01

RELATIVE VALUES FOR U238 ------ NU

GROUP	SRL	ANC	BAPL	BNL	CRNL
1	1.000	0.989	0.988	0.990	0.989
2	1.000	0.995	0.994	0.996	0.996
3	1.000	0.996	0.996	0.997	0.997
4	1.000	0.997	0.998	0.998	0.998
5	1.000	0.998	0.998	0.999	0.999
6	1.000	0.999	0.999	0.999	1.000
7	1.000	1.000	1.000	1.000	1.000
8	1.000	1.002	1.002	1.002	1.002
9	1.000	1.002	1.002	1.002	1.002
10	1.000	1.001	1.001	1.002	1.002
11	1.000	1.001	1.001	1.001	1.002
12	1.000	1.001	1.001	1.002	1.002
13	1.000	1.000	1.000	1.000	1.000
14	1.000	1.000	1.000	1.000	1.001
15	1.000	1.000	1.000	1.000	1.000
16	1.000	1.000	1.000	1.000	1.000
17	1.000	1.000	1.000	1.000	1.000
18	1.000	1.000	1.000	1.000	1.000
19	1.000	1.000	1.000	1.000	1.000
20	1.000	1.000	1.000	1.000	1.000

COMPARISON OF FAST CROSS SECTIONS FOR U238 ----- MU-BAR

GROUP	SRL	ANC	BAPL	BNL	CRNL
1	0.6845E 00	0.5343E 00	0.8075E 00	0.8089E 00	0.3329E 00
2	0.5563E 00	0.5140E 00	0.8044E 00	0.8054E 00	0.4800E 00
3	0.5145E 00	0.5179E 00	0.8043E 00	0.8048E 00	0.5158E 00
4	0.5177E 00	0.5181E 00	0.7864E 00	0.7864E 00	0.5174E 00
5	0.4871E 00	0.4864E 00	0.7372E 00	0.7389E 00	0.4859E 00
6	0.4254E 00	0.4252E 00	0.6576E 00	0.6587E 00	0.4243E 00
7	0.3753E 00	0.3765E 00	0.6009E 00	0.6015E 00	0.3748E 00
8	0.3308E 00	0.3328E 00	0.5423E 00	0.5429E 00	0.3308E 00
9	0.3247E 00	0.3268E 00	0.5041E 00	0.5044E 00	0.3249E 00
10	0.3106E 00	0.3121E 00	0.4417E 00	0.4440E 00	0.3108E 00
11	0.2996E 00	0.3006E 00	0.4026E 00	0.4030E 00	0.2997E 00
12	0.2749E 00	0.2754E 00	0.3488E 00	0.3497E 00	0.2750E 00
13	0.2508E 00	0.2514E 00	0.3041E 00	0.3052E 00	0.2510E 00
14	0.2269E 00	0.2274E 00	0.2641E 00	0.2654E 00	0.2273E 00
15	0.2007E 00	0.2012E 00	0.2269E 00	0.2279E 00	0.2011E 00
16	0.1715E 00	0.1718E 00	0.1895E 00	0.1904E 00	0.1718E 00
17	0.1457E 00	0.1460E 00	0.1580E 00	0.1590E 00	0.1460E 00
18	0.1202E 00	0.1205E 00	0.1275E 00	0.1285E 00	0.1207E 00
19	0.9864E-01	0.9897E-01	0.1024E 00	0.1032E 00	0.9910E-01
20	0.7971E-01	0.8009E-01	0.8135E-01	0.8219E-01	0.8028E-01

RELATIVE VALUES FOR U238 ----- MU-BAR

GROUP	SRL	ANC	BAPL	BNL	CRNL
1	1.000	0.737	1.180	1.182	0.574
2	1.000	0.924	1.446	1.448	0.863
3	1.000	1.037	1.563	1.564	1.003
4	1.000	1.001	1.519	1.519	0.999
5	1.000	0.999	1.514	1.517	0.998
6	1.000	1.000	1.546	1.548	0.997
7	1.000	1.003	1.601	1.603	0.999
8	1.000	1.036	1.639	1.641	1.000
9	1.000	1.006	1.553	1.553	1.001
10	1.000	1.005	1.422	1.429	1.001
11	1.000	1.003	1.344	1.345	1.000
12	1.000	1.002	1.269	1.272	1.000
13	1.000	1.002	1.212	1.217	1.001
14	1.000	1.002	1.164	1.170	1.002
15	1.000	1.002	1.131	1.136	1.002
16	1.000	1.002	1.105	1.110	1.002
17	1.000	1.002	1.085	1.091	1.002
18	1.000	1.002	1.061	1.069	1.004
19	1.000	1.003	1.038	1.046	1.005
20	1.000	1.005	1.021	1.031	1.007

COMPARISON OF FAST CROSS SECTIONS FOR U238 ----- N2N

GROUP	SRL	ANC	BAPL	CRNL
1	0.1415E 01	0.1361E 01	0.1360E 01	0.1365E 01
2	0.4943E 00	0.3602E 00	0.3402E 00	0.3729E 00
3	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0

RELATIVE VALUES FOR U238 ----- N2N

GROUP	SRL	ANC	BAFL	CRNL
1	1.000	0.962	0.961	0.965
2	1.000	0.729	0.688	0.754
3	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0

COMPARISON OF FAST CROSS SECTIONS FOR U238 ------ CHI

GROUP	SRL	ANC	CRNL
1	0.6650E-02	0.6094E-02	0.6165E-02
2	0.1923E-01	0.1812E-01	0.1826E-01
3	0.4096E-01	0.3929E-01	0.3945E-01
4	0.6811E-01	0.6644E-01	0.6645E-01
5	0.9340E-01	0.9236E-01	0.9207E-01
6	0.1102E 00	0.1101E 00	0.1094E 00
7	0.1155E 00	0.1163E 00	0.1154E 00
8	0.1102E 00	0.1118E 00	0.1107E 00
9	0.9784E-01	0.9985E-01	0.9870E-01
10	0.8212E-01	0.8417E-01	0.8312E-01
11	0.6597E-01	0.6783E-01	0.6692E-01
12	0.5123E-01	0.5278E-01	0.5202E-01
13	0.3868E-01	0.3996E-01	0.3937E-01
14	0.2862E-01	0.2961E-01	0.2915E-01
15	0.2083E-01	0.2158E-01	0.2124E-01
16	0.1498E-01	0.1553E-01	0.1528E-01
17	0.1066E-01	0.1106E-01	0.1088E-01
18	0.7532E-02	0.7814E-02	0.7687E-02
19	0.5284E-02	0.5488E-02	0.5397E-02
20	0.3692E-02	0.3836E-02	0.3772E-02

RELATIVE VALUES FOR U233 ------ CHI

GROUP	SRL	ANC	CRNL
1	1.000	0.916	0.927
2	1.000	0.943	0.947
3	1.000	0.959	0.963
4	1.000	0.975	0.976
5	1.000	0.989	0.986
6	1.000	0.999	0.993
7	1.000	1.007	0.999
8	1.000	1.015	1.005
9	1.000	1.021	1.009
10	1.000	1.025	1.012
11	1.000	1.028	1.014
12	1.000	1.031	1.016
13	1.000	1.033	1.018
14	1.000	1.035	1.019
15	1.000	1.036	1.020
16	1.000	1.037	1.020
17	1.000	1.038	1.021
18	1.000	1.037	1.021
19	1.000	1.039	1.021
20	1.000	1.039	1.022

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COMPARISON OF FAST CROSS SECTIONS FOR U238 ----- INELAST

GROUP	SRL	ANC	BAFL	EML	CRNL
1	0.5575E 00	0.6210E 00	0.6219E 00	0.3348E 01	0.6160E 00
2	0.1653E 01	0.1824E 01	0.1850E 01	0.2557E 01	0.1607E 01
3	0.2484E 01	0.2492E 01	0.2491E 01	0.2490E 01	0.2490E 01
4	0.2503E 01	0.2502E 01	0.2502E 01	0.2502E 01	0.2502E 01
5	0.2509E 01	0.2509E 01	0.2509E 01	0.2509E 01	0.2509E 01
6	0.2493E 01	0.2493E 01	0.2493E 01	0.2493E 01	0.2493E 01
7	0.2500E 01	0.2501E 01	0.2501E 01	0.2500E 01	0.2501E 01
8	0.2585E 01	0.2586E 01	0.2586E 01	0.2585E 01	0.2585E 01
9	0.2444E 01	0.2441E 01	0.2443E 01	0.2445E 01	0.2445E 01
10	0.2144E 01	0.2143E 01	0.2136E 01	0.2145E 01	0.2145E 01
11	0.1950E 01	0.1949E 01	0.1951E 01	0.1953E 01	0.1952E 01
12	0.1751E 01	0.1752E 01	0.1751E 01	0.1753E 01	0.1753E 01
13	0.1554E 01	0.1555E 01	0.1551E 01	0.1557E 01	0.1557E 01
14	0.1350E 01	0.1351E 01	0.1346E 01	0.1353E 01	0.1352E 01
15	0.1176E 01	0.1177E 01	0.1175E 01	0.1179E 01	0.1179E 01
16	0.1034E 01	0.1035E 01	0.1033E 01	0.1036E 01	0.1036E 01
17	0.8946E 00	0.8958E 00	0.8928E 00	0.8975E 00	0.8977E 00
18	0.7011E 00	0.7032E 00	0.6978E 00	0.7066E 00	0.7062E 00
19	0.4692E 00	0.4710E 00	0.4664E 00	0.4731E 00	0.4730E 00
20	0.2853E 00	0.2868E 00	0.2830E 00	0.2884E 00	0.2883E 00

RELATIVE VALUES FOR U238 ------ INELAST

GROUP	SRL	ANC	BAFL	ENL	CRNL
1	1.000	1.114	1.116	6.005	1.105
2	1.000	1.103	1.119	1.547	1.093
3	1.000	1.003	1.003	1.002	1.002
4	1.000	1.000	1.000	1.000	1.000
5	1.000	1.000	1.000	1.000	1.000
6	1.000	1.000	1.000	1.000	1.000
7	1.000	1.000	1.000	1.000	1.000
8	1.000	1.000	1.000	1.000	1.000
9	1.000	0.999	1.000	1.000	1.000
10	1.000	1.000	0.996	1.000	1.000
11	1.000	0.999	1.000	1.002	1.001
12	1.000	1.001	1.000	1.001	1.001
13	1.000	1.001	0.998	1.002	1.002
14	1.000	1.001	0.997	1.002	1.001
15	1.000	1.001	0.999	1.003	1.003
16	1.000	1.001	0.999	1.002	1.002
17	1.000	1.001	0.998	1.003	1.003
18	1.000	1.003	0.995	1.008	1.007
19	1.000	1.004	0.994	1.008	1.008
20	1.000	1.005	0.992	1.011	1.011

V. COMPARISON OF THERMAL MULTIGROUP CROSS SECTIONS

THERMAL GROUP STRUCTURE
(THERMOS GROUPS 1 - 30)

Group	Average Energy, eV	Weighting Factor	Upper Energy, eV
1	0.0002530	0.0005060	0.0005692
2	0.0010120	0.0010120	0.0015812
3	0.0022770	0.0015180	0.0030992
4	0.0040480	0.0020240	0.0051232
5	0.0063250	0.0025300	0.0076532
6	0.0091080	0.0030370	0.0106892
7	0.0123970	0.0035420	0.0142312
8	0.0161920	0.0040480	0.0182792
9	0.0204930	0.0045540	0.0228332
10	0.0253000	0.0050600	0.0278932
11	0.0306129	0.0055660	0.0334592
12	0.0364319	0.0060720	0.0395311
13	0.0427568	0.0065779	0.0461091
14	0.0495878	0.0070839	0.0531930
15	0.0569247	0.0075900	0.0607830
16	0.0651730	0.0089334	0.0697163
17	0.0748471	0.0104437	0.0801601
18	0.0861214	0.0121363	0.0922964
19	0.0991855	0.0140262	0.1063226
20	0.1139759	0.0155727	0.1218953
21	0.1312305	0.0190148	0.1409101
22	0.1524829	0.0236022	0.1645123
23	0.1790117	0.0296110	0.1941233
24	0.2124051	0.0373862	0.2315095
25	0.2546369	0.0473557	0.2788652
26	0.3081548	0.0600416	0.3389068
27	0.3759819	0.0760740	0.4149808
28	0.4618304	0.0962037	0.5111846
29	0.5702278	0.1213123	0.6324969
30	0.7066566	0.1524296	0.7849265

THERMAL MULTIGROUP EDITS

Pages 95 through 135

COMPARISON OF THERMAL CROSS SECTIONS FOR H-H2O ----- ELASTIC

GROUP	SRL	BAPL	BNL
1	0.2152E 03	0.2152E 03	0.2137E 03
2	0.1222E 03	0.1222E 03	0.1215E 03
3	0.9506E 02	0.9506E 02	0.9468E 02
4	0.8284E 02	0.8284E 02	0.8260E 02
5	0.7524E 02	0.7524E 02	0.7506E 02
6	0.6971E 02	0.6971E 02	0.6943E 02
7	0.6510E 02	0.6510E 02	0.6497E 02
8	0.6098E 02	0.6098E 02	0.6086E 02
9	0.5717E 02	0.5717E 02	0.5711E 02
10	0.5363E 02	0.5363E 02	0.5359E 02
11	0.5036E 02	0.5036E 02	0.5034E 02
12	0.4737E 02	0.4737E 02	0.4736E 02
13	0.4468E 02	0.4468E 02	0.4468E 02
14	0.4232E 02	0.4232E 02	0.4231E 02
15	0.4027E 02	0.4027E 02	0.4026E 02
16	0.3846E 02	0.3846E 02	0.3845E 02
17	0.3681E 02	0.3681E 02	0.3680E 02
18	0.3532E 02	0.3532E 02	0.3529E 02
19	0.3395E 02	0.3395E 02	0.3392E 02
20	0.3267E 02	0.3267E 02	0.3263E 02
21	0.3146E 02	0.3146E 02	0.3142E 02
22	0.3024E 02	0.3024E 02	0.3019E 02
23	0.2899E 02	0.2899E 02	0.2891E 02
24	0.2777E 02	0.2778E 02	0.2770E 02
25	0.2666E 02	0.2666E 02	0.2658E 02
26	0.2553E 02	0.2553E 02	0.2541E 02
27	0.2439E 02	0.2439E 02	0.2432E 02
28	0.2326E 02	0.2326E 02	0.2318E 02
29	0.2239E 02	0.2239E 02	0.2224E 02
30	0.2183E 02	0.2183E 02	0.2154E 02

RELATIVE VALUES FOR H-H2O ----- ELASTIC

GROUP	SRL	BAPL	BNL
1	1.000	1.000	0.993
2	1.000	1.000	0.994
3	1.000	1.000	0.996
4	1.000	1.000	0.997
5	1.000	1.000	0.998
6	1.000	1.000	0.996
7	1.000	1.000	0.998
8	1.000	1.000	0.998
9	1.000	1.000	0.999
10	1.000	1.000	0.999
11	1.000	1.000	1.000
12	1.000	1.000	1.000
13	1.000	1.000	1.000
14	1.000	1.000	1.000
15	1.000	1.000	1.000
16	1.000	1.000	1.000
17	1.000	1.000	1.000
18	1.000	1.000	0.999
19	1.000	1.000	0.999
20	1.000	1.000	0.999
21	1.000	1.000	0.999
22	1.000	1.000	0.998
23	1.000	1.000	0.997
24	1.000	1.000	0.997
25	1.000	1.000	0.997
26	1.000	1.000	0.995
27	1.000	1.000	0.997
28	1.000	1.000	0.997
29	1.000	1.000	0.993
30	1.000	1.000	0.987

COMPARISON OF THERMAL CROSS SECTIONS FOR H-H2O ----- CAPTURE

GROUP	SRL	BAPL	BNL
1	0.3320E 01	0.3320E 01	0.3320E 01
2	0.1660E 01	0.1660E 01	0.1660E 01
3	0.1107E 01	0.1107E 01	0.1107E 01
4	0.8300E 00	0.8300E 00	0.8300E 00
5	0.6640E 00	0.6640E 00	0.6640E 00
6	0.5534E 00	0.5533E 00	0.5533E 00
7	0.4743E 00	0.4742E 00	0.4743E 00
8	0.4150E 00	0.4150E 00	0.4150E 00
9	0.3689E 00	0.3689E 00	0.3689E 00
10	0.3320E 00	0.3320E 00	0.3320E 00
11	0.3018E 00	0.3018E 00	0.3018E 00
12	0.2767E 00	0.2767E 00	0.2767E 00
13	0.2554E 00	0.2554E 00	0.2554E 00
14	0.2371E 00	0.2371E 00	0.2371E 00
15	0.2213E 00	0.2213E 00	0.2213E 00
16	0.2068E 00	0.2068E 00	0.2069E 00
17	0.1930E 00	0.1930E 00	0.1930E 00
18	0.1799E 00	0.1799E 00	0.1799E 00
19	0.1677E 00	0.1676E 00	0.1677E 00
20	0.1563E 00	0.1564E 00	0.1564E 00
21	0.1458E 00	0.1458E 00	0.1458E 00
22	0.1352E 00	0.1352E 00	0.1352E 00
23	0.1248E 00	0.1248E 00	0.1248E 00
24	0.1145E 00	0.1146E 00	0.1146E 00
25	0.1046E 00	0.1046E 00	0.1046E 00
26	0.9511E-01	0.9510E-01	0.9513E-01
27	0.8611E-01	0.8610E-01	0.8612E-01
28	0.7768E-01	0.7769E-01	0.7771E-01
29	0.6991E-01	0.6991E-01	0.7016E-01
30	0.6280E-01	0.6280E-01	0.6300E-01

RELATIVE VALUES FOR H-H2O ----- CAPTURE

GROUP	SRL	BAPL	BNL
1	1.000	1.000	1.000
2	1.000	1.000	1.000
3	1.000	1.000	1.000
4	1.000	1.000	1.000
5	1.000	1.000	1.000
6	1.000	1.000	1.000
7	1.000	1.000	1.000
8	1.000	1.000	1.000
9	1.000	1.000	1.000
10	1.000	1.000	1.000
11	1.000	1.000	1.000
12	1.000	1.000	1.000
13	1.000	1.000	1.000
14	1.000	1.000	1.000
15	1.000	1.000	1.000
16	1.000	1.000	1.000
17	1.000	1.000	1.000
18	1.000	1.000	1.000
19	1.000	0.999	1.000
20	1.000	1.001	1.001
21	1.000	1.000	1.000
22	1.000	1.000	1.000
23	1.000	1.000	1.000
24	1.000	1.001	1.001
25	1.000	1.000	1.000
26	1.000	1.000	1.000
27	1.000	1.000	1.000
28	1.000	1.000	1.000
29	1.000	1.000	1.004
30	1.000	1.000	1.003

COMPARISON OF THERMAL CROSS SECTIONS FOR H-H2O ----- MU-BAR

GROUP	SRL	BAPL	BNL
1	-0.1801E-04	-0.2384E-04	-0.2031E-03
2	0.8880E-02	0.8875E-02	0.8774E-02
3	0.2851E-01	0.2851E-01	0.2854E-01
4	0.5162E-01	0.5162E-01	0.5167E-01
5	0.7043E-01	0.7043E-01	0.7035E-01
6	0.8774E-01	0.8775E-01	0.8854E-01
7	0.1047E 00	0.1047E 00	0.1061E 00
8	0.1226E 00	0.1226E 00	0.1250E 00
9	0.1427E 00	0.1427E 00	0.1424E 00
10	0.1626E 00	0.1626E 00	0.1633E 00
11	0.1829E 00	0.1829E 00	0.1830E 00
12	0.2030E 00	0.2030E 00	0.2029E 00
13	0.2229E 00	0.2229E 00	0.2227E 00
14	0.2416E 00	0.2416E 00	0.2414E 00
15	0.2589E 00	0.2589E 00	0.2589E 00
16	0.2753E 00	0.2754E 00	0.2755E 00
17	0.2916E 00	0.2916E 00	0.2917E 00
18	0.3075E 00	0.3075E 00	0.3078E 00
19	0.3233E 00	0.3233E 00	0.3237E 00
20	0.3388E 00	0.3389E 00	0.3397E 00
21	0.3546E 00	0.3545E 00	0.3554E 00
22	0.3713E 00	0.3713E 00	0.3724E 00
23	0.3901E 00	0.3901E 00	0.3915E 00
24	0.4109E 00	0.4109E 00	0.4124E 00
25	0.4335E 00	0.4335E 00	0.4356E 00
26	0.4549E 00	0.4549E 00	0.4569E 00
27	0.4742E 00	0.4743E 00	0.4766E 00
28	0.4926E 00	0.4926E 00	0.4944E 00
29	0.5109E 00	0.5109E 00	0.5136E 00
30	0.5312E 00	0.5312E 00	0.5282E 00

RELATIVE VALUES FOR F-H2O ----- MU-BAR

GROUP	SRL	BAFL	BNL
1	1.000	1.324	*****
2	1.000	0.999	0.988
3	1.000	1.000	1.001
4	1.000	1.000	1.001
5	1.000	1.000	0.999
6	1.000	1.000	1.009
7	1.000	1.000	1.013
8	1.000	1.000	1.020
9	1.000	1.000	0.998
10	1.000	1.000	1.004
11	1.000	1.000	1.001
12	1.000	1.000	1.000
13	1.000	1.000	0.999
14	1.000	1.000	0.999
15	1.000	1.000	1.000
16	1.000	1.000	1.001
17	1.000	1.000	1.000
18	1.000	1.000	1.001
19	1.000	1.000	1.001
20	1.000	1.000	1.003
21	1.000	1.000	1.002
22	1.000	1.000	1.003
23	1.000	1.000	1.004
24	1.000	1.000	1.004
25	1.000	1.000	1.005
26	1.000	1.000	1.004
27	1.000	1.000	1.005
28	1.000	1.000	1.004
29	1.000	1.000	1.005
30	1.000	1.000	0.994

COMPARISON OF THERMAL CROSS SECTIONS FOR D-D2O ----- ELASTIC

GROUP	SRL	BNL
1	0.1717E 02	0.1717E 02
2	0.1076E 02	0.1076E 02
3	0.8994E 01	0.8994E 01
4	0.8122E 01	0.8122E 01
5	0.7549E 01	0.7549E 01
6	0.7106E 01	0.7106E 01
7	0.6710E 01	0.6711E 01
8	0.6356E 01	0.6356E 01
9	0.6030E 01	0.6030E 01
10	0.5734E 01	0.5734E 01
11	0.5472E 01	0.5472E 01
12	0.5248E 01	0.5248E 01
13	0.5059E 01	0.5059E 01
14	0.4903E 01	0.4903E 01
15	0.4772E 01	0.4772E 01
16	0.4652E 01	0.4652E 01
17	0.4532E 01	0.4533E 01
18	0.4415E 01	0.4415E 01
19	0.4299E 01	0.4300E 01
20	0.4190E 01	0.4190E 01
21	0.4085E 01	0.4085E 01
22	0.3994E 01	0.3994E 01
23	0.3905E 01	0.3906E 01
24	0.3805E 01	0.3805E 01
25	0.3693E 01	0.3693E 01
26	0.3587E 01	0.3587E 01
27	0.3532E 01	0.3532E 01
28	0.3504E 01	0.3504E 01
29	0.3476E 01	0.3477E 01
30	0.3446E 01	0.3448E 01

RELATIVE VALUES FOR C-C2C ----- ELASTIC

GROUP	SRL	BNL
1	1.000	1.000
2	1.000	1.000
3	1.000	1.000
4	1.000	1.000
5	1.000	1.000
6	1.000	1.000
7	1.000	1.000
8	1.000	1.000
9	1.000	1.000
10	1.000	1.000
11	1.000	1.000
12	1.000	1.000
13	1.000	1.000
14	1.000	1.000
15	1.000	1.000
16	1.000	1.000
17	1.000	1.000
18	1.000	1.000
19	1.000	1.000
20	1.000	1.000
21	1.000	1.000
22	1.000	1.000
23	1.000	1.000
24	1.000	1.000
25	1.000	1.000
26	1.000	1.000
27	1.000	1.000
28	1.000	1.000
29	1.000	1.000
30	1.000	1.001

COMPARISON OF THERMAL CROSS SECTIONS FOR D-D2O ----- CAPTURE

GROUP	SRL	BNL
1	0.5200E-02	0.4600E-02
2	0.2600E-02	0.2300E-02
3	0.1733E-02	0.1533E-02
4	0.1300E-02	0.1150E-02
5	0.1040E-02	0.9200E-03
6	0.8667E-03	0.7667E-03
7	0.7429E-03	0.6571E-03
8	0.6500E-03	0.5750E-03
9	0.5778E-03	0.5111E-03
10	0.5200E-03	0.4593E-03
11	0.4727E-03	0.4131E-03
12	0.4332E-03	0.3744E-03
13	0.3999E-03	0.3421E-03
14	0.3713E-03	0.3146E-03
15	0.3465E-03	0.2911E-03
16	0.3238E-03	0.2697E-03
17	0.3021E-03	0.2494E-03
18	0.2816E-03	0.2304E-03
19	0.2625E-03	0.2128E-03
20	0.2446E-03	0.1967E-03
21	0.2281E-03	0.1817E-03
22	0.2116E-03	0.1669E-03
23	0.1952E-03	0.1525E-03
24	0.1792E-03	0.1384E-03
25	0.1636E-03	0.1250E-03
26	0.1488E-03	0.1122E-03
27	0.1347E-03	0.1003E-03
28	0.1215E-03	0.8929E-04
29	0.1093E-03	0.7956E-04
30	0.9818E-04	0.7046E-04

RELATIVE VALUES FOR D-D2O ----- CAPTURE

GROUP	SRL	BNL
1	1.000	0.885
2	1.000	0.885
3	1.000	0.885
4	1.000	0.885
5	1.000	0.885
6	1.000	0.885
7	1.000	0.885
8	1.000	0.885
9	1.000	0.885
10	1.000	0.883
11	1.000	0.874
12	1.000	0.864
13	1.000	0.855
14	1.000	0.847
15	1.000	0.840
16	1.000	0.833
17	1.000	0.826
18	1.000	0.818
19	1.000	0.811
20	1.000	0.804
21	1.000	0.797
22	1.000	0.789
23	1.000	0.781
24	1.000	0.772
25	1.000	0.764
26	1.000	0.754
27	1.000	0.745
28	1.000	0.735
29	1.000	0.728
30	1.000	0.718

COMPARISON OF THERMAL CROSS SECTIONS FOR D-D2O ----- ML-BAR

GROUP	SRL	BNL
1	-0.1708E-02	-0.1715E-02
2	0.9109E-02	0.9109E-02
3	0.2465E-01	0.2464E-01
4	0.3412E-01	0.3412E-01
5	0.4409E-01	0.4410E-01
6	0.5486E-01	0.5486E-01
7	0.6666E-01	0.6667E-01
8	0.8204E-01	0.8205E-01
9	0.9580E-01	0.9581E-01
10	0.1104E 00	0.1104E 00
11	0.1246E 00	0.1246E 00
12	0.1389E 00	0.1389E 00
13	0.1509E 00	0.1509E 00
14	0.1617E 00	0.1617E 00
15	0.1713E 00	0.1713E 00
16	0.1805E 00	0.1805E 00
17	0.1902E 00	0.1902E 00
18	0.2001E 00	0.2001E 00
19	0.2100E 00	0.2101E 00
20	0.2197E 00	0.2197E 00
21	0.2292E 00	0.2292E 00
22	0.2388E 00	0.2388E 00
23	0.2491E 00	0.2491E 00
24	0.2601E 00	0.2601E 00
25	0.2718E 00	0.2718E 00
26	0.2835E 00	0.2835E 00
27	0.2955E 00	0.2955E 00
28	0.3046E 00	0.3046E 00
29	0.3128E 00	0.3126E 00
30	0.3201E 00	0.3197E 00

RELATIVE VALLES FOR D-D20 ----- MU-EAR

GROUP	SRL	BNL
1	1.000	1.004
2	1.000	1.000
3	1.000	1.000
4	1.000	1.000
5	1.000	1.000
6	1.000	1.000
7	1.000	1.000
8	1.000	1.000
9	1.000	1.000
10	1.000	1.000
11	1.000	1.000
12	1.000	1.000
13	1.000	1.000
14	1.000	1.000
15	1.000	1.000
16	1.000	1.000
17	1.000	1.000
18	1.000	1.000
19	1.000	1.000
20	1.000	1.000
21	1.000	1.000
22	1.000	1.000
23	1.000	1.000
24	1.000	1.000
25	1.000	1.000
26	1.000	1.000
27	1.000	1.000
28	1.000	1.000
29	1.000	0.999
30	1.000	0.999

COMPARISON OF THERMAL CROSS SECTIONS FOR O16 ----- ELASTIC

GROUP	SRL	BAPL	BNL
1	0.1122E 02	0.3748E 01	0.3748E 01
2	0.6401E 01	0.3748E 01	0.3748E 01
3	0.5052E 01	0.3748E 01	0.3748E 01
4	0.4505E 01	0.3748E 01	0.3748E 01
5	0.4239E 01	0.3748E 01	0.3748E 01
6	0.4090E 01	0.3748E 01	0.3748E 01
7	0.4000E 01	0.3748E 01	0.3748E 01
8	0.3941E 01	0.3748E 01	0.3748E 01
9	0.3900E 01	0.3748E 01	0.3748E 01
10	0.3871E 01	0.3748E 01	0.3748E 01
11	0.3850E 01	0.3748E 01	0.3748E 01
12	0.3834E 01	0.3748E 01	0.3748E 01
13	0.3821E 01	0.3748E 01	0.3748E 01
14	0.3811E 01	0.3748E 01	0.3748E 01
15	0.3803E 01	0.3748E 01	0.3748E 01
16	0.3796E 01	0.3748E 01	0.3748E 01
17	0.3790E 01	0.3748E 01	0.3748E 01
18	0.3785E 01	0.3748E 01	0.3748E 01
19	0.3780E 01	0.3748E 01	0.3748E 01
20	0.3776E 01	0.3748E 01	0.3748E 01
21	0.3773E 01	0.3748E 01	0.3748E 01
22	0.3769E 01	0.3748E 01	0.3748E 01
23	0.3766E 01	0.3748E 01	0.3748E 01
24	0.3764E 01	0.3748E 01	0.3748E 01
25	0.3761E 01	0.3748E 01	0.3748E 01
26	0.3759E 01	0.3748E 01	0.3748E 01
27	0.3757E 01	0.3748E 01	0.3748E 01
28	0.3755E 01	0.3748E 01	0.3748E 01
29	0.3753E 01	0.3748E 01	0.3748E 01
30	0.3752E 01	0.3748E 01	0.3748E 01

RELATIVE VALUES FOR O16 ----- ELASTIC

GROUP	SRL	BAPL	BNL
1	1.000	0.334	0.334
2	1.000	0.586	0.586
3	1.000	0.742	0.742
4	1.000	0.832	0.832
5	1.000	0.884	0.884
6	1.000	0.916	0.916
7	1.000	0.937	0.937
8	1.000	0.951	0.951
9	1.000	0.961	0.961
10	1.000	0.968	0.968
11	1.000	0.974	0.974
12	1.000	0.978	0.978
13	1.000	0.981	0.981
14	1.000	0.983	0.983
15	1.000	0.986	0.986
16	1.000	0.987	0.987
17	1.000	0.989	0.989
18	1.000	0.990	0.990
19	1.000	0.992	0.992
20	1.000	0.993	0.993
21	1.000	0.993	0.993
22	1.000	0.994	0.994
23	1.000	0.995	0.995
24	1.000	0.996	0.996
25	1.000	0.997	0.997
26	1.000	0.997	0.997
27	1.000	0.998	0.998
28	1.000	0.998	0.998
29	1.000	0.999	0.999
30	1.000	0.999	0.999

COMPARISON OF THERMAL CROSS SECTIONS FOR O16 ----- CAPTURE

GROUP	SRL	BAPL	BNL
1	0.1780E-02	0.1780E-02	0.1780E-02
2	0.8899E-03	0.8899E-03	0.8899E-03
3	0.5933E-03	0.5933E-03	0.5933E-03
4	0.4450E-03	0.4450E-03	0.4450E-03
5	0.3560E-03	0.3560E-03	0.3560E-03
6	0.2967E-03	0.2966E-03	0.2967E-03
7	0.2543E-03	0.2542E-03	0.2543E-03
8	0.2225E-03	0.2225E-03	0.2225E-03
9	0.1978E-03	0.1978E-03	0.1978E-03
10	0.1780E-03	0.1780E-03	0.1780E-03
11	0.1618E-03	0.1618E-03	0.1618E-03
12	0.1483E-03	0.1483E-03	0.1483E-03
13	0.1369E-03	0.1369E-03	0.1369E-03
14	0.1271E-03	0.1271E-03	0.1271E-03
15	0.1187E-03	0.1187E-03	0.1187E-03
16	0.1109E-03	0.1109E-03	0.1109E-03
17	0.1035E-03	0.1035E-03	0.1035E-03
18	0.9647E-04	0.9648E-04	0.9647E-04
19	0.8992E-04	0.8990E-04	0.8990E-04
20	0.8382E-04	0.8385E-04	0.8386E-04
21	0.7817E-04	0.7816E-04	0.7815E-04
22	0.7251E-04	0.7250E-04	0.7250E-04
23	0.6692E-04	0.6692E-04	0.6691E-04
24	0.6142E-04	0.6143E-04	0.6143E-04
25	0.5610E-04	0.5611E-04	0.5610E-04
26	0.5100E-04	0.5100E-04	0.5100E-04
27	0.4618E-04	0.4617E-04	0.4617E-04
28	0.4166E-04	0.4166E-04	0.4166E-04
29	0.3749E-04	0.3749E-04	0.3761E-04
30	0.3368E-04	0.3368E-04	0.3378E-04

RELATIVE VALUES FOR O16 ----- CAPTURE

GROUP	SRL	BAPL	ENL
1	1.000	1.000	1.000
2	1.000	1.000	1.000
3	1.000	1.000	1.000
4	1.000	1.000	1.000
5	1.000	1.000	1.000
6	1.000	1.000	1.000
7	1.000	1.000	1.000
8	1.000	1.000	1.000
9	1.000	1.000	1.000
10	1.000	1.000	1.000
11	1.000	1.000	1.000
12	1.000	1.000	1.000
13	1.000	1.000	1.000
14	1.000	1.000	1.000
15	1.000	1.000	1.000
16	1.000	1.000	1.000
17	1.000	1.000	1.000
18	1.000	1.000	1.000
19	1.000	1.000	1.000
20	1.000	1.000	1.000
21	1.000	1.000	1.000
22	1.000	1.000	1.000
23	1.000	1.000	1.000
24	1.000	1.000	1.000
25	1.000	1.000	1.000
26	1.000	1.000	1.000
27	1.000	1.000	1.000
28	1.000	1.000	1.000
29	1.000	1.000	1.003
30	1.000	1.000	1.003

COMPARISON OF THERMAL CROSS SECTIONS FOR O16 ----- MU-BAR

GROUP	SRL	BAPL	BNL
1	0.3533E-02	0.4219E-01	0.0
2	0.6730E-02	0.4219E-01	0.0
3	0.1648E-01	0.4219E-01	0.0
4	0.2667E-01	0.4219E-01	0.0
5	0.3384E-01	0.4219E-01	0.0
6	0.3799E-01	0.4219E-01	0.0
7	0.4010E-01	0.4219E-01	0.0
8	0.4108E-01	0.4219E-01	0.0
9	0.4151E-01	0.4219E-01	0.0
10	0.4170E-01	0.4219E-01	0.0
11	0.4179E-01	0.4219E-01	0.0
12	0.4184E-01	0.4219E-01	0.0
13	0.4190E-01	0.4219E-01	0.0
14	0.4195E-01	0.4219E-01	0.0
15	0.4200E-01	0.4219E-01	0.0
16	0.4206E-01	0.4219E-01	0.0
17	0.4212E-01	0.4219E-01	0.0
18	0.4217E-01	0.4219E-01	0.0
19	0.4222E-01	0.4219E-01	0.0
20	0.4226E-01	0.4219E-01	0.0
21	0.4229E-01	0.4219E-01	0.0
22	0.4231E-01	0.4219E-01	0.0
23	0.4232E-01	0.4219E-01	0.0
24	0.4231E-01	0.4219E-01	0.0
25	0.4229E-01	0.4219E-01	0.0
26	0.4226E-01	0.4219E-01	0.0
27	0.4222E-01	0.4219E-01	0.0
28	0.4218E-01	0.4219E-01	0.0
29	0.4215E-01	0.4219E-01	0.0
30	0.4213E-01	0.4219E-01	0.0

RELATIVE VALUES FOR C16 ----- MU-EAR

GROUP	SRL	BAFL	BNL
1	1.000	*****	0.0
2	1.000	6.269	0.0
3	1.000	2.560	0.0
4	1.000	1.582	0.0
5	1.000	1.247	0.0
6	1.000	1.111	0.0
7	1.000	1.052	0.0
8	1.000	1.027	0.0
9	1.000	1.016	0.0
10	1.000	1.012	0.0
11	1.000	1.010	0.0
12	1.000	1.008	0.0
13	1.000	1.007	0.0
14	1.000	1.006	0.0
15	1.000	1.005	0.0
16	1.000	1.003	0.0
17	1.000	1.002	0.0
18	1.000	1.000	0.0
19	1.000	0.999	0.0
20	1.000	0.998	0.0
21	1.000	0.998	0.0
22	1.000	0.997	0.0
23	1.000	0.997	0.0
24	1.000	0.997	0.0
25	1.000	0.998	0.0
26	1.000	0.998	0.0
27	1.000	0.999	0.0
28	1.000	1.000	0.0
29	1.000	1.001	0.0
30	1.000	1.001	0.0

COMPARISON OF THERMAL CROSS SECTIONS FOR AL27 ----- ELASTIC

GROUP	SRL	BAPL	BNL
1	0.1348E 01	0.1348E 01	0.1348E 01
2	0.1348E 01	0.1348E 01	0.1348E 01
3	0.1348E 01	0.1348E 01	0.1348E 01
4	0.1348E 01	0.1348E 01	0.1348E 01
5	0.1348E 01	0.1348E 01	0.1348E 01
6	0.1348E 01	0.1348E 01	0.1348E 01
7	0.1348E 01	0.1348E 01	0.1348E 01
8	0.1348E 01	0.1348E 01	0.1348E 01
9	0.1348E 01	0.1348E 01	0.1348E 01
10	0.1348E 01	0.1348E 01	0.1348E 01
11	0.1348E 01	0.1348E 01	0.1348E 01
12	0.1348E 01	0.1348E 01	0.1348E 01
13	0.1348E 01	0.1348E 01	0.1348E 01
14	0.1348E 01	0.1348E 01	0.1348E 01
15	0.1348E 01	0.1348E 01	0.1348E 01
16	0.1347E 01	0.1347E 01	0.1347E 01
17	0.1347E 01	0.1347E 01	0.1347E 01
18	0.1347E 01	0.1347E 01	0.1347E 01
19	0.1347E 01	0.1347E 01	0.1347E 01
20	0.1346E 01	0.1347E 01	0.1347E 01
21	0.1347E 01	0.1347E 01	0.1347E 01
22	0.1347E 01	0.1347E 01	0.1347E 01
23	0.1347E 01	0.1347E 01	0.1347E 01
24	0.1347E 01	0.1347E 01	0.1347E 01
25	0.1347E 01	0.1347E 01	0.1347E 01
26	0.1347E 01	0.1347E 01	0.1347E 01
27	0.1347E 01	0.1347E 01	0.1347E 01
28	0.1347E 01	0.1347E 01	0.1347E 01
29	0.1347E 01	0.1347E 01	0.1347E 01
30	0.1347E 01	0.1347E 01	0.1347E 01

