DATA TESTING
OF
ENDF/B-VI

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MULTIGROUP LIBRARIES FROM NJOY

- MATXS10 uses 30 neutron groups and 12 photon groups spanning the range from thermal to fusion energies. The CLAW thermal+1/E+fission+fusion weight function is used. The Legendre order is P_4, the temperature is 300 K, self-shielding data are not included, and thermal upscatter data are not included.
- MATXS11 uses 80 neutron groups and 24 photon groups spanning the entire energy range. A fast-reactor+fission+fusion weight function is used. The Legendre order is P_5, self-shielding data are given for temperatures from 300 to 4000 K for a range of background cross sections, and thermal upscatter data are not included.
- MATXS12 uses 69 neutron groups and 24 photon groups spanning the energy range from thermal to 10 MeV. A LWR-type thermal+1/E +fission weight function is used. The Legendre order is P_5, self-shielding data are given for a range of temperatures and background cross section values, and thermal upscatter data are included.
- MATXS13 uses 187 neutron groups and 24 photon groups spanning the energy range from thermal to fusion. A smooth thermal+1/E +fission+fusion weight function is used. The Legendre order is P_5, self-shielding data are given for a range of temperatures and background cross section values, and thermal upscatter data are included.

- MATXS14 uses the VITAMIN-J 175-group neutron and 42-group photon structures. The VITAMIN-E thermal+1/E+fission+fusion weight function is used. The Legendre order is P_5, self-shielding data are included for a range of temperatures and background cross sections, and thermal upscatter data are not included.
- MATXS5 uses 30 groups with specifications similar to MATXS10, except ENDF/B-V.2 is used..
- MATXS6 uses 80 groups with specifications similar to MATXS11, except ENDF/B-V.2 is used..
- MATXS7 uses 69 groups with specifications similar to MATXS12, except ENDF/B-V.2 is used..
- MATXS1 uses 30 groups with specifications similar to MATXS10, except ENDF/B-IV is used..
- MATXS3 uses 69 groups with specifications similar to MATXS12, except ENDF/B-IV is used..

MONTE CARLO LIBRARIES FROM NJOY

- ENDF/B-VI.2
- ENDF/B-V.2
- ENDF/B-IV

USE OF GROUP STRUCTURES

Number of groups in each of four important energy ranges: thermal (1×10^{-5} – 4 eV), resonance (4 eV – 50 keV), fast (50 keV – 10 MeV), and fusion (10 MeV – 20 MeV).

Structure	Thermal	Resonance	Fast	Fusion
30	5	9	11	5
69	42	17	10	0
80	5	44	25	6
175	12	51	95	17
187	55	77	41	14

- The 69-group and 187-group structures are the only ones appropriate for thermal benchmarks.
- The 30-group, 80-group, 187-group, and 175-group libraries can all be used for fast-spectrum critical systems.
- The 30-group libraries are not suitable for problems where the resonance range is important.
- The 69-group libraries are not suitable for fusion problems.

METHODS

- MATXS and TRANSX transport tables.
  - mixing
  - self-shielding
  - narrow-resonance equivalance theory
  - fission source iteration
  - thermal upscatter
- ONEDANT and TWODANT S_N transport.
  - 1-D spherical
  - 1-D cylindrical with buckling
  - 2-D
  - MACRXS interace
- MCNP Monte Carlo code.

JEZEBEL

- Bare sphere of "clean" plutonium of radius 6.385 cm.
- ONEDANT calculation using 80 groups, P_3 transport-corrected cross sections, S_{16} quadrature, and 40 mesh intervals.

Quantity	Experiment	C/E VI	C/E V
k-eff	1.000±.002	.9989	.9982
$\sigma_f(^{238}U)/\sigma_f(^{235}U)$	0.2133±.0023	.975	.961
$\sigma_f(^{233}U)/\sigma_f(^{235}U)$	1.578±.027	1.000	.985
$\sigma_f(^{237}Np)/\sigma_f(^{235}U)$	.9835±.014	.970	.979
$\sigma_f(^{239}Pu)/\sigma_f(^{235}U)$	1.4609±.013	.975	.966

JEZEBEL CONTINUED

Effects of group structure

Quantity	30 groups	80 groups	187 groups	175 groups
uncorr. k-eff	.9970	.9974	.9968	.9966
k-eff	.9988	.9989	.9987	.9986
$\sigma_f(^{238}U)/\sigma_f(^{235}U)$	.969	.975	.977	.977
$\sigma_f(^{233}U)/\sigma_f(^{235}U)$	.998	1.000	1.000	1.000
$\sigma_f(^{237}Np)/\sigma_f(^{235}U)$	.967	.970	.970	.970
$\sigma_f(^{239}Pu)/\sigma_f(^{235}U)$	.972	.975	.975	.975

