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A COMPARISON OF WIMS-D4 AND WIMS-D4m GENERATED CROSS -SECTION DATA WITH MONTE CARLO*

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ABSTRACT

Cross-section and related data generated by a modified version of the WIMS-D4 code for both plate and rod type research reactor fuel are compared with Monte Carlo data from the VIM code. The modifications include the introduction of a capability for generating broad group microscopic data and to write selected microscopic cross-sections to an ISOTXS file format. The original WIMS-D4 library with H in ZrH, and ^{166}Er and ^{167}Er added gives processed microscopic cross-section data that agree well with VIM ENDF/B-V based data for both plate and TRIGA cells. Additional improvements are in progress including the capability to generate an ENDF/B-V based library

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Introduction

The WIMS-D4 code[1] has been modified to improve the performance for research reactor applications and to produce microscopic cross-sections that interface with current codes. This code has been used to generate cross-section data for both pin and plate type research reactor fuels. These data are compared with Monte Carlo data from the continuous energy VIM code.[2]

The Codes and Libraries

The original WIMS-D4 code and library were obtained from the Oak Ridge Radiation Shielding Information Center (RSIC). The library contained 101 isotopes with 69 energy group data. This version of the code uses a single spatial mesh point for each region (fuel, clad, coolant and moderator) with the full 69 energy groups in the initial collision probability solution. This coarse spatial flux is used for the resonance evaluation. These 69 group macroscopic cross-sections are then collapsed over each region to a selected intermediate group structure. These intermediate group data are used to compute a detailed spatial flux, eigenvalue, reaction rates,

and to collapse to the selected broad group structure (usually ~2-8 groups). The code gives macroscopic cross-sections for each region and a set of cell averaged data. The code is capable of treating multicell and cluster models (with rods or plates). The code also uses the 69 group coarse spatial flux to collapse regional microscopic cross-sections to the intermediate group structure

The use of this initial flat flux approximation to obtain broad group microscopic data can give poor results for a thick moderator, the extra region in a super-cell model, and for high absorption regions. The WIMS-D4m version[3] of the code introduces a broad group structure for use in the spatial averaging. The detailed spatial flux in the intermedate group structure is used for this purpose. This step is done for the user requested isotopes after the intermediate group averaging of the microscopic cross-sections. The broad group microscopic cross-sections may be burnup dependent and averaged over multiple sets of edit cells (groups of regions). These microscopic data are written in the binary ISOTXS format[4] in order to be compatible with many of the neutronics codes in the USA .

The original WIMS library has been augmented to include data for hydogen in ZrH and the isotopes ^{166}Er and ^{167}Er for TRIGA reactor applications. This library is based on data generated in the United Kingdom and not ENDF/B data. A comparison of selected data has found that the WIMS data falls somewhat between the ENDF/B versions IV and V data.

The VIM code uses ENDF/B data to provide a continuous energy Monte Carlo solution for generalized geometry neutron eigenvalue and fixed source problems. These VIM data for this study are based on ENDF/B version V data. The VIM results are used here as a standard for comparison of WIMS data. The solutions in each case include 2,000,000 neutron histories to give eigenvalues with standard deviations of ± 0.0005. The microscopic cross-section data are tallied to match the broad group structure of the WIMS model and have uncertainies of less than $\pm 0.5\%$ in all cases and less than $\pm 0.1\%$ in most cases.

Plate Type Model

The original IAEA benchmark geometry[5] has been selected as the basis for the plate type reactor comparisons. Many research institutions have experience in computing cross-section data in this three energy group model. The specified models for the standard and control super-cell were used for both the HEU and LEU fuels. The HEU case has the specified loading of 12.17 g ^{235}U/plate with UAl_x-Al fuel. The LEU case uses U_3Si_2-Al in a DOE standard fuel plate with a loading of 12.50 g ^{235}U/ plate. The HEU super-cell WIMS data are compared with the available data from the earlier cases in Table I.

The VIM comparisons for the absorption rates and k-infinity results are shown in Table II. Table III provides a comparison of some of the microscopic data averaged over the unit cell. The agreement for absorption rates is excellent, while the WIMS k-infinity for HEU shows a bias of almost -0.7%. In Table III, the three group spectra show some small differences with the largest for group 1 of the standard HEU cell at -2.2%. The microscopic cross-section data also show some

variations from the VIM data with the largest difference of -5.4% for the resonance group (2) in the LEU standard cell. This suggests that the library data and/or resonance treatment could be improved for WIMS.