RELATIVE VALUES FOR AL27 ----- ELASTIC

GROUP	SRL	BAPL	BNL
1	1.000	1.000	1.000
2	1.000	1.000	1.000
3	1.000	1.000	1.000
4	1.000	1.000	1.000
5	1.000	1.000	1.000
6	1.000	1.000	1.000
7	1.000	1.000	1.000
8	1.000	1.000	1.000
9	1.000	1.000	1.000
10	1.000	1.000	1.000
11	1.000	1.000	1.000
12	1.000	1.000	1.000
13	1.000	1.000	1.000
14	1.000	1.000	1.000
15	1.000	1.000	1.000
16	1.000	1.000	1.000
17	1.000	1.000	1.000
18	1.000	1.000	1.000
19	1.000	1.000	1.000
20	1.000	1.001	1.001
21	1.000	1.000	1.000
22	1.000	1.000	1.000
23	1.000	1.000	1.000
24	1.000	1.000	1.000
25	1.000	1.000	1.000
26	1.000	1.000	1.000
27	1.000	1.000	1.000
28	1.000	1.000	1.000
29	1.000	1.000	1.000
30	1.000	1.000	1.000

COMPARISON OF THERMAL CROSS SECTIONS FOR AL27 ----- CAPTURE

GROUP	SRL	BAPL	BNL
1	0.2320E 01	0.2320E 01	0.2320E 01
2	0.1160E 01	0.1160E 01	0.1160E 01
3	0.7733E 00	0.7733E 00	0.7733E 00
4	0.5800E 00	0.5800E 00	0.5800E 00
5	0.4640E 00	0.4640E 00	0.4640E 00
6	0.3867E 00	0.3866E 00	0.3866E 00
7	0.3314E 00	0.3314E 00	0.3314E 00
8	0.2900E 00	0.2900E 00	0.2900E 00
9	0.2578E 00	0.2578E 00	0.2578E 00
10	0.2320E 00	0.2320E 00	0.2320E 00
11	0.2110E 00	0.2110E 00	0.2110E 00
12	0.1935E 00	0.1935E 00	0.1935E 00
13	0.1786E 00	0.1786E 00	0.1786E 00
14	0.1659E 00	0.1659E 00	0.1659E 00
15	0.1549E 00	0.1549E 00	0.1549E 00
16	0.1448E 00	0.1448E 00	0.1448E 00
17	0.1352E 00	0.1352E 00	0.1352E 00
18	0.1260E 00	0.1260E 00	0.1260E 00
19	0.1175E 00	0.1175E 00	0.1175E 00
20	0.1095E 00	0.1096E 00	0.1096E 00
21	0.1021E 00	0.1021E 00	0.1021E 00
22	0.9471E-01	0.9470E-01	0.9470E-01
23	0.8739E-01	0.8739E-01	0.8739E-01
24	0.8020E-01	0.8021E-01	0.8021E-01
25	0.7323E-01	0.7325E-01	0.7324E-01
26	0.6656E-01	0.6656E-01	0.6656E-01
27	0.6025E-01	0.6025E-01	0.6025E-01
28	0.5434E-01	0.5435E-01	0.5435E-01
29	0.4890E-01	0.4890E-01	0.4906E-01
30	0.4391E-01	0.4391E-01	0.4404E-01

RELATIVE VALUES FOR AL27 ----- CAPTURE

GROUP	SRL	BAFL	BNL
1	1.000	1.000	1.000
2	1.000	1.000	1.000
3	1.000	1.000	1.000
4	1.000	1.000	1.000
5	1.000	1.000	1.000
6	1.000	1.000	1.000
7	1.000	1.000	1.000
8	1.000	1.000	1.000
9	1.000	1.000	1.000
10	1.000	1.000	1.000
11	1.000	1.000	1.000
12	1.000	1.000	1.000
13	1.000	1.000	1.000
14	1.000	1.000	1.000
15	1.000	1.000	1.000
16	1.000	1.000	1.000
17	1.000	1.000	1.000
18	1.000	1.000	1.000
19	1.000	1.000	1.000
20	1.000	1.001	1.001
21	1.000	1.000	1.000
22	1.000	1.000	1.000
23	1.000	1.000	1.000
24	1.000	1.000	1.000
25	1.000	1.000	1.000
26	1.000	1.000	1.000
27	1.000	1.000	1.000
28	1.000	1.000	1.000
29	1.000	1.000	1.003
30	1.000	1.000	1.003

COMPARISON OF THERMAL CROSS SECTIONS FOR AL27 ----- MU-BAR

GROUP	SRL	BAPL	BNL
1	0.2492E-01	0.2496E-01	0.0
2	0.2492E-01	0.2496E-01	0.0
3	0.2492E-01	0.2496E-01	0.0
4	0.2492E-01	0.2496E-01	0.0
5	0.2492E-01	0.2496E-01	0.0
6	0.2492E-01	0.2496E-01	0.0
7	0.2492E-01	0.2496E-01	0.0
8	0.2492E-01	0.2496E-01	0.0
9	0.2492E-01	0.2496E-01	0.0
10	0.2492E-01	0.2496E-01	0.0
11	0.2492E-01	0.2496E-01	0.0
12	0.2492E-01	0.2496E-01	0.0
13	0.2493E-01	0.2496E-01	0.0
14	0.2493E-01	0.2496E-01	0.0
15	0.2493E-01	0.2496E-01	0.0
16	0.2493E-01	0.2496E-01	0.0
17	0.2493E-01	0.2496E-01	0.0
18	0.2494E-01	0.2496E-01	0.0
19	0.2494E-01	0.2496E-01	0.0
20	0.2494E-01	0.2496E-01	0.0
21	0.2494E-01	0.2496E-01	0.0
22	0.2494E-01	0.2496E-01	0.0
23	0.2494E-01	0.2496E-01	0.0
24	0.2494E-01	0.2496E-01	0.0
25	0.2494E-01	0.2496E-01	0.0
26	0.2494E-01	0.2496E-01	0.0
27	0.2494E-01	0.2496E-01	0.0
28	0.2494E-01	0.2496E-01	0.0
29	0.2494E-01	0.2496E-01	0.0
30	0.2494E-01	0.2496E-01	0.0

RELATIVE VALUES FOR AL27 ----- MU-BAR

GROUP	SRL	BAPL	BNL
1	1.000	1.002	0.0
2	1.000	1.002	0.0
3	1.000	1.002	0.0
4	1.000	1.002	0.0
5	1.000	1.002	0.0
6	1.000	1.002	0.0
7	1.000	1.002	0.0
8	1.000	1.002	0.0
9	1.000	1.002	0.0
10	1.000	1.002	0.0
11	1.000	1.002	0.0
12	1.000	1.002	0.0
13	1.000	1.001	0.0
14	1.000	1.001	0.0
15	1.000	1.001	0.0
16	1.000	1.001	0.0
17	1.000	1.001	0.0
18	1.000	1.001	0.0
19	1.000	1.001	0.0
20	1.000	1.001	0.0
21	1.000	1.001	0.0
22	1.000	1.001	0.0
23	1.000	1.001	0.0
24	1.000	1.001	0.0
25	1.000	1.001	0.0
26	1.000	1.001	0.0
27	1.000	1.001	0.0
28	1.000	1.001	0.0
29	1.000	1.001	0.0
30	1.000	1.001	0.0

COMPARISON OF THERMAL CROSS SECTIONS FOR U235 ----- ELASTIC

GROUP	SRL	BAPL	BNL	CRNL
1	0.1563E 02	0.1563E 02	0.1563E 02	0.1563E 02
2	0.1563E 02	0.1563E 02	0.1562E 02	0.1562E 02
3	0.1562E 02	0.1562E 02	0.1562E 02	0.1562E 02
4	0.1561E 02	0.1561E 02	0.1561E 02	0.1561E 02
5	0.1560E 02	0.1560E 02	0.1560E 02	0.1560E 02
6	0.1558E 02	0.1558E 02	0.1558E 02	0.1558E 02
7	0.1556E 02	0.1556E 02	0.1556E 02	0.1556E 02
8	0.1554E 02	0.1554E 02	0.1555E 02	0.1554E 02
9	0.1552E 02	0.1552E 02	0.1552E 02	0.1552E 02
10	0.1550E 02	0.1550E 02	0.1550E 02	0.1550E 02
11	0.1547E 02	0.1547E 02	0.1547E 02	0.1547E 02
12	0.1544E 02	0.1544E 02	0.1544E 02	0.1544E 02
13	0.1541E 02	0.1541E 02	0.1541E 02	0.1541E 02
14	0.1538E 02	0.1538E 02	0.1538E 02	0.1538E 02
15	0.1534E 02	0.1534E 02	0.1534E 02	0.1534E 02
16	0.1530E 02	0.1530E 02	0.1530E 02	0.1530E 02
17	0.1525E 02	0.1525E 02	0.1525E 02	0.1525E 02
18	0.1520E 02	0.1520E 02	0.1520E 02	0.1520E 02
19	0.1514E 02	0.1513E 02	0.1513E 02	0.1513E 02
20	0.1506E 02	0.1507E 02	0.1507E 02	0.1506E 02
21	0.1499E 02	0.1498E 02	0.1498E 02	0.1498E 02
22	0.1489E 02	0.1489E 02	0.1489E 02	0.1489E 02
23	0.1477E 02	0.1477E 02	0.1477E 02	0.1477E 02
24	0.1463E 02	0.1463E 02	0.1463E 02	0.1463E 02
25	0.1451E 02	0.1450E 02	0.1451E 02	0.1451E 02
26	0.1449E 02	0.1450E 02	0.1449E 02	0.1449E 02
27	0.1434E 02	0.1435E 02	0.1434E 02	0.1434E 02
28	0.1405E 02	0.1405E 02	0.1405E 02	0.1405E 02
29	0.1372E 02	0.1372E 02	0.1373E 02	0.1372E 02
30	0.1337E 02	0.1337E 02	0.1338E 02	0.1337E 02

RELATIVE VALUES FOR U235 ----- ELASTIC

GROUP	SKL	BAPL	BNL	CRNL
1	1.000	1.000	1.000	1.000
2	1.000	1.000	0.999	0.999
3	1.000	1.000	1.000	1.000
4	1.000	1.000	1.000	1.000
5	1.000	1.000	1.000	1.000
6	1.000	1.000	1.000	1.000
7	1.000	1.000	1.000	1.000
8	1.000	1.000	1.001	1.000
9	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000
11	1.000	1.000	1.000	1.000
12	1.000	1.000	1.000	1.000
13	1.000	1.000	1.000	1.000
14	1.000	1.000	1.000	1.000
15	1.000	1.000	1.000	1.000
16	1.000	1.000	1.000	1.000
17	1.000	1.000	1.000	1.000
18	1.000	1.000	1.000	1.000
19	1.000	0.959	0.999	0.999
20	1.000	1.001	1.001	1.000
21	1.000	0.999	0.999	0.999
22	1.000	1.000	1.000	1.000
23	1.000	1.000	1.000	1.000
24	1.000	1.000	1.000	1.000
25	1.000	0.999	1.000	1.000
26	1.000	1.001	1.000	1.000
27	1.000	1.001	1.000	1.000
28	1.000	1.000	1.000	1.000
29	1.000	1.000	1.001	1.000
30	1.000	1.000	1.001	1.000

COMPARISON OF THERMAL CROSS SECTIONS FOR U235 ----- CAPTURE

GROUP	SRL	BAPL	BNL	CRNL
1	0.1076E 04	0.1076E 04	0.1076E 04	0.1076E 04
2	0.5369E 03	0.5373E 03	0.5369E 03	0.5370E 03
3	0.3560E 03	0.3559E 03	0.3560E 03	0.3560E 03
4	0.2657E 03	0.2657E 03	0.2658E 03	0.2658E 03
5	0.2110E 03	0.2110E 03	0.2110E 03	0.2110E 03
6	0.1742E 03	0.1742E 03	0.1742E 03	0.1742E 03
7	0.1470E 03	0.1470E 03	0.1470E 03	0.1470E 03
8	0.1264E 03	0.1264E 03	0.1264E 03	0.1264E 03
9	0.1104E 03	0.1104E 03	0.1104E 03	0.1104E 03
10	0.9769E 02	0.9770E 02	0.9769E 02	0.9769E 02
11	0.8735E 02	0.8735E 02	0.8735E 02	0.8735E 02
12	0.7886E 02	0.7886E 02	0.7886E 02	0.7886E 02
13	0.7179E 02	0.7179E 02	0.7179E 02	0.7179E 02
14	0.6580E 02	0.6579E 02	0.6580E 02	0.6580E 02
15	0.6063E 02	0.6063E 02	0.6063E 02	0.6063E 02
16	0.5595E 02	0.5596E 02	0.5596E 02	0.5596E 02
17	0.5161E 02	0.5152E 02	0.5160E 02	0.5160E 02
18	0.4769E 02	0.4768E 02	0.4769E 02	0.4769E 02
19	0.4426E 02	0.4418E 02	0.4424E 02	0.4424E 02
20	0.4177E 02	0.4178E 02	0.4179E 02	0.4178E 02
21	0.3953E 02	0.3952E 02	0.3952E 02	0.3952E 02
22	0.3831E 02	0.3831E 02	0.3831E 02	0.3831E 02
23	0.3825E 02	0.3791E 02	0.3825E 02	0.3825E 02
24	0.4110E 02	0.4102E 02	0.4110E 02	0.4110E 0
25	0.4588E 02	0.4597E 02	0.4589E 02	0.4589E
26	0.4268E 02	0.4394E 02	0.4268E 02	0.426
27	0.2325E 02	0.2278E 02	0.2324E 02	0.2
28	0.1176E 02	0.1151E 02	0.1176E 02	0.
29	0.7608E 01	0.7532E 01	0.7688E 01	
30	0.5790E 01	0.5705E 01	0.5820E 01	

RELATIVE VALUES FOR U235 ----- CAPTURE

GROUP	SKL	BAPL	BNL	CRNL
1	1.000	1.000	1.000	1.000
2	1.000	1.001	1.000	1.000
3	1.000	1.000	1.000	1.000
4	1.000	1.000	1.000	1.000
5	1.000	1.000	1.000	1.000
6	1.000	1.000	1.000	1.000
7	1.000	1.000	1.000	1.000
8	1.000	1.000	1.000	1.000
9	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000
11	1.000	1.000	1.000	1.000
12	1.000	1.000	1.000	1.000
13	1.000	1.000	1.000	1.000
14	1.000	1.000	1.000	1.000
15	1.000	1.000	1.000	1.000
16	1.000	1.000	1.000	1.000
17	1.000	0.998	1.000	1.000
18	1.000	1.000	1.000	1.000
19	1.000	0.998	1.000	1.000
20	1.000	1.000	1.000	1.000
21	1.000	1.000	1.000	1.000
22	1.000	1.000	1.000	1.000
23	1.000	0.991	1.000	1.000
24	1.000	0.998	1.000	1.000
25	1.000	1.002	1.000	1.000
26	1.000	1.030	1.000	1.000
27	1.000	0.980	1.000	1.000
28	1.000	0.979	1.000	1.000
29	1.000	0.990	1.011	1.000
30	1.000	0.985	1.005	1.000

COMPARISON OF THERMAL CROSS SECTIONS FOR U235 ----- FISSION

GROUP	SRL	BAPL	BNL	CRNL
1	0.6214E 04	0.6214E 04	0.6214E 04	0.6216E 04
2	0.3103E 04	0.3105E 04	0.3103E 04	0.3103E 04
3	0.2060E 04	0.2060E 04	0.2060E 04	0.2060E 04
4	0.1539E 04	0.1539E 04	0.1539E 04	0.1539E 04
5	0.1225E 04	0.1225E 04	0.1225E 04	0.1225E 04
6	0.1014E 04	0.1014E 04	0.1014E 04	0.1014E 04
7	0.8623E 03	0.8621E 03	0.8623E 03	0.8623E 03
8	0.7477E 03	0.7478E 03	0.7477E 03	0.7477E 03
9	0.6578E 03	0.6580E 03	0.6578E 03	0.6578E 03
10	0.5853E 03	0.5854E 03	0.5853E 03	0.5853E 03
11	0.5254E 03	0.5254E 03	0.5254E 03	0.5254E 03
12	0.4750E 03	0.4750E 03	0.4750E 03	0.4750E 03
13	0.4320E 03	0.4320E 03	0.4320E 03	0.4320E 03
14	0.3949E 03	0.3949E 03	0.3949E 03	0.3949E 03
15	0.3625E 03	0.3625E 03	0.3625E 03	0.3625E 03
16	0.3327E 03	0.3327E 03	0.3327E 03	0.3327E 03
17	0.3045E 03	0.3044E 03	0.3045E 03	0.3045E 03
18	0.2784E 03	0.2784E 03	0.2784E 03	0.2784E 03
19	0.2546E 03	0.2546E 03	0.2546E 03	0.2546E 03
20	0.2327E 03	0.2328E 03	0.2329E 03	0.2328E 03
21	0.2131E 03	0.2130E 03	0.2130E 03	0.2130E 03
22	0.1957E 03	0.1956E 03	0.1957E 03	0.1957E 03
23	0.1826E 03	0.1820E 03	0.1826E 03	0.1826E 03
24	0.1779E 03	0.1774E 03	0.1779E 03	0.1779E 03
25	0.1881E 03	0.1881E 03	0.1881E 03	0.1881E 03
26	0.1832E 03	0.1873E 03	0.1832E 03	0.1832E 03
27	0.1312E 03	0.1306E 03	0.1312E 03	0.1312E 03
28	0.9324E 02	0.9255E 02	0.9324E 02	0.9324E 02
29	0.7165E 02	0.7132E 02	0.7209E 02	0.7164E 02
30	0.5983E 02	0.5957E 02	0.6008E 02	0.5982E 02

RELATIVE VALUES FOR U235 ----- FISSION

GROUP	SRL	BAPL	BNL	CRNL
1	1.000	1.000	1.000	1.000
2	1.000	1.001	1.000	1.000
3	1.000	1.000	1.000	1.000
4	1.000	1.000	1.000	1.000
5	1.000	1.000	1.000	1.000
6	1.000	1.000	1.000	1.000
7	1.000	1.000	1.000	1.000
8	1.000	1.000	1.000	1.000
9	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000
11	1.000	1.000	1.000	1.000
12	1.000	1.000	1.000	1.000
13	1.000	1.000	1.000	1.000
14	1.000	1.000	1.000	1.000
15	1.000	1.000	1.000	1.000
16	1.000	1.000	1.000	1.000
17	1.000	1.000	1.000	1.000
18	1.000	1.000	1.000	1.000
19	1.000	1.000	1.000	1.000
20	1.000	1.000	1.001	1.000
21	1.000	1.000	1.000	1.000
22	1.000	0.999	1.000	1.000
23	1.000	0.997	1.000	1.000
24	1.000	0.997	1.000	1.000
25	1.000	1.000	1.000	1.000
26	1.000	1.022	1.000	1.000
27	1.000	0.995	1.000	1.000
28	1.000	0.993	1.000	1.000
29	1.000	0.995	1.006	1.000
30	1.000	0.996	1.004	1.000

COMPARISON OF THERMAL CROSS SECTIONS FOR U235 ----- NL

GROUP	SRL	BAPL	CRNL
1	0.2419E 01	0.2419E 01	0.2419E 01
2	0.2419E 01	0.2419E 01	0.2419E 01
3	0.2419E 01	0.2419E 01	0.2419E 01
4	0.2419E 01	0.2419E 01	0.2419E 01
5	0.2419E 01	0.2419E 01	0.2419E 01
6	0.2419E 01	0.2419E 01	0.2419E 01
7	0.2419E 01	0.2419E 01	0.2419E 01
8	0.2419E 01	0.2419E 01	0.2419E 01
9	0.2419E 01	0.2419E 01	0.2419E 01
10	0.2419E 01	0.2419E 01	0.2419E 01
11	0.2419E 01	0.2419E 01	0.2419E 01
12	0.2419E 01	0.2419E 01	0.2419E 01
13	0.2419E 01	0.2419E 01	0.2419E 01
14	0.2419E 01	0.2419E 01	0.2419E 01
15	0.2419E 01	0.2419E 01	0.2419E 01
16	0.2419E 01	0.2419E 01	0.2419E 01
17	0.2419E 01	0.2419E 01	0.2419E 01
18	0.2419E 01	0.2419E 01	0.2419E 01
19	0.2419E 01	0.2419E 01	0.2419E 01
20	0.2418E 01	0.2419E 01	0.2419E 01
21	0.2419E 01	0.2419E 01	0.2419E 01
22	0.2419E 01	0.2419E 01	0.2419E 01
23	0.2419E 01	0.2419E 01	0.2419E 01
24	0.2419E 01	0.2419E 01	0.2419E 01
25	0.2419E 01	0.2419E 01	0.2419E 01
26	0.2419E 01	0.2419E 01	0.2419E 01
27	0.2419E 01	0.2419E 01	0.2419E 01
28	0.2419E 01	0.2419E 01	0.2419E 01
29	0.2419E 01	0.2419E 01	0.2419E 01
30	0.2419E 01	0.2419E 01	0.2419E 01

RELATIVE VALUES FOR U235 ----- NU

GROUP	SRL	BAPL	CRNL
1	1.000	1.000	1.000
2	1.000	1.000	1.000
3	1.000	1.000	1.000
4	1.000	1.000	1.000
5	1.000	1.000	1.000
6	1.000	1.000	1.000
7	1.000	1.000	1.000
8	1.000	1.000	1.000
9	1.000	1.000	1.000
10	1.000	1.000	1.000
11	1.000	1.000	1.000
12	1.000	1.000	1.000
13	1.000	1.000	1.000
14	1.000	1.000	1.000
15	1.000	1.000	1.000
16	1.000	1.000	1.000
17	1.000	1.000	1.000
18	1.000	1.000	1.000
19	1.000	1.000	1.000
20	1.000	1.000	1.000
21	1.000	1.000	1.000
22	1.000	1.000	1.000
23	1.000	1.000	1.000
24	1.000	1.000	1.000
25	1.000	1.000	1.000
26	1.000	1.000	1.000
27	1.000	1.000	1.000
28	1.000	1.000	1.000
29	1.000	1.000	1.000
30	1.000	1.000	1.000

COMPARISON OF THERMAL CROSS SECTIONS FOR U235 ----- MU-BAR

GROUP	SRL	BAPL	BNL
1	0.3000E-02	0.2861E-02	0.0
2	0.2875E-02	0.2861E-02	0.0
3	0.2861E-02	0.2861E-02	0.0
4	0.2862E-02	0.2861E-02	0.0
5	0.2865E-02	0.2861E-02	0.0
6	0.2867E-02	0.2861E-02	0.0
7	0.2870E-02	0.2861E-02	0.0
8	0.2874E-02	0.2861E-02	0.0
9	0.2862E-02	0.2861E-02	0.0
10	0.2867E-02	0.2861E-02	0.0
11	0.2872E-02	0.2861E-02	0.0
12	0.2876E-02	0.2861E-02	0.0
13	0.2868E-02	0.2861E-02	0.0
14	0.2874E-02	0.2861E-02	0.0
15	0.2865E-02	0.2861E-02	0.0
16	0.2873E-02	0.2861E-02	0.0
17	0.2865E-02	0.2861E-02	0.0
18	0.2876E-02	0.2861E-02	0.0
19	0.2871E-02	0.2861E-02	0.0
20	0.2870E-02	0.2861E-02	0.0
21	0.2867E-02	0.2861E-02	0.0
22	0.2865E-02	0.2861E-02	0.0
23	0.2863E-02	0.2861E-02	0.0
24	0.2862E-02	0.2861E-02	0.0
25	0.2862E-02	0.2861E-02	0.0
26	0.2861E-02	0.2861E-02	0.0
27	0.2859E-02	0.2861E-02	0.0
28	0.2864E-02	0.2861E-02	0.0
29	0.2863E-02	0.2861E-02	0.0
30	0.2864E-02	0.2861E-02	0.0

RELATIVE VALUES FOR U235 ----- MU-BAR

GROUP	SRL	BAPL	BNL
1	1.000	0.954	0.0
2	1.000	0.995	0.0
3	1.000	1.000	0.0
4	1.000	1.000	0.0
5	1.000	0.999	0.0
6	1.000	0.958	0.0
7	1.000	0.997	0.0
8	1.000	0.995	0.0
9	1.000	1.000	0.0
10	1.000	0.998	0.0
11	1.000	0.956	0.0
12	1.000	0.954	0.0
13	1.000	0.998	0.0
14	1.000	0.995	0.0
15	1.000	0.959	0.0
16	1.000	0.996	0.0
17	1.000	0.999	0.0
18	1.000	0.955	0.0
19	1.000	0.997	0.0
20	1.000	0.957	0.0
21	1.000	0.998	0.0
22	1.000	0.999	0.0
23	1.000	0.559	0.0
24	1.000	1.000	0.0
25	1.000	1.000	0.0
26	1.000	1.000	0.0
27	1.000	1.001	0.0
28	1.000	0.999	0.0
29	1.000	0.999	0.0
30	1.000	0.999	0.0

COMPARISON OF THERMAL CROSS SECTIONS FOR U238 ----- ELASTIC

GROUP	SRL	BAPL	BNL	CRNL
1	0.8955E 01	0.8955E 01	0.8955E 01	0.8955E 01
2	0.8955E 01	0.8955E 01	0.8955E 01	0.8955E 01
3	0.8955E 01	0.8955E 01	0.8955E 01	0.8954E 01
4	0.8954E 01	0.8954E 01	0.8954E 01	0.8954E 01
5	0.8954E 01	0.8954E 01	0.8954E 01	0.8954E 01
6	0.8954E 01	0.8954E 01	0.8954E 01	0.8954E 01
7	0.8953E 01	0.8953E 01	0.8953E 01	0.8953E 01
8	0.8953E 01	0.8953E 01	0.8953E 01	0.8953E 01
9	0.8952E 01	0.8952E 01	0.8952E 01	0.8952E 01
10	0.8952E 01	0.8952E 01	0.8952E 01	0.8952E 01
11	0.8951E 01	0.8951E 01	0.8951E 01	0.8951E 01
12	0.8951E 01	0.8951E 01	0.8951E 01	0.8950E 01
13	0.8950E 01	0.8950E 01	0.8950E 01	0.8950E 01
14	0.8949E 01	0.8949E 01	0.8949E 01	0.8949E 01
15	0.8948E 01	0.8948E 01	0.8948E 01	0.8948E 01
16	0.8947E 01	0.8947E 01	0.8947E 01	0.8947E 01
17	0.8946E 01	0.8946E 01	0.8946E 01	0.8946E 01
18	0.8945E 01	0.8945E 01	0.8945E 01	0.8945E 01
19	0.8943E 01	0.8943E 01	0.8943E 01	0.8943E 01
20	0.8941E 01	0.8941E 01	0.8941E 01	0.8941E 01
21	0.8939E 01	0.8939E 01	0.8939E 01	0.8939E 01
22	0.8937E 01	0.8937E 01	0.8937E 01	0.8937E 01
23	0.8933E 01	0.8933E 01	0.8933E 01	0.8933E 01
24	0.8929E 01	0.8929E 01	0.8929E 01	0.8929E 01
25	0.8924E 01	0.8924E 01	0.8924E 01	0.8924E 01
26	0.8917E 01	0.8917E 01	0.8917E 01	0.8917E 01
27	0.8909E 01	0.8909E 01	0.8909E 01	0.8909E 01
28	0.8898E 01	0.8898E 01	0.8898E 01	0.8898E 01
29	0.8884E 01	0.8884E 01	0.8884E 01	0.8884E 01
30	0.8865E 01	0.8866E 01	0.8866E 01	0.8865E 01

RELATIVE VALUES FOR U233 ----- ELASTIC

GROUP	SRL	BAPL	BNL	CRNL
1	1.000	1.000	1.000	1.000
2	1.000	1.000	1.000	1.000
3	1.000	1.000	1.000	1.000
4	1.000	1.000	1.000	1.000
5	1.000	1.000	1.000	1.000
6	1.000	1.000	1.000	1.000
7	1.000	1.000	1.000	1.000
8	1.000	1.000	1.000	1.000
9	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000
11	1.000	1.000	1.000	1.000
12	1.000	1.000	1.000	1.000
13	1.000	1.000	1.000	1.000
14	1.000	1.000	1.000	1.000
15	1.000	1.000	1.000	1.000
16	1.000	1.000	1.000	1.000
17	1.000	1.000	1.000	1.000
18	1.000	1.000	1.000	1.000
19	1.000	1.000	1.000	1.000
20	1.000	1.000	1.000	1.000
21	1.000	1.000	1.000	1.000
22	1.000	1.000	1.000	1.000
23	1.000	1.000	1.000	1.000
24	1.000	1.000	1.000	1.000
25	1.000	1.000	1.000	1.000
26	1.000	1.000	1.000	1.000
27	1.000	1.000	1.000	1.000
28	1.000	1.000	1.000	1.000
29	1.000	1.000	1.000	1.000
30	1.000	1.000	1.000	1.000

COMPARISON OF THERMAL CROSS SECTIONS FOR U238 ----- CAPTURE

GROUP	SRL	BAPL	BNL	CRNL
1	0.2688E 02	0.2688E 02	0.2688E 02	0.2688E 02
2	0.1344E 02	0.1344E 02	0.1344E 02	0.1344E 02
3	0.8963E 01	0.8963E 01	0.8963E 01	0.8963E 01
4	0.6724E 01	0.6724E 01	0.6724E 01	0.6724E 01
5	0.5382E 01	0.5382E 01	0.5382E 01	0.5382E 01
6	0.4487E 01	0.4487E 01	0.4487E 01	0.4487E 01
7	0.3848E 01	0.3848E 01	0.3848E 01	0.3848E 01
8	0.3369E 01	0.3370E 01	0.3369E 01	0.3369E 01
9	0.2997E 01	0.2998E 01	0.2997E 01	0.2997E 01
10	0.2700E 01	0.2700E 01	0.2700E 01	0.2700E 01
11	0.2457E 01	0.2457E 01	0.2457E 01	0.2457E 01
12	0.2255E 01	0.2255E 01	0.2255E 01	0.2254E 01
13	0.2083E 01	0.2083E 01	0.2083E 01	0.2083E 01
14	0.1937E 01	0.1937E 01	0.1937E 01	0.1937E 01
15	0.1810E 01	0.1810E 01	0.1810E 01	0.1810E 01
16	0.1694E 01	0.1694E 01	0.1694E 01	0.1694E 01
17	0.1584E 01	0.1584E 01	0.1584E 01	0.1584E 01
18	0.1480E 01	0.1480E 01	0.1480E 01	0.1480E 01
19	0.1382E 01	0.1382E 01	0.1382E 01	0.1382E 01
20	0.1293E 01	0.1293E 01	0.1293E 01	0.1293E 01
21	0.1209E 01	0.1209E 01	0.1209E 01	0.1209E 01
22	0.1126E 01	0.1126E 01	0.1126E 01	0.1126E 01
23	0.1044E 01	0.1044E 01	0.1044E 01	0.1044E 01
24	0.9645E 00	0.9645E 00	0.9645E 00	0.9645E 00
25	0.8880E 00	0.8880E 00	0.8880E 00	0.8880E 00
26	0.8155E 00	0.8154E 00	0.8155E 00	0.8155E 00
27	0.7481E 00	0.7480E 00	0.7481E 00	0.7481E 00
28	0.6866E 00	0.6865E 00	0.6865E 00	0.6865E 00
29	0.6316E 00	0.6315E 00	0.6331E 00	0.6316E 00
30	0.5837E 00	0.5836E 00	0.5849E 00	0.5837E 00

RELATIVE VALUES FOR U238 ----- CAPTURE

GROUP	SRL	BAPL	BNL	CRNL
1	1.000	1.000	1.000	1.000
2	1.000	1.000	1.000	1.000
3	1.000	1.000	1.000	1.000
4	1.000	1.000	1.000	1.000
5	1.000	1.000	1.000	1.000
6	1.000	1.000	1.000	1.000
7	1.000	1.000	1.000	1.000
8	1.000	1.000	1.000	1.000
9	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000
11	1.000	1.000	1.000	1.000
12	1.000	1.000	1.000	1.000
13	1.000	1.000	1.000	1.000
14	1.000	1.000	1.000	1.000
15	1.000	1.000	1.000	1.000
16	1.000	1.000	1.000	1.000
17	1.000	1.000	1.000	1.000
18	1.000	1.000	1.000	1.000
19	1.000	1.000	1.000	1.000
20	1.000	1.000	1.000	1.000
21	1.000	1.000	1.000	1.000
22	1.000	1.000	1.000	1.000
23	1.000	1.000	1.000	1.000
24	1.000	1.000	1.000	1.000
25	1.000	1.000	1.000	1.000
26	1.000	1.000	1.000	1.000
27	1.000	1.000	1.000	1.000
28	1.000	1.000	1.000	1.000
29	1.000	1.000	1.002	1.000
30	1.000	1.000	1.002	1.000

COMPARISON OF THERMAL CROSS SECTIONS FOR U238 ----- MU-BAR

GROUP	SRL	BAPL	BNL
1	0.2825E-02	0.2825E-02	0.0
2	0.2825E-02	0.2825E-02	0.0
3	0.2825E-02	0.2825E-02	0.0
4	0.2825E-02	0.2825E-02	0.0
5	0.2825E-02	0.2825E-02	0.0
6	0.2825E-02	0.2825E-02	0.0
7	0.2825E-02	0.2825E-02	0.0
8	0.2825E-02	0.2825E-02	0.0
9	0.2825E-02	0.2825E-02	0.0
10	0.2825E-02	0.2825E-02	0.0
11	0.2825E-02	0.2825E-02	0.0
12	0.2825E-02	0.2825E-02	0.0
13	0.2825E-02	0.2825E-02	0.0
14	0.2825E-02	0.2825E-02	0.0
15	0.2825E-02	0.2825E-02	0.0
16	0.2825E-02	0.2825E-02	0.0
17	0.2825E-02	0.2825E-02	0.0
18	0.2825E-02	0.2825E-02	0.0
19	0.2825E-02	0.2825E-02	0.0
20	0.2824E-02	0.2825E-02	0.0
21	0.2824E-02	0.2825E-02	0.0
22	0.2824E-02	0.2825E-02	0.0
23	0.2824E-02	0.2825E-02	0.0
24	0.2824E-02	0.2825E-02	0.0
25	0.2824E-02	0.2825E-02	0.0
26	0.2824E-02	0.2825E-02	0.0
27	0.2824E-02	0.2825E-02	0.0
28	0.2824E-02	0.2825E-02	0.0
29	0.2824E-02	0.2825E-02	0.0
30	0.2824E-02	0.2825E-02	0.0

RELATIVE VALUES FOR U238 ----- MU-BAR

GROUP	SRL	BAPL	BNL
1	1.000	1.000	0.0
2	1.000	1.000	0.0
3	1.000	1.000	0.0
4	1.000	1.000	0.0
5	1.000	1.000	0.0
6	1.000	1.000	0.0
7	1.000	1.000	0.0
8	1.000	1.000	0.0
9	1.000	1.000	0.0
10	1.000	1.000	0.0
11	1.000	1.000	0.0
12	1.000	1.000	0.0
13	1.000	1.000	0.0
14	1.000	1.000	0.0
15	1.000	1.000	0.0
16	1.000	1.000	0.0
17	1.000	1.000	0.0
18	1.000	1.000	0.0
19	1.000	1.000	0.0
20	1.000	1.000	0.0
21	1.000	1.000	0.0
22	1.000	1.000	0.0
23	1.000	1.000	0.0
24	1.000	1.000	0.0
25	1.000	1.000	0.0
26	1.000	1.000	0.0
27	1.000	1.000	0.0
28	1.000	1.000	0.0
29	1.000	1.000	0.0
30	1.000	1.000	0.0

APPENDIX B

APPENDIX B

FAST REACTOR DATA TESTING RESULTS

SUBMITTED BY:

Argonne National Laboratory

Brookhaven National Laboratory

General Atomic Co.

General Electric Co.

Hanford Engineering Development Laboratory

Los Alamos Scientific Laboratory

Oak Ridge National Laboratory

Westinghouse

ARGONNE NATIONAL LABORATORY

(ANL)

ENDF/B-IV Fast Reactor Data Testing

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CALCULATIONAL METHODS

Fast reactor data testing was carried out at Argonne National Laboratory for eight of the benchmark assemblies specified in the November 1974 edition of ENDF-202. These assemblies are VERA-11A, ZPR-3-48, ZEBRA-3, ZPR-3-11, ZPPR-2, ZPR-6-7, ZPR-6-6A and ZEBRA-2.

Multigroup cross sections were produced by MC^2-2 for each region of each assembly as specified in the one-dimensional models. For core regions the consistent P_1 option with a search on B^2 to give $k_{eff} = 1$ was used, while blanket and reflector regions used the ordinary P_1 option with zero buckling. The MC^2-2 library was produced by processing the original ENDF/B-IV tapes through CRECT (when necessary), RIGEL, ETOE-2 and MERMC2-2. The corrections made by CRECT were those received from the NNCSC. RIGEL was used to convert the tapes to the binary alternate format required for input to ETOE-2. The ETOE-2 code produces a binary library with eight files in the format required by MC^2-2. Libraries produced by ETOE-2 are merged by MERMC2-2 to produce one MC^2-2 library containing all of the materials required.

The fission spectra in ENDF/B usually have temperatures specified as a function of incident neutron energy, while the MC^2-2 library requires energy-independent temperatures. Thus temperatures in the MC^2-2 library are given at suitable average energies. Table I gives the temperatures for the fissionable materials appearing in the data testing assemblies. These temperatures refer to the LF = 7 law in ENDF/B, except for ^{238}Pu and ^{242}Pu which have LF = 9 laws.

TABLE I. Fission Spectrum Temperatures Used in MC^2-2

Material	Temperature, MeV	Material	Temperature, MeV
^{238}Pu	1.33330	^{234}U	1.48023
^{239}Pu	1.39697	^{235}U	1.32679
^{240}Pu	1.36847	^{236}U	1.48023
^{241}Pu	1.36435	^{238}U	1.34748
^{242}Pu	1.33974	^{241}Am	1.37600

The multigroup cross sections produced for each assembly by MC^2-2 were input to the S_n-transport or diffusion theory modules in the ARC System in order to calculate k_{eff} and real and adjoint fluxes. For ZEBRA-2 the transport theory code ANISN was used. The fission spectrum used in these calculations was generally that for the core of each assembly, which is an average spectrum for the fissionable isotopes in the core. For ZPR-6-7 the fission spectra of the individual isotopes in both core and blanket were used, and for ZPR-6-6A both the core spectrum and the individual spectra were used in separate problems for comparative purposes.

A Fortran editing routine was written to use the multigroup cross sections, fluxes, and adjoint fluxes to calculate one-group cross sections and hence reaction rate ratios at the core center, as well as to renormalize the real and adjoint central fluxes so that $\sum_i \phi_i = 100$ and $\sum_i \phi_i^* \chi_i = 1$.

The real and adjoint fluxes and multigroup cross sections were also used in ARC System perturbation modules to calculate β_{eff}, prompt neutron lifetimes, inhours/%Δk/k, and central worths. For problems in which fluxes were calculated by diffusion theory the diffusion theory perturbation module was used. Both transport and diffusion perturbation modules were used for comparative purposes for problems where S_n-transport theory fluxes had been calculated. Both the delayed neutron yields and spectra involved in these calculations were taken from the ENDF/B-IV tapes.

The ZPR-6-7 calculations for k_{eff}, fluxes, and central reaction rate ratios were also done using the VIM Monte Carlo code. The library was processed from the ENDF/B-IV tapes using VIM library production routines. A total of 120,000 histories were run in the VIM calculations.

RESULTS

Table II presents uncorrected values of k_{eff} obtained in the prescribed diffusion or transport theory calculations along with the specified heterogeneity and equivalent S_∞ corrections leading to the corrected k_{eff} values. For the diffusion and transport theory problems the convergence criteria on k_{eff} were Δk_{eff} = 0.00001 and 0.00005, respectively. The diffusion theory boundary conditions were $\phi' = 0$ at $r = 0$, and $\phi' + (0.4692192/D)\phi = 0$ at the outer boundary of the reactor. For transport theory the boundary conditions were reflective at r = 0 and incoming angular flux zero at the outer boundary. The number of mesh points used were as suggested in the specifications, and were of constant width in each region, except that the central mesh interval was always taken one centimeter thick. The heterogeneity and S_∞ corrections came from the specifications except for ZPPR-2 and ZPR-6-6A. For these assemblies no values were given in ENDF-202, and therefore values calculated by Hardie et al at HEDL were used. Broad group structures were as prescribed in ENDF-202, including a default "thermal" group with cross sections based on the lowest non-thermal group. For ZPPR-2 the specifications were incomplete, and 34 groups of lethargy width 0.5 plus a "thermal" group were used.