Effects of different angular treatment (80 groups)

Quantity	P_1/S_{16}	P_3/S_{16}	P_3/S_8	P_3/S_{32}
k-eff	.9988	.9989	1.0015	.9981
$\sigma_f(^{238}U)/\sigma_f(^{235}U)$	.974	.974	.975	.974
$\sigma_f(^{233}U)/\sigma_f(^{235}U)$	1.000	1.000	1.000	1.000
$\sigma_f(^{237}Np)/\sigma_f(^{235}U)$	.970	.970	.970	.970
$\sigma_f(^{239}Pu)/\sigma_f(^{235}U)$	.975	.975	.975	.975

GODIVA

- Bare sphere of enriched uranium metal of radius 8.741 cm.
- ONEDANT calculation using 80 groups, P_3 transport-corrected cross sections, S_{16} quadrature, and 40 mesh intervals.

Quantity	Experiment	C/E VI	C/E V
k-eff	1.000±.002	.9983	.9990
$\sigma_f(^{238}U)/\sigma_f(^{235}U)$	0.1643±.0018	.971	1.038
$\sigma_f(^{233}U)/\sigma_f(^{235}U)$	1.59±.03	1.000	.986
$\sigma_f(^{237}Np)/\sigma_f(^{235}U)$	.8516±.012	.960	1.044
$\sigma_f(^{239}Pu)/\sigma_f(^{235}U)$	1.4152±.014	.977	.985

- 30-group and Monte Carlo results

Quantity	ENDF/V-VI	ENDF/B-V	ENDF/B-IV
30-g k-eff	0.9982	.9995	1.0071
MC k-eff	.9963±.0006	.9985±.0009	1.0061±.0006

JEZEBEL-23

- Bare sphere of enriched ^{233}U metal (98.13%) with radius 5.983 cm.
- ONEDANT calculation using 80 groups, P_3 transport-corrected cross sections, S_{16} quadrature, and 40 mesh intervals.

Quantity	Experiment	C/E VI	C/E V
k-eff	1.000±.001	.9940	.9940
$\sigma_f(^{238}U)/\sigma_f(^{235}U)$	0.2131±.0026	1.009	.996
$\sigma_f(^{237}Np)/\sigma_f(^{235}U)$	.9970±.015	.987	.993

JEZEBEL-PU

- Bare sphere of plutonium metal containing 20.1% ^{240}Pu of radius 6.65985 cm.
- ONEDANT calculation using 80 groups, P_3 transport-corrected cross sections, S_{16} quadrature, and 40 mesh intervals.

Quantity	Experiment	C/E VI	C/E V
k-eff	1.000±.002	.9981	.9983
$\sigma_f(^{238}U)/\sigma_f(^{235}U)$	0.2071±.0021	.959	.945
$\sigma_f(^{237}Np)/\sigma_f(^{235}U)$	.9365±.011	.996	1.007

Earlier calculations of this assembly used a radius of 6.599 (evidently a misprint in ENDF-202) and got k_{eff} values of about 0.992.

FLATTOP-25

- Spherical system consisting of a highly enriched uranium core in a thick natural uranium reflector.
- The core radius is 6.116 cm and the outer radius of the reflector is 24.13 cm.
- ONEDANT calculation using 80 groups, P_3 transport-corrected cross sections, S_{16} quadrature, 40 mesh intervals in the core, and 20 mesh intervals in the reflector.

Quantity	Experiment	C/E VI	C/E V
k-eff	1.000±.001	1.0030	1.0054
$\sigma_f(^{238}U)/\sigma_f(^{235}U)$	0.1492±.0016	.977	1.034
$\sigma_f(^{233}U)/\sigma_f(^{235}U)$	1.608±.003	.989	.975
$\sigma_f(^{237}Np)/\sigma_f(^{235}U)$	.7804±.010	.979	1.054
$\sigma_f(^{239}Pu)/\sigma_f(^{235}U)$	1.3847±.012	.983	.989

- 30-group and Monte Carlo results

Quantity	ENDF/V-VI	ENDF/B-V	ENDF/B-IV
30-g k-eff	1.0019	1.0024	1.0098
MC k-eff	1.0020±.0007	1.0049±.0009	1.0091±.0007

FLATTOP-PU

- Spherical system consisting of a plutonium core in a thick natural uranium reflector.
- The radius of the core is 4.533 cm and the outer radius of the reflector is 24.13 cm.
- ONEDANT calculation using 80 groups, P_3 transport-corrected cross sections, S_{16} quadrature, 40 mesh intervals in the core, and 20 mesh intervals in the reflector.