Table I. IAEA HEU Benchmark Comparison

		Super-cell Data	
	g	WIMS	EPRI-CELL
U-235 Absorption	1	1.877	1.727
	2	39.36	39.24
	3	427.0	422.8
U-235 Fisson	1	1.602	1.453
	2	25.81	25.99
	3	362.9	360.5
U-238 Absorption	1	0.371	0.345
	2	26.94	27.14
	3	1.805	1.769
U-238 Fission	1	0.195	0.180
	2	0	0
	3	0	0

Table II. Relative Absorption Rates -Plate Cells

	HEU Element				LEU Element			
	Standard		Control		Standard		Control	
Isotope	WIMS	VIM	WIMS	VIM	WIMS	VIM	WIMS	VIM
U-235	0.8587	0.8596	0.8147	0.8146	0.8025	0.8018	0.7768	0.7757
U-238	0.0046	0.0045	0.0032	0.0031	0.0813	0.0837	0.0644	0.0662
Al	0.0452	0.0437	0.0464	0.0457	0.0362	0.0348	0.0382	0.0374
Si	-----	-----	-----	-----	0.0008	0.0008	0.0007	0.0007
O	0.0027	0.0022	0.0029	0.0024	0.0026	0.0022	0.0029	0.0023
H	0.0889	0.0900	0.1329	0.1342	0.0765	0.0770	0.1170	0.1178
k-inf.	1.7352	1.7468	1.6580	1.6678	1.6283	1.6356	1.5858	1.5926
± 1 Sigma		0.0005		0.0005		0.0005		0.0005
Diff., %	-0.664		-0.588		-0.446		-0.427	

TRIGA Models

The TRIGA fuel designs and fuel types are characterized in Table IV with HEU FLIP fuel and two LEU fuels, referred to as 20-20 and 20-30. The single rod element is typical of the standard Mark series design, while the four rod element is typical of conversions where plate type fuel was replaced with TRIGA fuel. The broad group energy structure chosen for this comparison is shown in Table V, and matches as closely as possible the standard seven group set used by General Atomic (GA)[6] for most neutronic analyses.

Table III. Few Group Spectra and Microscopic Cross-sections - Plate Cells

	HEU Element				LEU Element			
	Standard		Control		Standard		Control	
g	WIMS	VIM	WIMS	VIM	WIMS	VIM	WIMS	VIM
Spectra Data								
1	0.5206	0.5322	0.4783	0.4760	0.5393	0.5383	0.4959	0.4946
2	0.2617	0.2583	0.2398	0.2364	0.2630	0.2595	0.2431	0.2394
3	0.2177	0.2095	0.2819	0.2876	0.1978	0.2022	0.2610	0.2660
U-235 Absorption Data								
1	1.868+0	1.739+0	1.869+0	1.741+0	1.870+0	1.740+0	1.869+0	1.741+0
2	3.937+1	3.997+1	4.008+1	4.050+1	3.859+1	3.922+1	3.939+1	3.988+1
3	4.299+2	4.198+2	4.572+2	4.474+2	4.223+2	4.122+2	4.506+2	4.405+2
U-235 Fission Data								
1	1.596+0	1.465+0	1.602+0	1.472+0	1.597+0	1.465+0	1.602+0	1.471+0
2	2.582+1	2.639+1	2.625+1	2.671+1	2.532+1	2.600+1	2.581+1	2.641+1
3	3.654+2	3.579+2	3.889+2	3.817+2	3.588+2	3.514+2	3.833+2	3.758+2
U-238 Absorption Data								
1	3.728-1	3.532-1	3.783-1	3.598-1	3.705-1	3.512-1	3.765-1	3.584-1
2	2.650+1	2.664+1	2.713+1	2.731+1	6.961+0	7.357+0	7.991+0	8.421+0
3	1.817+0	1.763+0	1.919+0	1.865+0	1.788+0	1.735+0	1.894+0	1.839+0
Al Absorption Data								
1	4.550-3	4.292-3	4.712-3	4.531-3	4.539-3	4.280-3	4.698-3	4.512-3
2	1.704-2	1.074-2	1.712-2	1.087-2	1.687-2	1.046-2	1.699-2	1.065-2
3	1.560-1	1.520-1	1.652-1	1.610-2	1.539-1	1.498-1	1.636-1	1.591-1
H Absorption Data								
1	2.074-6	9.382-5	2.040-6	9.221-5	2.082-6	9.405-5	2.046-6	9.246-5
2	1.417-2	1.453-2	1.436-2	1.474-2	1.378-2	1.412-2	1.407-2	1.441-2
3	2.353-1	2.309-1	2.501-1	2.456-1	2.322-1	2.278-1	2.477-1	2.431-1