Table III presents some other quantities of interest including the MC^2-2 critical core buckling, the MC^2-2 blanket k_{eff} for zero buckling, and the delayed-neutron-dependent parameters β_{eff}, ℓ (prompt neutron lifetime), and inhours/%Δk/k.

Tables II and III present results for ZPR-6-6A using isotope fission spectra as well as the fission spectrum for the core, as used for the other assemblies except ZPR-6-7. Note that the use of isotope spectra makes little difference in the results. Also results are given for ZPR-6-6A using two versions of ^{238}U in addition to the standard ENDF/B-IV version. These calculations were done because the breakdown of the single-level Breit-Wigner formula for ^{238}U led to a slightly negative elastic removal cross section for group 18 in the ZPR-6-6A blanket. This in turn led to negative fluxes in groups 19-21 in the outer part of the blanket in the diffusion theory flux calculations. One of the versions of ^{238}U was the same as the standard version except that the flag in ENDF/B File 2 specifying SLBW was changed to the MLBW flag. The other version was the same as the standard version except that some positive smooth elastic scattering background was added in certain energy regions in File 3 to avoid the negative elastic scattering cross sections obtained from the SLBW resonance parameter alone. The two versions of ^{238}U did not produce results which differed significantly for the parameters given in Tables II and III from those given by the standard version.

Table IV presents central reaction rate ratios computed for the various assemblies along with the corresponding experimental values. For assemblies ZPR-3-48, ZPR-6-7 and ZPR-6-6A the direct computed values have been corrected as specified in ENDF-202 to give the values in Table IV.

Central worths for all the assemblies are presented in Table V along with experimental values. For three of the assemblies in which fluxes and adjoint fluxes were calculated by transport theory, central worths are given as calculated both by transport perturbation theory and by diffusion perturbation theory. Otherwise diffusion perturbation theory is used, with the option that $\Delta D = \frac{D}{D'} (D' - D)$ where D and D' are the unperturbed and perturbed diffusion coefficients, respectively. The experimental values are those from ENDF-202 multiplied by the ratio of inhours/%Δk/k in ENDF-202 to inhours/%Δk/k calculated here using Version-IV data including the delayed neutron information. Since the ARC System codes calculate perturbations as $\Delta k/k^2$, the results as printed out were multiplied by the uncorrected k_{eff} values of Table II to yield the values in Table V. No experimental results are given for VERA-11A because ENDF-202 gives experimental results in terms of perturbation cross sections.

In comparing the reactivity calculations of several data testers, Kidman noted that differences in k_{eff} could be explained in large part by differences in the fission spectrum distribution used and the quadrature used in the statistical integrations. These two effects have been studied for the ZPR-6-6A benchmark assembly using the SDX code system. In Table VI the sensitivity of k_{eff} and spectral indices to changes in fission spectrum and the Porter-Thomas quadrature for this assembly are presented.

Tables VII-XV present the fluxes and adjoint fluxes at the core centers for all the assemblies normalized such that $\sum_i \phi_i = 100$ and $\sum_i \chi_i \phi_i^* = 1$. The fission spectra for the cores, which were used in the adjoint flux normalization, are also given.

TABLE II. k_{eff} for Fast Data Testing Assemblies

Assembly	Method	Uncorrected k_{eff}	Heterogeneity Correction	Correction S_{∞}	Corrected k_{eff}
VERA-11A	S_8	0.98767	--	-0.0024	0.9853
ZPR-3-48	Diffusion	0.97061	+0.0183	+0.0072	0.9961
ZEBRA-3	S_8	0.99568	--	-0.001	0.9947
ZPR-3-11	S_4	1.00355	--	-0.0013	1.0023
ZPPR-2	Diffusion	0.96766	+0.0175	+0.0024[d]	0.9876
ZPR-6-7	Diffusion	0.9666	+0.0166	+0.0018	0.9850
	Monte Carlo	0.9680 ±0.0019	+0.0166	--	0.9846 ±0.0019
ZPR-6-6A	Diffusion	0.97600	+0.0073	+0.0013[e]	0.9846
ZPR-6-6A	Diffusion[a]	0.97604	+0.0073	+0.0013[e]	0.9846
ZPR-6-6A	Diffusion[b]	0.97642	+0.0073	+0.0013[e]	0.9850
ZPR-6-6A	Diffusion[c]	0.97642	+0.0073	+0.0013[e]	0.9850
ZEBRA-2	S_4	0.9882	--	-0.0005	0.9877

[a]Isotope Fission spectra

[b]Multilevel version of ^{238}U

[c]Single level with background version of ^{238}U

[d,e]Corrections calculated by Hardie et al.

TABLE III. MC^2-2 and Delayed-Neutron-Dependent Parameters

Assembly	Critical Core $B^2_?$ cm^{-2}	Blanket k_{eff}	β_{eff}	ℓ, sec	Inhours/ %Δk/k
VERA-11A	0.015530	0.4172	0.003043	6.912×10^{-8}	992.6
ZPR-3-48	0.0024039	0.3467	0.003591	2.609×10^{-7}	919.6
ZEBRA-3	0.0084606	0.4305	0.004415	6.079×10^{-8}	823.2
ZPR-3-11	0.0057571	0.3490	0.007305	6.884×10^{-8}	473.9
ZPPR-2	0.00066956[d]	0.2375[f]	0.003361	4.522×10^{-7}	947.0
	0.0016343[e]	0.2349[g]			
ZPR-6-7	0.00073484	0.3484	0.003396	4.584×10^{-7}	944.3
ZPR-6-6A	0.00066816	0.3286	0.007249	5.034×10^{-7}	435.6
ZPR-6-6A[a]	---	---	0.007247	5.033×10^{-7}	435.7
ZPR-6-6A[b]	0.00066815	0.3285	0.007249	5.064×10^{-7}	435.6
ZPR-6-6A[c]	0.00066813	0.3285	0.007249	5.067×10^{-7}	435.6
ZEBRA-2	0.0027612	0.4305	0.007429	2.306×10^{-7}	449.2

[a]Isotope fission spectra

[b]Multilevel version of ^{238}U

[c]Single level with background version of ^{238}U

[d]Inner core

[e]Outer core

[f]Inner blanket

[g]Outer blanket

TABLE IV. Central Reaction Rate Ratios

Reaction Rate Ratio	VERA-11A Calculated	VERA-11A Experimental	ZPR-3-48 Calculated[a]	ZPR-3-48 Experimental	ZEBRA-3 Calculated	ZEBRA-3 Experimental	ZPR-3-11 Calculated	ZPR-3-11 Experimental
$^{238}U(n,f)/^{235}U(n,f)$	0.08527	0.077 ± 0.002	0.03221	0.0321 ± 0.0016	0.04425	0.0461 ± 0.0008	0.03846	0.038 ± 0.001
$^{239}Pu(n,f)/^{235}U(n,f)$	1.155	1.07 ± 0.02			1.178	1.190 ± 0.014	1.171	1.19 ± 0.02
$^{240}Pu(n,f)/^{235}U(n,f)$	0.5087	0.475 ± 0.020			0.3748	0.373 ± 0.005		
$^{238}U(n,\gamma)/^{235}U(n,f)$			0.1279	0.131 ± 0.007			0.1085	0.112 ± 0.005
$^{234}U(n,f)/^{235}U(n,f)$							0.3169	0.31 ± 0.03

Reaction Rate Ratio	ZPPR-2 Calculated	ZPPR-2 Experimental	ZPR-6-7 Calculated[a]	ZPR-6-7 Experimental	ZPR-6-6A Calculated[a]	ZPR-6-6A Experimental	ZEBRA-2 Calculated	ZEBRA-2 Experimental
$^{238}U(n,f)/^{235}U(n,f)$	0.02116	0.0201 ± 0.0004			0.02232	0.02411 ± 0.0072	0.0324	0.0320 ± 0.0005
$^{239}Pu(n,f)/^{235}U(n,f)$	0.9185	0.9372 ± 0.0142					0.9876	0.987 ± 0.010
$^{240}Pu(n,f)/^{235}U(n,f)$	0.1846	0.1704 ± 0.0026						
$^{238}U(n,\gamma)/^{235}U(n,f)$					0.1420	0.1378 ± 0.0041	0.1314	0.136 ± 0.001
$^{238}U(n,f)/^{239}Pu(n,f)$			0.02229[b]	0.02336				
$^{235}U(n,f)/^{239}Pu(n,f)$			1.1026[c]	1.061				
$^{238}U(n,\gamma)/^{239}Pu(n,f)$			0.1530[d]	0.1400				

[a] direct computed values modified as specified in ENDF-202

[b] Monte Carlo (VIM) calculation gives 0.02221 ± 0.00020

[c] Monte Carlo (VIM) calculation gives 1.1030 ± 0.0020

[d] Monte Carlo (VIM) calculation gives 0.1546 ± 0.0005

TABLE V. Central Reactivity Worths (10^{-5} Δk/k/mole)

Material	ZPR-3-48 Diffusion	ZPR-3-48 Experiment	ZEBRA-3 Transport	ZEBRA-3 Diffusion	ZEBRA-3 Experiment	ZPR-3-11 Transport	ZPR-3-11 Diffusion	ZPR-3-11 Experiment
^{238}U	-6.264	-6.10	-11.33	-11.34	-10.4	-6.610	-6.624	-6.5
^{235}U	100.3	85.3	241.3	241.3	206	132.2	132.2	122
^{239}Pu	134.9	115.6	388.1	388.0	332	214.1	214.1	207
Na	-0.3374	-0.158						
^{10}B	-91.86	-97.03	-110.9	-110.9	-110	-67.54	-67.53	-71
Fe	-0.9382	-0.747				-2.097	-2.103	-1.7
Cr	-1.065	-0.696				-2.106	-2.113	-1.7
Ni	-1.569	-1.16				-3.296	-3.310	-2.4
Mn	-2.998	-1.37				-2.637	-2.648	-1.8
Al	-0.5663	-0.461	-3.129	-3.135	-3.6			
Mo	-6.299	-4.52						
C	-0.3895	-0.059	-4.275	-4.279	-4.0			
Cu			-7.796	-7.803	-6.7			

Material	ZPPR-2 Diffusion	ZPPR-2 Experiment	ZPR-6-7 Diffusion	ZPR-6-7 Experiment	ZPR-6-6A Diffusion	ZPR-6-6A Experiment	VERA-11A Transport	VERA-11A Diffusion
^{238}U			-2.67	-2.75	-2.140	-1.923	10.63	10.65
^{235}U	26.79	22.37	38.30	33.16	24.69	22.53	455.2	455.2
^{239}Pu	33.03	30.34	47.14	40.1	32.90	31.34	769.3	769.3
Na	-0.1476	-0.1257	-0.206	-0.165	-0.0183	0.0085		
^{10}B			-32.34	-31.2	-26.93	-30.18		
Fe	-0.2114	-0.1862	-0.2989	-0.2525				
Cr	-0.2551	-0.187	-0.3618	-0.2498				
Ni	-0.3645	-0.2955	-0.5154	-0.4020				
Mn	-0.7672	-0.444						
Al	-0.1681	-0.172						
Mo	-1.529	-1.312	-2.199	-1.563				
C	-0.2038	-0.1446						
^{241}Pu	50.02	41.5						

TABLE V. Central Reactivity Worths (10^{-5} $\Delta k/k$/mole) Contd.

	ZEBRA-2	
Material	Diffusion	Experiment
^{238}U	-5.9	-5.7 ± 0.3
^{235}U	80.2	73.1 ± 0.7
^{239}Pu	111.3	104.0 ± 1.2
^{10}B	-86	-100 ± 3
Fe	-0.9	-0.6 ± 0.1
Cr	-0.9	-0.6 ± 0.1
Ni	-1.2	-1.3 ± 0.1
Mn	-2.3	-0.91 ± 0.1
Al	-0.4	-0.29 ± 0.10
Cu	-2.6	-1.9 ± 0.1
C	0.16	0.33 ± 0.05
H	14.4	16 ± 1

TABLE VI. Effects of Fission Spectrum and Statistical Quadrature on Integral Parameters for ZPR-6-6A

		k_{eff}	c^{28}/f^{25}	f^{28}/f^{25}
1)	^{235}U chi* Hwang Quadrature	.9764	.1436	.02264
2)	1.35 MeV chi Hwang Quadrature	.9780	.1434	.02306
3)	^{239}Pu chi** Hwang Quadrature	.9808	.1432	.02375
4)	^{235}U chi Equal Area Quadrature	.9776	.1434	.02261
5)	1.35 MeV chi Equal Area Quadrature	.9792	.1433	.02303

*1.32679 MeV

**1.39697 MeV

VERA-11A S8 TRANSPORT SET CHI

GROUP	LOWER ENERGY	CHI	FLUX	ADJOINT FLUX
1	0.60653D 07	0.31317D-01	0.92962D 00	0.11034D 01
2	0.36788D 07	0.11964D 00	0.37968D 01	0.10050D 01
3	0.22313D 07	0.20979D 00	0.80937D 01	0.10285D 01
4	0.13534D 07	0.22346D 00	0.11811D 02	0.98990D 00
5	0.82085D 06	0.17401D 00	0.12704D 02	0.95769D 00
6	0.49787D 06	0.11158D 00	0.12604D 02	0.97324D 00
7	0.30197D 06	0.63500D-01	0.11397D 02	0.99838D 00
8	0.18316D 06	0.33595D-01	0.95287D 01	0.10232D 01
9	0.11109D 06	0.17000D-01	0.77749D 01	0.10519D 01
10	0.67380D 05	0.83733D-02	0.60606D 01	0.10697D 01
11	0.40868D 05	0.40569D-02	0.46550D 01	0.10720D 01
12	0.24788D 05	0.19461D-02	0.33265D 01	0.10840D 01
13	0.15034D 05	0.92789D-03	0.26371D 01	0.10705D 01
14	0.91188D 04	0.44080D-03	0.18363D 01	0.10919D 01
15	0.55308D 04	0.20894D-03	0.12054D 01	0.11227D 01
16	0.33546D 04	0.98900D-04	0.78822D 00	0.11486D 01
17	0.20347D 04	0.46776D-04	0.41641D 00	0.12037D 01
18	0.12341D 04	0.22112D-04	0.25900D 00	0.12554D 01
19	0.74852D 03	0.10450D-04	0.11011D 00	0.13477D 01
20	0.45400D 03	0.49376D-05	0.44238D-01	0.13711D 01
21	0.27536D 03	0.23328D-05	0.16209D-01	0.15051D 01
22	0.16702D 03	0.11020D-05	0.40578D-02	0.15812D 01
23	0.10130D 03	0.52060D-06	0.11134D-02	0.16881D 01
24	0.61442D 02	0.24592D-06	0.18374D-03	0.21223D 01
25	0.37267D 02	0.11617D-06	0.17794D-04	0.21377D 01
26	0.22603D 02	0.54875D-07	0.15716D-04	0.10593D 01
27	0.0	0.0	0.13429D-04	0.10593D 01

TABLE VII.

ZPR-3-48 DIFFUSION THEORY SET CHI

GROUP	LOWER ENERGY	CHI	FLUX	ADJOINT FLUX
1	0.60653D 07	0.30808D-01	0.40794D 00	0.12602D 01
2	0.36788D 07	0.11866D 00	0.16940D 01	0.10958D 01
3	0.22313D 07	0.20922D 00	0.37908D 01	0.10878D 01
4	0.13534D 07	0.22367D 00	0.61195D 01	0.10095D 01
5	0.82085D 06	0.17457D 00	0.79851D 01	0.91205D 00
6	0.49787D 06	0.11210D 00	0.10087D 02	0.90863D 00
7	0.30197D 06	0.63853D-01	0.11512D 02	0.90309D 00
8	0.18316D 06	0.33800D-01	0.10654D 02	0.89233D 00
9	0.11109D 06	0.17110D-01	0.99557D 01	0.88008D 00
10	0.67380D 05	0.84288D-02	0.84517D 01	0.86246D 00
11	0.40868D 05	0.40843D-02	0.70904D 01	0.83906D 00
12	0.24788D 05	0.19594D-02	0.55810D 01	0.82732D 00
13	0.15034D 05	0.93427D-03	0.49881D 01	0.82286D 00
14	0.91188D 04	0.44383D-03	0.38851D 01	0.84116D 00
15	0.55308D 04	0.21038D-03	0.24585D 01	0.87087D 00
16	0.33546D 04	0.99584D-04	0.16722D 01	0.90200D 00
17	0.20347D 04	0.47100D-04	0.73560D 00	0.93934D 00
18	0.12341D 04	0.22266D-04	0.13371D 01	0.97500D 00
19	0.74852D 03	0.10522D-04	0.80233D 00	0.10289D 01
20	0.45400D 03	0.49719D-05	0.44700D 00	0.11297D 01
21	0.27536D 03	0.23489D-05	0.21638D 00	0.11776D 01
22	0.10130D 03	0.16339D-05	0.11835D 00	0.12569D 01
23	0.37267D 02	0.36460D-06	0.96666D-02	0.18263D 01
24	0.13710D 02	0.81355D-07	0.27855D-03	0.51308D 00
25	0.50435D 01	0.18153D-07	0.42635D-05	0.14211D 01
26	0.68256D 00	0.49542D-08	0.13204D-05	0.94890D 00
27	0.0	0.0	0.16767D-07	0.94879D 00

TABLE VIII.

ZEBRA-3 S8 TRANSPORT SET CHI

GROUP	LOWER ENERGY	CHI	FLUX	ADJOINT FLUX
1	0.60653D 07	0.30225D-01	0.49046D 00	0.15878D 01
2	0.36788D 07	0.11752D 00	0.19310D 01	0.11795D 01
3	0.22313D 07	0.20856D 00	0.38727D 01	0.11531D 01
4	0.13534D 07	0.22390D 00	0.54517D 01	0.10312D 01
5	0.82085D 06	0.17521D 00	0.88918D 01	0.82566D 00
6	0.49787D 06	0.11270D 00	0.15185D 02	0.81447D 00
7	0.30197D 06	0.64261D-01	0.18045D 02	0.82235D 00
8	0.18316D 06	0.34037D-01	0.15463D 02	0.80906D 00
9	0.11109D 06	0.17236D-01	0.11761D 02	0.79105D 00
10	0.67380D 05	0.84932D-02	0.84525D 01	0.75013D 00
11	0.40868D 05	0.41161D-02	0.56544D 01	0.68600D 00
12	0.24788D 05	0.19748D-02	0.25685D 01	0.63830D 00
13	0.15034D 05	0.94167D-03	0.15237D 01	0.59475D 00
14	0.91188D 04	0.44737D-03	0.48650D 00	0.57738D 00
15	0.55308D 04	0.21206D-03	0.14721D 00	0.59317D 00
16	0.33546D 04	0.10038D-03	0.51079D-01	0.61978D 00
17	0.20347D 04	0.47477D-04	0.14081D-01	0.69712D 00
18	0.12341D 04	0.22444D-04	0.69144D-02	0.75717D 00
19	0.74852D 03	0.10607D-04	0.17267D-02	0.87305D 00
20	0.45400D 03	0.50117D-05	0.65446D-03	0.93881D 00
21	0.27536D 03	0.23678D-05	0.26508D-03	0.10729D 01
22	0.16702D 03	0.11186D-05	0.76730D-04	0.11023D 01
23	0.10130D 03	0.52841D-06	0.39691D-04	0.10612D 01
24	0.61442D 02	0.24961D-06	0.14385D-04	0.15367D 01
25	0.37267D 02	0.11791D-06	0.71854D-05	0.16165D 01
26	0.22603D 02	0.55698D-07	0.57163D-05	0.51736D 00
27	0.0	0.0	0.29893D-05	0.51736D 00

TABLE IX.

ZPR-3-11 S4 TRANSPORT SET CHI

GROUP	LOWER ENERGY	CHI	FLUX	ADJOINT FLUX
1	0.60653D 07	0.26170D-01	0.37515D 00	0.16298D 01
2	0.36788D 07	0.10956D 00	0.15907D 01	0.11968D 01
3	0.22313D 07	0.20386D 00	0.33906D 01	0.11640D 01
4	0.13534D 07	0.22548D 00	0.49488D 01	0.10292D 01
5	0.82085D 06	0.17975D 00	0.63230D 01	0.82277D 00
6	0.49787D 06	0.11695D 00	0.14910D 02	0.80323D 00
7	0.30197D 06	0.67149D-01	0.18509D 02	0.83537D 00
8	0.18316D 06	0.35719D-01	0.16097D 02	0.84334D 00
9	0.11109D 06	0.18135D-01	0.12368D 02	0.83758D 00
10	0.67380D 05	0.89501D-02	0.89510D 01	0.81374D 00
11	0.40868D 05	0.43417D-02	0.59146D 01	0.77105D 00
12	0.24788D 05	0.20842D-02	0.26264D 01	0.74416D 00
13	0.15034D 05	0.99420D-03	0.14190D 01	0.73169D 00
14	0.91188D 04	0.47243D-03	0.39763D 00	0.75562D 00
15	0.55308D 04	0.22396D-03	0.11321D 00	0.81249D 00
16	0.33546D 04	0.10602D-03	0.45802D-01	0.90500D 00
17	0.20347D 04	0.50149D-04	0.94408D-02	0.96629D 00
18	0.12341D 04	0.23708D-04	0.85453D-02	0.10568D 01
19	0.74852D 03	0.11204D-04	0.15676D-02	0.10146D 01
20	0.45400D 03	0.52941D-05	0.50479D-03	0.12739D 01
21	0.27536D 03	0.25012D-05	0.14131D-03	0.11868D 01
22	0.16702D 03	0.11816D-05	0.96412D-04	0.12708D 01
23	0.10130D 03	0.55819D-06	0.34395D-04	0.11514D 01
24	0.61442D 02	0.26368D-06	0.16534D-04	0.10856D 01
25	0.37267D 02	0.12456D-06	0.82733D-05	0.15856D 01
26	0.22603D 02	0.58837D-07	0.28596D-05	0.89599D 00
27	0.0	0.0	0.17220D-05	0.89599D 00

TABLE X.

ZPPR-2 DIFFUSION H INCLUDED SET CHI

GROUP	LOWER ENERGY	CHI	FLUX	ADJOINT FLUX
1	0.60653D 07	0.30759D-01	0.26663D 00	0.12387D 01
2	0.36788D 07	0.11857D 00	0.11080D 01	0.10966D 01
3	0.22313D 07	0.20919D 00	0.28354D 01	0.11054D 01
4	0.13534D 07	0.22369D 00	0.41915D 01	0.10188D 01
5	0.82085D 06	0.17462D 00	0.53139D 01	0.92154D 00
6	0.49787D 06	0.11214D 00	0.95860D 01	0.90155D 00
7	0.30197D 06	0.63877D-01	0.89642D 01	0.87375D 00
8	0.18316D 06	0.33813D-01	0.10876D 02	0.84412D 00
9	0.11109D 06	0.17116D-01	0.11477D 02	0.81506D 00
10	0.67380D 05	0.84318D-02	0.10057D 02	0.78320D 00
11	0.40868D 05	0.40857D-02	0.84449D 01	0.75010D 00
12	0.24788D 05	0.19600D-02	0.65477D 01	0.73005D 00
13	0.15034D 05	0.93456D-03	0.65939D 01	0.72335D 00
14	0.91188D 04	0.44397D-03	0.48028D 01	0.73351D 00
15	0.55308D 04	0.21044D-03	0.26572D 01	0.75678D 00
16	0.33546D 04	0.99612D-04	0.17050D 01	0.78332D 00
17	0.20347D 04	0.47113D-04	0.59968D 00	0.81078D 00
18	0.12341D 04	0.22272D-04	0.17581D 01	0.83386D 00
19	0.74852D 03	0.10525D-04	0.11209D 01	0.86954D 00
20	0.45400D 03	0.49732D-05	0.63431D 00	0.98589D 00
21	0.27536D 03	0.23496D-05	0.27807D 00	0.10179D 01
22	0.16702D 03	0.11100D-05	0.12297D 00	0.11069D 01
23	0.10130D 03	0.52435D-06	0.46532D-01	0.11197D 01
24	0.61442D 02	0.24769D-06	0.10974D-01	0.16687D 01
25	0.37267D 02	0.11700D-06	0.13403D-02	0.17364D 01
26	0.22603D 02	0.55270D-07	0.20374D-03	0.38365D 00
27	0.13710D 02	0.26108D-07	0.27214D-04	0.83316D 00
28	0.83153D 01	0.12332D-07	0.27754D-05	0.15316D 01
29	0.50435D 01	0.58255D-08	0.41993D-06	0.66589D 00
30	0.30590D 01	0.27518D-08	0.65724D-06	0.12700D 01
31	0.18554D 01	0.12999D-08	0.71460D-06	0.11429D 01
32	0.11254D 01	0.61402D-09	0.49556D-06	0.10107D 01
33	0.68256D 00	0.29005D-09	0.12937D-07	0.10789D 00
34	0.41400D 00	0.13702D-09	0.85750D-08	0.17914D 01
35	0.0	0.0	0.83339D-09	0.17913D 01

TABLE XI.

CORE CENTER DIFFUSION THEORY ZPR-6-7

GROUP	LOWER ENERGY	CHI	FLUX	ADJOINT FLUX
1	0.60653E 07	0.30759E-01	0.26597E 00	0.12361E 01
2	0.36788E 07	0.11856E 00	0.11049E 01	0.10952E 01
3	0.22313E 07	0.20917E 00	0.28339E 01	0.11046E 01
4	0.13534E 07	0.22368E 00	0.41910E 01	0.10186E 01
5	0.82085E 06	0.17462E 00	0.53081E 01	0.92239E 00
6	0.49787E 06	0.11215E 00	0.95853E 01	0.90256E 00
7	0.30197E 06	0.63887E-01	0.89442E 01	0.87495E 00
8	0.18316E 06	0.33820E-01	0.10884E 02	0.84559E 00
9	0.11109E 06	0.17120E-01	0.11440E 02	0.81687E 00
10	0.67380E 05	0.84342E-02	0.10026E 02	0.78539E 00
11	0.40868E 05	0.40870E-02	0.84194E 01	0.75259E 00
12	0.24788E 05	0.19607E-02	0.65287E 01	0.73269E 00
13	0.15034E 05	0.93490E-03	0.66014E 01	0.72613E 00
14	0.91188E 04	0.44474E-03	0.48190E 01	0.73646E 00
15	0.55308E 04	0.21052E-03	0.26691E 01	0.75987E 00
16	0.33546E 04	0.99652E-04	0.17190E 01	0.78647E 00
17	0.20347E 04	0.47132E-04	0.60620E 00	0.81393E 00
18	0.12341E 04	0.22281E-04	0.17806E 01	0.83701E 00
19	0.74852E 03	0.10530E-04	0.11421E 01	0.87298E 00
20	0.45400E 03	0.49753E-05	0.65194E 00	0.99063E 00
21	0.27536E 03	0.23505E-05	0.28846E 00	0.10211E 01
22	0.10130E 03	0.16350E-05	0.17797E 00	0.11110E 01
23	0.37267E 02	0.36485E-06	0.13620E-01	0.16707E 01
24	0.13710E 02	0.81411E-07	0.25460E-03	0.41196E 00
25	0.50435E 01	0.18166E-07	0.42892E-05	0.13125E 01
26	0.18554E 01	0.40534E-08	0.18079E-05	0.17852E 01
27	0.0	0.0	0.33604E-07	0.19543E 01

TABLE XII.

CORE CENTER VIM MONTE CARLO ZPR-6-7

GROUP	LOWER ENERGY	CHI	FLUX	STANDARD DEV. (%)
1	0.60653E 07	0.30159E-01	0.25432E 00	0.39000E 01
2	0.36788E 07	0.11612E 00	0.10740E 01	0.24000E 01
3	0.22313E 07	0.20912E 00	0.28570E 01	0.14000E 01
4	0.13534E 07	0.22315E 00	0.41960E 01	0.11000E 01
5	0.82085E 06	0.17541E 00	0.52445E 01	0.11000E 01
6	0.49787E 06	0.11272E 00	0.94673E 01	0.93000E 00
7	0.30197E 06	0.64176E-01	0.89135E 01	0.65000E 00
8	0.18316E 06	0.35076E-01	0.10875E 02	0.53000E 00
9	0.11109E 06	0.17792E-01	0.11429E 02	0.59000E 00
10	0.67380E 05	0.86252E-02	0.10063E 02	0.65000E 00
11	0.40868E 05	0.40584E-02	0.84661E 01	0.64000E 00
12	0.24788E 05	0.19667E-02	0.65262E 01	0.71000E 00
13	0.15034E 05	0.77502E-03	0.66272E 01	0.83000E 00
14	0.91188E 04	0.52501E-03	0.48853E 01	0.90000E 00
15	0.55308E 04	0.20000E-03	0.26998E 01	0.10000E 01
16	0.33546E 04	0.50001E-04	0.17120E 01	0.11000E 01
17	0.20347E 04	0.50001E-04	0.62153E 00	0.14000E 01
18	0.12341E 04	0.80002E-05	0.18262E 01	0.14000E 01
19	0.74852E 03	0.0	0.11815E 01	0.19000E 01
20	0.45400E 03	0.0	0.64284E 00	0.30000E 01
21	0.27536E 03	0.0	0.25771E 00	0.43000E 01
22	0.10130E 03	0.0	0.17040E 00	0.68000E 01
23	0.37267E 02	0.0	0.10669E-01	0.25000E 02
24	0.13710E 02	0.0	0.11222E-03	0.10000E 03
25	0.50435E 01	0.0	0.0	0.0
26	0.18554E 01	0.0	0.0	0.0

TABLE XIII.

ZPR-6-6A DIFFUSION THEORY S[illegible] CHI

GROUP	LOWER ENERGY	CHI	FLUX	ADJOINT FLUX
1	0.60653D 07	0.25923D-01	0.23143D 00	0.12189D 01
2	0.36788D 07	0.10906D 00	0.10446D 01	0.10766D 01
3	0.22313D 07	0.20355D 00	0.28464D 01	0.10822D 01
4	0.13534D 07	0.22557D 00	0.43377D 01	0.10057D 01
5	0.82085D 06	0.18003D 00	0.55304D 01	0.92776D 00
6	0.49787D 06	0.11722D 00	0.10036D 02	0.92240D 00
7	0.30197D 06	0.67333D-01	0.94039D 01	0.93165D 00
8	0.18316D 06	0.35826D-01	0.11418D 02	0.92824D 00
9	0.11109D 06	0.18192D-01	0.11909D 02	0.92333D 00
10	0.67380D 05	0.89792D-02	0.10303D 02	0.91762D 00
11	0.40868D 05	0.43561D-02	0.85160D 01	0.90878D 00
12	0.24788D 05	0.20912D-02	0.64617D 01	0.91063D 00
13	0.15034D 05	0.99756D-03	0.63382D 01	0.92415D 00
14	0.91188D 04	0.47403D-03	0.44454D 01	0.95800D 00
15	0.55308D 04	0.22473D-03	0.23541D 01	0.99782D 00
16	0.33546D 04	0.10639D-03	0.14588D 01	0.10344D 01
17	0.20347D 04	0.50320D-04	0.50149D 00	0.10522D 01
18	0.12341D 04	0.23788D-04	0.13933D 01	0.10690D 01
19	0.74852D 03	0.11242D-04	0.81458D 00	0.10692D 01
20	0.45400D 03	0.53121D-05	0.40355D 00	0.12480D 01
21	0.27536D 03	0.25097D-05	0.15650D 00	0.12173D 01
22	0.10130D 03	0.17457D-05	0.88870D-01	0.12551D 01
23	0.37267D 02	0.38956D-06	0.69447D-02	0.12703D 01
24	0.13710D 02	0.8692[illegible]D-07	0.76447D-04	0.52925D 00
25	0.50435D 01	0.19396D-07	0.26672D-05	0.90840D 00
26	0.68256D 00	0.52934D-08	0.13550D-05	0.14002D 01
27	0.0	0.0	0.30707D-07	0.14001D 01

TABLE XIV.

ZEBRA-2 S4 (ANISN) SET CHI

GROUP	LOWER ENERGY	CHI	FLUX	ADJOINT FLUX
1	0.60653D 07	0.26037D-01	0.38529D 00	0.14465D 01
2	0.36788D 07	0.10929D 00	0.16972D 01	0.11660D 01
3	0.22313D 07	0.20370D 00	0.37417D 01	0.11180D 01
4	0.13534D 07	0.22553D 00	0.58676D 01	0.10007D 01
5	0.82085D 06	0.17990D 00	0.77040D 01	0.86923D 00
6	0.49787D 06	0.11709D 00	0.10161D 02	0.87017D 00
7	0.30197D 06	0.67246D-01	0.11292D 02	0.88679D 00
8	0.18316D 06	0.35775D-01	0.10788D 02	0.89199D 00
9	0.11109D 06	0.18165D-01	0.96988D 01	0.89222D 00
10	0.67380D 05	0.89655D-02	0.84931D 01	0.88853D 00
11	0.40868D 05	0.43493D-02	0.73515D 01	0.88269D 00
12	0.24788D 05	0.20879D-02	0.59613D 01	0.89026D 00
13	0.15034D 05	0.99598D-03	0.48519D 01	0.90790D 00
14	0.91188D 04	0.47327D-03	0.37881D 01	0.94237D 00
15	0.55308D 04	0.22437D-03	0.26958D 01	0.98790D 00
16	0.33546D 04	0.10622D-03	0.20271D 01	0.10431D 01
17	0.20347D 04	0.50239D-04	0.13588D 01	0.10851D 01
18	0.12341D 04	0.23750D-04	0.92286D 00	0.11387D 01
19	0.74852D 03	0.11224D-04	0.55000D 00	0.11636D 01
20	0.45400D 03	0.53036D-05	0.31414D 00	0.12887D 01
21	0.27536D 03	0.25057D-05	0.17462D 00	0.12811D 01
22	0.16702D 03	0.11837D-05	0.89013D-01	0.12771D 01
23	0.10130D 03	0.55919D-06	0.44195D-01	0.12184D 01
24	0.61442D 02	0.26415D-06	0.21895D-01	0.12771D 01
25	0.37267D 02	0.12478D-06	0.10381D-01	0.14548D 01
26	0.22603D 02	0.58943D-07	0.39832D-02	0.10229D 01
27	0.0	0.0	0.49041D-02	0.10229D 01

TABLE XV.

BROOKHAVEN NATIONAL LABORATORY

(BNL)

BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC., UPTON, L.I., N.Y. 11973

NATIONAL NEUTRON CROSS SECTION CENTER

TELEPHONE: (516) 345-2902, 2903, 2904

July 28, 1975

Dr. Ed Bohn
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Il. 60439

Dear Ed:

As pointed out by R. Kidman at our recent meeting of the Fast Data Testing Subcommittee, the differences between the HEDL and BNL calculation of ZPR-6-7 calculation could be due in part to modifications made in the F-factor interpolation technique in 1DX*.

I checked our version of 1DX and found that it had the orginial interpolation techniques described in BNWL-954. Wayne Hardie recently supplied me with the programming modifications to up-date subroutine RCCAL2 which calculates the F factors.

I then proceeded to calculate the ZPR-6-7 benchmark, using the new F-factor prescription. At the same time, I calculated ZPR-6-7, using a fission spectrum for T = 1.41 MeV. (Our reported benchmarks were calculated with composition dependent Chi values. However, since 1DX and ANISN admit only one vector, the Chi's for the central core region were selected.).

The enclosed results indicate that the Chi difference is worth approximately 0.0017Δk, as independently reported by H. Henryson at our July 15th meeting. The F-factor modification changed k by 0.13% in ZPR-6-7. Changes in central reactivity worths were nominal.

* R.B. Kidman, "An Improved F-Factor Interpolation Scheme for 1DX, " TANS 18, 156, (June 1974).

Sincerely,
Phil
Phil Rose

PR:lh
Enclosure: Tabulation of Results
Distribution (external)

Tabulation of Results

ZPR-6-7 (Direct Computed Values).

	CALCULATION*			
k_{eff}	A	B	C	Experiment
transport (S4)	.97384	.97513	.97680	1.0000±.001
diffusion (1DX)	.97310	.97436	.97603	
Central fission ratio				
σ_f(U-238)/σ_f(Pu-239)	.02265	.022608	.022944	.02336±2%
σ_f(U-235)/σ_f(Pu-239)	1.0924	1.0913	1.0905	1.061±2%
Central Reactivity Worths ($10^{-5}\Delta k/k$/mole)				
Material				
^{239}Pu	47.0	46.9	46.7	37.6±0.40
^{235}U	38.41	38.21	38.06	31.10±0.47
^{238}U	-2.71	-2.72	-2.70	-2.58±0.108
^{10}B	-32.8	-33.1	-32.9	-29.3±0.63
Na	-0.187	-0.180	-0.181	-0.155±0.008
Ta	-12.0	-12.1	-12.1	-7.739±0.78
C	-0.248	-0.238	-0.238	-0.1454±0.0025
Al	-0.263	-0.260	-0.260	-0.1800±0.0045
Fe	-0.297	-0.294	-0.296	-0.2368±0.0086
Ni	-0.486	-0.479	-0.482	-0.3770±0.0108
Cr	-0.369	-0.368	-0.368	-0.2343±0.0191
Mo	-2.17	-0.219	-2.18	-1.466±0.010

* Calculation A 1DX original F-factor calculation, Composition dependent Chi.
Calculation B 1DX Modified F-factor calculation, Composition dependent Chi.
Calculation C 1DX Modified F-factor calculation, Chi for T=1.41 MeV.

BNL AUI

BROOKHAVEN NATIONAL LABORATORY

ASSOCIATED UNIVERSITIES, INC., UPTON, L.I., N.Y. 11973

NATIONAL NEUTRON CROSS SECTION CENTER

TELEPHONE: (516) 345-2902, 2903, 2904

August 11, 1975

Dr. Ed Bohn
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Il. 60439

Dear Ed:

Rus Kidman kindly pointed out that modifications to the F-factor prescription in 1DX were also made in subroutine RCSTUP which computes F-factors for temperature dependent materials. Rus supplied me with the necessary fortran programming changes.

I repeated the ZPR-6-7 calculation, using the fully updated 1DX code. The calculation used the composition dependent set of Chi values. For this case k_{eff} was 0.97410, as compared to 0.97436, where only programming modifications were made to subroutine RCCAL2, and as reported to you in my letter of July 28, 1975.

Sincerely,

Phil

Phil Rose

PR:lh

Distribution

C.L. Cowan	GE
R.W. Hardie	HEDL
H. Henryson	ANL
A. Hess	GAC
R.B. Kidman	LASL
R.J. LaBauve	LASL
R. MacFarlane	LASL
N.C. Paik	WARD
E.M. Pennington	ANL
R.E. Schenter	HEDL
C.R. Weisbin	ORNL

Appendix - BNL Contribution to Fast Data Testing

A series of 6 fast benchmark criticals were analyzed at Brookhaven National Laboratory using one dimensional diffusion and transport theory for the Referential Data Testing Report. All calculations were made according to specifications in ENDF-202.[1]

The basic ENDF/B-IV multigroup cross sections used for this study were obtained from HEDL in a 42 group scheme in the Russian format. Table 1 presents the energy group scheme. The ETOX computer code was used to generate the cross sections. Ten groups of down scatter were allowed for all isotopes. The cross sections were processed into a binary library for 1DX using the PUPX code.[2]

A composition dependent fission spectrum was used in all spatial calculations. The fission spectrum for each assembly was specified on the basis of the central fuel zone composition. The composition dependent fission source fraction in group i is given as

$$\chi_i \cong \frac{\sum_j \Phi^j \Delta E^j \sum_m \chi_{mi} \upsilon\Sigma_{fm}^j}{\sum_j \Phi^j \Delta E^j \sum_m \upsilon\Sigma_{fm}^j}$$

where

Φ^j = weighting flux in group j (taken from previous calculations.)

χ_{mi} = fraction of fission source for material m and group i calculated by ETOX subroutines.[3]

Table 2 lists the fission spectra for all assemblies studied.

42 group 1DX calculations were made for all benchmark assemblies. The resultant composition dependent cross section set (self shielded and temperature dependent) generated by 1DX was collapsed into a 26 group set for effective multiplication calculations, and as input to ANISN.