Quantity	Experiment	C/E VI	C/E V
k-eff	1.000±.0014	1.0055	1.0050
$\sigma_f(^{238}U)/\sigma_f(^{235}U)$	0.1799±.0020	.984	.974
$\sigma_f(^{237}Np)/\sigma_f(^{235}U)$	.8561±.012	.987	1.002

FLATTOP-23

- Spherical metallic system consisting of a ^{233}U (98.13%) core in a thick natural uranium reflector.
- The radius of the core is 4.610 cm, there is a 0.218 cm gap between the core and the reflector, and the outer radius of the reflector is 24.13 cm.
- ONEDANT calculation using 80 groups, P_3 transport-corrected cross sections, S_{16} quadrature, 40 mesh intervals in the core, and 20 mesh intervals in the reflector.

Quantity	Experiment	C/E VI	C/E V
k-eff	1.000±.0014	1.0041	1.0041
$\sigma_f(^{238}U)/\sigma_f(^{235}U)$	0.1916±.0021	1.002	.988
$\sigma_f(^{237}Np)/\sigma_f(^{235}U)$	.9103±.013	.996	1.002

BIGTEN

- Cylindrical assembly.
- Core is made up of interleaved plates of highly enriched uranium and depleted uranium such that the average ^{235}U content is a uniform 10 wt%.
- The core is surrounded by a depleted uranium reflector.
- CSEWG spherical model for this system is a core of radius 30.48 cm and a reflector with an outer radius of 45.72 cm.
- Self-shielding modeled with mixture and escape effects.
- ONEDANT calculations using 80 groups, P_3 transport-corrected cross sections, S_{16} quadrature, 40 mesh intervals in the core, and 20 mesh intervals in the reflector.

BIGTEN CONTINUED

Without self-shielding

Quantity	Experiment	C/E VI	C/E V
k-eff	.996±.003	1.0041	1.0038
$\sigma_f(^{238}U)/\sigma_f(^{235}U)$	.03739±.00034	1.057	1.073
$\sigma_f(^{233}U)/\sigma_f(^{235}U)$	1.580±.030	.996	.987
$\sigma_f(^{237}Np)/\sigma_f(^{235}U)$	.3223±.0039	1.051	1.113
$\sigma_f(^{239}Pu)/\sigma_f(^{235}U)$	1.1936±.0084	.989	.998
$\sigma_\gamma(^{238}U)/\sigma_f(^{235}U)$	.110±.003	.986	1.001

With self-shielding

Quantity	Experiment	C/E VI SS	C/E V SS
k-eff	.996±.003	1.0105	1.0093
$\sigma_f(^{238}U)/\sigma_f(^{235}U)$	.03739±.00034	1.048	1.065
$\sigma_f(^{233}U)/\sigma_f(^{235}U)$	1.580±.030	.995	.986
$\sigma_f(^{237}Np)/\sigma_f(^{235}U)$	.3223±.0039	1.044	1.106
$\sigma_f(^{239}Pu)/\sigma_f(^{235}U)$	1.1936±.0084	.986	.996
$\sigma_\gamma(^{238}U)/\sigma_f(^{235}U)$	.110±.003	.943	.965

BIGTEN CONTINUED

- Effects of using different group structures (without self-shielding).

Quantity	30 groups	80 groups	175 groups
k-eff	.9992	1.0041	1.0034
$\sigma_f(^{238}U)/\sigma_f(^{235}U)$	1.071	1.057	1.053
$\sigma_f(^{233}U)/\sigma_f(^{235}U)$	.994	.996	.997
$\sigma_f(^{237}Np)/\sigma_f(^{235}U)$	1.106	1.051	1.051
$\sigma_f(^{239}Pu)/\sigma_f(^{235}U)$	.989	.989	.991
$\sigma_\gamma(^{238}U)/\sigma_f(^{235}U)$	1.010	.986	.983

- Two-D results using TWODANT, 80 groups, P_3 transport-corrected cross sections, and S_{16} quadrature.
- The radial mesh used 40 divisions in the core region and 20 divisions in the reflector.
- The axial mesh used 40 divisions in the core and 20 in the reflector. No self shielding was done.
- Reaction-rate ratios were computed using the central flux in the core region.