1. National Neutron Cross Section Center, "Cross Section Evaluation Working Group Benchmark Specifications, " BNL 19302 (ENDF-202), Nov. 1974.

2. R.E. Schenter, Private Communication.

Table 1 shows the 26 group structure. The quadrature for the ANISN calculations was Sn with n varying between 4 and 16 for individual benchmarks. The spatial mesh and boundary conditions for the various assemblies was as specified in ENDF-202.

Lastly PERTID[(4)] calculations were made for central worths. PERTID utilizes the angular neutron flux from forward and adjoint one dimensional transport calculations (ANISN).

Fig. 1 shows a schematic diagram of the calculational procedure. Tables 3 through 6 present the benchmark results.

---

3. Nuclear temperatures for these calculations were: ^{234}U, T=1.31 MeV; ^{235}U, T=1.33 MeV; ^{238}U, T=1.31 MeV; ^{239}Pu, T=1.40 MeV; ^{240}Pu, T=1.36 MeV; ^{241}Pu, T=1.37 MeV.

4. R. Horvitz, Internal BNL code. (Based upon material presented in Chapter 6, C.E. Lee, "The Discrete Sn approximation to Transport theory," LA-2595, 1962).

Fig. 1 Benchmark Computations

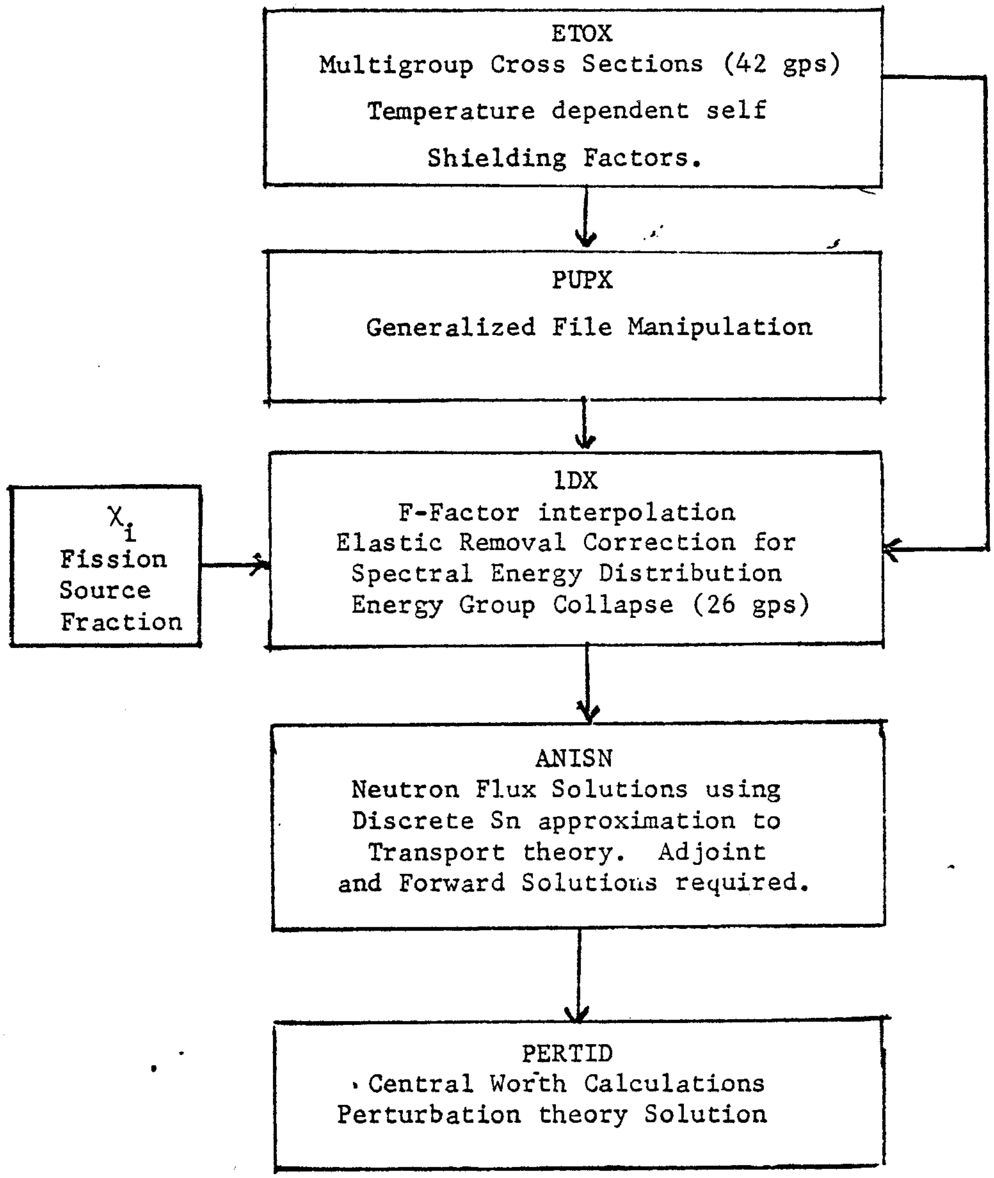

Table 1

Structure for 1DX (42 gps) and ANISN (26 gps) Energy Group

HEDL 42 Gp Input Set

Group	E_{low}(ev)	Δu	26 Group	Δu
1	6.065 +6	.5	1	.5
2	3.679 +6	.5	2	.5
3	2.231 +6	.5	3	.5
4	1.353 +6	.5	4	.5
5	8.208 +5	.5	5	.5
6	4.979 +5	.5	6	.5
7	3.877 +5	.25		
8	3.020 +5	.25	7	.5
9	1.832 +5	.5	8	.5
10	1.111 +5	.5	9	.5
11	6.738 +4	.5	10	.5
12	4.087 +4	.5	11	.5
13	2.554 +4	.47	12	.47
14	1.989 +4	.25		
15	1.503 +4	.28	13	.53
16	9.119 +3	.5	14	.5
17	5.531 +3	.5	15	.5
18	3.355 +3	.5	16	.5
19	2.840 +3	.167		
20	2.404 +3	.167		
21	2.035 +3	.167	17	.5
22	1.234 +3	.5	18	.5
23	7.485 +2	.5	19	.5
24	4.540 +2	.5	20	.5
25	2.754 +2	.5	21	.5
26	1.670 +2	.5	22	.5
27	1.013 +2	.5	23	.5
28	6.144 +1	.5	24	.5
29	3.727 +1	.5	25	.5
30	2.260 +1	.5		
31	1.371 +1	.5		
32	8.315 +0	.5		
33	5.043 +0	.5		
34	3.059 +0	.5		
35	1.855 +0	.5		
36	1.125 +0	.5		
37	6.826 -1	.5		
38	4.140 -1	.5		
39	2.511 -1	.5		
40	1.523 -1	.5		
41	9.237 -2	.5		
42	Thermal	1.3	26	7.3

Table 2

Fission Spectra (normalized to unity) (26 Gp Scheme)

Group	JEZEBEL	ZPR-3-48	GODIVA	ZPR-6-7
1	.033981	.032989	.02770	.032565
2	.11970	.117957	.10892	.117224
3	.20955	.208519	.20332	.208091
4	.22284	.223207	.22519	.22336
5	.17325	.174269	.17957	.174699
6	.11107	.112018	.11693	.112418
7	.063199	.063851	.067185	.064123
8	.033427	.033804	.035738	.033962
9	.016924	.017126	.018164	.017210
10	.008333	.0084351	.008961	.0084781
11	.004036	.0040865	.004346	.0041077
12	.001857	.001880	.00200	.0018900
13	.001003	.001016	.001082	.0010218
14	.000438	.000444	.000472	.0004463
15	.000208	.0002106	.000224	.0002117
16	.000098	.0000994	.0001060	.0000999
17	.000047	.0000472	.000050	.0000473
18	.000022	.0000225	.000024	.0000226
19	.000010	.0000104	.000011	.0000105
20	.000007	.000008	.000007	.000009
21	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0
26	0.0	0.0	0.0	0.0

Group	VERA-1B	ZPR-III-6F
1	.027725	.027660
2	.10897	.10885
3	.20335	.20327
4	.22519	.22521
5	.17954	.17961
6	.11690	.11697
7	.067164	.06721
8	.035729	.035756
9	.018154	.018168
10	.0089573	.0089674
11	.0043440	.0043477
12	.0019996	.0020013
13	.0010813	.0010823
14	.000472	.000473
15	.000224	.000224
16	.000106	.000106
17	.000050	.000050
18	.000024	.000024
19	.000011	.000011
20	.000005	.000005
21	0.0	0.0
22	0.0	0.0
23	0.0	0.0
24	0.0	0.0
25	0.0	0.0
26	0.0	0.0

Table 3 Effective Multiplication Results - Direct Computed Values
(Sn approximation in parenthesis)

Code	JEZEBEL	ZPR-3-48	GODIVA	ZPR-6-7	VERA-1B	ZPR-111-6F
1DX	.94576	.97635	.97296	.97310	.97745	.99408
ANISN	.99734(S16)	---	1.00946(S16)	---	.9997(S8)	1.01565(S4)

Table 4 Activation Ratios at Core Center - Direct Computed Values

Type						
$\sigma_f{}^{238}U/\sigma_f{}^{235}U$	0.19175	0.0330	0.16591		0.0788	0.0776
$\sigma_f{}^{239}Pu/\sigma_f{}^{235}U$	1.392		1.379			1.245
$\sigma_f{}^{233}U/\sigma_f{}^{235}U$	1.496		1.507			
$\sigma_f{}^{234}U/\sigma_f{}^{238}U$			4.560			
$\sigma_f{}^{232}th/\sigma_f{}^{238}U$			0.2319			
$\sigma_f{}^{236}U/\sigma_f{}^{235}U$					0.1666	
$\sigma_f{}^{240}Pu/\sigma_f{}^{235}U$						0.5373
$\sigma_f{}^{238}U/\sigma_f{}^{239}Pu$				0.02265		
$\sigma_f{}^{235}U/\sigma_f{}^{239}Pu$				1.0924		

Table 5 Central Reactivity Worths - Direct Computed Values
(10^{-5} $\Delta k/k$ mole at Core Center)

Material	JEZEBEL	ZPR-3-48	GODIVA	ZPR-6-7	VERA-1B	ZPR-III-6F
^{233}U	2585.6		1607.6			
^{234}U			729.33		90.659	61.615
^{235}U	1642.63	101.38	1011.13	38.41	231.55	151.69
^{236}U					15.381	
^{238}U	205.07	-6.48	156.88	-2.71	9.825	3.374
^{239}Pu	3132.2	136.17	1922.4	47.0	411.92	271.44
^{240}Pu	2039.15	22.84	1211.7	4.14	172.58	114.15
^{241}Pu		192.88		71.45		
^{242}Pu		19.52				
^{232}Th	-129.6		-35.42			-14.313
H	-39.5		251.10		107.72	
^{10}B	-473.2	-92.85	-327.6	-32.8	-260.77	-86.247
Be	-40.3		3.516			
^{12}C	-14.73	-0.368	8.31	-0.248	6.580	
^{16}O	-21.27			-0.240		
Al	-24.44	-0.491	-1.23	-0.263	3.413	0.0564
Na		-0.327		-0.187	5.184	
Fe	-44.10	-0.978	-8.02	-0.297	2.656	-1.246
Ni	-94.9	-1.63	-34.8	-0.486	-1.257	-3.392
Cr		-1.133		-0.369	1.815	-1.283
Mo	-84.7	-6.34		-2.17		-5.124
Mn		-2.53		-0.951		-0.7549
Si		-0.519				
V	-41.9					
Nb			-24.8			
^{181}Ta	-212.8	-33.2	-74.34	-12.0		-20.058
Cu			-17.0			

Table 6

Scalar Flux at Core Center-ANISN Results
(Integral of fission source over system equals Unity).

Group	JEZEBEL Calculated Flux	JEZEBEL Calculated Adjoint	ZPR-3-48 Calculated Flux	ZPR-3-48 Calculated Adjoint	GODIVA Calculated Flux	GODIVA Calculated Adjoint
1	2.158×10^{-4}	1.986×10^{-4}	1.709×10^{-6}	4.080×10^{-6}	8.944×10^{-5}	7.319×10^{-5}
2	7.402	2.364	6.384	5.027	3.422×10^{-4}	7.845
3	1.326×10^{-3}	3.523	1.544×10^{-5}	6.344	7.015	7.393
4	1.567	2.648	2.397	5.171	9.009	6.984
5	1.492	2.499	3.052	5.132	8.951	7.402
6	1.207	2.409	4.104	4.897	7.966	7.428
7	8.402×10^{-4}	2.279	4.538	4.884	6.130	7.773
8	5.049	2.103	4.369	4.489	3.706	6.852
9	2.811	1.872	3.867	4.245	1.984	7.363
10	1.431	1.705	3.396	4.094	9.784×10^{-5}	7.291
11	6.978×10^{-5}	1.602	2.699	3.951	4.402	7.238
12	3.106	1.580	2.219	3.795	1.727	6.581
13	1.459	1.585	2.190	3.656	7.229×10^{-6}	6.382
14	5.240×10^{-6}	1.616	1.469	3.559	2.244	6.118
15	2.128	1.711	9.973×10^{-6}	3.568	8.211×10^{-7}	6.101
16	8.497×10^{-7}	1.694	5.787	3.604	3.095	5.956
17	3.586	1.668	2.872	3.691	1.248	5.712
18	1.589	1.581	5.258	3.759	4.487×10^{-8}	5.364
19	6.090×10^{-8}	1.485	3.138	3.807	1.713	4.953
20	3.674	1.484	1.591	3.849	9.224×10^{-9}	4.630
21	5.040×10^{-10}	1.510	7.732×10^{-7}	3.877	7.966×10^{-11}	4.378
22	4.872×10^{-11}	1.584	3.332	3.898	5.464×10^{-13}	4.424
23	2.795	1.710	1.190	4.318	4.193×10^{-15}	4.615
24	9.681×10^{-14}	1.743	3.023×10^{-8}	4.672	2.805×10^{-17}	4.741
25	5.061×10^{-16}	1.734	7.418×10^{-9}	4.714	8.158×10^{-20}	4.732
26	4.221×10^{-18}	2.152	3.952	5.433	2.684×10^{-22}	6.282

Table 6 (Continued)

Group	ZPR-6-7 Calculated Flux	ZPR-6-7 Calculated Adjoint	VERA-1B Calculated Flux	VERA-1B Calculated Adjoint	ZPR-III-6F Calculated Flux	ZPR-III-6F Calculated Adjoint
1	3.344×10^{-7}	1.059×10^{-6}	1.003×10^{-5}	1.684×10^{-5}	6.591×10^{-6}	1.089×10^{-5}
2	1.290×10^{-6}	1.302	4.028	1.795	2.693×10^{-5}	1.223
3	3.219	1.664	1.095×10^{-4}	1.744	6.359	1.092
4	4.943	1.324	1.650	1.713	9.395	1.087
5	6.448	1.350	1.725	1.766	1.235×10^{-4}	1.116
6	1.115×10^{-5}	1.252	1.681	1.798	1.543	1.117
7	1.014	1.260	1.514	1.870	1.571	1.223
8	1.374	1.127	1.315	1.738	1.202	1.043
9	1.339	1.072	1.070	1.752	.7734	1.100
10	1.227	1.042	8.660×10^{-5}	1.736	.5806	1.063
11	9.407×10^{-6}	1.011	6.791	1.722	.3817	1.046
12	7.858	9.725×10^{-7}	5.007	1.661	.1664	.9658
13	8.738	9.406	4.355	1.602	.1290	.8916
14	5.521	9.230	2.889	1.539	2.003×10^{-6}	.8135
15	3.262	9.286	1.944	1.501	5.361×10^{-7}	.8561
16	1.882	9.487	1.267	1.450	2.047	.8360
17	7.178×10^{-7}	9.875	7.716×10^{-6}	1.402	6.181×10^{-8}	.8464
18	2.176×10^{-6}	1.024×10^{-6}	3.815	1.348	1.646	.8284
19	1.379	1.059	1.699	1.287	3.782×10^{-9}	.7837
20	7.077×10^{-7}	1.094	6.274×10^{-7}	1.219	1.081	.7419
21	3.235	1.126	2.290	1.138	4.512×10^{-10}	.6972
22	1.592	1.151	6.466×10^{-8}	1.073	1.654	.6971
23	5.586×10^{-8}	1.271	1.814	1.045	6.619×10^{-12}	.7639
24	1.397	1.372	5.139×10^{-9}	1.065	2.678×10^{-13}	.8074
25	3.258×10^{-9}	1.366	9.010×10^{-10}	1.050	6.103×10^{-15}	:8108
26	1.542	1.547	1.942	1.151	1.534×10^{-16}	.9966

GENERAL ATOMIC CO.

(GAC)

APPENDIX GA

DESCRIPTION OF METHODS USED IN GENERAL ATOMIC CO. FAST BENCHMARK ANALYSES WITH ENDF/B-4

The basic data from the ENDF/B tapes are first processed by the codes GFE4 and GAND3. GFE4 produces 99-fine-group, infinite-dilution material cross sections on a GAM tape for the fast section of GGC5[1]. GAND3 uses the ENDF/B resonance parameters to construct hyperfine-group (14,000 point) fission and capture cross sections to write on the GAR tape for the resolved range (to 7.5 KeV) of GGC5. In GGC5, the GAR treatment solves the point-wise slowing-down equations in a two-region-cell integral-transport formulation to obtain 14,000-point cell fluxes which are then used to evaluate resonance integrals over the fine-group energy intervals in the resolved range. The GANDY section of GGC5 uses card input unresolved-resonance parameters to derive fine-group cross-sections in the intermediate range. The GAR and GANDY results then are combined with the fast-region data to obtain 99-group microscopic and macroscopic cross-sections. The macroscopic data is used in a fine-group spectrum calculation, solving the P_0 to P_3 or B_1 to B_3 equations. The fine-group fluxes and currents then are used to collapse to desired broad group sets, including higher-order scattering matrices.

To fully account for heterogeneity effects in the benchmark-assembly drawer cells, the two-region GGC5 results must be combined with cell-plate flux advantage factors, as can be derived from slab calculations via discrete-ordinate or integral-transport codes (since only the resonance-range heterogeneity effect is obtained in the GAR section). At GA, the DTFX[2] code is used, and the flux-advantage factors for the fast-range groups are input to the GGC5 combining section to output heterogeneity-corrected broad-group cross-sections. For the homogeneous treatments used in the basic benchmark tests, equal region parameters are used in the GGC5 problem.

The neutronics codes used at GA for the version-4 tests include the 1-D diffusion code GAZE[3], and the 2-D diffusion code ADGAUGE[4] and the SN code DTFX. Central worths were calculated from the ADGAUGE 10-group 2-D real and adjoint fluxes using the code STOER[4] and/or the fluxes output from DTFX using the GAPER[5] code. Local utility codes 1DREAP and REAP are used to generate pointwise reaction rate profiles and ratios.

Fig. 1 is a flow chart of the analytical methods. Tables GA-1 and GA-2 give the group structures used and the analytical models. Tables GA-3 through 7 list the results of the various calculations.

Reference 6 gives further details on the methods for reactor analysis in use at General Atomic Co.

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3. S. R. Lenihan, "GAZE-2, A One-dimensional Multigroup Neutron Diffusion Theory Code for the IBM-7090," GA-3152 (Aug. 1962).

4. D. Haschke and U. Nyffenegger, "The Nuclear Design Codes ADGAUGE and STOER," EIR Bericht No. 199 (May 1971) (Federal Institute for Reactor Research, Switzerland).

5. D. A. Sargis, "GAPER, A Transport Perturbation Theory Program," GA-8667 (April 1968).

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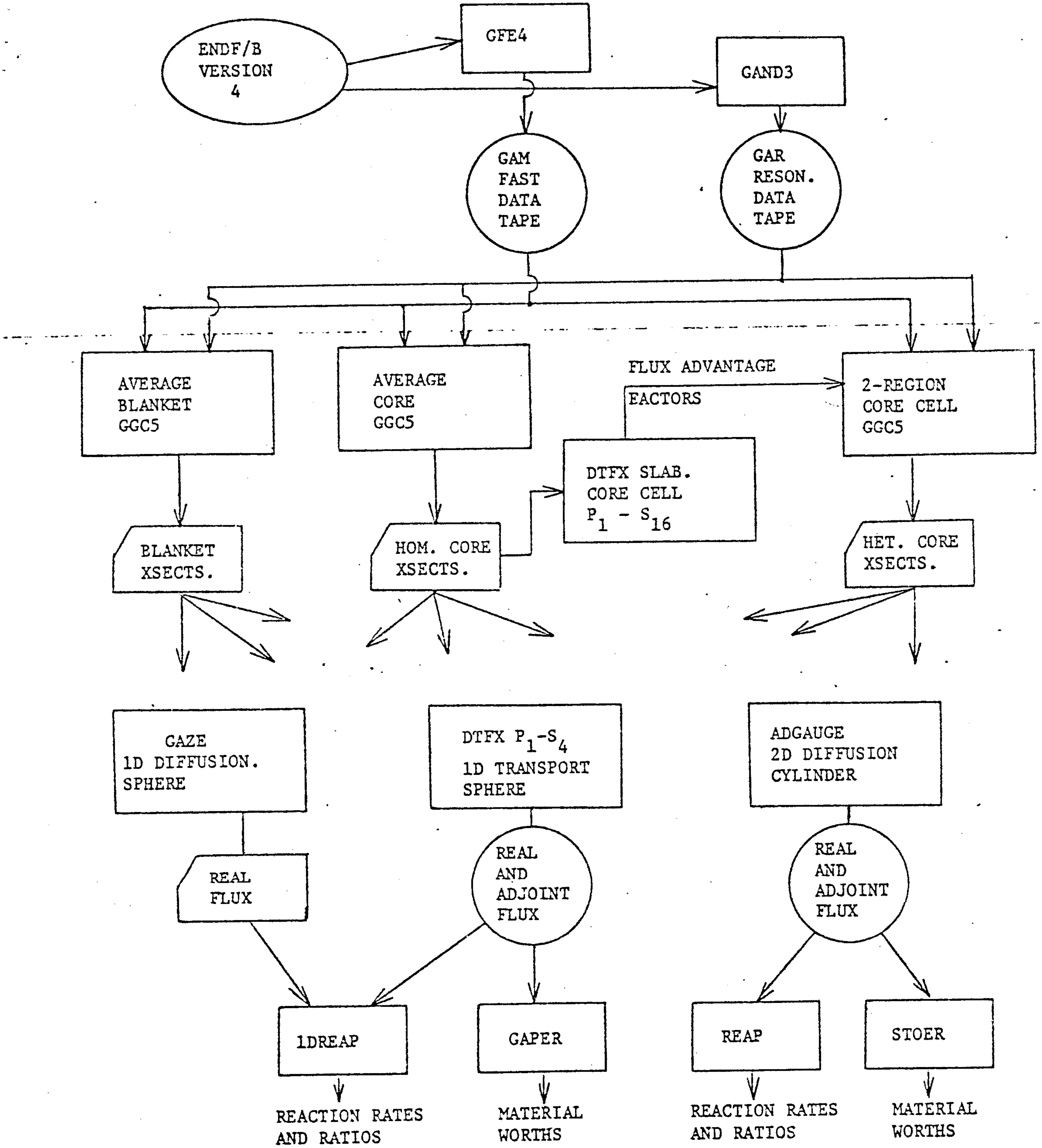

FIG. 1: FLOW CHART FOR GENERAL ATOMIC ANALYSES OF CSEWG BENCHMARKS FOR TESTING ENDF/B-4

Table GA-1 - Group Structure and Fission Spectra used in General Atomic ENDF/B-V4 Tests

Group Lower Boundary[a]	ZPR3-48 Analysis		Analyses for ZPPR-2, ZPR6-7 and ZPR6-6A			
	Group No.[b]	Core and Blanket Fission Spectrum	Group No.[b]	ZPPR-2 and ZPR6-7 Core Fission Spectrum	ZPR6-6A Core Fission Spectrum	Blanket Fission Spectrum
10.00 MeV	1	2.3720-03				
6.065	2	3.0986-02	1	3.3358-02	2.7293-02	2.4775-02
3.679	3	1.1888-01	2	1.1888-01	1.0830-01	1.0345-01
2.231	4	2.0903-01	3	2.0903-01	2.0284-01	1.9970-01
1.353	5	2.2303-01	4	2.2303-01	2.2528-01	2.2609-01
820.8 KeV	6	1.7386-01	5	1.7386-01	1.8005-01	1.8287-01
497.9	7	1.1156-01	6	1.1156-01	1.1732-01	1.2005-01
302.0	8	6.3513-02	7	6.3513-01	6.7430-02	6.9309-02
183.2	9	3.3610-02	8	3.3610-02	3.5890-02	3.6991-02
111.1	10	1.7010-02	9	1.7010-02	1.8228-02	1.8819-02
67.38	11	8.3790-03	10	8.3790-03	8.9978-03	9.2993-03
40.87	12	4.0599-03	11	4.0599-03	4.3654-03	4.5145-03
24.79	13	1.9476-03	12	1.9476-03	2.0958-03	2.1682-03
15.03	14	9.2862-04	13	9.2862-04	9.9977-04	1.0345-03
9.119	15	4.4116-04	14	4.4116-04	4.7508-04	4.9169-04
5.531	16	2.0910-04	15	2.0910-04	2.2523-04	2.3311-04
3.355	17	9.8980-05	16	9.8980-05	1.0662-05	1.1036-04
2.055	18	4.6814-05	17	4.6814-05	5.0433-05	5.2202-05
1.234	19	2.2131-05	18	2.2131-05	2.3842-05	2.4678-05
748.5 eV	20	1.0458-05	19	1.0458-05	1.1267-05	1.1664-05
454.0	21	4.9418-06	20	4.9418-06	5.3243-06	5.5111-06
275.4	22	2.3345-06	21	2.3345-06	2.5150-06	2.6037-06
101.3	23	1.6238-06	22	1.6238-06	1.7496-06	1.8108-06
37.27	24	3.6225-07	23	3.6225-07	3.9038-07	4.0413-07
13.71	25	8.0814-08	24	8.0814-08	8.7130-08	9.0051-08
5.044	26	1.7955-08	25	1.7955-08	1.9380-08	2.0155-08
2.383	27	3.5401-09				
1.855			26	4.0385-09	4.3422-09	4.4549-09
0.6826	28	1.3980-09				
0.4139	29	1.3098-10	27	1.0306-09	1.0787-09	1.1415-09

a. Upper boundary for group 1 in all cases was 14.918 MeV

b. Underlined indices are boundaries for corresponding 10-group sets

Table GA-2 - Specifications for Neutronics Calculations for ENDF/B-V4 Benchmark Analyses

Benchmark Assembly	ZPR3-48		ZPPR-2		ZPR6-7		ZPR6-6A	
	Region Width, cm	No. of Mesh Intervals	Region Width, cm	No. of Mesh Intervals	Region Width, cm	No. of Mesh Intervals	Region Width, cm	No. of Mesh Intervals
<u>1-D Model (GAZE + DTFX Problems) Geometry</u>	Sphere		Cylinder		Sphere		Sphere	
<u>Mesh Regions</u>								
Core	45.245	30	64.400	40	88.160	50	95.670	50
			26.670	20				
Blanket	30.000	20	18.740	15	33.810	20	33.810	20
			19.060	10				
Reflector			11.710	5				
<u>R-2 Model for 10-Group ADCAUCE Problems</u>								
<u>Radial Mesh Regions</u>								
Core	14.313	8	30.755	9				
	27.277	16	33.645	9				
			26.670	8				
Blanket	24.640	12	18.740	5				
	9.850	3	19.060	5				
Reflector			11.710	3				
<u>Axial Mesh Regions</u>								
Core	10.236	6	30.556	10				
	27.940	18	15.254	6				
Blanket	15.244	9	41.360	15				
	15.900	6						
Reflector			20.320	7				

Table GA-3 - Summary of Eigenvalue Calculations for ENDF/B-V4 Benchmark Analyses

Assembly Core-Cell Method	ZPR3-48 Homogeneous	ZPR3-48 Heterogeneous	ZPPR-2 Homogeneous	ZPR6-7 Homogeneous	ZPR6-6A Homogeneous
<u>10-Group, 1-D Diffusion:</u>					
Calculated k	0.98075	0.99450	--	--	--
Convergence	0.00001	0.00001			
<u>27-Group (29, for ZPR3-48), 1-D Diffusion:</u>					
Calculated k	0.98039	0.99409	0.98551	0.98104 *	0.98755
Convergence	0.00001	0.00001	0.00001	0.00002	0.00002
<u>10-Group, RZ Diffusion:</u>					
Calculated k	0.98003	0.99296	0.97983	--	--
Convergence	0.00005	0.00010	0.00004		
<u>27-Group (or 29) DTFX, P_1-S_4</u>					
Calculated k	0.98760	1.00139	--	0.98396	0.99028
Convergence	0.00001	0.00002		0.00002	

*Use of ANL Porter-Thomas quadrature scheme gives a Δk = 0.0014 for ZPR6-7.

Table GA-4 - Calculated Central Spectra from Benchmark Analyses Using ENDF/B-4

Case	ZPR-3 Assembly 48		ZPPR-2	ZPR6-7	ZPR6-6A
Code	GAZE	DTFX	GAZE	GAZE	GAZE
Cell	Homogeneous	Heterogeneous	Homogeneous	Homogeneous	Homogeneous
Group Lower E					
10.00 MeV	0.0315	0.0312			
6.065	0.419	0.413	0.295	0.295	0.252
3.679	1.713	1.682	1.118	1.118	1.056
2.231	3.815	3.744	2.867	2.872	2.900
1.353	6.151	6.050	4.218	4.227	4.410
820.8 keV	8.009	7.922	5.356	5.361	5.637
579.9	10.030	9.966	9.495	9.507	10.059
302.0	11.546	11.490	8.899	8.899	8.587
183.2	10.619	10.562	10.799	10.780	11.417
111.1	9.990	9.874	11.280	11.270	11.861
67.38	8.524	8.502	10.259	10.235	10.640
40.87	7.257	7.236	8.940	8.924	9.090
24.79	5.121	5.120	5.698	5.647	5.675
15.03	5.160	5.208	6.709	6.716	6.460
9.119	3.855	3.897	4.842	4.843	4.489
5.531	2.499	2.544	2.767	2.776	2.463
3.555	1.696	1.764	1.776	1.783	1.530
2.035	0.625	0.659	0.495	0.498	0.418
1.234	1.297	1.385	1.621	1.634	1.285
748.5 eV	0.825	0.898	1.170	1.184	0.874
454.0	0.495	0.553	0.759	0.774	0.516
275.4	0.248	0.287	0.356	0.365	0.2192
101.3	0.1474	0.1863	0.251	0.260	0.1426
37.27	1.589-02	2.461-02	0.0280	0.0293	0.0191
13.71	1.055-03	2.281-03	1.48-03	1.57-03	5.7-04
5.044	4.721-05	1.555-04	5.67-05	6.0-05	2.6-05
2.383	4.315-06	1.740-05			
1.855			4.26-06	5.4-06	1.7-06
0.6826	1.509-06	5.824-06			
0.4139	1.412-07	1.986-07	8.22-07	1.0-06	0.4-06

Table GA-5: Summary of Core-center Reaction Ratios Calculated in Benchmark Analyses Using ENDF/B-4

Benchmark	ZPR-3 Assembly 48				ZPPR Assembly 2		ZPR6-7	ZPR6-6A
Flux Calculation	GAZE and ADGAUGE	GAZE	DTFX	DTFX	ADGAUGE	GAZE	GAZE	GAZE
Cell Treatment	Homog.	Homog.	Homog.	Heterog.	Homog.	Homog.	Homog.	Homog.
No. of Groups	10	29	29	29	10	27	27	27
Ratios to ^{235}U-fission								
$^{10}B(n,\alpha)$	1.3408	1.3409	1.3439	1.3632	1.4561			
$C\text{-}U^{235}$	0.2880	0.2880	0.2886	0.2921	0.3125	0.3127	0.3131	0.2986
$C\text{-}U^{238}$	0.1361	0.1361	0.1362	0.1360	0.1431	0.1414	0.1430	0.1443
$C\text{-}Pu^{239}$	0.2466	0.2467	0.2475	0.2534	0.2811	0.2811	0.2823	0.2706
$C\text{-}Pu^{240}$	0.2606	0.2607	0.2614	0.2675	0.2863	0.2864		
$C\text{-}Pu^{241}$	0.2338			0.2367	0.2531	0.2532		
$f\text{-}U^{238}$	0.03289	0.03291	0.03267	0.03172	0.02118	0.02080	0.02103	0.02258
$f\text{-}Pu^{239}$	0.9694	0.9693	0.9680	0.9611	0.9207	0.9049	0.9195	0.9607
$f\text{-}Pu^{240}$	0.2522	0.2523	0.2509	0.2534	0.1821	0.1816		
$f\text{-}Pu^{241}$	1.2921			1.2916	1.2877	1.2876		

Table GA-6: Summary of Core-center Reactivity Coefficients Calculated in Benchmark Analyses Using ENDF/B-4

Benchmark	ZPR-3 Assembly 48			ZPPR-2	ZPR6-7	ZPR6-6A
Flux Calculation	ADGAUGE	DTFX	DTFX	ADGAUGE	DTFX	DTFX
Cell Treatment	Homog.	Homog.	Heterog.	Homog.	Homog.	Homog.
No. of Groups	10	29	29	10	27	27
Material Worth 10^{-5} Δk/k/mole						
^{10}B	- 98.08	- 97.04	-102.26	- 24.79	- 34.82	- 27.99
C	- 0.375	- 0.359	- 0.329	- 0.2110	- 0.2606	+ 0.0223
O	- 0.405	- 0.362	- 0.357	- 0.1740		
Na	- 0.413	- 0.280	- 0.309	- 0.1328	- 0.1779	- 0.0219
Al	- 0.497	- 0.561	- 0.590	- 0.1546	- 0.2289	
Cr	- 1.001	- 1.075	- 1.123	- 0.2731	- 0.3724	- 0.2135
Mn	- 3.713	- 3.266	- 3.618	- 1.0545		
Fe	- 0.982	- 0.969	- 1.016	- 0.2377	- 0.3019	- 0.1526
Ni	- 1.859	- 1.630	- 1.636	- 0.4315	- 0.5134	- 0.2730
Mo	- 7.210	- 7.178	- 7.676	- 1.6262	- 2.290	
Ta	- 35.828	- 35.756	- 38.759	- 9.120	- 13.132	- 9.589
^{235}U	105.82	99.70	99.63	28.23	37.83	24.68
^{238}U	- 6.677	- 6.675	- 7.227	- 1.781	- 2.860	- 2.252
^{239}Pu	142.38	136.26	135.83	34.62	47.25	33.43
^{240}Pu	23.70	22.06	20.27	2.663		
^{241}Pu				52.77		

Table GA-7: Summary of Adjoint-Flux Spectra Calculated at Core Center in Benchmark Analyses with ENDF/B-4

Group Lower Energy	Calculated Core-Center Adjoint Spectra, Normalized to 1.00 for Fission-Spectrum Neutron			
	1-D Diffusion (GAZE) Calculations, Homogeneous			
	ZPR3-48	ZPPR-2	ZPR6-7	ZPR6-6A
10.00 MeV	1.4684			
6.065	1.2587	1.2479	1.2458	1.2281
3.679	1.0913	1.0920	1.0911	1.0735
2.231	1.0830	1.1005	1.1001	1.0789
1.353	1.0070	1.0170	1.0167	1.0051
820.8 KeV	0.9117	0.9225	0.9228	0.9292
479.9	0.9113	0.9032	0.9038	0.9252
302.0	0.9067	0.8769	0.8781	0.9336
183.2	0.8962	0.8466	0.8482	0.9293
111.1	0.8854	0.8194	0.8217	0.9241
67.38	0.8684	0.7887	0.7915	0.9171
40.87	0.8453	0.7564	0.7597	0.9064
24.79	0.8384	0.7408	0.7446	0.9112
15.03	0.8325	0.7354	0.7394	0.9225
9.119	0.8537	0.7498	0.7542	0.9557
5.531	0.8865	0.7792	0.7841	0.9942
3.355	0.9277	0.8163	0.8214	1.0383
2.035	0.9736	0.8499	0.8550	1.0571
1.234	1.0012	0.8684	0.8735	1.0703
748.5 eV	1.0680	0.9153	0.9206	1.0614
454.0	1.0804	0.9476	0.9540	1.2006
275.4	1.1625	1.0117	1.0182	1.2009
101.3	1.1985	1.0667	1.0741	1.2088
37.27	1.5587	1.4123	1.4232	1.1855
13.71	0.7669	0.6321	0.6338	0.8071
5.044	1.4422	1.4226	1.4309	1.1407
2.383	1.3310			
1.855		1.1227	1.1916	1.0522
0.6826	1.1059			
0.4139	1.7594	0.9720	0.9829	1.6224

GENERAL ELECTRIC

(GE)

DESCRIPTION OF THE ANALYSIS OF BENCHMARK
CRITICAL ASSEMBLIES AS PERFORMED AT GE-FBRD

Processing of the ENDF/B-IV data involved using the 50-group generalized cross-section library generated by the code MINX[1] as provided by Los Alamos Scientific Laboratory and linking it to the code TDOWN-II[2] to produce composition-dependent and spatially-dependent group cross sections of the specified structure. The fission spectrum for each of the benchmark assemblies was calculated by weighting the flux averaged fission spectra for each of the isotopes in accordance with their contribution to the total neutron source in the core (or the inner-core-zone if more than one zone is specified). The fission spectrum fraction for coarse group i is then given by

$$\bar{\chi}_i = \frac{\sum\limits_m N_m \chi_{i,m} \sum\limits_j \nu_{j,m} \sigma_{f,jm} \phi_j}{\sum\limits_m \sum\limits_j N_m \nu_{j,m} \sigma_{f,jm} \phi_j}$$

where $\sum\limits_m$ = summation over all materials in the composition,

and $\sum\limits_j$ = summation over all groups.

Only one fission spectrum is used throughout all the regions of a given assembly.

The benchmark calculations were carried out with the code SN1D[3]. SN1D is a one-dimensional discrete ordinates transport code with a diffusion theory option. The recommended corrections were applied to the calculated results. The central reactivity worths were obtained using the forward and adjoint fluxes from SN1D and the perturbation code PERT-V[4].

(1) The MINX Code, Los Alamos Scientific Laboratory, to be published.

(2) C.L. Cowan, et al., "TDOWN-II - A Code to Generate Composition and Spatially Dependent Cross Sections", GEAP-13740, August 1971.

(3) R. Protsik, et al., "SN1D - - A One-Dimensional Discrete Ordinates Transport Code with General Anisotropic Scattering, GEAO-0064 Rev. 1, May 1970.

(4) R.W. Hardie and W.W. Little, Jr., "PERT-V, A Two-Dimensional Perturbation Code for Fast Reactor Analysis", BNWL-1162, September 1969.

TABLE 1

CALCULATED EIGENVALUES FOR FAST REACTOR BENCHMARKS*
USING ENDF/B-IV

Assembly	k ENDF/B-IV
JEZEBEL	0.9990
SNEAK-7A	0.98995
SNEAK-7B	0.98996
ZPR-3-48	0.99397
ZPR-3-56B	0.98477
ZPR-6-7	0.99092
ZPPR-2	0.9911

*Calculated eigenvalues include heterogeneity and transport corrections as given in the CSEWG benchmark specifications.

TABLE 2

CALCULATED TO EXPERIMENTAL REACTION RATE RATIOS FOR SEVERAL FAST REACTOR BENCHMARKS

Reaction Rate Ratio	CALCULATED TO EXPERIMENTAL (C/E) VALUES						
	JEZEBEL	SNEAK-7A	SNEAK-7B	ZPR-3-48	ZPR-3-56B	ZPR-6-7	ZPPR-2
	ENDF/B-IV	ENDF/B-IV	ENDF/B-IV	ENDF/B-IV	ENDF/B-IV	ENDF/B-IV	ENDF/B-IV
$\sigma_f^{U-238}/\sigma_f^{U-235}$	0.944	0.931	0.979	1.040	0.965	0.945	1.081
$\sigma_f^{Pu-239}/\sigma_f^{U-235}$	0.935	0.962	0.989		0.951	0.967	0.985
$\sigma_f^{Pu-240}/\sigma_f^{U-235}$					0.855		1.120
$\sigma_c^{U-238}/\sigma_f^{U-235}$		0.990	1.033	0.971		1.044	
$\sigma_f^{U-235}/\sigma_f^{Pu-239}$						1.035	
$\sigma_f^{U-238}/\sigma_f^{Pu-239}$						0.978	
$\sigma_c^{U-238}/\sigma_f^{Pu-239}$						1.080	

TABLE 3

CALCULATED TO EXPERIMENTAL CENTRAL REACTIVITY WORTHS
FOR SEVERAL FAST REACTOR BENCHMARKS

CALCULATED TO EXPERIMENTAL (C/E) VALUES

	JEZEBEL	SNEAK-7A	SNEAK-7B	ZPR-3-48	ZPR-3-56B	ZPR-6-7	ZPPR-2*
Material	ENDF/B-IV	ENDF/B-IV	ENDF/B-IV	ENDF/B-IV	ENDF/B-IV	ENDF/B-IV	ENDF/B-IV
Na				2.547	2.196	1.377	1.188
U-235	1.062	1.160	1.116	1.251	1.055	1.232	1.349
U-238	0.962	1.326	1.219	1.052	1.068	1.017	
Pu-239	1.025	1.167	1.106	1.243	1.101	1.255	1.237
Pu-240	1.030	1.040	1.135				
B-10		1.095	1.078	0.976	0.852	1.085	
Fe		1.007	1.159	1.343	0.931	1.215	1.208

*These calculations assumed that both the forward and adjoint fluxes have an axial cosine shape with an extrapolated length of 129.12 cm.

Installation: GE-FBRD
Code: TDOWN-II

NEUTRON SPECTRA: ZPR-6-7

Normalization

- flux: 1 watt/cm - height
- adjoint: Average of adjoint over reactor is unity

SCALAR FLUX AT CORE CENTER

Group	E_{min} (eV)	Calculated Flux	Measured Flux	Calculated Adjoint
1	1.0 +7	2.454 +3		4.095
2	6.065 +6	3.224 +4		4.633
3	3.679 +6	1.312 +5		6.031
4	2.231 +6	3.164 +5		4.869
5	1.353 +6	4.505 +5		5.059
6	8.208 +5	5.671 +5		4.631
7	4.979 +5	1.010 +6		4.434
8	3.020 +5	9.624 +5		3.867
9	1.832 +5	1.278 +6		3.592
10	1.111 +5	1.294 +6		3.493
11	6.738 +4	1.121 +6		3.399
12	4.087 +4	9.216 +5		3.306
13	2.479 +4	6.996 +5		3.231
14	1.503 +4	7.348 +5		3.208
15	9.119 +3	5.091 +5		3.258
16	5.531 +3	2.880 +5		3.368
17	3.355 +3	1.773 +5		3.514
18	2.035 +3	6.283 +4		3.643
19	1.234 +3	1.876 +5		3.764
20	7.485 +2	1.242 +5		3.883
21	4.540 +2	6.567 +4		3.991
22	2.754 +2	2.651 +4		4.073
23	1.670 +2	1.365 +4		4.532
24	1.013 +2	4.836 +3		4.869
25	6.144 +1	1.229 +3		4.838
26	3.727 +1	2.742 +2		5.480
27	2.511 -1	1.401 +2		6.049

HANFORD ENGINEERING DEVELOPMENT LABORATORY

(HEDL)

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AN ANALYSIS OF SELECTED FAST CRITICAL ASSEMBLIES USING ENDF/B-IV

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ABSTRACT

Measured integral quantities such as k_{eff}, central reaction rate ratios, and central reactivity coefficients for 18 fast critical assemblies were calculated using the ENDF/B-IV cross section set. The correlations between calculation and experiment using Version IV were then compared to those obtained with earlier cross section data, specifically, Versions I-III of ENDF/B and the Bondarenko cross section set.

In general, ENDF/B-IV was found to do an excellent job of calculating k_{eff}. However, discrepancies between calculation and experiment did exist for both reaction rate ratios and reactivity coefficients. Of particular interest, the fissile fuel central worth discrepancy for plutonium assemblies was found to be approximately 20 percent.

I. INTRODUCTION

The reactor designer, when presented with a new cross section set, immediately asks "How well does it work?" To answer this question, the newly released Version IV of ENDF/B was evaluated by calculating measured integral quantities for 18 fast critical assemblies. More specifically, the integral quantities investigated in this study were k_{eff}, central reaction rate ratios, and central reactivity coefficients. Also, to determine how ENDF/B-IV compares with earlier cross section sets, k_{eff} calculations were performed using Versions I, II, III, and the Bondarenko cross section set. In addition, reaction rate ratios and worths were calculated using ENDF/B-III data.

II. DESCRIPTION OF CRITICAL ASSEMBLIES

Seventeen fast critical assemblies have been designated by the Cross Section Evaluation Working Group (CSEWG) as "Phase II Fast Reactor Data Testing Criticals."(1) Fourteen of these assemblies were used in this study. In addition, four ZPR-3 assemblies of particular interest were also included: Assemblies 49, 50, 53, and 54. A tabulation listing key characteristics of all critical assemblies used in this study is given in Table II.1, and a tabulation of the atom densities and both the 1-D and 2-D dimensions for these assemblies appear in Appendix A. Note that the characteristics of the assemblies vary considerably--from 12 liters to 4000 liters in size, and from almost no fertile fuel to a fertile-to-fissile ratio greater than eight.

The ZPR-3-48, 49, 50, 53, 54, and 56 assemblies are particularly interesting because they provide the opportunity to examine a single item. For example, Assembly 49 had a composition identical to 48, with the exception that the sodium was removed. Assembly 50 is the same as 49, except additional carbon was added to soften the spectrum. The core compositions of Assemblies 53 and 54 were identical, but 53 had a U-238 reflector while 54 had a predominantly iron reflector. Finally, the reflector for Assembly 56 was largely nickel.

ZPPR-2, ZPR-6-7, and ZPR-6-6A are valuable because they enable the cross section data to be checked in an environment similar to that of a large LMFBR. Although the fissile fuel in large LMFBR's will be plutonium, six uranium-fueled assemblies were studied to determine if a consistent calculational bias is associated with a particular fuel type.

Table II.1

Critical Assembly Characteristics

Assembly	Fissile Fuel	Fertile-to-Fissile Ratio	Approximate Core Volume (liters)	Comments
VERA-11A	Pu	0.05	12	No U in the core
VERA-1B	U	0.08	30	Enriched U core
ZPR-3-6F	U	1.1	50	
ZEBRA-3	Pu	8.6	60	Hard spectrum
ZPR-3-12	U	3.8	100	C added to soften spectrum
SNEAK-7A	Pu	3.0*	110	
ZPR-3-11	U	7.5	140	
ZPR-3-54	Pu	1.6	190	Similar to Ass'y 53, except an Fe reflector
ZPR-3-53	Pu	1.6	220	Similar to Ass'y 54, except a U reflector
SNEAK-7B	Pu	7.0	310	
ZPR-3-50	Pu	4.5	340	Similar to Ass'y 49, except additional C added
ZPR-3-48	Pu	4.5	410	C added to soften spectrum
ZEBRA-2	U	6.2	430	
ZPR-3-49	Pu	4.5	450	Similar to Ass'y 48, except Na removed
ZPR-3-56B	Pu	4.6	610	Predominantly Ni reflector
ZPPR-2	Pu	6.5*	2400	Equal volume 2-zone core, L/D $\approx$ .5
ZPR-6-7	Pu	6.5	3100	L/D $\approx$ .9
ZPR-6-6A	U	5.0	4000	L/D $\approx$ .8

*Fertile-to-fissile ratio in the inner core zone.

III. DESCRIPTION OF PROCEDURE

The basic reactor model with which the 18 critical assemblies were analyzed was a one-dimensional diffusion theory calculation in spherical geometry. The exception to this was ZPPR-2, in which case the model was a one dimensional cylinder. Therefore, one to two dimensional, diffusion to transport theory, and heterogeneity correction factors were applied to the calculated k_{eff}'s. In addition, 1-D to 2-D correction factors were applied to the 1-D reactivity coefficients. All of the above correction factors were determined in this study, except for the heterogeneity corrections to k_{eff}. For the 14 CSEWG criticals in Reference 1, the heterogeneity corrections were either provided or the calculational models had been adjusted to account for heterogeneities. For the 4 non-CSEWG assemblies, heterogeneity corrections obtained in an unpublished study were used. In this case, the spatial self-shielding component, calculated using a 26-group S_{12} cell model with a homogeneous B^2 leakage, was added to the energy self-shielding component calculated using the Bell approximation.

The procedure followed in this analysis is shown in Figure 3.1. First, the ETOX code[(2)] was used to generate cross sections in the Bondarenko[(3)] format using data from the ENDF/B tapes. In these calculations, 30 groups were generated for ENDF/B-I, 29 groups for Versions II and III, and 42 groups for ENDF/B-IV. The Bondarenko set was obtained from Reference 3. Using ENDF/B-III, 1DX[(4)] generated resonance self-shielded cross sections for each assembly, and these were then collapsed to 12 energy groups for the remainder of the calculations. 1DX was next used to calculate 1-D fluxes and adjoint fluxes for PERT-V,[(5)] a one- and two-dimensional perturbation theory code. Similarly, 2DB[(6)] was used to calculate 2-D fluxes and adjoint fluxes. Therefore, comparing

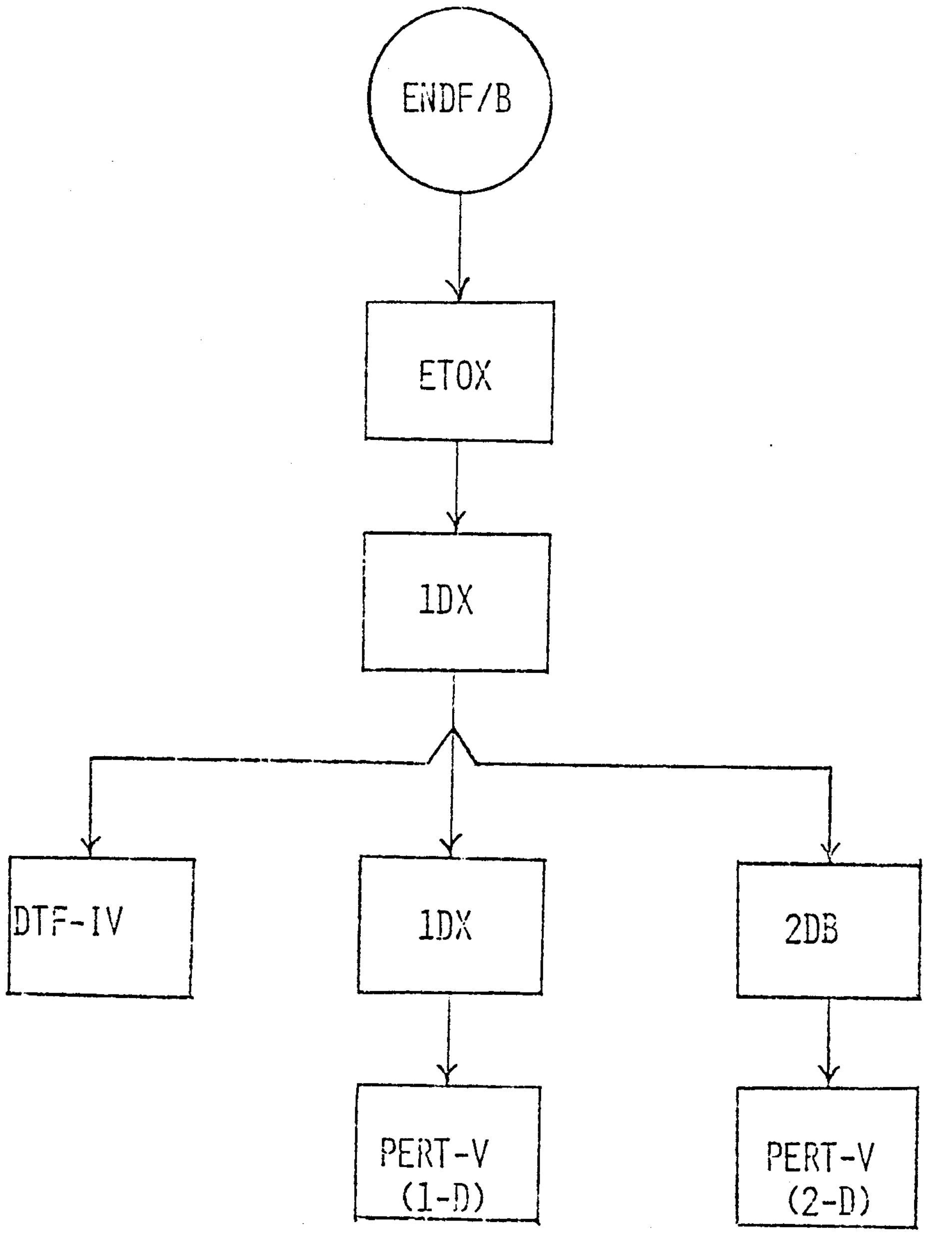

Fig. 3.1. Procedure for Critical Assembly Analysis

the k_{eff}'s from 1DX and 2DB gives the 1-D to 2-D correction factors for k_{eff}, and comparing PERT-V worths using fluxes and adjoints from 1DX and 2DB gives the 1-D to 2-D correction factors for the reactivity coefficients. The difference between 1-D and 2-D central reaction rate ratios was found to be negligible. Finally, the diffusion to transport theory correction factors for k_{eff} were obtained by comparing the 12 group result from the 1-D S_n code DTF-IV[(7)] in S_8 with the 12 group result from 1DX. The correction factors to k_{eff} obtained by the above sequence using ENDF/B-III are given in Table III.1. These were then applied to the 1-D diffusion theory calculations for all other cross section sets. The 1-D to 2-D correction factors to reactivity coefficients were only applied to the ENDF/B-IV values, since worths were not calculated using the other cross section sets.

Sixty mesh intervals were used in the 1-D transport theory calculations and eighty intervals in the 1-D diffusion calculations. The 2-D diffusion theory mesh detail is shown in Table III.2.

Group boundaries and fission spectra are given in Table III.3 for the 42 group ENDF/B-IV cross section set. The T=1.35 MeV fission spectrum was used for U assemblies and the T=1.41 MeV spectrum was used for Pu assemblies. The same table also gives the collapsing scheme used to generate the 12 group set. The energy bounds for the first 25 groups of the 30 group ENDF/B-I set and the 29 group ENDF/B-II and III sets were identical to the first 25 groups of the 42 group set. The remaining 17 groups in the 42 group set were combined into 4 groups for the 29 group set, and into 5 groups for the 30 group set. Energy bounds and fission spectra for the Bondarenko cross section set are given in Reference 3. With the Bondarenko set, the fission spectrum for ν=2.4 was used for U assemblies, while the spectrum for ν=3.0 was used for criticals fueled with Pu.

Table III.1

Correction Factors to k_{eff} for Homogeneous, One-Dimensional Diffusion Calculations

Assembly	1-D to 2-D	Diffusion to Transport (S8)	Heterogeneity
VERA-11A	.0035	.0472	.0[(1)]
VERA-1B	.0038	.0237	.0[(1)]
ZPR-3-6F	-.0028	.0192	.0[(1)]
ZEBRA-3	-.0006	.0126	.0[(1)]
ZPR-3-12	-.0009	.0099	.0[(1)]
SNEAK-7A	.0061	.0120	-.0045[(2)]
ZPR-3-11	.0001	.0060	.0[(1)]
ZPR-3-54	-.0164	.0144	.0230
ZPR-3-53	-.0150	.0087	.0230
SNEAK-7B	.0042	.0047	-.0021[(2)]
ZPR-3-50	-.0133	.0056	.0220
ZPR-3-48	-.0009	.0064	.0183
ZEBRA-2	-.0007	.0033	.0[(1)]
ZPR-3-49	-.0139	.0068	.0158
ZPR-3-56B	-.0166	.0065	.0102
ZPPR-2	.0003	.0024	.0175
ZPR-6-7	-.0020	.0016	.0166
ZPR-6-6A	-.0013	.0013	.0073

(1) The atom densities and/or sizes were adjusted to account for heterogeneities.

(2) Includes corrections for cylindrization, actual control rod position, and heterogeneities.

Table III.2

Mesh Detail for 2-D Diffusion Theory Calculations

Assembly	Number of Mesh Points in the RxZ Direction
VERA-11A	40x40
VERA-1B	40x40
ZPR-3-6F	40x40
ZEBRA-3	40x40
ZPR-3-12	40x40
SNEAK-7A	40x40
ZPR-3-11	40x40
ZPR-3-54	50x50
ZPR-3-53	50x50
SNEAK-7B	50x50
ZPR-3-50	50x50
ZPR-3-48	50x50
ZEBRA-2	50x50
ZPR-3-49	50x50
ZPR-3-56B	50x50
ZPPR-2	90x65
ZPR-6-7	70x70
ZPR-6-6A	70x70

Table III.3

Group Boundaries and Fission Spectra

Group No. for 42 Group Set	Group No. for 12 Group Set	Lower Energy Boundary (eV)	Fission Spectrum for T = 1.35 MeV	Fission Spectrum for T = 1.41 MeV
1	1	6.065+6	.0276	.0325
2		3.679+6	.1124	.1218
3	2	2.231+6	.2056	.2109
4		1.353+6	.2250	.2230
5	3	8.208+5	.1781	.1728
6		4.979+5	.1154	.1105
7	4	3.877+5	.0380	.0361
8		3.020+5	.0281	.0266
9	5	1.832+5	.0351	.0332
10		1.111+5	.0178	.0168
11	6	6.738+4	.0088	.0083
12		4.087+4	.0043	.0040
13	7	2.554+4	.0020	.0018
14		1.989+4	.0006	.0006
15		1.503+4	.0005	.0004
16	8	9.119+3	.0005	.0004
17		5.531+3	.0002	.0002
18	9	3.355+3	.0001	.0001
19		2.840+3	.0	.0
20		2.404+3	.0	.0
21		2.035+3	.0	.0
22	10	1.234+3	.0	.0
23		7.485+2	.0	.0
24	11	4.540+2	.0	.0
25		2.754+2	.0	.0
26	12	1.670+2	.0	.0
27		1.013+2	.0	.0
28		6.144+1	.0	.0
29		3.727+1	.0	.0
30		2.260+1	.0	.0
31		1.371+1	.0	.0
32		8.315+0	.0	.0
33		5.043+0	.0	.0
34		3.059+0	.0	.0
35		1.855+0	.0	.0
36		1.125+0	.0	.0
37		6.826-1	.0	.0
38		4.140-1	.0	.0
39		2.511-1	.0	.0
40		1.523-1	.0	.0
41		9.237-2	.0	.0
42		Thermal+	.0	.0

IV. DISCUSSION OF k_{eff} CALCULATIONS

The results of the k_{eff} calculations are given in Table IV.1--the values for k_{eff} have all been corrected using the correction factors from Table III.1. The Bondarenko set gives calculated k_{eff}'s that are much higher than the measured value of unity--about 2.7 percent on the average. There is also a large scatter in k_{eff}, from 1.0051 for ZEBRA-3 to 1.0452 for ZPPR-2. Therefore, a simple change in ν of U-235 and Pu-239 would not remove the discrepancy. It should be mentioned that the values for ν were almost identical for all the cross section sets.

The eigenvalues calculated using ENDF/B-I represent an improvement. A notable exception is ZEBRA-3, with a k_{eff} of .9526. However, ENDF/B-I is generally better for predicting criticality than the Bondarenko set, although there is still a considerable variation among the calculated k_{eff}'s.

ENDF/B-II, however, is another story. The calculated k_{eff}'s using ENDF/B-II are, on the average, less than unity by more than 3 percent. Two assemblies, ZEBRA-3 and ZPR-3-54, were calculated more than 5 percent subcritical.

The first cross section data which accurately predicted k_{eff} was ENDF/B-III. Version III does a remarkable job of predicting criticality, with only one assembly, ZEBRA-3, having an eigenvalue differing from unity by more than 1 percent. It is clear that ENDF/B-III was a major improvement over previous cross section sets.

There are no major changes in the results obtained using ENDF/B-IV insofar as k_{eff} is concerned. The calculated eigenvalues using Version IV

Table IV.1

Results of k_{eff} Calculations

Assembly	Fuel	Approximate Volume	Corrected k_{eff} Bondarenko	ENDF/B-I	ENDF/B-II	ENDF/B-III	ENDF/B-IV
VERA-11A	Pu	12	1.0186	0.9824	0.9695	0.9935	0.9945
VERA-1B	U	30	1.0242	1.0095	0.9904	1.0026	1.0021
ZPR-3-6F	U	50	1.0274	1.0135	0.9938	1.0087	1.0112
ZEBRA-3	Pu	60	1.0051	0.9526	0.9435	0.9816	1.0004
ZPR-3-12	U	100	1.0222	1.0048	0.9848	1.0017	1.0055
SNEAK-7A	Pu	110	1.0376	0.9912	0.9710	1.0006	1.0022
ZPR-3-11	U	140	1.0072	0.9869	0.9677	0.9924	1.0107
ZPR-3-54	Pu	190	1.0032	1.0229	0.9482	0.9940	0.9620
ZPR-3-53	Pu	220	1.0387	1.0098	0.9856	1.0008	0.9955
SNEAK-7B	Pu	310	1.0287	0.9712	0.9546	0.9893	0.9967
ZPR-3-50	Pu	340	1.0386	0.9938	0.9690	0.9940	0.9948
ZPR-3-48	Pu	410	1.0418	0.9878	0.9690	0.9997	1.0015
ZEBRA-2	U	430	1.0121	0.9889	0.9725	0.9902	0.9965
ZPR-3-49	Pu	450	1.0401	0.9824	0.9642	0.9985	1.0021
ZPR-3-56B	Pu	610	1.0271	0.9888	0.9636	0.9948	0.9882
ZPPR-2	Pu	2400	1.0452	0.9881	0.9673	0.9994	0.9976
ZPR-6-7	Pu	3100	1.0420	0.9805	0.9595	0.9926	0.9917
ZPR-6-6A	U	4000	1.0250	0.9968	0.9772	0.9988	0.9967
Average k_{eff}			1.0269	0.9918	0.9695	0.9963	0.9972
Average $\|k_{eff} - 1\|$			0.0269	0.0150	0.0305	0.0053	0.0068

are slightly better than Version III, with one notable exception--ZPR-3-54. Preliminary indications are that the problem with Assembly 54 may at least partially originate in the cross section processing codes. More specifically, Assembly 54 has a highly concentrated iron reflector, and the iron cross sections in ENDF/B-IV have deep minima in the total cross section. This can cause a problem if the asymptotic $1/\Sigma_t$ flux weighting spectrum is used in a medium consisting primarily of iron. However, it will be shown in Section VI that the central reactivity coefficient for iron using Version IV is more negative than with Version III. Since central reactivity worths for iron depend primarily on the absorption cross section, this indicates the problem may not lie entirely with the deep minima in the iron scattering cross section. Using the iron cross sections from ENDF/B-III and all other cross sections from ENDF/B-IV in a k_{eff} calculation increased the eigenvalue for Assembly 54 by about 2 percent. Disregarding Assembly 54 gives an average value of k_{eff} of .9993 with ENDF/B-IV, and an average deviation from unity of .0049.

In summary, both ENDF/B-III and IV do an excellent job of calculating k_{eff} for a set of critical assemblies whose characteristics vary considerably.

V. CENTRAL REACTION RATE RATIOS

Calculated and experimental central reaction rate ratios for σ_f^{U-238}, σ_f^{Pu-239}, σ_f^{Pu-240}, and σ_c^{U-238} are given in Tables V.1 through V.4. The reaction rates are all relative to that of fission in U^{235}. For a few critical assemblies, there are very large discrepancies between the experimental and calculated values obtained using either Versions III or IV. The fact that the C/E values for both $\sigma_f^{U-238}/\sigma_f^{U-235}$ and $\sigma_f^{Pu-240}/\sigma_f^{U-235}$ are both high suggests that part of the discrepancy may be caused by incorrectly calculated spectra. The average error in $\sigma_f^{Pu-239}/\sigma_f^{U-235}$ is only about 3 percent using either cross section set. It should be noted that all averages in this paper are simple averages and are not weighted with the experimental uncertainties.

It is difficult to draw firm conclusions regarding the relative performance of Versions III and IV for calculating reaction rate ratios. However, one conclusion that may be drawn is that the differences between III and IV are considerably less than the differences between calculation and experiment. It is possible that the discrepancy between calculation and experiment could be reduced by a more consistent treatment of heterogeneity effects.

The ratio of the capture rate in U^{238} to the fission rate in Pu^{239} is an important component of the breeding ratio, the other component of importance being the capture to fission ratio in Pu^{239}. Calculated and experimental values of $\sigma_c^{U-238}/\sigma_f^{Pu-239}$ are tabulated in Table V.5. Note that the calculated-to-experimental value using Version IV is about 2 percent less than Version III for most criticals. It is also interesting to note that the C/E values for assemblies fueled with U are about 10 percent lower than for assemblies fueled with Pu.

Table V.1

$\sigma_f^{U-238}/\sigma_f^{U-235}$

Assembly	Fuel	Experimental	C/E ENDF/B-III (1-D)	C/E ENDF/B-IV (1-D)
VERA-11A	Pu	0.077	1.088	1.090
VERA-1B	U	0.066	1.190	1.180
ZPR-3-6F	U	0.078	0.958	1.000
ZEBRA-3	Pu	0.0461	0.903	1.001
ZPR-3-12	U	0.047	0.982	1.060
SNEAK-7A	Pu	0.0448	0.877	0.911
ZPR-3-11	U	0.038	0.952	1.064
ZPR-3-54	Pu	0.0254	1.152	1.176
ZPR-3-53	Pu	0.0254	1.128	1.125
SNEAK-7B	Pu	0.0330	0.902	0.967
ZPR-3-50	Pu	0.0251	1.091	1.132
ZPR-3-48	Pu	0.0326	0.977	1.026
ZEBRA-2	U	0.0320	0.971	1.048
ZPR-3-49	Pu	0.0345	0.998	1.055
ZPR-3-56B	Pu	0.0308	0.900	0.940
ZPPR-2	Pu	0.0201	1.014	1.053
ZPR-6-7	Pu	0.0230	0.886	0.914
ZPR-6-6A	U	0.0245	0.900	0.926
Average C/E			0.993	1.037
Average |C/E -1.0|			0.081	0.075

Table V.2

$\sigma_f^{Pu-239}/\sigma_f^{U-235}$

Assembly	Fuel	Experimental	C/E ENDF/B-III (1-D)	C/E ENDF/B-IV (1-D)
VERA-11A	Pu	1.07	1.072	1.073
VERA-1B	U	1.070	1.062	1.062
ZPR-3-6F	U	1.22	1.016	1.020
ZEBRA-3	Pu	1.190	0.978	0.988
ZPR-3-12	U	1.12	0.985	0.996
SNEAK-7A	Pu	1.016	0.951	0.960
ZPR-3-11	U	1.19	0.976	0.987
ZPR-3-54	Pu	0.928	0.937	0.936
ZPR-3-53	Pu	0.928	0.933	0.928
SNEAK-7B	Pu	1.012	0.973	0.985
ZPR-3-50	Pu	0.903	0.982	0.986
ZPR-3-48	Pu	0.976	0.985	0.993
ZEBRA-2	U	0.987	0.994	1.007
ZPR-3-49	Pu	0.986	0.996	1.008
ZPR-3-56B	Pu	1.028	0.936	0.944
ZPPR-2	Pu	0.937	0.974	0.981
ZPR-6-7	Pu	0.953	0.955	0.961
ZPR-6-6A	U	-		
Average C/E			0.983	0.989
Average |C/E -1.0|			0.035	0.031

Table V.3

$\sigma_f^{Pu-240}/\sigma_f^{U-235}$

Assembly	Fuel	Experimental	C/E ENDF/B-III (1-D)	C/E ENDF/B-IV (1-D)
VERA-11A	Pu	0.475	0.964	1.035
VERA-1B	U	0.399	1.114	1.186
ZPR-3-6F	U	0.53	0.914	1.005
ZEBRA-3	Pu	0.373	0.913	1.023
ZPR-3-12	U	-		
SNEAK-7A	Pu	-		
ZPR-3-11	U	0.34	0.951	1.065
ZPR-3-54	Pu	0.174	1.093	1.196
ZPR-3-53	Pu	0.174	1.066	1.147
SNEAK-7B	Pu	-		
ZPR-3-50	Pu	0.159	1.192	1.311
ZPR-3-48	Pu	0.243	0.942	1.040
ZEBRA-2	U	0.237	0.982	1.092
ZPR-3-49	Pu	-		
ZPR-3-56B	Pu	0.282	0.751	0.824
ZPPR-2	Pu	0.170	0.992	1.081
ZPR-6-7	Pu	-		
ZPR-6-6A	U	-		
Average C/E			0.990	1.084
Average |C/E -1.0|			0.088	0.113

Table V.4

$\sigma_c^{U-238} / \sigma_f^{U-235}$

Assembly	Fuel	Experimental	C/E ENDF/B-III (1-D)	C/E ENDF/B-IV (1-D)
VERA-11A	Pu	-		
VERA-1B	U	0.131	0.930	0.927
ZPR-3-6F	U	0.104	0.951	0.919
ZEBRA-3	Pu	-		
ZPR-3-12	U	0.123	0.971	0.954
SNEAK-7A	Pu	0.1376	0.991	0.979
ZPR-3-11	U	0.112	0.976	0.949
ZPR-3-54	Pu	-		
ZPR-3-53	Pu	-		
SNEAK-7B	Pu	0.131	1.032	1.025
ZPR-3-50	Pu	-		
ZPR-3-48	Pu	0.138	0.976	0.963
ZEBRA-2	U	0.136	0.982	0.968
ZPR-3-49	Pu	-		
ZPR-3-56B	Pu	-		
ZPPR-2	Pu	-		
ZPR-6-7	Pu	0.136	1.046	1.044
ZPR-6-6A	U	0.139	1.022	1.017
Average C/E			0.988	0.974
Average |C/E -1.0|			0.032	0.043

Table V.5

$\sigma_c^{U-238}/\sigma_f^{Pu-239}$

Assembly	Fuel	Experimental	C/E ENDF/B-III (1-D)	C/E ENDF/B-IV (1-D)
VERA-11A	Pu	-		
VERA-1B	U	0.122	0.876	0.873
ZPR-3-6F	U	0.085	0.936	0.901
ZEBRA-3	Pu	-		
ZPR-3-12	U	0.110	0.986	0.958
SNEAK-7A	Pu	0.135	1.048	1.026
ZPR-3-11	U	0.094	1.000	0.962
ZPR-3-54	Pu	-		
ZPR-3-53	Pu	-		
SNEAK-7B	Pu	0.129	1.067	1.046
ZPR-3-50	Pu	-		
ZPR-3-48	Pu	0.141	0.991	0.970
ZEBRA-2	U	0.138	0.988	0.961
ZPR-3-49	Pu	-		
ZPR-3-56B	Pu	-		
ZPPR-2	Pu	-		
ZPR-6-7	Pu	0.143	1.095	1.086
ZPR-6-6A	U	-		
Average C/E Over All Assemblies			0.999	0.976
Average C/E Over All U Assemblies			0.957	0.931
Average C/E Over All Pu Assemblies			1.050	1.032

VI. CENTRAL REACTIVITY COEFFICIENTS

The discrepancy between calculated and measured small sample central reactivity worths has received much attention in recent years. Central reactivity coefficients for these assemblies were calculated using Versions III and IV of ENDF/B. Bohn et al.[(8)] have collected much of the data that exists on earlier calculations of U^{235}, Pu^{239}, U^{238}, and B^{10} reactivity coefficients to determine correlations that might help isolate the sources of the discrepancy.

The CSEWG benchmark specifications report reactivity coefficients in units of $\Delta k/k$ while also providing the inhour to $\Delta k/k$ conversion factors that were used to convert the measured values. We converted the worths back to inhours to allow a more consistent comparison to be made between measurement and calculation, since converting to $\Delta k/k$ requires the use of specific delayed neutron data. All delayed neutron data used in this study were obtained from the ENDF/B-IV data tape and are given in Table VI.1, except for the delayed fission spectrum. In this case, Sloan and Woodruff's data were used[(9)] and the values are shown in Table VI.2. A two-dimensional calculation was made for each assembly in order to obtain the value of β_{eff}, the conversion factor from inhours to $\Delta k/k$, and the neutron generation time using this delayed neutron data and Version III cross sections. The results are shown in Table VI.3. These conversion factors were used to convert calculated reactivities in units of $\Delta k/k$ to inhours. Thus, the conversion for all assemblies was performed in a consistent manner with the latest delayed neutron data.

Reactivity coefficients using Version III and calculated in one and two dimensions are compared with the experimental values in Tables VI.4 -

Table VI.1

Delayed Neutron Data

	U-235		U-238		Pu-239		Pu-240		Pu-241		Pu-242	
Absolute Delayed Neutron Yield per Fission	.0167		.0460		.00645		.0090		.0157		.0527	
Delayed Group	Fractional Yields	Decay Constant (sec^{-1})	Fractional Yields	Decay Constant (sec^{-1})	Fractional Yields	Decay Constant (sec^{-1})	Fractional Yields	Decay Constant (sec^{-1})	Fractional Yields	Decay Constant (sec^{-1})	Fractional Yields	Decay Constant (sec^{-1})
1	.038	1.272-2	.013	1.323-2	.038	1.290-2	.028	1.294-2	.010	1.230-2	.034	1.237-2
2	.213	3.174-2	.137	3.212-2	.280	3.110-2	.273	3.131-2	.229	2.990-2	.150	3.340-2
3	.188	1.160-1	.162	1.390-1	.216	1.340-1	.192	1.350-1	.173	1.240-1	.155	1.210-1
4	.407	3.110-1	.388	3.590-1	.328	3.320-1	.350	3.330-1	.390	3.520-1	.446	3.210-1
5	.128	1.400	.225	1.410	.103	1.260	.128	1.360	.182	1.610	.172	1.210
6	.026	3.870	.075	4.030	.035	3.210	.029	4.03	.016	3.470	.043	3.290

Table VI.2

12-Group Delayed Fission Spectrum

Group*	Delayed Fission Spectrum
1	.0
2	.0100
3	.1261
4	.1224
5	.3389
6	.3343
7	.0683
8	.0683
9	.0
10	.0
11	.0
12	.0

*For energy structure given in Table III.3.

Table VI.3

Calculated β_{eff}'s, Inhour to $\Delta k/k$ Conversion Factors, and Neutron Generation Times Using ENDF/B-III

Assembly	β_{eff}	Number of Inhours per % $\Delta k/k$	Generation Time (sec) ($x10^6$)
VERA-11A	.003309	925.5	.0706
VERA-1B	.008056	376.9	.0988
ZPR-3-6F	.007824	407.2	.0723
ZEBRA-3	.004397	837.9	.0611
ZPR-3-12	.007727	427.6	.0961
SNEAK-7A	.003609	911.8	.1657
ZPR-3-11	.007451	462.6	.0671
ZPR-3-54	.002928	968.8	.6350
ZPR-3-53	.003175	950.3	.4429
SNEAK-7B	.004106	843.7	.1551
ZPR-3-50	.003550	930.1	.3340
ZPR-3-48	.003588	932.5	.2529
ZEBRA-2	.007522	442.3	.1856
ZPR-3-49	.003612	934.4	.2267
ZPR-3-56B	.003258	975.6	.4428
ZPPR-2	.003370	963.4	.4415
ZPR-6-7	.003373	972.5	.4781
ZPR-6-6A	.007317	431.9	.4728

VI.12. The results of a one-dimensional calculation with Version IV and estimated two-dimensional reactivity coefficients are also shown. The two-dimensional values were obtained by estimating a correction factor utilizing the 1-D and 2-D Version III results. This was accomplished with the following relation:

$$\text{Worth}^{IV}_{2\text{-}D} = \frac{\text{Worth}^{III}_{2\text{-}D}}{\text{Worth}^{III}_{1\text{-}D}} \times \text{Worth}^{IV}_{1\text{-}D} \quad .$$

Version IV U-235 worths (Table VI.4) show little change from Version III -- the average C/E worth has decreased by less than 1 percent. Although the average C/E for uranium fueled assemblies is very close to unity, the fissile fuel central worth discrepancy is still apparent for Pu fueled assemblies. Similar conclusions can be drawn from the results for Pu-239 worths (Table VI.5). Calculated to experimental values for U-238 worths are closer to unity by more than 10 percent using Version IV (Table VI.6). It is not clear if this is an improvement, however, because if the normalization in calculating reactivity coefficients is in error by about 20 percent, then the calculated U-238 worths would be too low.

The hard-to-calculate central sodium worth is still hard to calculate (Table VI.7). Although there are some significant differences between results with Versions III and IV, it is unclear which cross section set is better.