Quantity	C/E 1-D	C/E 2-D
k-eff	1.0041	1.0018
$\sigma_f(^{238}U)/\sigma_f(^{235}U)$	1.057	1.060
$\sigma_f(^{233}U)/\sigma_f(^{235}U)$	.996	.997
$\sigma_f(^{237}Np)/\sigma_f(^{235}U)$	1.051	1.054
$\sigma_f(^{239}Pu)/\sigma_f(^{235}U)$	.989	.990
$\sigma_\gamma(^{238}U)/\sigma_f(^{235}U)$	.986	.986

BIGTEN ACTIVATION RATIOS

Quantity	Experiment	C/E VI SS	C/E VI	C/E V
^{10}B(n,α)	1.011$\pm$.014	.904	.899	.845
^{27}Al(n,α)	.000078$\pm$.000002	1.087	1.097	1.066
^{45}Sc(n,γ)	.0132$\pm$.0003	1.085	1.075	1.032
^{46}Ti(n,p)	.00130$\pm$.00003	.953	.962	.963
^{47}Ti(n,p)	.00215$\pm$.00009	1.221	1.231	1.244
^{48}Ti(n,p)	.000036$\pm$.000001	.914	.922	.897
^{54}Fe(n,p)	.0090$\pm$.0003	1.018	1.0027	1.036
^{58}Fe(n,γ)	.0031$\pm$.0001	1.114	1.491	.820
^{58}Ni(n,p)	.0123$\pm$.0002	1.003	1.012	.997
^{59}Co(n,γ)	.0095$\pm$.0002	.830	.899	.954
^{63}Cu(n,γ)	.0164$\pm$.0010	.906	1.063	.975
^{197}Au(n,γ)	.167$\pm$.003	.954	.953	.920

ZPR-6/7

- Large uniform dilute plutonium oxide fueled cylindrical core with a single-drawer unit cell and a fully depleted uranium blanket.
- One-dimensional spherical model has a core radius of 88.16 cm and a blanket thickness of 33.81 cm.
- ONEDANT results using 80 groups, P_0 transported-corrected cross sections, S_8 quadrature, 40 points in the core region, and 20 points in the reflector region.
- The standard ANL corrections (including streaming) were applied.

Quantity	Experiment	Correction	C/E VI	C/E V
k-eff	1.000	$-.0136$	1.0070	.9997
$\sigma_f(^{238}U)/\sigma_f(^{239}Pu)$	$0.02336 \pm .0005$	$\times 1.030$	1.023	1.021
$\sigma_f(^{235}U)/\sigma_f(^{239}Pu)$	$1.061 \pm .021$	$\times$ .989	1.037	1.020
$\sigma_\gamma(^{238}U)/\sigma_f(^{239}Pu)$	$0.1400 \pm .003$	$\times 1.023$	1.057	1.082

ZPR-6/6A

- Similar to Assembly 7 except uranium fueled.
- Spherical model uses a core radius of 95.67 cm and a blanket thickness of 30.65 cm.
- ONEDANT calculation used 80 groups, P_0 transported-corrected cross sections, S_8 quadrature, 40 points in the core region, and 20 points in the reflector region.
- Standard ANL correction used (including streaming).

Quantity	Experiment	Correction	C/E VI	C/E V
k-eff	1.000	$-.0043$	1.0063	.9894
$\sigma_{\rm f}(^{238}{\rm U})/\sigma_{\rm f}(^{235}{\rm U})$	$0.02411\pm.00072$	$\times1.016$	.968	.980
$\sigma_{\gamma}(^{238}{\rm U})/\sigma_{\rm f}(^{235}{\rm U})$	$0.1378\pm.0041$	$\times1.011$	1.003	1.042

AQUEOUS URANIUM CRITICALS

- Unreflected spheres from the ORNL series containing ^{235}U in the form of uranyl nitrate dissolved in water (ORNL-1, ORNL-2, ORNL-10).
- High-leakage spheres using uranyl fluoride solutions (L7, L8, L9).

Assembly	Exp k	VI 187	V 187	VI 69	V 69	IV 69
ORNL-1	1.00026	0.9969	1.0003	0.9984	1.0020	1.0012
ORNL-2	0.99975	0.9967	1.0000	0.9982	1.0017	1.0009
ORNL-10	1.00031	0.9972	1.0000	0.9979	1.0009	0.9969
L7	1.0000	1.0050	1.0069	1.0015	1.0091	1.0182
L8	1.0000	1.0044	1.0082		1.0134	1.0114
L9	1.0000	1.0025	1.0060		1.0089	1.0057

AQUEOUS PLUTONIUM CRITICALS

- Unreflected spheres of plutonium nitrate solution.