Calculated reactivity worths for chromium (Table VI.8) are very high. The calculated reactivity worths for iron (Table VI.9) increased significantly from Version III to IV. If a 20 percent error in the normalization of worths is assumed, both the iron and nickel worths (Table VI.10) would

Table VI.4

Reactivity Coefficients for U-235

Assembly	Fuel	Experimental (inhours/kg)	C/E ENDF/B-III (1-D)	C/E ENDF/B-III (2-D)	C/E ENDF/B-IV (1-D)	Estimated C/E ENDF/B-IV (2-D)
VERA-11A	Pu					
VERA-1B	U	391.	0.927	0.903	0.938	0.914
ZPR-3-6F	U	320.	0.817	0.819	0.811	0.813
ZEBRA-3	Pu	721.	1.255	1.237	1.190	1.173
ZPR-3-12	U	285.	0.967	0.963	0.956	0.952
SNEAK-7A	Pu	757.	1.176	1.079	1.150	1.055
ZPR-3-11	U	246.	1.096	1.084	1.074	1.062
ZPR-3-54	Pu	567.	1.357	1.421	1.482	1.552
ZPR-3-53	Pu	520.	1.254	1.310	1.281	1.338
SNEAK-7B	Pu	435.	1.138	1.098	1.107	1.068
ZPR-3-50	Pu	464.	1.135	1.190	1.115	1.169
ZPR-3-48	Pu	334.	1.232	1.225	1.196	1.189
ZEBRA-2	U	140.	1.156	1.141	1.125	1.110
ZPR-3-49	Pu	282.	1.194	1.253	1.148	1.205
ZPR-3-56B	Pu	295.	1.155	1.228	1.165	1.239
ZPPR-2	Pu	90.	1.260	1.261	1.248	1.249
ZPR-6-7	Pu	133.	1.213	1.218	1.199	1.204
ZPR-6-6A	U	42.	1.089	1.092	1.078	1.081
Average Over All Assemblies				1.148		1.140
Average Over All U Assemblies				1.000		0.989
Average Over All Pu Assemblies				1.229		1.222

Table VI.5

Reactivity Coefficients for Pu-239

Assembly	Fuel	Experimental (inhours/kg)	C/E ENDF/B-III (1-D)	C/E ENDF/B-III (2-D)	C/E ENDF/B-IV (1-D)	Estimated C/E ENDF/B-IV (2-D)
VERA-11A	Pu	-				
VERA-1B	U	674.	0.944	0.919	0.945	0.920
ZPR-3-6F	U	452.	0.990	0.992	0.982	0.984
ZEBRA-3	Pu	1144.	1.233	1.214	1.178	1.160
ZPR-3-12	U	436.	0.956	0.951	0.950	0.945
SNEAK-7A	Pu	1023.	1.168	1.071	1.146	1.051
ZPR-3-11	U	411.	1.037	1.025	1.023	1.011
ZPR-3-54	Pu	738.	1.307	1.370	1.407	1.475
ZPR-3-53	Pu	681.	1.198	1.250	1.195	1.247
SNEAK-7B	Pu	584.	1.110	1.071	1.090	1.052
ZPR-3-50	Pu	564.	1.128	1.183	1.104	1.158
ZPR-3-48	Pu	445.	1.216	1.209	1.185	1.178
ZEBRA-2	U	195.	1.122	1.107	1.104	1.089
ZPR-3-49	Pu	415.	1.084	1.137	1.051	1.102
ZPR-3-56B	Pu	372.	1.196	1.273	1.212	1.290
ZPPR-2	Pu	120.	1.143	1.143	1.133	1.133
ZPR-6-7	Pu	158.	1.232	1.237	1.217	1.222
ZPR-6-6A	U	57.	1.046	1.049	1.040	1.043
Average Over All Assemblies				1.129		1.121
Average Over All U Assemblies				1.007		.999
Average Over All Pu Assemblies				1.196		1.188

Table VI.6

Reactivity Coefficients for U-238

Assembly	Fuel	Experimental (inhours/kg)	C/E ENDF/B-III (1-D)	C/E ENDF/B-III (2-D)	C/E ENDF/B-IV (1-D)	Estimated C/E ENDF/B-IV (2-D)
VERA-11A	Pu	-				
VERA-1B	U	13.1	1.602	1.449	1.194	1.080
ZPR-3-6F	U	2.7	2.285	2.269	2.627	2.609
ZEBRA-3	Pu	-36.0	1.188	1.168	1.028	1.011
ZPR-3-12	U	-12.0	1.054	1.045	0.900	0.892
SNEAK-7A	Pu	-38.8	1.408	1.322	1.264	1.187
ZPR-3-11	U	-13.0	1.052	1.040	0.964	0.953
ZPR-3-54	Pu	-82.0	1.054	1.060	1.013	1.019
ZPR-3-53	Pu	-75.1	1.062	1.074	1.008	1.019
SNEAK-7B	Pu	-24.2	1.251	1.221	1.145	1.118
ZPR-3-50	Pu	-42.1	1.023	1.040	0.926	0.941
ZPR-3-48	Pu	-23.6	1.164	1.154	1.038	1.029
ZEBRA-2	U	-10.7	1.097	1.081	1.008	0.993
ZPR-3-49	Pu	-18.5	1.158	1.167	1.025	1.033
ZPR-3-56B	Pu	-18.4	1.289	1.312	1.200	1.221
ZPPR-2	Pu	-				
ZPR-6-7	Pu	-10.9	1.088	1.085	1.016	1.013
ZPR-6-6A	U	- 3.5	1.158	1.156	1.120	1.118
Average Over All Assemblies (neglecting ZPR-3-6F)				1.158		1.042
Average Over All U Assemblies				1.154		1.007
Average Over All Pu Assemblies				1.160		1.059

Table VI.7

Reactivity Coefficients for Na

Assembly	Fuel	Experimental (inhours/kg)	C/E ENDF/B-III (1-D)	C/E ENDF/B-III (2-D)	C/E ENDF/B-IV (1-D)	Estimated C/E ENDF/B-IV (2-D)
VERA-11A	Pu	-				
VERA-1B	U	235.	0.362	0.347	0.354	0.339
ZPR-3-6F	U	59.9	0.405	0.404	0.309	0.308
ZEBRA-3	Pu	-104.7	1.023	1.006	1.184	1.164
ZPR-3-12	U	-				
SNEAK-7A	Pu	-				
ZPR-3-11	U	- 14.	1.194	1.176	1.724	1.698
ZPR-3-54	Pu	-				
ZPR-3-53	Pu	57.9	0.569	0.627	0.436	0.480
SNEAK-7B	Pu	-				
ZPR-3-50	Pu	- 11.3	-0.129	-0.254	0.344	-
ZPR-3-48	Pu	- 6.3	1.595	1.576	2.078	2.053
ZEBRA-2	U	2.9	-0.280	-0.265	-0.379	-0.359
ZPR-3-49	Pu	- 13.8	0.896	0.865	1.078	1.041
ZPR-3-56B	Pu	- 8.9	1.735	1.705	1.939	1.905
ZPPR-2	Pu	- 5.2	0.983	0.981	1.080	1.078
ZPR-6-7	Pu	- 6.8	1.036	1.025	1.140	1.128
ZPR-6-6A	U	.16	-0.56	-0.70	0.170	-

Table VI.8

Reactivity Coefficients for Cr

Assembly	Fuel	Experimental (inhours/kg)	C/E ENDF/B-III (1-D)	C/E ENDF/B-III (2-D)	C/E ENDF/B-IV (1-D)	Estimated C/E ENDF/B-IV (2-D)
VERA-11A	Pu	-				
VERA-1B	U	-				
ZPR-3-6F	U	- 4.6	1.480	1.486	1.638	1.645
ZEBRA-3	Pu	-				
ZPR-3-12	U	-				
SNEAK-7A	Pu	-				
ZPR 3-11	U	- 15.4	1.135	1.120	1.242	1.226
ZPR-3-54	Pu	-				
ZPR-3-53	Pu	- 10.1	1.847	1.842	2.014	2.009
SNEAK-7B	Pu	-				
ZPR-3-50	Pu	- 13.1	1.713	1.751	1.728	1.766
ZPR-3-48	Pu	- 12.3	1.529	1.512	1.546	1.529
ZEBRA-2	U	- 5.5	1.444	1.423	1.446	1.425
ZPR-3-49	Pu	- 11.8	1.431	1.469	1.429	1.467
ZPR-3-56B	Pu	- 12.7	1.183	1.219	1.233	1.271
ZPPR-2	Pu	- 3.4	1.362	1.365	1.407	1.410
ZPR-6-7	Pu	- 4.5	1.440	1.446	1.483	1.489
ZPR-6-6A	U	-				
Average Over All Assemblies				1.463		1.524

Table VI.9

Reactivity Coefficients for Fe

Assembly	Fuel	Experimental (inhours/kg)	C/E ENDF/B-III (1-D)	C/E ENDF/B-III (2-D)	C/E ENDF/B-IV (1-D)	Estimated C/E ENDF/B-IV (2-D)
VERA-11A	Pu	-				
VERA-1B	U	-				
ZPR-3-6F	U	- 6.9	0.512	0.515	0.966	0.972
ZEBRA-3	Pu	-				
ZPR-3-12	U	-11.5	0.860	0.851	1.108	1.096
SNEAK-7A	Pu	-32.2	0.845	0.779	0.936	0.863
ZPR-3-11	U	-14.3	0.990	0.977	1.278	1.261
ZPR-3-54	Pu	-				
ZPR-3-53	Pu	- 4.5	1.958	1.898	2.333	2.262
SNEAK-7B	Pu	-21.2	1.010	0.980	1.111	1.078
ZPR-3-50	Pu	-13.2	1.188	1.209	1.306	1.329
ZPR-3-48	Pu	-12.2	1.147	1.138	1.260	1.250
ZEBRA-2	U	- 5.2	1.099	1.083	1.300	1.281
ZPR-3-49	Pu	-14.1	0.907	0.929	0.992	1.016
ZPR-3-56B	Pu	-12.3	0.928	0.954	1.010	1.038
ZPPR-2	Pu	- 3.2	1.087	1.089	1.163	1.165
ZPR-6-7	Pu	- 4.3	1.125	1.130	1.202	1.207
ZPR-6-6A	U	-				
Average Over All Assemblies				1.041		1.217

Table VI.10

Reactivity Coefficients for Ni

Assembly	Fuel	Experimental (inhours/kg)	C/E ENDF/B-III (1-D)	C/E ENDF/B-III (2-D)	C/E ENDF/B-IV (1-D)	Estimated C/E ENDF/B-IV (2-D)
VERA-11A	Pu	-				
VERA-1B	U	-				
ZPR-3-6F	U	-12.5	1.547	1.540	1.660	1.652
ZEBRA-3	Pu	-				
ZPR-3-12	U	-20.0	1.025	1.014	1.095	1.083
SNEAK-7A	Pu	-				
ZPR-3-11	U	-19.2	1.159	1.144	1.339	1.322
ZPR-3-54	Pu	-				
ZPR-3-53	Pu	-20.5	1.377	1.371	1.381	1.375
SNEAK-7B	Pu	-				
ZPR-3-50	Pu	-21.6	1.283	1.308	1.309	1.335
ZPR-3-48	Pu	-18.2	1.382	1.370	1.403	1.391
ZEBRA-2	U	- 9.8	0.943	0.928	0.965	0.950
ZPR-3-49	Pu	-20.7	1.154	1.179	1.158	1.183
ZPR-3-56B	Pu	-16.8	1.240	1.275	1.264	1.300
ZPPR-2	Pu	- 4.8	1.216	1.214	1.237	1.235
ZPR-6-7	Pu	- 6.5	1.260	1.265	1.279	1.284
ZPR-6-6A	U	-				
Average Over All Assemblies				1.237		1.283

Table VI.11

Reactivity Coefficients for B-10

Assembly	Fuel	Experimental (inhours/kg)	C/E ENDF/B-III (1-D)	C/E ENDF/B-III (2-D)	C/E ENDF/B-IV (1-D)	Estimated C/E ENDF/B-IV (2-D)
VERA-11A	Pu	-				
VERA-1B	U	- 9846.	0.946	0.927	0.958	0.939
ZPR-3-6F	U	- 3693.	0.999	1.000	0.933	0.932
ZEBRA-3	Pu	- 9018.	1.115	1.098	1.024	1.008
ZPR-3-12	U	-				
SNEAK-7A	Pu	-19368.	1.060	0.983	1.038	0.963
ZPR-3-11	U	- 3380.	0.988	0.977	0.935	0.925
ZPR-3-54	Pu	-42500.	0.801	0.823	0.823	0.846
ZPR-3-53	Pu	-39029.	0.753	0.772	0.733	0.751
SNEAK-7B	Pu	- 7542.	1.035	1.005	1.022	0.992
ZPR-3-50	Pu	-17515.	0.858	0.885	0.833	0.859
ZPR-3-48	Pu	- 8912.	0.988	0.980	0.959	0.951
ZEBRA-2	U	- 4506.	0.774	0.764	0.778	0.768
ZPR-3-49	Pu	- 6967.	0.943	0.970	0.913	0.939
ZPR-3-56B	Pu	- 7000.	0.981	1.019	0.990	1.028
ZPPR-2	Pu	- 2269.	0.999	1.001	0.994	0.996
ZPR-6-7	Pu	- 2947.	1.100	1.102	1.092	1.094
ZPR-6-6A	U	- 1313.	0.874	0.873	0.899	0.898
Average Over All Assemblies				0.949		0.931
Average Over All U Assemblies				0.908		0.892
Average Over All Pu Assemblies				0.967		0.948

Table VI.12

Reactivity Coefficients for Ta

Assembly	Fuel	Experimental (inhours/kg)	C/E ENDF/B-III (1-D)	C/E ENDF/B-III (2-D)	C/E ENDF/B-IV (1-D)	Estimated C/E ENDF/B-IV (2-D)
VERA-11A	Pu	-				
VERA-1B	U	-				
ZPR-3-6F	U	- 40.	1.070	1.072	1.055	1.057
ZEBRA-3	Pu	-143.	1.183	1.164	1.081	1.064
ZPR-3-12	U	- 73.	0.992	0.986	0.974	0.968
SNEAK-7A	Pu	-410.	0.918	0.851	0.918	0.851
ZPR-3-11	U	- 51.	1.003	0.991	0.954	0.943
ZPR-3-54	Pu	-				
ZPR-3-53	Pu	-851.	0.819	0.840	0.833	0.854
SNEAK-7B	Pu	-139.	0.957	0.923	0.940	0.907
ZPR-3-50	Pu	-350.	0.952	0.982	0.954	0.984
ZPR-3-48	Pu	-164.	1.035	1.028	1.024	1.017
ZEBRA-2	U	- 62.	0.996	0.982	1.027	1.013
ZPR-3-49	Pu	-115.	1.032	1.061	1.015	1.044
ZPR-3-56B	Pu	-120.	1.050	1.090	1.095	1.137
ZPPR-2	Pu	- 51.	0.878	0.882	0.886	0.890
ZPR-6-7	Pu	- 43.	1.500	1.500	1.507	1.507
ZPR-6-6A	U	- 12.5	1.654	1.654	1.741	1.741
Average Over All Assemblies				1.067		1.065

improve. However, chromium would still pose a problem. B^{10} worths (Table VI.11) remain unchanged and continue to be puzzling, since B^{10} cross sections are thought to be known fairly accurately while calculations of B^{10} reactivity worths yield a C/E of about 0.95. If all the calculated reactivity coefficients for Pu assemblies were reduced in magnitude by about 20 percent, then the C/E for B^{10} would be much too low. Finally, the tantalum worths are relatively unchanged (Table VI.12). The C/E for tantalum lies between that of B^{10} and the fissile fuels.

VII. CONCLUSIONS

Both versions III and IV of ENDF/B represent a significant improvement over the Bondarenko data and earlier ENDF/B versions for criticality predictions. For an extremely wide range of fast critical assemblies, both sets of data compute k_{eff} with an average error of approximately 1/2 percent, which is approximately the uncertainty in the calculational procedure.

However, reaction rate ratios have significant discrepancies between calculation and experiment--particularly for the spectra-sensitive fertile fuel fission rates. With a few notable exceptions, the calculated $\sigma_f^{Pu-239}/\sigma_f^{U-235}$ ratios agree well with experiment. An inconsistent treatment of cell heterogeneities may be responsible for a portion of these discrepancies.

Finally, the most notable observation to be made regarding the reactivity coefficient calculations is that the fissile fuel central worth discrepancy for Pu-fueled criticals still exists. Although many studies have been performed attempting to solve this long-standing difference, it still remains one of the most puzzling problems in reactor physics.

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APPENDIX A

CRITICAL ASSEMBLY ATOM DENSITIES AND DIMENSIONS

One-dimensional and two-dimensional specifications for each critical assembly are given in Table A-1. All 2-D models are cylinders, while all but one of the 1-D models are spheres. The single exception was ZPPR-2, where the 1-D model was represented by an infinite cylinder with a buckling of 5.92×10^{-4} cm^{-2}. Dimensions and atom densities for the 14 CSEWG criticals are all based on data from Reference 1. A few minor simplifications were made to some of the models. For the most part, however, the published CSEWG specifications were used. Specifications for the 4 non-CSEWG criticals (ZPR-3-49, -50, -53, and -54) were obtained from a 1970 unpublished document for which the data was gathered from ANL monthly reports.

TABLE A-1

CRITICAL ASSEMBLY ATOM DENSITIES (atoms/barn-cm) AND DIMENSIONS

Material	VERA-11A Core	VERA-11A Reflector	VERA-1B Core	VERA-1B Reflector	ZPR-3-6F Core	ZPR-3-6F Reflector	ZEBRA-3 Core	ZEBRA-3 Reflector	ZPR-3-12 Core	ZPR-3-12 Reflector	SNEAK 7-A Spherical Core	SNEAK 7-A Inner Core	SNEAK 7-A Outer Core	SNEAK 7-A Reflector
U-234			.000092		.000069				.000046					
U-235		.000250	.007349	.000250	.006727	.000089	.0002264	.000298	.004516	.000089	.0000586	.0000586	.0002958	.0001624
U-236			.000014		.000029									
U-238		.034400	.000455	.034400	.007547	.040026	.031775	.041269	.016948	.040026	.0079604	.0079604	.0080456	.0399401
Pu-238														
Pu-239	.007213						.003466				.0026374	.0026374	.0023434	
Pu-240	.000370						.0001834				.0002369	.0002369	.0002105	
Pu-241	.000028						.0000127				.0000215	.0000215	.0000191	
Pu-242											.0000011	.0000011	.0000010	
O											.0218462	.0218462	.0211909	
C	.046204		.057540				.000042	.000042	.026762		.0260987	.0260987	.0255387	.0000135
Na														
Al					.019019	.001359	.000019	.000019			.0000080	.0000080	.0011906	
Cr	.001579	.00170	.000689	.000708	.001918	.001129	.000864	.000864	.001419	.001237	.0022423	.0022423	.0022390	.0011080
Fe	.006084	.00650	.006283	.006464	.007712	.004539	.004578	.003323	.005704	.004971	.0079713	.0079713	.0079824	.0039549
Ni	.000665	.000710	.001635	.001682	.000839	.000494	.000483	.000483	.000621	.000541	.0011664	.0011664	.0011818	.0009845
Mo							.000008	.000008			.0000165	.0000165	.0000145	.0000100
Mn					.000080	.000047	.000064	.000064	.000059	.000052	.0001109	.0001109	.0001178	.0000875
Cu	.007402						.0043702	.000004						
Nb											.0000089	.0000089	.0000077	.0000085
Si							.000054	.000054	.000069	.000060	.0000933	.0000933	.0000932	.0000453
H			.000058											
Mg														
Ga	.000449													
Sn	.000043													
Pb	.000035													
Ti							.000016	.000016						
V							.000005	.000005						
Am-241														
For 2-D Model: Radial Distance from Core Axis to Outer Zone Boundary (cm)	13.22	52.22	19.107	60.907	20.293	51.983	23.12	53.62	26.96	57.46		15.86	28.55	58.55
For 2-D Model: Axial Distance from Core Mid-plane to Outer Zone Boundary (cm)	10.875	58.875	13.575	50.675	20.422	50.922	17.52	48.02	22.96	53.46		22.02	22.02	52.02
For 1-D Model: Distance from Core Center to Outer Zone Boundary (cm)	13.99	56.99	19.138	58.59	22.995	53.495	23.68	54.18	28.76	59.26	28.50			58.50

TABLE A-1 (Cont'd.)

Material	ZPR-3-11 Core	ZPR-3-11 Reflector	ZPR-3-54 Core	ZPR-3-54 Reflector	ZPR-3-53 Core	ZPR-3-53 Spherical Reflector	ZPR-3-53 Radial Reflector	ZPR-3-53 Axial Reflector	SNEAK-7B Core	SNEAK-7B Reflector	ZPR-3-50 Core	ZPR-3-50 Spherical Reflector	ZPR-3-50 Radial Reflector	ZPR-3-50 Axial Reflector
U-234	.000046													
U-235	.004567	.000089	.000006		.000006	.000083	.000083	.000083	.0002663	.0001624	.000016	.000083	.000083	.000082
U-236	.000019													
U-238	.034373	.040025	.002615		.002615	.039770	.039770	.039770	.0145794	.0399401	.007404	.039613	.039798	.038377
Pu-238														
Pu-239			.001669		.001669				.0018312		.001645			
Pu-240			.000107		.000107				.0001645		.000106			
Pu-241			.000008		.000008				.0000149		.000011			
Pu-242									.0000007		.0000004			
O									.0331936					
C			.055898	.001587	.055898	.000024	.000023	.000029	.0000631	.0000135	.04594			
Na														
Al			.000111		.000111				.0012112		.00011			
Cr	.001486	.001196	.002081	.001334	.002081	.001311	.001263	.001603	.0027560	.0011080	.001816	.001161	.001126	.001398
Fe	.005681	.004925	.007134	.074805	.007134	.004496	.004333	.005494	.0098021	.0039549	.0073	.004671	.004529	.005622
Ni	.000718	.000536	.000970	.000629	.000970	.000611	.000589	.000747	.0014594	.0009845	.000796	.000508	.000493	.000612
Mo			.000208	.000512	.000208				.0000184	.0000100	.000205			
Mn	.000208	.000111							.0000646	.0000875	.000076	.000048	.000047	.000058
Cu														
Nb									.0000084	.0000085				
Si									.0001174	.0000453				
H									.0000071					
Mg									.0000095					
Ga														
Sn														
Pb														
Ti														
V														
Am-241														
For 2-D Model: Radial Distance from Core Axis to Outer Zone Boundary (cm)	29.64	64.20	31.80	65.80	34.02		68.02	34.02	37.63	67.63	37.82		75.82	37.82
For 2-D Model: Axial Distance from Core Mid-plane to Outer Zone Boundary (cm)	25.50	56.00	30.48	60.48	30.48		60.48	60.48	35.03	65.03	38.175		68.175	68.175
For 1-D Model: Distance from Core Center to Outer Zone Boundary (cm)	31.61	61.61	35.889	73.232	37.546	74.876			40.64	70.64	43.43	83.77		

TABLE A-1 (Cont'd.)

Material	ZPR-3-48 Core	ZPR-3-48 Spherical Reflector	ZPR-3-48 Radial Reflector	ZPR-3-48 Axial Reflector	ZEBRA-2 Core	ZEBRA-2 Reflector	ZPR-3-49 Core	ZPR-3-49 Spherical Reflector	ZPR-3-49 Radial Reflector	ZPR-3-49 Axial Reflector	ZPR-3-56B Core	ZPR-3-56B Spherical Reflector	ZPR-3-56B Radial Reflector	ZPR-3-56B Axial Reflector
U-234														
U-235	.000016	.000083	.0000803	.000082	.002526	.000298	.000016	.000083	.000083	.000082	.000014			
U-236														
U-238	.007405	.039690	.038497	.039330	.015667	.041269	.007406	.039556	.039798	.038377	.006195			
Pu-238														
Pu-239	.001645						.001644				.001358			
Pu-240	.000106						.000106				.000181			
Pu-241	.000011						.000011							
Pu-242	.0000004						.0000004							
O					.0001544						.015			
C	.020770				.037992	.000042	.020766				.00103			
Na	.006231										.008669	.007879	.006570	.013460
Al	.000109				.000019	.000019	.000109							
Cr	.002531	.001225	.001460	.001401	.000864	.000864	.002508	.001242	.001193	.001481	.0025	.001941	.001880	.002200
Fe	.010180	.004925	.005871	.005633	.0036485	.003323	.010083	.004626	.004444	.005515	.0137	.007824	.007590	.008820
Ni	.001119	.000536	.000639	.000613	.000483	.000483	.001121	.000611	.000587	.000729	.00109	.042261	.047600	.019500
Mo	.000206				.000008	.000008	.000206				.000343			
Mn	.000106	.000051	.000061	.000059	.000064	.000064	.000105				.00022	.00030	.00030	.00030
Cu					.000004	.000004								
Nb														
Si	.000124	.000060	.000072	.000069	.000054	.000054								
H					.00030876									
Mg														
Ga														
Sn														
Pb														
Ti					.000016	.000016								
V					.000005	.000005								
Am-241														
For 2-D Model: Radial Distance from Core Axis to Outer Zone Boundary (cm)	41.59		76.06	41.59	40.27	73.53	43.30		76.05	43.30	46.18		76.18	46.18
For 2-D Model: Axial Distance from Core Mid-plane to Outer Zone Boundary (cm)	38.176		69.32	69.32	41.72	72.20	38.175		68.175	68.175	45.80		75.80	75.80
For 1-D Model: Distance from Core Center to Outer Zone Boundary (cm)	45.245	75.245			45.450	77.15	47.53	83.96			52.72	87.06		

TABLE A-1 (Cont'd.)

Material	ZPPR-2 Inner Core	ZPPR-2 Outer Core	ZPPR-2 Inner Radial Blanket	ZPPR-2 Outer Radial Blanket	ZPPR-2 Axial Blanket Inner Core	ZPPR-2 Axial Blanket Outer Core	ZPPR-2 Radial Reflector	ZPPR-2 Na-Steel Axial Reflector	ZPR-6-7 Spherical Core	ZPR-6-7 Inner Core	ZPR-6-7 Outer Core	ZPR-6-7 Spherical Reflector	ZPR-6-7 Radial Reflector	ZPR-6-7 Axial Reflector
U-234										.00000006	.00000006		.00000040	.00000040
U-235	.0000123	.0000115	.000024	.000024	.000016	.000016			.0000126	.0000126	.0000126	.0000856	.0000866	.0000834
U-236										.0000003	.0000003		.00000020	.00000020
U-238	.0055549	.0051980	.011085	.011085	.007036	.007057			.00578036	.005777	.005802	.0396179	.04006	.03859
Pu-238	.0000006	.0000009								.00000033	.00000033			
Pu-239	.0008433	.0012741							.00088672	.0008867	.0008879			
Pu-240	.0001117	.0001687							.00011944	.0001177	.0001178			
Pu-241	.0000153	.0000231							.0000133	.0000133	.0000133			
Pu-242	.0000018	.0000028								.00000141	.00000177			
O	.013116	.011761	.020132	.020133	.013895	.014008			.01390	.01398	.01482	.000024	.000021	.000030
C	.000030	.000023	.001013	.001013	.000036	.000030	.000558	.000214						
Na	.008796	.008564	.006398	.005963	.008739	.008808		.008966	.0092904	.0092904	.009132			
Al	.000003	.000004	.000002	.000003	.000002	.000002		.000002						
Cr	.002702	.002523	.001991	.002172	.002835	.002418	.001205	.005347	.002842	.002709	.002697	.001295	.00117	.001579
Fe	.012576	.013852	.006923	.007541	.010751	.009355	.075161	.035713	.013431	.01297	.01353	.004637	.004197	.005652
Ni	.001221	.001160	.000898	.000987	.001275	.001095	.000513	.002412	.001291	.001240	.001212	.0005635	.0005082	.000691
Mo	.000231	.000341	.000014	.000015	.000014	.000014	.000012	.000014	.0002357	.0002357	.0002382	.0000038	.0000034	.0000046
Mn	.000209	.000202	.000157	.000174	.000230	.000205	.000598	.000611	.000221	.000212	.000213	.0000998	.0000897	.000123
Cu	.000019	.000020	.000017	.000018	.000017	.000017	.000013	.000017						
Nb														
Si	.000137	.000118	.000094	.000102	.000150	.000119	.000091	.000305						
H			.000008	.000008										
Mg														
Ga														
Sn														
Pb														
Ti														
V														
Am-241	.0000029	.0000043								.0000030	.0000028			
For 2-D Model: Radial Distance from Core Axis to Outer Zone Boundary (cm)	64.40	91.07	109.81	128.87	64.40	91.07	140.58	128.87		24.34	80.30		113.84	80.30
For 2-D Model: Axial Distance from Core Mid-plane to Outer Zone Boundary (cm)	45.81	45.81	87.17	87.17	87.17	87.17	107.49	107.49		76.28	76.28		110.55	110.55
For 1-D Model: Distance from Core Center to Outer Zone Boundary (cm)	64.40	91.07	109.81	128.87			140.58		88.16			121.97		

TABLE A-1 (Cont'd.)

Material	ZPR-6-6A Spherical Core	Cylinder Inner Core	Cylinder Outer Core	Spherical Reflector	Radial Reflector	Axial Reflector
U-234		.000011	.000011		.0000004	.0000004
U-235	.001153	.001153	.001149	.0000856	.0000866	.0000836
U-236		.0000056	.0000056		.0000020	.0000020
U-238	.0058176	.005801	.005784	.0395508	.04006	.038650
Pu-238						
Pu-239						
Pu-240						
Pu-241						
Pu-242						
O	.01390	.01390	.01474	.0000230	.000022	.000026
C						
Na	.0092904	.0092904	.009202			
Al						
Cr	.002842	.002842	.002841	.001247	.001172	.001378
Fe	.013431	.01342	.01399	.0044669	.004197	.004931
Ni	.001291	.001291	.001264	.0005407	.0005082	.0005977
Mo		.000011	.000011		.0000034	.000004
Mn	.000221	.000221	.000222	.0000960	.0000897	.000107
Cu						
Nb						
Si						
H						
Mg						
Ga						
Sn						
Pb						
Ti						
V						
Am-241						
For 2-D Model: Radial Distance from Core Axis to Outer Zone Boundary (cm)		24.34	91.34		119.95	91.34
For 2-D Model: Axial Distance from Core Mid-plane to Outer Zone Boundary (cm)		76.28	76.28		110.50	110.50
For 1-D Model: Distance from Core Center to Outer Zone Boundary (cm)	95.67			129.48		

LOS ALAMOS SCIENTIFIC LABORATORY

(LASL)

LASL PROCEDURE AND RESULTS

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Figure I is a diagram of the procedure and codes used at LASL to perform the benchmark calculations. Some of the important MINX input options chosen are as follows: Fractional resonance reconstruction error < 0.01, Fractional linearization error < 0.01, Fractional doppler thinning error < 0.005, Fractional adaptive integration error < 0.001, Maxwellian temperature = 0.025 eV, Maxwellian-1/E breakpoint energy = 0.1 eV, Fission spectrum temperature = 1.4 MeV, 1/E- Fission breakpoint energy = 0.8208 MeV. The transport cross section provided to DTF is calculated with 1DX in the following manner:

$$\sigma_{tr} = F_e\sigma_e(1-\mu_e) + F_f\sigma_f + F_c\sigma_c + \sigma_{in}$$

Finally, all DTF runs were run in S_{16} angular quadrature.

All benchmark specifications were taken from ENDF-202. The group energies and CHI vectors used in our calculations are shown in Table I. The CHI vectors were generated from a simple fission spectrum shape with nuclear temperatures of Θ = 1.41 MeV (for a Pu-239 system) and Θ = 1.35 MeV (for a U-235 system).

Our calculated eigenvalues, central spectral indices, and central spectra are shown in Tables II-IV, respectively.

We also made a study to determine the sensitivity of the calculated k_{eff} and spectral indices of Jezebel and Godiva to Legendre order and S_n quadrature. The group structure was half-lethargy widths from 10 MeV, and the weighting function used in the MINX runs were those previously calculated for Jezebel and Godiva using earlier versions of ENDF/B.

To determine the effects of quadrature, the infinitely dilute P-5 cross sections generated from MINX were used in several DTF-IV runs for quadratures of S-4, S-8, S-16, S-32, and S-44 for the two assemblies. Results are given in Table V. Note from this table that the correction for k_{eff} from S-16 to S-∞ is-0.0021 for Jezebel and -0.0017 for Godiva. Also note that the corrections for the calculated spectral indices are negligible for both assemblies.

Series of calculations were also made to determine the effects of the accuracy of representing anisotropy of the scattering cross sections. DTF-IV problems were run with the cross section tables truncated at P-0, P-1, P-2, P-3, and P-4 and quadrature S-16. In addition the Bell, Hansen, Sandmeier treatment[1] was used to combine two higher order tables into a single table.

The results were treated as half-orders, e.g., combining the P-2 and P-3 tables was considered to be P-2.5. The results of these calculations for both assemblies are given in Table VI.

Cross sections formed by combining the P-0 and P-1 tables (P-0.5) are usually referred to as "single table, transport corrected". Results given in Table VI indicate that the correction from P-0.5 to P-∞ is -0.0032 for k_{eff} for Jezebel and -0.0030 for Godiva. Note that values of k_{eff} quoted above for transport corrected cross sections obtained via 1DX are somewhat different from those in Table VI. This is due to the corrections for self-shielding of the cross sections in the 1DX code. Also, a more detailed group structure (50 gps vs 26 gps) was used in 1DX.

In an interlaboratory comparison such as this different arbitrary choices in procedure by each lab, can lead to significant differences in the final results. Tables VII and VIII show an after-the-fact attempt to remove these arbitrary differences and introduce a modicum of uniformity to the calculation and results of benchmarks ZPR-6-7 and ZPR-6-6A, respectively. It appears that this exercise brings a majority of the labs into closer agreement.

Table IX shows the effect of the new ANL Porter Thomas Integration Scheme on the central spectral indices of ZPR-6-7 and ZPR-6-6A. The effects are rather small. The "old scheme" results of Table IX are different from Table III because the latter use cross sections from MINX while the former use cross sections from ETOX.

REFERENCES

1. G. I. Bell, G. E. Hansen, and H. A. Sandmeier, "Multitable Treatments of Anisotropic Scattering in S_n Multigroup Transport Calculations," Nuc. Sci. Eng. 28, 376-383 (1967).

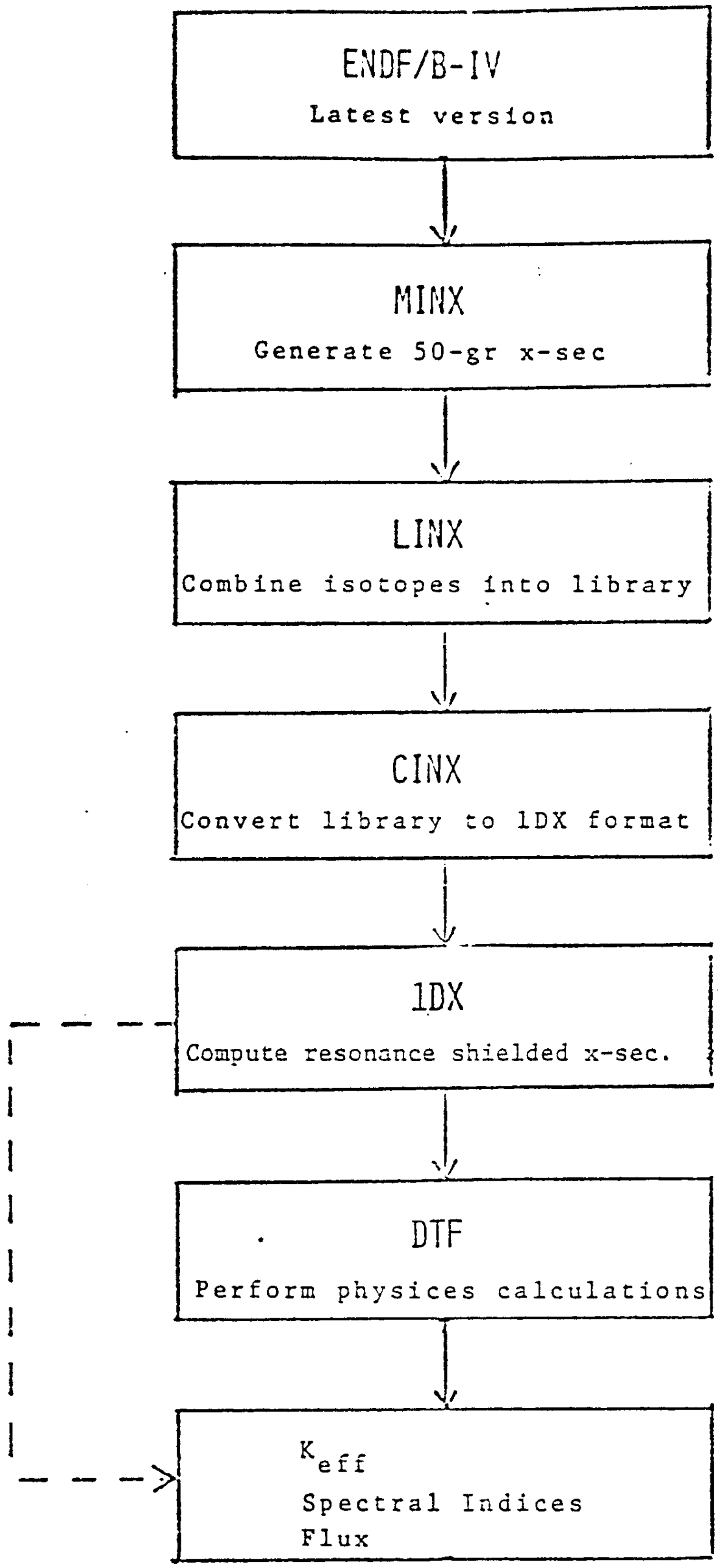

Fig. 1. LASL Procedure

TABLE I

GROUP	GROUP BOUNDARIES(EV)		DELU	CHI(EM=1.41)	CHI(EM=1.35)
1	1.00E+07	2.00E+07	.692	2.66500E-03	1.98200E-03
2	6.07E+06	1.00E+07	.500	3.23930E-02	2.75000E-02
3	3.68E+06	6.07E+06	.500	1.21445E-01	1.12174E-01
4	2.23E+06	3.68E+06	.500	2.10381E-01	2.05204E-01
5	1.35E+06	2.23E+06	.500	2.22367E-01	2.24516E-01
6	8.21E+05	1.35E+06	.500	1.72323E-01	1.77776E-01
7	4.98E+05	8.21E+05	.500	1.10173E-01	1.15178E-01
8	3.88E+05	4.98E+05	.250	3.60350E-02	3.79300E-02
9	3.02E+05	3.88E+05	.250	2.65500E-02	2.80330E-02
10	2.35E+05	3.02E+05	.250	1.92630E-02	2.03880E-02
11	1.83E+05	2.35E+05	.250	1.38100E-02	1.46440E-02
12	1.43E+05	1.83E+05	.250	9.80900E-03	1.04160E-02
13	1.11E+05	1.43E+05	.250	6.91600E-03	7.35300E-03
14	8.65E+04	1.11E+05	.250	4.84900E-03	5.16000E-03
15	6.74E+04	8.65E+04	.250	3.38500E-03	3.60500E-03
16	5.25E+04	6.74E+04	.250	2.35500E-03	2.50900E-03
17	4.09E+04	5.25E+04	.250	1.63400E-03	1.74100E-03
18	3.18E+04	4.09E+04	.250	1.13100E-03	1.20600E-03
19	2.48E+04	3.18E+04	.250	7.82000E-04	8.34000E-04
20	1.93E+04	2.48E+04	.250	5.40000E-04	5.76000E-04
21	1.50E+04	1.93E+04	.250	3.72000E-04	3.97000E-04
22	1.17E+04	1.50E+04	.250	2.57000E-04	2.74000E-04
23	9.12E+03	1.17E+04	.250	1.77000E-04	1.89000E-04
24	7.10E+03	9.12E+03	.250	1.22000E-04	1.30000E-04
25	5.53E+03	7.10E+03	.250	8.40000E-05	8.90000E-05
26	4.31E+03	5.53E+03	.250	5.80000E-05	6.10000E-05
27	3.35E+03	4.31E+03	.250	4.00000E-05	4.20000E-05
28	2.61E+03	3.35E+03	.250	2.70000E-05	2.90000E-05
29	2.03E+03	2.61E+03	.250	1.90000E-05	2.00000E-05
30	1.58E+03	2.03E+03	.250	1.30000E-05	1.40000E-05
31	1.23E+03	1.58E+03	.250	9.00000E-06	9.00000E-06
32	9.61E+02	1.23E+03	.250	6.00000E-06	6.00000E-06
33	7.49E+02	9.61E+02	.250	4.00000E-06	4.00000E-06
34	5.83E+02	7.49E+02	.250	3.00000E-06	3.00000E-06
35	4.54E+02	5.83E+02	.250	2.00000E-06	2.00000E-06
36	3.54E+02	4.54E+02	.250	1.00000E-06	1.00000E-06
37	2.75E+02	3.54E+02	.250	1.00000E-06	1.00000E-06
38	1.67E+02	2.75E+02	.500	1.00000E-06	1.00000E-06
39	1.01E+02	1.67E+02	.500	0.	1.00000E-06
40	6.14E+01	1.01E+02	.500	0.	0.
41	3.73E+01	6.14E+01	.500	0.	0.
42	2.26E+01	3.73E+01	.500	0.	0.
43	1.37E+01	2.26E+01	.500	0.	0.
44	8.32E+00	1.37E+01	.500	0.	0.
45	5.04E+00	8.32E+00	.500	0.	0.
46	3.06E+00	5.04E+00	.500	0.	0.
47	1.86E+00	3.06E+00	.500	0.	0.
48	1.13E+00	1.86E+00	.500	0.	0.
49	6.83E+01	1.13E+00	.500	0.	0.
50	1.00E-05	6.83E-01	11.31	0.	0.

TABLE II

UNCORRECTED EIGENVALUES

Benchmark	K_{eff}
Jezebel ($DTF\ S_{16}$)	1.00093
Vera-11A ($DTF\ S_{16}$)	.99310
Godiva ($DTF\ S_{16}$)	1.01201
ZPR-3-11 ($DTF\ S_{16}$)	1.01493
ZPR-6-7 (1DX)	.97257
ZPR-6-6A (1DX)	.98730

TABLE III

CENTRAL SPECTRAL INDICES (C/E)

RATIO	JEZEBEL (DTF)	VERA-11A (DTF)	GODIVA (DTF)	ZPR-3-11 (DTF)	ZPR-6-7* (1DX)	ZPR-6-6A* (1DX)
$U238_f/U235_f$	.9485	1.1527	1.0680	1.0537		.9349
$U233_f/U235_f$	.9286	.9962	.9244	.9984		
$Pu239_f/U235_f$	.9363	1.0851	.9704	.9851		
$Np237_f/U235_f$	.9448	1.1809		1.0545		
$Pu240_f/U235_f$		1.0894		1.0579		
$Au197_g/U235_f$			.8590			
$U234_f/U238_f$			.9041			
$U238_g/U238_f$			.9371			
$Th232_f/U238_f$			.9909			
$U234_f/U235_f$				1.0438		
$U236_f/U235_f$				.7874		
$U238_g/U235_f$				.9679		1.0213
$U238_g/Pu239_f$					1.0753	
$U238_f/Pu239_f$					.9692	
$U235_f/Pu239_f$					1.0327	

*Used the ENDF 202 correction factors to convert the heterogenous experimental value to a homogenous value to compare with the calculated values.