Assembly	Exp k	VI 187	V 187	VI 69	V 69
PNL-1	1.0000	1.0087	1.0166	1.0110	1.0202
PNL-2	1.0000	1.0037	1.0092	1.0031	1.0114
PNL-3	1.0000	0.9904	0.9978	0.9923	1.0007
PNL-4	1.0000	0.9971	1.0049	0.9983	1.0076

The scatter in the results for the aqueous plutonium criticals has always been very large, probably because of inadequacies in the descriptions of the experiments.

TRX LATTICES

- Triangular arrays of slightly-enriched metallic uranium rods in a water moderator.
- Modeled as an infinite lattice of pin cells.
- Results homogenized and used for a full-core calculation with cylindrical geometry and a buckling height.
- ONEDANT runs used P_1 consistent-P cross sections, S_8 quadrature, and 69 groups.
- Cell calculations used 17 points in the fuel, 3 in the void, 3 in the clad, and 17 points in the moderator.
- Assembly calculation used 30 points in the core and 30 in the reflector.

Quantity	Experiment	C/E 69 VI	C/E 187 VI	C/E 69 V	C/E 187 V
k-∞		1.1789	1.1822	1.1791	1.1829
k-eff	1.000	.9869	.9892	.9881	.9903
ρ^{28}	1.320$\pm$.021	1.033	1.023	1.040	1.032
δ^{25}	0.0987$\pm$.0010	.9993	1.004	1.013	1.018
δ^{28}	0.0946$\pm$.0041	1.021	1.036	1.021	1.037
C*	.797$\pm$.008	1.003	1.000	1.007	1.003

- ρ^{28} is the ratio of epithermal-to-thermal ^{238}U captures.
- δ^{25} is the ratio of epithermal-to-thermal ^{235}U fissions.
- δ^{28} is the ratio of ^{238}U fissions to ^{235}U fissions.
- C^* is the ratio of ^{238}U captures to ^{235}U fissions.

TRX-2

TRX-2 run parameters were the same as for TRX-1.

Quantity	Experiment	C/E 69 VI	C/E 187 VI	C/E 69 V	C/E 187 V
k-∞		1.1652	1.1667	1.1664	1.1684
k-eff	1.000	.9891	.9910	.9912	.9936
ρ^{28}	0.837$\pm$.016	1.010	1.005	1.016	1.013
δ^{25}	0.0614$\pm$.0008	.985	.989	.998	1.002
δ^{28}	0.0693$\pm$.0035	.986	1.002	.985	1.001
C*	.647$\pm$.006	.992	.992	.995	.993

BAPL-1

- Triangular lattice of slightly-enriched uranium oxide rods in a water moderator.
- Analyzed using the methods used for the TRX lattices.

Quantity	Experiment	C/E 69 VI	C/E 187 VI	C/E 69 V	C/E 187 V
k-∞		1.1460	1.1462	1.1475	1.1483
k-eff	1.000	.9949	.9953	.9970	.9976
ρ^{28}	1.39$\pm$.01	1.003	1.003	1.007	1.010
δ^{25}	0.084$\pm$.002	.986	.993	1.000	1.006
δ^{28}	0.078$\pm$.004	.954	.970	.952	.968

- ρ^{28} is the ratio of epithermal-to-thermal ^{238}U captures.
- δ^{25} is the ratio of epithermal-to-thermal ^{235}U fissions.
- δ^{28} is the ratio of ^{238}U fissions to ^{235}U fissions.

Monte Carlo *vs* 69-group results

Quantity	ENDF/B-VI	ENDF/B-IV
69-g k-∞	1.1460	1.1331
MC k-∞	1.1400$\pm$.0017	1.1333$\pm$.0017

BAPL-2 AND BAPL-3

- Results for BAPL-2

Quantity	Experiment	C/E 69 VI	C/E 187 VI	C/E 69 V	C/E 187 V
k-∞		1.1498	1.1497	1.1516	1.1520
k-eff	1.000	.9959	.9962	.9982	.9991
ρ^{28}	1.12$\pm$.01	1.032	1.035	1.036	1.042
δ^{25}	0.068$\pm$.001	.993	.999	1.007	1.013
δ^{28}	0.070$\pm$.004	.912	.927	.911	.926

- Results for BAPL-3

Quantity	Experiment	C/E 69 VI	C/E 187 VI	C/E 69 V	C/E 187 V
k-∞		1.1352	1.1348	1.1374	1.1374
k-eff	1.000	.9974	.9973	1.0001	1.0000
ρ^{28}	0.906$\pm$.01	1.000	1.004	1.003	1.011
δ^{25}	0.052$\pm$.001	.998	1.003	1.012	1.017
δ^{28}	0.057$\pm$.003	.916	.933	.914	.932