TABLE IV
CENTRAL FLUX

GROUP NO.	JEZEBEL	VERA-11A	GODIVA
1	1.70150E-05	1.84111E-06	6.37473E-06
2	2.04163E-04	1.99075E-05	8.79482E-05
3	7.45678E-04	9.13610E-05	3.48396E-04
4	1.32194E-03	2.00525E-04	6.88208E-04
5	1.55436E-03	2.73615E-04	8.80475E-04
6	1.47518E-03	2.97105E-04	8.83493E-04
7	1.19264E-03	2.91610E-04	7.86296E-04
8	4.60082E-04	1.37856E-04	3.33754E-04
9	3.67750E-04	1.28782E-04	2.77606E-04
10	2.84451E-04	1.16376E-04	2.14961E-04
11	2.14840E-04	1.04318E-04	1.61793E-04
12	1.61500E-04	9.39558E-05	1.19292E-04
13	1.21782E-04	8.36577E-05	8.72419E-05
14	8.91159E-05	7.35063E-05	6.23868E-05
15	5.94606E-05	6.51740E-05	4.10728E-05
16	3.73523E-05	5.72859E-05	2.50146E-05
17	2.56431E-05	5.02488E-05	1.71787E-05
18	1.58779E-05	4.15249E-05	9.75708E-06
19	1.00299E-05	3.53230E-05	5.44551E-06
20	6.39185E-06	3.29118E-05	3.79212E-06
21	4.34953E-06	2.73837E-05	2.06252E-06
22	2.91130E-06	2.28105E-05	1.23832E-06
23	1.83659E-06	1.84652E-05	7.43912E-07
24	1.21762E-06	1.51648E-05	4.73960E-07
25	8.07222E-07	1.24856E-05	2.81194E-07
26	5.33367E-07	9.78132E-06	1.75872E-07
27	3.42073E-07	7.68398E-06	1.07972E-07
28	2.06191E-07	5.50035E-06	6.81824E-08
29	1.46147E-07	3.93616E-06	4.32487E-08
30	9.85720E-08	2.98745E-06	2.66053E-08
31	6.42435E-08	2.09708E-06	1.66778E-08
32	3.81492E-08	1.32407E-06	9.87233E-09
33	2.61069E-08	8.66716E-07	6.48062E-09
34	2.03447E-08	5.64486E-07	4.29199E-09
35	1.00699E-08	2.97527E-07	2.78320E-09
36	6.05277E-09	1.91378E-07	1.40159E-09
37	4.45635E-09	1.04261E-07	1.34804E-09
38	3.40233E-09	7.25979E-08	1.09433E-09
39	2.24879E-11	1.98949E-08	1.20731E-09
40	7.83236E-14	3.45084E-09	8.40889E-12
41	4.15629E-16	6.31364E-10	2.44133E-14
42	3.46409E-18	2.63198E-10	8.07590E-17
43	9.35802E-21	3.82991E-11	2.90392E-19
44	2.63528E-23	6.12460E-12	6.88584E-22
45	9.79761E-26	1.48173E-12	2.62930E-24
46	5.92856E-28	5.85387E-13	1.57086E-26
47	2.60901E-30	1.78333E-13	8.45460E-29
48	4.57251E-33	2.10983E-14	3.34114E-31
49	3.36135E-36	8.33237E-16	5.33676E-34
50	1.10867E-39	1.12483E-17	3.22295E-37

TABLE IV (CONT.)
CENTRAL FLUX

GROUP NO.	ZPR-3-11	ZPR-6-7	ZPR-6-6A
1	1.89556E-07	.26691E-07	.16228E-07
2	2.51097E-06	.31455E-06	.21521E-06
3	1.03889E-05	.13605E-05	.10177E-05
4	2.17869E-05	.32741E-05	.25995E-05
5	3.14694E-05	.48704E-05	.39775E-05
6	5.37152E-05	.69809E-05	.57477E-05
7	9.58191E-05	.11342E-04	.93888E-05
8	5.64524E-05	.42875E-05	.35626E-05
9	5.89407E-05	.62587E-05	.52029E-05
10	5.43694E-05	.68342E-05	.56722E-05
11	4.74241E-05	.65730E-05	.54440E-05
12	4.12897E-05	.68617E-05	.56601E-05
13	3.49627E-05	.66441E-05	.54539E-05
14	3.22363E-05	.60516E-05	.49372E-05
15	2.73232E-05	.60047E-05	.48673E-05
16	2.19176E-05	.49514E-05	.39904E-05
17	1.76704E-05	.50107E-05	.40045E-05
18	9.85325E-06	.40456E-05	.32068E-05
19	6.19483E-06	.34747E-05	.27233E-05
20	5.39783E-06	.44556E-05	.34411E-05
21	2.80097E-06	.34051E-05	.25934E-05
22	1.48580E-06	.30327E-05	.22649E-05
23	7.82504E-07	.24165E-05	.17628E-05
24	3.58839E-07	.16168E-05	.11597E-05
25	2.78464E-07	.15325E-05	.10722E-05
26	1.44621E-07	.11991E-05	.82459E-06
27	8.79478E-08	.69071E-06	.46590E-06
28	2.42998E-08	.15892E-06	.10695E-06
29	8.80758E-09	.52132E-06	.34964E-06
30	1.15959E-08	.10110E-05	.65457E-06
31	5.07398E-09	.10309E-05	.63356E-06
32	1.42982E-09	.73646E-06	.43259E-06
33	9.01796E-10	.58401E-06	.32560E-06
34	4.55158E-10	.44176E-06	.21771E-06
35	2.60134E-10	.28822E-06	.13915E-06
36	9.35759E-11	.19602E-06	.85104E-07
37	7.74540E-11	.11297E-06	.48517E-07
38	1.36913E-10	.14819E-06	.55374E-07
39	8.00211E-11	.51250E-07	.17608E-07
40	3.33215E-12	.12645E-07	.54899E-08
41	7.78339E-14	.28256E-08	.12649E-08
42	1.94058E-15	.11963E-08	.24114E-09
43	3.63487E-17	.17260E-09	.40411E-10
44	7.23531E-19	.38818E-10	.71776E-11
45	8.62169E-21	.45938E-11	.85918E-12
46	3.71706E-22	.24150E-11	.28070E-12
47	2.16579E-23	.12890E-11	.11924E-12
48	8.86259E-25	.20922E-12	.38491E-13
49	1.64461E-26	.99625E-14	.63563E-14
50	9.53956E-29	.34182E-15	.32705E-15

TABLE V
EFFECT OF S-N QUADRATURE ON INTEGRAL PARAMETERS.

RESULTS FOR JEZEBEL

QUADRATURE	KEFF	49F/25F	28F/25F
S-4	1.02555	1.3976	0.1967
S-8	0.99629	1.3950	0.1918
S-16	0.99210	1.3946	0.1904
S-32	0.99010	1.3945	0.1908
S-44	0.99002	1.3945	0.1908
EXPERIMENT	1.000	1.49	0.205
	+OR-.003	+OR-.03	+OR-.008

RESULTS FOR GODIVA

QUADRATURE	KEFF	49F/25F	28F/25F	24F/28F	28C/28F
S-4	1.04450	1.3856	0.1740	4.4460	0.4151
S-8	1.00722	1.3811	0.1663	4.5746	0.4426
S-16	1.00347	1.3805	0.1652	4.5947	0.4468
S-32	1.00186	1.3803	0.1649	4.6015	0.4481
S-44	1.00182	1.3803	0.1649	4.6011	0.4481
EXPERIMENT	1.000	1.42	0.156	5.00	0.47
	+OR-.003	+OR-.02	+OR-.005	+OR-.20	+OR-.02

TABLE VI
EFFECT OF LEGENDRE ORDER ON INTEGRAL QUANTITIES.

RESULTS FOR JEZEBEL

LEGENDRE ORDER	KEFF	49F/25F	28F/25F
P-0	1.07996	1.3958	0.1923
P-0.5	0.99531	1.3945	0.1947
P-1	0.98623	1.3933	0.1889
P-1.5	0.99198	1.3943	0.1907
P-2	0.99222	1.3946	0.1910
P-2.5	0.99203	1.3944	0.1907
P-3	0.99203	1.3943	0.1905
P-3.5	0.99203	1.3943	0.1907
P-4	0.99210	1.3946	0.1914
P-4.5	0.99206	1.3945	0.1908
P-5	0.99210	1.3946	0.1910
EXPERIMENT	1.000	1.49	0.205
	+OR-.003	+OR-.03	+OR-.008

RESULTS FOR GODIVA

LEGENDRE ORDER	KEFF	49F/25F	28F/25F	24F/28F	28C/28F
P-0	1.11203	1.3820	0.1668	4.5650	0.4398
P-0.5	1.00649	1.3804	0.1648	4.6044	0.4484
P-1	0.99816	1.3793	0.1633	4.6284	0.4543
P-1.5	1.00331	1.3802	0.1647	4.6033	0.4487
P-2	1.00348	1.3803	0.1650	4.5994	0.4478
P-2.5	1.00335	1.3802	0.1648	4.6027	0.4485
P-3	1.00336	1.3801	0.1646	4.6061	0.4493
P-3.5	1.00335	1.3802	0.1647	4.6032	0.4486
P-4	1.00348	1.3805	0.1653	4.5929	0.4465
P-4.5	1.00341	1.3803	0.1649	4.6005	0.4480
P-5	1.00347	1.3805	0.1652	4.5947	0.4468
EXPERIMENT	1.000	1.42	0.156	5.0	0.47
	+OR-.003	+OR-.02	+OR-.005	+OR-.02	+OR-.02

TABLE VII

INTRODUCING UNIFORMITY ON ZPR-6-7

	Original K_{eff}	Correction to ANL P.T. Scheme	Correction to 1.41 MeV Chi	Correction to Latest 1DX Scheme	To 50-Gp, Latest ENDF, Same Convergence	To Latest MINX Results	Final K_{eff}
ANL	0.9666		+ 0.0025				0.9691
BNL	0.9731	- 0.0043	+ 0.0017	+ 0.0010	- 0.0012		0.9703
GA	0.9810						0.9810
HEDL	0.9754	- 0.0043			- 0.0012		0.9699
LASL	0.9726	- 0.0043					0.9683
ORNL	0.9688	- 0.0043	+ 0.0013				0.9658
WARD	0.9686	- 0.0043	+ 0.0013			- 0.0008	0.9648

TABLE VIII

INTRODUCING UNIFORMITY ON ZPR-6-6A

	Original K_{eff}	Correction to ANL P.T. Scheme	Correction to 1.35 MeV Chi	Correction to 50-Gr. latest ENDF, same convergence	Correction to latest MINX results	Final K_{eff}
ANL	0.9760		+ 0.0019			0.9779
GA	0.9876					0.9876
HEDL	0.9894	- 0.0046		- 0.0018		0.9830
LASL	0.9873	- 0.0046				0.9827
WARD	0.9873	- 0.0046	+ 0.0041		- 0.0015	0.9853

TABLE IX

EFFECT OF NEW PORTER THOMAS INTEGRATION SCHEME

ZPR-6-7	Central Spectral Indicies (C/E*) Old Scheme	New Scheme
$U238_g/Pu239_f$	1.0878	1.0948
$U238_f/Pu239_f$	0.9601	0.9642
$U235_f/Pu239_f$	1.0410	1.0411
ZPR-6-6A		
$U238_f/U235_f$	0.9308	0.9349
$U238_g/U235_f$	1.0243	1.0293

*Used the ENDF 202 correction factors to convert the heterogeneous experimental values to homogeneous values to compare with the calculated values.

OAK RIDGE NATIONAL LABORATORY

(ORNL)

Appendix

A-1

Analysis Results

(50-group MINX library generated at LASL, 171-group MINX library generated at ORNL, diffusion calculations performed with SPHINX)

	50-Group	171-Group
ZPR-6/7		
k_{eff} uncorrected	0.9711	0.9701
k_{eff} corrected	0.9895	0.9885
$^{49}f/^{25}f$	0.9109*	0.9044*
C/E $^{49}f/^{25}f$	0.966	0.960
$^{28}f/^{25}f$	0.02050*	0.02026*
C/E $^{28}f/^{25}f$	0.931	0.921
$^{28}C/^{25}f$	0.1376	0.1360
C/E $^{28}C/^{25}f$	1.043	1.030
ZPR-6/6A		
k_{eff} uncorrected	0.9864	0.9900
k_{eff} corrected	0.9950	0.9986
$^{28}f/^{25}f$	0.02203*	0.02213*
C/E $^{28}f/^{25}f$	0.914	0.918
ZPR-3/11		
k_{eff} uncorrected	1.0028	1.0013
k_{eff} corrected	1.0095	1.0080
$^{28}f/^{25}f$	0.03947	0.03857
C/E $^{28}f/^{25}f$	1.039	1.015
ZPR-3/56B		
k_{eff} uncorrected	0.9839	0.9829
k_{eff} corrected	1.0016	1.0006
$^{49}f/^{25}f$	0.9779	0.9703
C/E $^{49}f/^{25}f$	0.951	0.944
$^{28}f/^{25}f$	0.02950	0.02926

*These ratios are heterogeneity corrected as per ENDF-202.

Note that these new numbers reflect the calculation of $\sigma_{d,e} = (XI\sigma_{el})/\Delta u$ rather than as previously reported ($\sigma_{d,e} = \sigma_{el} - \sigma_{g \to g}$). The difference between these methods of calculation is significant (0.9711 vs 0.9688 respectively for ZPR-6/7 in 50 groups).

Tables for mesh spacings, fission fractions, and group structure are enclosed. For the MINX generation, we employed the following

Tolerances for 171-Group ORNL Library Generation

Reconstruction	.005
Linearization	.01
Thinning	.005
Integration	.001

Tolerances for 50-Group LASL Library Generation

Reconstruction	.01
Linearization	.01
Thinning	.005
Integration	.001

The ORNL MINX 171-group library gave a consistent and independent check on the LASL 50-group numbers which many testers employed.

Going from the oldest LASL 50-group tape, to the one received July 11 resulted in a 0.2% increase in k_{eff} (ZPR-6/7).

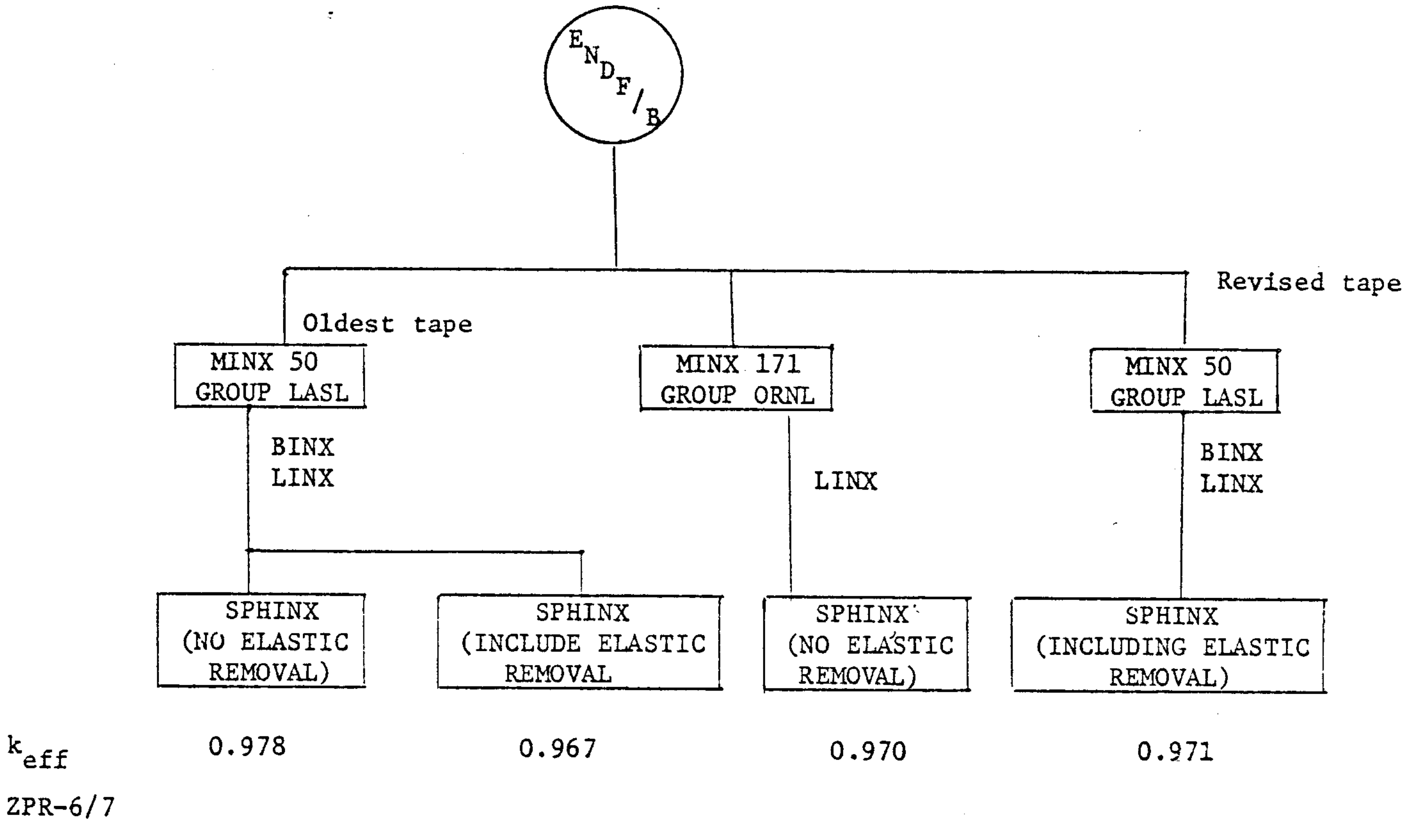

Fig. A.1. Fast Reactor Data Testing Calculational Techniques

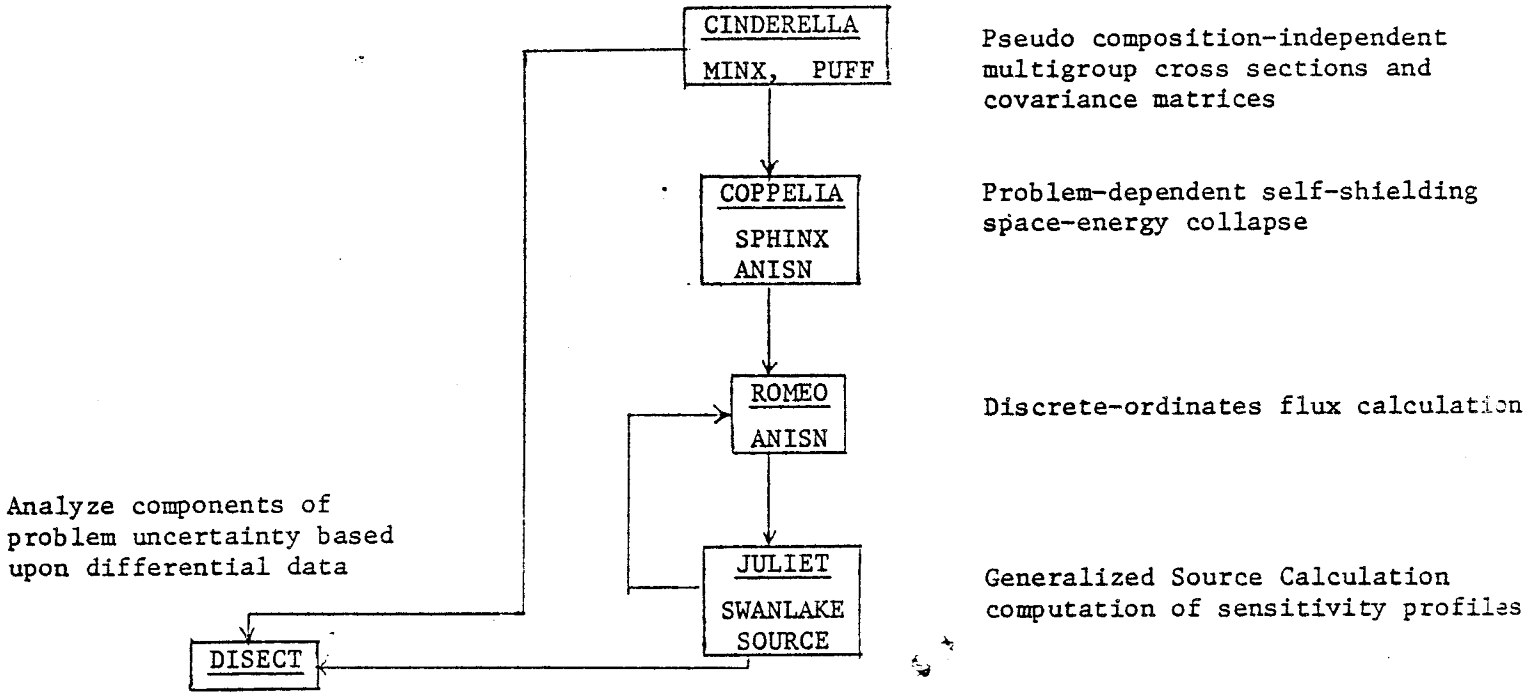

Fig. A.2. Calculational Technique for Fast Reactor Sensitivity Analysis

Table A.1. ZPR-6/7 Mesh Points and Fifty-Group Fission Fraction

MESH POINTS

RO 62

0.0	0.20000D 01	0.40000D 01	0.60000D 01	0.80000D 01	0.10000D 02	0.12000D 02	0.14000D 02	0.16000D 02	0.18000D 02
0.20000D 02	0.22000D 02	0.24000D 02	0.26000D 02	0.28000D 02	0.30000D 02	0.32000D 02	0.34000D 02	0.36000D 02	0.38000D 02
0.40000D 02	0.42000D 02	0.44000D 02	0.46000D 02	0.48000D 02	0.50000D 02	0.52000D 02	0.54000D 02	0.56000D 02	0.58000D 02
0.60000D 02	0.62000D 02	0.64000D 02	0.66000D 02	0.68000D 02	0.70000D 02	0.72000D 02	0.74000D 02	0.76000D 02	0.78000D 02
0.80000D 02	0.82000D 02	0.84000D 02	0.86000D 02	0.88160D 02	0.90000D 02	0.92000D 02	0.94000D 02	0.96000D 02	0.98000D 02
0.10000D 03	0.10200D 03	0.10400D 03	0.10600D 03	0.10800D 03	0.11000D 03	0.11200D 03	0.11400D 03	0.11600D 03	0.11800D 03
0.12000D 03	0.12157D 03								

FISSION FRACTIONS

K7 50

0.40000E-04	0.32480E-01	0.12175E 00	0.21095E 00	0.22301E 00	0.17277E 00	0.11045E 00	0.36130E-01	0.26620E-01	0.19340E-01
0.13820E-01	0.97800E-02	0.69800E-02	0.48200E-02	0.34400E-02	0.23300E-02	0.16700E-02	0.10700E-02	0.87000E-03	0.56600E-03
0.42800E-03	0.25300E-03	0.18100E-03	0.12000E-03	0.86000E-04	0.56900E-04	0.40700E-04	0.27000E-04	0.19200E-04	0.12600E-04
0.90000E-05	0.61800E-05	0.44200E-05	0.28400E-05	0.20200E-05	0.13400E-05	0.96000E-06	0.61000E-06	0.61000E-06	0.61000E-06
0.65000E-07	0.65000E-07	0.65000E-07	0.38000E-08	0.38000E-08	0.38000E-08	0.38000E-08	0.38000E-08	0.38000E-08	0.0

Table A.2 ZPR-6/6A Mesh Points and Fifty-Group Fission Fraction

MESH POINTS
R0 67

0.0	0.20000D 01	0.40000D 01	0.60000D 01	0.80000D 01	0.10000D 02	0.12000D 02	0.14000D 02	0.16000D 02	0.18000D 02
0.20000D 02	0.22000D 02	0.24000D 02	0.26000D 02	0.28000D 02	0.30000D 02	0.32000D 02	0.34000D 02	0.36000D 02	0.38000D 02
0.40000D 02	0.42000D 02	0.44000D 02	0.46000D 02	0.48000D 02	0.50000D 02	0.52000D 02	0.54000D 02	0.56000D 02	0.58000D 02
0.60000D 02	0.62000D 02	0.64000D 02	0.66000D 02	0.68000D 02	0.70000D 02	0.72000D 02	0.74000D 02	0.76000D 02	0.78000D 02
0.80000D 02	0.82000D 02	0.84000D 02	0.86000D 02	0.88000D 02	0.90000D 02	0.92000D 02	0.94000D 02	0.95670D 02	0.97110D 02
0.98550D 02	0.10000D 03	0.10200D 03	0.10400D 03	0.10600D 03	0.10800D 03	0.11000D 03	0.11200D 03	0.11400D 03	0.11600D 03
0.11800D 03	0.12000D 03	0.12200D 03	0.12400D 03	0.12600D 03	0.12800D 03	0.12948D 03			

FISSION FRACTIONS
K7 5C

0.16968E-02	0.25501E-01	0.10606E 00	0.20267E 00	0.22532E 00	0.18017E 00	0.11746E 00	0.38807E-01	0.28722E-01	0.20911E-01
0.15034E-01	0.10702E-01	0.75574E-02	0.53061E-02	0.37076E-02	0.25814E-02	0.17919E-02	0.12413E-02	0.85850E-03	0.59284E-03
0.40886E-03	0.28178E-03	0.19415E-03	0.13366E-03	0.91987E-04	0.63287E-04	0.43533E-04	0.29938E-04	0.20587E-04	0.14156E-04
0.97310E-05	0.66899E-05	0.45988E-05	0.31611E-05	0.21729E-05	0.14934E-05	0.10267E-05	0.11904E-05	0.56243E-06	0.26566E-06
0.12550E-06	0.59230E-07	0.28000E-07	0.13229E-07	0.62482E-08	0.29516E-08	0.13941E-08	0.65854E-09	0.31112E-09	0.27850E-09

Table A.3. ZPR-3/11 Mesh Points and Fifty Group Fission Fraction

MESH POINTS

RO 63

0.0	0.10000D 01	0.20000D 01	0.30000D 01	0.40000D 01	0.50000D 01	0.60000D 01	0.70000D 01	0.80000D 01	0.90000D 01
0.10000D 02	0.11000D 02	0.12000D 02	0.13000D 02	0.14000D 02	0.15000D 02	0.16000D 02	0.17000D 02	0.18000D 02	0.19000D 02
0.20000D 02	0.21000D 02	0.22000D 02	0.23000D 02	0.24000D 02	0.25000D 02	0.26000D 02	0.27000D 02	0.28000D 02	0.29000D 02
0.30000D 02	0.31000D 02	0.31610D 02	0.32610D 02	0.33610D 02	0.34610D 02	0.35610D 02	0.36610D 02	0.37610D 02	0.38610D 02
0.39610D 02	0.40610D 02	0.41610D 02	0.42610D 02	0.43610D 02	0.44610D 02	0.45610D 02	0.46610D 02	0.47610D 02	0.48610D 02
0.49610D 02	0.50610D 02	0.51610D 02	0.52610D 02	0.53610D 02	0.54610D 02	0.55610D 02	0.56610D 02	0.57610D 02	0.58610D 02
0.59610D 02	0.60610D 02	0.61610D 02							

FISSION FRACTIONS

K7 50

0.16968E-02	0.25501E-01	0.10806E 00	0.20267E 00	0.22532E 00	0.18017E 00	0.11746E 00	0.38807E-01	0.28722E-01	0.20911E-01
0.15034E-01	0.10702E-01	0.75574E-02	0.53061E-02	0.37076E-02	0.25814E-02	0.17919E-02	0.12413E-02	0.85830E-03	0.59284E-03
0.40886E-03	0.28178E-03	0.19415E-03	0.13366E-03	0.91987E-04	0.63287E-04	0.43533E-04	0.29938E-04	0.20587E-04	0.14156E-04
0.97310E-05	0.66899E-05	0.45988E-05	0.31611E-05	0.21729E-05	0.14934E-05	0.10267E-05	0.11904E-05	0.56243E-06	0.26566E-06
0.12550E-06	0.59280E-07	0.28000E-07	0.13229E-07	0.62482E-08	0.29516E-08	0.13941E-08	0.65854E-09	0.31112E-09	0.27850E-09

Table A.4. ZPR-3/56B Mesh Points and 171 Group Fission Fraction

MESH POINTS

	61								
0.0	0.150000 01	0.300000 01	0.450000 01	0.600000 01	0.750000 01	0.900000 01	0.105000 02	0.120000 02	0.135000 02
0.150000 02	0.165000 02	0.180000 02	0.195000 02	0.210000 02	0.225000 02	0.240000 02	0.255000 02	0.270000 02	0.285000 02
0.300000 02	0.315000 02	0.330000 02	0.345000 02	0.360000 02	0.375000 02	0.390000 02	0.405000 02	0.420000 02	0.435000 02
0.450000 02	0.465000 02	0.480000 02	0.492000 02	0.504000 02	0.516000 02	0.527200 02	0.538000 02	0.550000 02	0.565000 02
0.580000 02	0.595000 02	0.610000 02	0.625000 02	0.640000 02	0.655000 02	0.670000 02	0.685000 02	0.700000 02	0.715000 02
0.730000 02	0.745000 02	0.760000 02	0.775000 02	0.790000 02	0.805000 02	0.820000 02	0.833000 02	0.846000 02	0.859000 02
0.870600 02									

FISSION FRACTIONS

<7	5C								
0.40000E-04	0.32480E-01	0.12175E 00	0.21095E 00	0.22301E 00	0.17277E 00	0.11045E 00	0.36130E-01	0.26620E-01	0.19340E-01
0.13820E-01	0.97800E-02	0.69800E-02	0.48200E-02	0.34400E-02	0.23300E-02	0.16700E-02	0.10700E-02	0.87000E-03	0.56600E-03
0.42800E-03	0.25300E-03	0.18100E-03	0.12000E-03	0.86000E-04	0.56900E-04	0.40700E-04	0.27000E-04	0.19200E-04	0.12600E-04
0.90000E-05	0.61800E-05	0.44200E-05	0.28400E-05	0.20200E-05	0.13400E-05	0.96000E-06	0.61000E-06	0.61000E-06	0.61000E-05
0.65000E-07	0.65000E-07	0.65000E-07	0.38000E-08	0.38000E-08	0.38000E-08	0.38000E-08	0.38000E-08	0.38000E-08	0.0

Table A.5. ZPR-6/7 Mesh Points and 171 Group Fission Fraction

MESH POINTS

RO 62

0.0	0.20000D 01	0.40000D 01	0.60000D 01	0.80000D 01	0.10000D 02	0.12000D 02	0.14000D 02	0.16000D 02	0.18000D 02
0.20000D 02	0.22000D 02	0.24000D 02	0.26000D 02	0.28000D 02	0.30000D 02	0.32000D 02	0.34000D 02	0.36000D 02	0.38000D 02
0.40000D 02	0.42000D 02	0.44000D 02	0.46000D 02	0.48000D 02	0.50000D 02	0.52000D 02	0.54000D 02	0.56000D 02	0.58000D 02
0.60000D 02	0.62000D 02	0.64000D 02	0.66000D 02	0.68000D 02	0.70000D 02	0.72000D 02	0.74000D 02	0.76000D 02	0.78000D 02
0.80000D 02	0.82000D 02	0.84000D 02	0.86000D 02	0.88160D 02	0.90000D 02	0.92000D 02	0.94000D 02	0.96000D 02	0.98000D 02
0.10000D 03	0.10200D 03	0.10400D 03	0.10600D 03	0.10800D 03	0.11000D 03	0.11200D 03	0.11400D 03	0.11600D 03	0.11800D 03
0.12000D 03	0.12197D 03								

FISSION FRACTIONS

K7 171

0.12650E-04	0.21197E-04	0.34546E-04	0.24298E-04	0.30402E-04	0.37893E-04	0.46625E-04	0.12750E-03	0.18738E-03	0.26985E-03
0.37936E-03	0.52401E-03	0.70976E-03	0.94275E-03	0.12310E-02	0.15811E-02	0.19988E-02	0.24888E-02	0.30547E-02	0.36990E-02
0.44215E-02	0.16476E-02	0.35718E-02	0.60908E-02	0.70271E-02	0.80232E-02	0.90647E-02	0.10148E-01	0.11257E-01	0.12378E-01
0.28099E-01	0.32398E-01	0.36335E-01	0.19476E-01	0.20264E-01	0.20942E-01	0.21533E-01	0.22037E-01	0.22439E-01	0.15133E-01
0.38240E-02	0.38044E-02	0.76432E-02	0.15326E-01	0.23087E-01	0.23119E-01	0.23076E-01	0.22942E-01	0.22723E-01	0.22426E-01
0.22089E-01	0.21694E-01	0.21252E-01	0.20710E-01	0.20227E-01	0.19600E-01	0.19054E-01	0.18407E-01	0.34888E-01	0.13788E-01
0.18506E-01	0.15160E-01	0.14510E-01	0.13863E-01	0.13229E-01	0.12608E-01	0.11994E-01	0.11403E-01	0.10825E-01	0.10265E-01
0.97223E-02	0.91987E-02	0.86992E-02	0.15969E-01	0.14198E-01	0.64841E-02	0.61000E-02	0.11124E-01	0.98072E-02	0.10549E-02
0.39430E-03	0.81129E-03	0.21900E-02	0.41742E-02	0.75721E-02	0.34285E-02	0.32073E-02	0.29994E-02	0.28046E-02	0.26200E-02
0.24480E-02	0.22881E-02	0.21326E-02	0.19938E-02	0.18566E-02	0.17352E-02	0.16151E-02	0.15078E-02	0.14060E-02	0.13074E-02
0.12205E-02	0.26951E-02	0.22544E-02	0.75662E-03	0.55461E-03	0.13458E-02	0.79884E-03	0.17726E-02	0.63176E-03	0.91046E-03
0.75739E-03	0.85219E-03	0.30308E-03	0.38939E-03	0.16865E-03	0.10365E-03	0.13690E-03	0.64783E-04	0.62438E-04	0.17400E-03
0.25015E-03	0.38036E-03	0.28203E-03	0.18052E-03	0.12427E-03	0.85518E-04	0.58834E-04	0.26072E-04	0.14397E-04	0.12394E-04
0.10672E-04	0.47632E-05	0.44206E-05	0.79083E-05	0.68060E-05	0.13158E-04	0.90452E-05	0.62183E-05	0.42746E-05	0.29362E-05
0.20197E-05	0.13881E-05	0.95426E-06	0.65580E-06	0.45068E-06	0.30985E-06	0.21291E-06	0.14634E-06	0.10058E-06	0.69131E-07
0.47511E-07	0.31990E-07	0.23113E-07	0.15426E-07	0.10600E-07	0.72877E-08	0.50079E-08	0.34419E-08	0.23657E-08	0.16259E-08
0.11175E-08	0.77856E-09	0.51725E-09	0.36277E-09	0.24932E-09	0.17140E-09	0.11778E-09	0.80946E-10	0.55637E-10	0.10775E-09
0.14493E-10									

Table A.6. ZPR-6/6A Mesh Points and 171 Group Fission Fraction

MESH POINTS
RO 67

0.0	0.20000D 01	0.40000D 01	0.60000D 01	0.80000D 01	0.10000D 02	0.12000D 02	0.14000D 02	0.16000D 02	0.18000D 02
0.20000D 02	0.22000D 02	0.24000D 02	0.26000D 02	0.28000D 02	0.30000D 02	0.32000D 02	0.34000D 02	0.36000D 02	0.38000D 02
0.40000D 02	0.42000D 02	0.44000D 02	0.46000D 02	0.48000D 02	0.50000D 02	0.52000D 02	0.54000D 02	0.56000D 02	0.58000D 02
0.60000D 02	0.62000D 02	0.64000D 02	0.66000D 02	0.68000D 02	0.70000D 02	0.72000D 02	0.74000D 02	0.76000D 02	0.78000D 02
0.80000D 02	0.82000D 02	0.84000D 02	0.86000D 02	0.88000D 02	0.90000D 02	0.92000D 02	0.94000D 02	0.95670D 02	0.97110D 02
0.98550D 02	0.10000D 03	0.10200D 03	0.10400D 03	0.10600D 03	0.10800D 03	0.11000D 03	0.11200D 03	0.11400D 03	0.11600D 03
0.11800D 03	0.12000D 03	0.12200D 03	0.12400D 03	0.12600D 03	0.12800D 03	0.12948D 03			

FISSION FRACTIONS
K7 171

0.73687E-05	0.12722E-04	0.21331E-04	0.15302E-04	0.19401E-04	0.24495E-04	0.30522E-04	0.85060E-04	0.12795E-03	0.18839E-03
0.27050E-03	0.38122E-03	0.52631E-03	0.71191E-03	0.94582E-03	0.12349E-02	0.15858E-02	0.20041E-02	0.24949E-02	0.30621E-02
0.37074E-02	0.13927E-02	0.30374E-02	0.52301E-02	0.61009E-02	0.70393E-02	0.80329E-02	0.90790E-02	0.10162E-01	0.11271E-01
0.25900E-01	0.30307E-01	0.34448E-01	0.18634E-01	0.19500E-01	0.20264E-01	0.20944E-01	0.21541E-01	0.22038E-01	0.14919E-01
0.37768E-02	0.37600E-02	0.75622E-02	0.15196E-01	0.22967E-01	0.23089E-01	0.23130E-01	0.23076E-01	0.22932E-01	0.22705E-01
0.22430E-01	0.22093E-01	0.21702E-01	0.21203E-01	0.20760E-01	0.20164E-01	0.19645E-01	0.19018E-01	0.36154E-01	0.14327E-01
0.19262E-01	0.15808E-01	0.15154E-01	0.14500E-01	0.13856E-01	0.13224E-01	0.12596E-01	0.11990E-01	0.11395E-01	0.10818E-01
0.10257E-01	0.97143E-02	0.91956E-02	0.16902E-01	0.15052E-01	0.68824E-02	0.64792E-02	0.11827E-01	0.10440E-01	0.11236E-02
0.42004E-03	0.86432E-03	0.23336E-02	0.44495E-02	0.80775E-02	0.36599E-02	0.34252E-02	0.32045E-02	0.29976E-02	0.28013E-02
0.26183E-02	0.24481E-02	0.22825E-02	0.21346E-02	0.19882E-02	0.18588E-02	0.17305E-02	0.16159E-02	0.15072E-02	0.14018E-02
0.13089E-02	0.28914E-02	0.24196E-02	0.81230E-03	0.59551E-03	0.14453E-02	0.85810E-03	0.19046E-02	0.67900E-03	0.97872E-03
0.81488E-03	0.91647E-03	0.32599E-03	0.41888E-03	0.18143E-03	0.11151E-03	0.14729E-03	0.69704E-04	0.67181E-04	0.18723E-03
0.26918E-03	0.40935E-03	0.28205E-03	0.19434E-03	0.13379E-03	0.92074E-04	0.63348E-04	0.28073E-04	0.15502E-04	0.13345E-04
0.11492E-04	0.51291E-05	0.47601E-05	0.85158E-05	0.73310E-05	0.14169E-04	0.97403E-05	0.66963E-05	0.46032E-05	0.31641E-05
0.21750E-05	0.14949E-05	0.10276E-05	0.70623E-06	0.48534E-06	0.33368E-06	0.22929E-06	0.15759E-06	0.10832E-06	0.74448E-07
0.51165E-07	0.34450E-07	0.24891E-07	0.16612E-07	0.11415E-07	0.78482E-08	0.53930E-08	0.37066E-08	0.25476E-08	0.17509E-08
0.12035E-08	0.63844E-09	0.55703E-09	0.39067E-09	0.26849E-09	0.18459E-09	0.12683E-09	0.87172E-10	0.59916E-10	0.11603E-09
0.15607E-10									

Table A.7. ZPR-3/11 Mesh Points and 171 Group Fission Fraction

MESH POINTS

RO 63

0.0	0.100000D 01	0.200000D 01	0.300000D 01	0.400000D 01	0.500000D 01	0.600000D 01	0.700000D 01	0.800000D 01	0.900000D 01
0.100000D 02	0.110000D 02	0.120000D 02	0.130000D 02	0.140000D 02	0.150000D 02	0.160000D 02	0.170000D 02	0.180000D 02	0.190000D 02
0.200000D 02	0.210000D 02	0.220000D 02	0.230000D 02	0.240000D 02	0.250000D 02	0.260000D 02	0.270000D 02	0.280000D 02	0.290000D 02
0.300000D 02	0.310000D 02	0.316100D 02	0.326100D 02	0.336100D 02	0.346100D 02	0.356100D 02	0.366100D 02	0.376100D 02	0.386100D 02
0.396100D 02	0.406100D 02	0.416100D 02	0.426100D 02	0.436100D 02	0.446100D 02	0.456100D 02	0.466100D 02	0.476100D 02	0.486100D 02
0.496100D 02	0.506100D 02	0.516100D 02	0.526100D 02	0.536100D 02	0.546100D 02	0.556100D 02	0.566100D 02	0.576100D 02	0.586100D 02
0.596100D 02	0.606100D 02	0.616100D 02							

Fission Fractions - same as Table A.6.

Table A.8. ZPR-3/56B Mesh Points and 171 Group Fission Fraction

```
MESH POINTS
         RO    61
0.0            0.150000D 01 0.300000D 01 0.450000D 01 0.600000D 01 0.750000D 01 0.900000D 01 0.105000D 02 0.120000D 02 0.135000D 02
0.150000D 02 0.165000D 02 0.180000D 02 0.195000D 02 0.210000D 02 0.225000D 02 0.240000D 02 0.255000D 02 0.270000D 02 0.285000D 02
0.300000D 02 0.315000D 02 0.330000D 02 0.345000D 02 0.360000D 02 0.375000D 02 0.390000D 02 0.405000D 02 0.420000D 02 0.435000D 02
0.450000D 02 0.465000D 02 0.480000D 02 0.492000D 02 0.504000D 02 0.516000D 02 0.527200D 02 0.538000D 02 0.550000D 02 0.565000D 02
0.580000D 02 0.595000D 02 0.610000D 02 0.625000D 02 0.640000D 02 0.655000D 02 0.670000D 02 0.685000D 02 0.700000D 02 0.715000D 02
0.730000D 02 0.745000D 02 0.760000D 02 0.775000D 02 0.790000D 02 0.805000D 02 0.820000D 02 0.833000D 02 0.846000D 02 0.859000D 02
0.870600D 02
```

Fission Fractions - same as Table A.5.

Table A.9. JEZEBEL Mesh Points and 126 Group Fission Fractions

Mesh Points

We used 40 equally-spaced mesh intervals as specified in ENDF 202.

Fission Fractions

0.52249E-03	0.18830E-02	0.57536E-02	0.13664E-01	0.11310E-01	0.15050E-01	0.42848E-01	0.60497E-01	0.55811E-01	0.20264E-01
0.20942E-01	0.21533E-01	0.22037E-01	0.22439E-01	0.15133E-01	0.38240E-02	0.11448E-01	0.15326E-01	0.23087E-01	0.23119E-01
0.23076E-01	0.22942E-01	0.22723E-01	0.22426E-01	0.22089E-01	0.21694E-01	0.21252E-01	0.20710E-01	0.20227E-01	0.19600E-01
0.19054E-01	0.18407E-01	0.34888E-01	0.13788E-01	0.18506E-01	0.15160E-01	0.14510E-01	0.13863E-01	0.13229E-01	0.12608E-01
0.11994E-01	0.11403E-01	0.10825E-01	0.10265E-01	0.97223E-02	0.91987E-02	0.86992E-02	0.15969E-01	0.14198E-01	0.12584E-01
0.11124E-01	0.98072E-02	0.10549E-02	0.39430E-03	0.81129E-03	0.21900E-02	0.41742E-02	0.75721E-02	0.66358E-02	0.29994E-02
0.28046E-02	0.26200E-02	0.24480E-02	0.22881E-02	0.21326E-02	0.19938E-02	0.18566E-02	0.17352E-02	0.16151E-02	0.15078E-02
0.14060E-02	0.13074E-02	0.12205E-02	0.26951E-02	0.22544E-02	0.75662E-03	0.55461E-03	0.13458E-02	0.79884E-03	0.17726E-02
0.63176E-03	0.91046E-03	0.75789E-03	0.85219E-03	0.30308E-03	0.38939E-03	0.16865E-03	0.10365E-03	0.13690E-03	0.12722E-03
0.17400E-03	0.25015E-03	0.38036E-03	0.26203E-03	0.18052E-03	0.12427E-03	0.85518E-04	0.58834E-04	0.26072E-04	0.14397E-04
0.12394E-04	0.10672E-04	0.47632E-05	0.44206E-05	0.79083E-05	0.68080E-05	0.13158E-04	0.90452E-05	0.62183E-05	0.42746E-05
0.49579E-05	0.23424E-05	0.65580E-06	0.45068E-06	0.52276E-06	0.24692E-06	0.69131E-07	0.47511E-07	0.55103E-07	0.33314E-07
0.10815E-07	0.35220E-08	0.11293E-08	0.42576E-09	0.10775E-09	0.14493E-10				

Table A.10. GODIVA Mesh Points and 126 Group Fission Fractions

Mesh Points

We used 40 equally-spaced mesh intervals as specified in ENDF 202.

Fission Fractions

0.34415E-03	0.13664E-02	0.44784E-02	0.11268E-01	0.96602E-02	0.13140E-01	0.38545E-01	0.56207E-01	0.53082E-01	0.19500E-01
0.20264E-01	0.20944E-01	0.21541E-01	0.22038E-01	0.14919E-01	0.37768E-02	0.11322E-01	0.15196E-01	0.22967E-01	0.23089E-01
0.23130E-01	0.23076E-01	0.22932E-01	0.22705E-01	0.22430E-01	0.22093E-01	0.21702E-01	0.21203E-01	0.20760E-01	0.20164E-01
0.19645E-01	0.19018E-01	0.36154E-01	0.14327E-01	0.19262E-01	0.15808E-01	0.15154E-01	0.14500E-01	0.13856E-01	0.13224E-01
0.12596E-01	0.11990E-01	0.11395E-01	0.10818E-01	0.10257E-01	0.97143E-02	0.91956E-02	0.16902E-01	0.15052E-01	0.13362E-01
0.11827E-01	0.10440E-01	0.11236E-02	0.42004E-03	0.86432E-03	0.23336E-02	0.44495E-02	0.80775E-02	0.70851E-02	0.32045E-02
0.29976E-02	0.28013E-02	0.26183E-02	0.24481E-02	0.22825E-02	0.21346E-02	0.19882E-02	0.18568E-02	0.17305E-02	0.16159E-02
0.15072E-02	0.14018E-02	0.13089E-02	0.28914E-02	0.24196E-02	0.81230E-03	0.59551E-03	0.14453E-02	0.85810E-03	0.19046E-02
0.67900E-03	0.97872E-03	0.81488E-03	0.91647E-03	0.32599E-03	0.41888E-03	0.18143E-03	0.11151E-03	0.14729E-03	0.13688E-03
0.18723E-03	0.26918E-03	0.40935E-03	0.28205E-03	0.19434E-03	0.13379E-03	0.92074E-04	0.63348E-04	0.28073E-04	0.15502E-04
0.13345E-04	0.11492E-04	0.51291E-05	0.47601E-05	0.85158E-05	0.73310E-05	0.14169E-04	0.97403E-05	0.66963E-05	0.46032E-05
0.53391E-05	0.25225E-05	0.70623E-06	0.48534E-06	0.56297E-06	0.26591E-06	0.74448E-07	0.51165E-07	0.59341E-07	0.35875E-07
0.11647E-07	0.37928E-08	0.12162E-08	0.45851E-09	0.11603E-09	0.15607E-10				

Table A.11. 171-Group Structure

0.17333E 08	0.16487E 08	0.15683E 08	0.14918E 08	0.14550E 08	0.14191E 08	0.13840E 08	0.13499E 08	0.12840E 08	0.12214E 08
0.11618E 08	0.11052E 08	0.10513E 08	0.10000E 08	0.95123E 07	0.90484E 07	0.86071E 07	0.81873E 07	0.77880E 07	0.74082E 07
0.70469E 07	0.67032E 07	0.65924E 07	0.63763E 07	0.60653E 07	0.57695E 07	0.54881E 07	0.52205E 07	0.49659E 07	0.47237E 07
0.44933E 07	0.40657E 07	0.36788E 07	0.33287E 07	0.31664E 07	0.30119E 07	0.28650E 07	0.27253E 07	0.25924E 07	0.24660E 07
0.23852E 07	0.23653E 07	0.23457E 07	0.23069E 07	0.22313E 07	0.21225E 07	0.20190E 07	0.19205E 07	0.18268E 07	0.17377E 07
0.16530E 07	0.15724E 07	0.14957E 07	0.14227E 07	0.13534E 07	0.12873E 07	0.12246E 07	0.11648E 07	0.11080E 07	0.10026E 07
0.96164E 06	0.90718E 06	0.86294E 06	0.82085E 06	0.78082E 06	0.74274E 06	0.70651E 06	0.67206E 06	0.63928E 06	0.60810E 06
0.57844E 06	0.55023E 06	0.52340E 06	0.49787E 06	0.45049E 06	0.40762E 06	0.38774E 06	0.36883E 06	0.33373E 06	0.30197E 06
0.29850E 06	0.29720E 06	0.29452E 06	0.28725E 06	0.27324E 06	0.24724E 06	0.23518E 06	0.22371E 06	0.21280E 06	0.20242E 06
0.19255E 06	0.18316E 06	0.17422E 06	0.16573E 06	0.15764E 06	0.14996E 06	0.14264E 06	0.13569E 06	0.12907E 06	0.12277E 06
0.11679E 06	0.11109E 06	0.98037E 05	0.86517E 05	0.82500E 05	0.79500E 05	0.72000E 05	0.67379E 05	0.56562E 05	0.52475E 05
0.46309E 05	0.40868E 05	0.34307E 05	0.31828E 05	0.28500E 05	0.27000E 05	0.26058E 05	0.24788E 05	0.24176E 05	0.23579E 05
0.21875E 05	0.19305E 05	0.15034E 05	0.11709E 05	0.91188E 04	0.71017E 04	0.55308E 04	0.43074E 04	0.37074E 04	0.33546E 04
0.30354E 04	0.27465E 04	0.26126E 04	0.24852E 04	0.22487E 04	0.20347E 04	0.15846E 04	0.12341E 04	0.96112E 03	0.74852E 03
0.58295E 03	0.45400E 03	0.35358E 03	0.27536E 03	0.21445E 03	0.16702E 03	0.13007E 03	0.10130E 03	0.78893E 02	0.61442E 02
0.47851E 02	0.37267E 02	0.29203E 02	0.22603E 02	0.17603E 02	0.13710E 02	0.10677E 02	0.83153E 01	0.64760E 01	0.50435E 01
0.39279E 01	0.30590E 01	0.23724E 01	0.18554E 01	0.14450E 01	0.11254E 01	0.87642E 00	0.68256E 00	0.53158E 00	0.41399E 00
0.10000E 00	0.10000E-04								

Table A.12. 126-Group Structure

0.17333E 08	0.12214E 08	0.10000E 08	0.81873E 07	0.67032E 07	0.60653E 07	0.54881E 07	0.44933E 07	0.36788E 07	0.31664E 07
0.30119E 07	0.28650E 07	0.27253E 07	0.25924E 07	0.24660E 07	0.23852E 07	0.23653E 07	0.23069E 07	0.22313E 07	0.21225E 07
0.20190E 07	0.19205E 07	0.18268E 07	0.17377E 07	0.16530E 07	0.15724E 07	0.14957E 07	0.14227E 07	0.13534E 07	0.12873E 07
0.12246E 07	0.11648E 07	0.11080E 07	0.10026E 07	0.96164E 06	0.90718E 06	0.86294E 06	0.82085E 06	0.78082E 06	0.74274E 06
0.70651E 06	0.67206E 06	0.63928E 06	0.60810E 06	0.57844E 06	0.55023E 06	0.52340E 06	0.49787E 06	0.45049E 06	0.40762E 06
0.36883E 06	0.33373E 06	0.30197E 06	0.29850E 06	0.29720E 06	0.29452E 06	0.28725E 06	0.27324E 06	0.24724E 06	0.22371E 06
0.21280E 06	0.20242E 06	0.19255E 06	0.18316E 06	0.17422E 06	0.16573E 06	0.15764E 06	0.14996E 06	0.14264E 06	0.13569E 06
0.12907E 06	0.12277E 06	0.11679E 06	0.11109E 06	0.98037E 05	0.86517E 05	0.82500E 05	0.79500E 05	0.72000E 05	0.67379E 05
0.56562E 05	0.52475E 05	0.46309E 05	0.40868E 05	0.34307E 05	0.31828E 05	0.28500E 05	0.27000E 05	0.26058E 05	0.24788E 05
0.23579E 05	0.21875E 05	0.19305E 05	0.15034E 05	0.11709E 05	0.91188E 04	0.71017E 04	0.55308E 04	0.43074E 04	0.37074E 04
0.33546E 04	0.30354E 04	0.27465E 04	0.26126E 04	0.24852E 04	0.22487E 04	0.20347E 04	0.15846E 04	0.12341E 04	0.96112E 03
0.74852E 03	0.45400E 03	0.27536E 03	0.21445E 03	0.16702E 03	0.10130E 03	0.61442E 02	0.47851E 02	0.37267E 02	0.22603E 02
0.10677E 02	0.50435E 01	0.23724E 01	0.11254E 01	0.41399E 00	0.10000E 00	0.10000E-04			

WESTINGHOUSE

(W)

ARD ENDF/B-IV DATA TESTING RESULTS

BY

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General

ARD has performed analyses of CSEWG benchmark critical assemblies JEZEBEL, ZEBRA-3, ZPR-6-6A, ZPR-6-7, and ZPPR-2 using ENDF/B-IV data. Two different cross-section libraries were used, a 50 group library with P_3 scattering components produced by the MINX[1] code at LASL, and a 42 group library with P_0 scattering components produced by the ETOX[2] code at HEDL. The analyses were performed using the SPHINX[3] code and homogeneous models of the benchmarks as specified in ENDF-202, Edition 2 (except for JEZEBEL which was modeled according to the original CSEWG description).

Calculational Method

Figure 1 is a flow diagram of the SPHINX calculations. Each calculation consisted of a resonance self-shielded cross section calculation followed by a one-dimensional diffusion theory or transport theory calculation of k_{eff}, fluxes and collapsed cross sections (which are reaction rates when the collapse is to a single group).

In the Resonance Module of SPHINX, there are two methods of treating the elastic scattering cross sections. The first method is identical to the treatment of the 1DX[4] code, one of the precursors of SPHINX. In that case, the elastic in-group scattering and first downscattering cross sections are computed by:

$$\sigma^{el}_{g,g+1} = \sigma^{el}_{g} * XI_g/\Delta U_g$$

$$\sigma^{el}_{g,g} = \sigma^{el}_{g} - \sigma^{el}_{g,g+1}$$

where

σ_{g,g^1}^{el} = elastic scattering cross section from group g to group g^1.

σ_{g}^{el} = total elastic scattering cross section in group g.

XI_g = average lethargy increment per elastic scatter in group g.

ΔU_g = lethargy width of group g.

The second method is simply to use the elastic scattering matrix. All results reported here, except those for JEZEBEL, use the first method. This method has the advantage that the results can be compared to XSRES/1DX[4] or XSRES/ANISN[5] calculations, which should give identical results to SPHINX resonance/diffusion or resonance/transport calculations, respectively. It also facilitates comparisons of SPHINX calculations using MINX data sets (which have elastic scattering matrices) and those using ETOX data sets (which do not). ARD has found that the first method produces k_{eff} values about 0.2% higher than the second method, using the 50 group MINX library.

Comparison of the Two Libraries

There are significant differences between the two cross section libraries, as is apparent from Table 1, which compares eigenvalues computed by SPHINX using the two cross section libraries. To investigate the differences, ARD collapsed the two libraries in CCCC format[6] to a common 23 group structure using the MINX auxiliary code CINX[7]. The principal cross sections on the collapsed ISOTXS[6] files were compared, and significant differences in Pu^{239} and U^{238} capture and Pu^{239} fission cross sections were found. These differences are presented in Tables 2 and 3.

Results

The diffusion and transport modules of the SPHINX code require a fission fraction vector (chi) on the ISOTXS file. For JEZEBEL, ZEBRA-3, ZPR-6-7, and ZPPR-2, ARD used a chi vector which was based on a 30 group chi vector for a typical plutonium reactor. For ZPR-6-6A, an assembly dependent 30 group chi vector was used. These chis were calculated assuming a nuclear temperature of 1.42 MeV for Pu^{239}, 1.34 MeV for U^{238} and 1.32 MeV for U^{235}. To go from 30 group chis to 42 or 50 group chis, some of the 30 group chis had to be divided into more than one group. The division was performed in such a way as to produce an exponential decrease in chi (except for JEZEBEL and ZPR-6-6A, for which the division was into equal parts). Tables 4 through 8 list the 50 group chis used in the computation of JEZEBEL, ZEBRA-3, ZPR-6-6A, ZPR-6-7, and ZPPR-2. These tables also list the computed central flux spectra for these assemblies.

Calculated integral parameters are listed in Tables 1 (k_{eff}) and 9 (central reaction rate ratios). The central reaction rates were calculated in SPHINX by collapsing the cross sections to a single group, using the fluxes at core center.

Material worth calculations for ZPR-6-7 have been performed using the MINX library. The calculations were performed as follows. The library was converted to ETOX format and used in XSRES/1DX regular and adjoint calculations of ZPR-6-7 cross sections and fluxes. The calculated fluxes and cross sections were then used as input to the perturbation theory code PERT-V[8]. The results of a one-dimensional calculation of material worths at core center are shown in Table 10. For Fe, Ni, Cr, U-235, U-238 and Pu-239, the worths differ by 0-3% from the results of a similar calculation at HEDL[9] which used the 42 group ETOX ENDF/B-IV library. The sodium worths differ by 6% in the two calculations, the calculation with the MINX data predicting the greater worth.

Supplementary Results

The XSRES/1DX calculation of ZPR-6-7 yielded the same eigenvalue and central reaction rate ratios as in the SPHINX Resonance/Diffusion calculation as shown in Tables 1 and 9. Since XSRES in the 1DX code is the precursor of the SPHINX Resonance Module and 1DX is the precursor of the SPHINX diffusion module, this agreement is to be expected.

In addition to 50 group calculations of CSEWG benchmarks, ARD has performed 240 group SPHINX calculations of a 5 isotope, two zone, spherical reactor model using MINX produced ENDF/B-IV cross sections for O^{16}, Na^{23}, Fe, U^{238}, and Pu^{239}. The results of the eigenvalue calculation are in good agreement with a 50 group calculation of the same model.

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TABLE 1

SPHINX EIGENVALUE CALCULATIONS USING ENDF/B-IV DATA

CRITICAL ASSEMBLY	ETOX (42 GROUPS) DIFFUSION THEORY	MINX (50 GROUPS) DIFFUSION THEORY	MINX (50 GROUPS) TRANSPORT THEORY (S_n)
JEZEBEL	--	--	0.9912[a] (S_{16})
ZEBRA-3	.9907	.9937	1.0044[b] (S_8)
ZPR-6-6A[c]	--	.9946	--
ZPR-6-7[d]	.9943	.9864	--
ZPPR-2[e]	.9941	.9866	--

(a) Effective S_∞ correction of -.0008 Δk/k, as specified in ENDF-202, Edition 2, has been applied.

(b) Effective S_∞ correction of -.001 Δk, as specified in ENDF-202, Edition 2, has been applied.

(c) Heterogeneity correction of +.0073 Δk/k, as specified in ENDF-202, Edition 2, has been applied.

(d) Heterogeneity correction of +0.0166 Δk/k, and transport correction of +.0018 Δk/k, as specified in ENDF-202, Edition 2, have been applied.

(e) Heterogeneity correction of +0.0175 Δk/k, as specified in ENDF-202, Edition 2, has been applied.

TABLE 2

COMPARISON OF MINX AND ETOX DATA
FOR U^{238} AND PU^{239} CAPTURE CROSS SECTIONS[(a)]

Isotope	Energy Range	σ_c (barns) ETOX	σ_c (barns) MINX	$\frac{\sigma_c(ETOX)-\sigma_c(MINX)}{\sigma_c(MINX)}$ (%)
U-238	40.9 - 67.4 keV	0.33000	0.32453	1.7
	24.8[(b)] - 40.9 keV	0.42590	0.41007	3.9
	3.35 - 5.53 keV	1.0384	1.0630	-2.3
	2.04 - 3.35 keV	1.3493	1.4146	-4.6
	1.23 - 2.04 keV	1.7525	1.7765	-1.3
Pu-239	24.8[(b)] - 40.9 keV	0.48590	0.49157	-1.2
	15.0 - 24.8[(b)] keV	0.70904	0.72338	-2.0
	9.12 - 15.0 keV	0.98830	1.0054	-1.7

(a) Differences greater than 1% are presented here.

(b) This is MINX energy boundary. The energy boundary for ETOX data was 25.5 keV.

TABLE 3

COMPARISON OF PU-239 FISSION CROSS SECTIONS ON ENDF/B-IV LIBRARIES PROCESSED BY ETOX AND MINX[a]

Energy Range	ETOX	MINX	$\frac{ETOX-MINX}{MINX}$ (%)
821 keV - 1.35 MeV	1.7446	1.7494	-0.27
24.8[b] - 40.9 keV	1.6191	1.6213	-0.14
15.0 - 24.8[b] keV	1.7230	1.7299	-0.40
9.12 - 15.0 keV	1.8673	1.8704	-0.17
3.35 - 5.53 keV	2.5950	2.5773	+0.69
2.03 - 3.35 keV	3.4410	3.4199	+0.62
1.23 - 2.03 keV	4.2679	4.2564	+0.27
749 eV - 1.23 keV	6.4519	6.4419	+0.16
454 eV - 749 eV	9.8929	9.8737	+0.19
275 - 454 eV	10.617	10.662	-0.42

(a) Differences greater than 0.1% are presented here.

(b) This is MINX energy boundary. The energy boundary for ETOX data was 25.5 keV.

TABLE 4

GROUP STRUCTURE, FISSION FRACTIONS, AND CENTRAL FLUXES
CSEWG BENCHMARK ASSEMBLY JEZEBEL

Group	Minimum Energy	Fission Fraction	Fractional Flux at Core Center
-	19.64 MeV		-
1	10.00	4.00×10^{-5}	3.05×10^{-5}
2	6.065	.03244	.0245
3	3.679	.12175	.0893
4	2.231	.21095	.1572
5	1.353	.22301	.1836
6	820.8 KeV	.17277	.1754
7	497.9	.11045	.1423
8	387.7	.03613	.0554
9	302.0	.02662	.0444
10	235.2	.01658	.0317
11	183.2	.01658	.0288
12	142.6	.00838	.0182
13	111.1	.00838	.0158
14	86.52	.00413	9.62×10^{-3}
15	67.38	.00413	7.99×10^{-3}
16	52.48	.00200	4.69×10^{-3}
17	40.87	.00200	3.91×10^{-3}
18	31.83	9.20×10^{-4}	2.23×10^{-3}
19	24.79	9.20×10^{-4}	1.76×10^{-3}
20	19.30	5.66×10^{-4}	1.08×10^{-3}
21	15.03	4.28×10^{-4}	7.61×10^{-4}
22	11.71	2.17×10^{-4}	4.37×10^{-4}
23	9.119	2.17×10^{-4}	3.39×10^{-4}
24	7.102	1.03×10^{-4}	1.80×10^{-4}
25	5.531	1.03×10^{-4}	1.42×10^{-4}
26	4.307	4.88×10^{-5}	7.24×10^{-5}
27	3.355	4.88×10^{-5}	5.56×10^{-5}
28	2.613	2.31×10^{-5}	2.56×10^{-5}
29	2.035	2.31×10^{-5}	2.41×10^{-5}
30	1.585	1.08×10^{-5}	1.22×10^{-5}
31	1.234	1.08×10^{-5}	1.03×10^{-5}
32	961.1 eV	5.30×10^{-6}	4.64×10^{-6}
33	748.5	5.30×10^{-6}	4.29×10^{-6}
34	582.9	2.43×10^{-6}	1.94×10^{-6}
35	454.0	2.43×10^{-6}	1.67×10^{-6}
36	353.6	1.15×10^{-6}	1.11×10^{-6}
37	275.4	1.15×10^{-6}	7.80×10^{-7}
38	167.0	6.10×10^{-7}	4.06×10^{-7}
39	101.3	6.10×10^{-7}	2.78×10^{-7}
40	61.44	6.10×10^{-7}	1.23×10^{-7}
41	37.27	6.50×10^{-8}	1.99×10^{-8}
42	22.60	6.50×10^{-8}	3.93×10^{-8}
43	13.71	6.50×10^{-8}	1.38×10^{-8}
44	8.315	3.80×10^{-9}	8.07×10^{-10}
45	5.043	3.80×10^{-9}	1.20×10^{-9}
46	3.059	3.80×10^{-9}	1.72×10^{-9}
47	1.855	3.80×10^{-9}	1.18×10^{-9}
48	1.125	3.80×10^{-9}	4.21×10^{-10}
49	0.6176	3.80×10^{-9}	1.37×10^{-10}
50	0.2511	0.0	3.21×10^{-14}

TABLE 5

GROUP STRUCTURE, FISSION FRACTIONS, AND CENTRAL FLUXES
CSEWG BENCHMARK ASSEMBLY ZEBRA-3

Group	Minimum Energy	Fission Fraction	Fractional Flux at Core Center
-	19.64 MeV		-
1	10.00	4.00×10^{-5}	6.87×10^{-6}
2	6.065	.03244	5.35×10^{-3}
3	3.679	.12175	.0203
4	2.231	.21095	.0402
5	1.353	.22301	.0562
6	820.8 KeV	.17277	.0913
7	497.9	.11045	.1517
8	387.7	.03613	.0831
9	302.0	.02662	.0921
10	235.2	.01934	.0820
11	183.2	.01382	.0688
12	142.6	.00978	.0577
13	111.1	.00698	.0563
14	86.52	.00482	.0448
15	67.38	.00344	.0451
16	52.48	.00233	.0294
17	40.87	.00167	.0245
18	31.83	.00107	.0155
19	24.79	7.70×10^{-4}	.0161
20	19.30	5.66×10^{-4}	8.66×10^{-3}
21	15.03	4.28×10^{-4}	4.28×10^{-3}
22	11.71	2.53×10^{-4}	2.85×10^{-3}
23	9.119	1.81×10^{-4}	1.64×10^{-3}
24	7.102	1.20×10^{-4}	8.72×10^{-4}
25	5.531	8.60×10^{-5}	6.15×10^{-4}
26	4.307	5.69×10^{-5}	3.53×10^{-4}
27	3.355	4.07×10^{-5}	2.10×10^{-4}
28	2.613	2.7×10^{-5}	7.16×10^{-5}
29	2.035	1.92×10^{-5}	4.80×10^{-5}
30	1.585	1.26×10^{-5}	1.92×10^{-5}
31	1.234	9.00×10^{-6}	9.80×10^{-6}
32	961.1 eV	6.18×10^{-6}	6.40×10^{-6}
33	748.5	4.42×10^{-6}	3.34×10^{-6}
34	582.9	2.84×10^{-6}	1.68×10^{-6}
35	454.0	2.02×10^{-6}	9.17×10^{-7}
36	353.6	1.34×10^{-6}	6.71×10^{-7}
37	275.4	9.60×10^{-7}	4.52×10^{-7}
38	167.0	6.10×10^{-7}	2.62×10^{-7}
39	101.3	6.10×10^{-7}	8.70×10^{-8}
40	61.44	6.10×10^{-7}	7.93×10^{-8}
41	37.27	6.50×10^{-8}	1.05×10^{-8}
42	22.60	6.50×10^{-8}	1.42×10^{-8}
43	13.71	6.50×10^{-8}	3.14×10^{-9}
44	8.315	3.80×10^{-9}	8.30×10^{-10}
45	5.043	3.80×10^{-9}	2.44×10^{-10}
46	3.059	3.80×10^{-9}	1.26×10^{-9}
47	1.855	3.80×10^{-9}	1.19×10^{-9}
48	1.125	3.80×10^{-9}	4.39×10^{-10}
49	0.6176	3.80×10^{-9}	1.29×10^{-10}
50	0.2511	0.0	3.61×10^{-12}

TABLE 6

GROUP STRUCTURE, FISSION FRACTIONS, AND CENTRAL FLUXES
CSEWG BENCHMARK ASSEMBLY ZPR-6-6A

Group	Minimum Energy	Fission Fraction	Fractional Flux at Core Center
-	19.64 MeV		-
1	10.00	3.00×10^{-5}	2.64×10^{-6}
2	6.065	.0242	2.08×10^{-3}
3	3.679	.10805	.0104
4	2.231	.20298	.0270
5	1.353	.22578	.0427
6	820.8 KeV	.18054	.0569
7	497.9	.11773	.0953
8	387.7	.03890	.0370
9	302.0	.02879	.0539
10	235.2	.01802	.0593
11	183.2	.01802	.0581
12	142.6	.00916	.0604
13	111.1	.00916	.0585
14	86.52	.00452	.0531
15	67.38	.00452	.0522
16	52.48	.00219	.0433
17	40.87	.00219	.0429
18	31.83	7.77×10^{-4}	.0348
19	24.79	7.77×10^{-4}	.0298
20	19.30	7.77×10^{-4}	.0375
21	15.03	7.77×10^{-4}	.0284
22	11.71	2.39×10^{-4}	.0248
23	9.119	2.39×10^{-4}	.0194
24	7.102	1.13×10^{-4}	.0128
25	5.531	1.13×10^{-4}	.0118
26	4.307	5.36×10^{-5}	9.16×10^{-3}
27	3.355	5.36×10^{-5}	5.11×10^{-3}
28	2.613	2.53×10^{-5}	1.18×10^{-3}
29	2.035	2.53×10^{-5}	3.86×10^{-3}
30	1.585	1.19×10^{-5}	7.20×10^{-3}
31	1.234	1.19×10^{-5}	6.94×10^{-3}
32	961.1 eV	5.78×10^{-6}	4.75×10^{-3}
33	748.5	5.78×10^{-6}	3.56×10^{-3}
34	582.9	2.67×10^{-6}	2.37×10^{-3}
35	454.0	2.67×10^{-6}	1.51×10^{-3}
36	353.6	1.26×10^{-6}	9.22×10^{-4}
37	275.4	1.26×10^{-6}	5.30×10^{-4}
38	167.0	6.75×10^{-7}	5.96×10^{-4}
39	101.3	6.75×10^{-7}	1.92×10^{-4}
40	61.44	6.75×10^{-7}	6.02×10^{-5}
41	37.27	7.11×10^{-8}	1.41×10^{-5}
42	22.60	7.11×10^{-8}	2.76×10^{-6}
43	13.71	7.11×10^{-8}	4.84×10^{-7}
44	8.315	4.14×10^{-9}	9.08×10^{-8}
45	5.043	4.14×10^{-9}	1.32×10^{-8}
46	3.059	4.14×10^{-9}	8.00×10^{-9}
47	1.855	4.14×10^{-9}	7.17×10^{-9}
48	1.125	4.14×10^{-9}	4.76×10^{-9}
49	0.6176	4.14×10^{-9}	1.87×10^{-9}
50	0.2511	0.0	6.39×10^{-10}

TABLE 7

GROUP STRUCTURE, FISSION FRACTIONS, AND CENTRAL FLUXES
CSEWG BENCHMARK ASSEMBLY ZPR-6-7

Group	Minimum Energy	Fission Fraction	Fractional Flux at Core Center
-	19.64 MeV		-
1	10.00	4.00×10^{-5}	3.41×10^{-6}
2	6.065	.03244	2.63×10^{-3}
3	3.679	.12175	.0115
4	2.231	.21095	.0275
5	1.353	.22301	.0416
6	820.8 KeV	.17277	.0548
7	497.9	.11045	.0910
8	387.7	.03613	.0353
9	302.0	.02662	.0512
10	235.2	.01934	.0569
11	183.2	.01382	.0555
12	142.6	.00978	.0581
13	111.1	.00698	.0564
14	86.52	.00482	.0516
15	67.38	.00344	.0509
16	52.48	.00233	.0425
17	40.87	.00167	.0425
18	31.83	.00107	.0348
19	24.79	7.70×10^{-4}	.0300
20	19.30	5.66×10^{-4}	.0385
21	15.03	4.28×10^{-4}	.0295
22	11.71	2.53×10^{-4}	.0263
23	9.119	1.81×10^{-4}	.0210
24	7.102	1.20×10^{-4}	.0141
25	5.531	8.60×10^{-5}	.0133
26	4.307	5.69×10^{-5}	.0105
27	3.355	4.07×10^{-5}	5.99×10^{-3}
28	2.613	2.7×10^{-5}	1.38×10^{-3}
29	2.035	1.92×10^{-5}	4.55×10^{-3}
30	1.585	1.26×10^{-5}	8.79×10^{-3}
31	1.234	9.00×10^{-6}	8.94×10^{-3}
32	961.1 eV	6.18×10^{-6}	6.40×10^{-3}
33	748.5	4.42×10^{-6}	5.07×10^{-3}
34	582.9	2.84×10^{-6}	3.83×10^{-3}
35	454.0	2.02×10^{-6}	2.50×10^{-3}
36	353.6	1.34×10^{-6}	1.70×10^{-3}
37	275.4	9.60×10^{-7}	9.95×10^{-4}
38	167.0	6.10×10^{-7}	1.29×10^{-3}
39	101.3	6.10×10^{-7}	4.54×10^{-4}
40	61.44	6.10×10^{-7}	1.13×10^{-4}
41	37.27	6.50×10^{-8}	2.54×10^{-5}
42	22.60	6.50×10^{-8}	1.09×10^{-5}
43	13.71	6.50×10^{-8}	1.62×10^{-6}
44	8.315	3.80×10^{-9}	3.62×10^{-7}
45	5.043	3.80×10^{-9}	4.61×10^{-8}
46	3.059	3.80×10^{-9}	2.96×10^{-8}
47	1.855	3.80×10^{-9}	2.10×10^{-8}
48	1.125	3.80×10^{-9}	4.78×10^{-9}
49	0.6176	3.80×10^{-9}	5.31×10^{-10}
50	0.2511	0.0	3.58×10^{-10}

TABLE 8

GROUP STRUCTURE, FISSION FRACTIONS, AND CENTRAL FLUXES
CSEWG BENCHMARK ASSEMBLY ZPPR-2

Group	Minimum Energy	Fission Fraction	Fractional Flux at Core Center
-	19.64 MeV		-
1	10.00	4.00×10^{-5}	3.42×10^{-6}
2	6.065	.03244	2.64×10^{-3}
3	3.679	.12175	.0115
4	2.231	.21095	.0275
5	1.353	.22301	.0416
6	820.8 KeV	.17277	.0553
7	497.9	.11045	.0915
8	387.7	.03613	.0354
9	302.0	.02662	.0513
10	235.2	.01934	.0571
11	183.2	.01382	.0556
12	142.6	.00978	.0583
13	111.1	.00698	.0565
14	86.52	.00482	.0518
15	67.38	.00344	.0511
16	52.48	.00233	.0426
17	40.87	.00167	.0426
18	31.83	.00107	.0348
19	24.79	7.70×10^{-4}	.0300
20	19.30	5.66×10^{-4}	.0383
21	15.03	4.28×10^{-4}	.0294
22	11.71	2.53×10^{-4}	.0262
23	9.119	1.81×10^{-4}	.0209
24	7.102	1.20×10^{-4}	.0140
25	5.531	8.60×10^{-5}	.0132
26	4.307	5.69×10^{-5}	.0104
27	3.355	4.07×10^{-5}	5.91×10^{-3}
28	2.613	2.7×10^{-5}	1.36×10^{-3}
29	2.035	1.92×10^{-5}	4.45×10^{-3}
30	1.585	1.26×10^{-5}	8.65×10^{-3}
31	1.234	9.00×10^{-6}	8.79×10^{-3}
32	961.1 eV	6.18×10^{-6}	6.21×10^{-3}
33	748.5	4.42×10^{-6}	4.90×10^{-3}
34	582.9	2.84×10^{-6}	3.68×10^{-3}
35	454.0	2.02×10^{-6}	2.38×10^{-3}
36	353.6	1.34×10^{-6}	1.61×10^{-3}
37	275.4	9.60×10^{-7}	9.16×10^{-4}
38	167.0	6.10×10^{-7}	1.15×10^{-3}
39	101.3	6.10×10^{-7}	3.73×10^{-4}
40	61.44	6.10×10^{-7}	8.37×10^{-5}
41	37.27	6.50×10^{-8}	1.83×10^{-5}
42	22.60	6.50×10^{-8}	7.29×10^{-6}
43	13.71	6.50×10^{-8}	8.60×10^{-7}
44	8.315	3.80×10^{-9}	1.93×10^{-7}
45	5.043	3.80×10^{-9}	2.14×10^{-8}
46	3.059	3.80×10^{-9}	1.69×10^{-8}
47	1.855	3.80×10^{-9}	1.29×10^{-8}
48	1.125	3.80×10^{-9}	3.46×10^{-9}
49	0.6176	3.80×10^{-9}	4.70×10^{-10}
50	0.2511	0.0	3.53×10^{-10}

TABLE 9

CENTRAL REACTION RATE RATIOS FROM SPHINX CALCULATIONS

Critical Assembly	Parameter	ETOX (42 group) Diffusion Theory	MINX (50 group) Diffusion Theory	MINX (50 group) Transport Theory (S_n)	Experiment
ZEBRA-3	$\sigma_f^{U238}/\sigma_f^{U235}$	0.0468	0.0468	0.0468	0.0461±0.008
	$\sigma_f^{Pu239}/\sigma_f^{U235}$	1.178	1.178	1.178	1.190±0.014
	$\sigma_f^{Pu240}/\sigma_f^{U235}$	0.385	0.383	0.386	0.373±0.005
ZPR-6-6A[(a)]	$\sigma_f^{U238}/\sigma_f^{U235}$		0.02188		0.02411±0.00072
	$\sigma_c^{U238}/\sigma_f^{U235}$		0.1407		0.1378±0.0041
ZPR-6-7[(a)]	$\sigma_f^{U238}/\sigma_f^{Pu239}$	0.02225	0.02249		0.02236 (1σ=2%)
	$\sigma_c^{U238}/\sigma_f^{Pu239}$	0.1516	0.1519		0.1400 (1σ=2%)
	$\sigma_f^{U235}/\sigma_f^{Pu239}$	1.104	1.105		1.061 (1σ=2%)
ZPPR-2	$\sigma_f^{U238}/\sigma_f^{U235}$	0.0212	0.0214		0.0201±0.004
	$\sigma_f^{Pu239}/\sigma_f^{U235}$	0.9208	0.9200		0.9372±0.0142
	$\sigma_f^{Pu240}/\sigma_f^{U235}$	0.1845	0.1852		0.1704±0.0026

(a) Heterogeneity correction, as specified in ENDF-202, Edition 2, has been applied.

TABLE 10

ONE-DIMENSIONAL CENTRAL WORTH CALCULATIONS USING ENDF/B-IV DATA

CSEWG BENCHMARK CRITICAL ASSEMBLY ZPR-6-7

Material	Central Worths (In-hours/kg)[a] MINX Data Calculation	ETOX Data Calculation	Experiment
Pu-239	192.4	192.3	158
U-235	160.0	159.5	133
U-238	-10.88	-11.07	-10.9
Na-23	- 8.24	- 7.75	- 6.8
Fe	- 5.23	- 5.17	- 4.3
Cr	- 6.88	- 6.67	- 4.5
Ni	- 8.08	- 8.31	- 6.5

(a) A conversion factor of 972.5 In-hours = 1% $\Delta k/k$, as cited in Reference 9, is used. Reference 9 is also the source of the calculated ETOX results and the experimental values.

FIGURE 1

FLOW DIAGRAM OF ARD CALCULATIONS