Table IV. TRIGA Fuel Design Data

Design Parameters		
Fuel Element	Single Rod	Four Rods
Element Geometry	Hexagonal	Square
Fuel Rod Pitch, cm	4.250 (hex.)	3.886 (square)
Central Zr Rod OD, cm	0.635	0.457
Fuel Pellet OD, cm	3.632	3.482
Fuel Rod OD, cm	3.734	3.584

Fuel	Specifications		
FLIP	Er in Pellet, w/o	1.6	1.5
	Fuel Enrichment ^{235}U, w/o	70.0	70.0
	U in Pellet, w/o	8.5	8.5
	^{235}U Loading/rod, g	135.0	126.0
LEU20	Er in Pellet, w/o	0.50	0.4
(20-20)	Fuel Enrichment ^{235}U, w/o	19.75	19.75
	U in Pellet, w/o	20.0	20.0
	^{235}U Loading/rod, g	98.0	91.0
LEU30	Er in Pellet, w/o	0.90	0.84
(20-30)	Fuel Enrichment ^{235}U, w/o	19.75	19.75
	U in Pellet, w/o	30.0	30.0
	^{235}U Loading/rod, g	161.0	150.0

Table V. Broad Group Energy Structure -TRIGA

	Upper Bound of Energy Group, eV	
g	WIMS/VIM	GA
1	1.000+7	1.49+7
2	5.000+5	6.08+5
3	9.118+3	9.12+3
4	1.123	1.125
5	0.400	0.420
6	0.140	0.140
7	0.050	0.050

Table VI. Relative Absorption Rates - Single Rod TRIGA

	HEU		LEU 20		LEU 30	
Isotope	WIMS	VIM	WIMS	VIM	WIMS	VIM
U-235	0.6752	0.6787	0.6939	0.6974	0.6754	0.6774
U-238	0.0272	0.0281	0.0925	0.0935	0.1119	0.1132
Er166	0.0101	0.0105	0.0045	0.0046	0.0065	0.0067
Er167	0.1988	0.1986	0.0930	0.0924	0.1263	0.1269
H in ZrH	0.0196	0.0197	0.0271	0.0272	0.0147	0.0148
H in H2O	0.0191	0.0189	0.0254	0.0251	0.0167	0.0162
Zr in ZrH	0.0252	0.0208	0.0278	0.0231	0.0225	0.0182
Fe	0.0145	0.0144	0.0194	0.0192	0.0125	0.0122
Cr	0.0050	0.0051	0.0067	0.0067	0.0043	0.0043
Ni	0.0037	0.0036	0.0049	0.0047	0.0032	0.0031
O	0.0009	0.0007	0.0009	0.0007	0.0009	0.0008
k-inf.	1.3260	1.3400	1.3922	1.4087	1.3383	1.3508
± 1 Sigma		0.0005		0.0005		0.0005
Diff., %	-1.045		-1.171		-0.925	

Table VII. Relative Absorption Rates - Four Rod TRIGA

	HEU		LEU 20		LEU 30	
Isotope	WIMS	VIM	WIMS	VIM	WIMS	VIM
U-235	0.6857	0.6872	0.7017	0.7039	0.6857	0.6873
U-238	0.0263	0.0270	0.0890	0.0893	0.1084	0.1088
Er166	0.0093	0.0095	0.0039	0.0039	0.0059	0.0061
Er167	0.1856	0.1844	0.0814	0.0804	0.1162	0.1159
H in ZrH	0.0200	0.0201	0.0286	0.0287	0.0150	0.0151
H in H2O	0.0232	0.0256	0.0303	0.0326	0.0202	0.0222
Zr in ZrH	0.0238	0.0202	0.0277	0.0233	0.0218	0.0176
Fe	0.0154	0.0153	0.0206	0.0203	0.0133	0.0131
Cr	0.0053	0.0054	0.0071	0.0071	0..0046	0.0046
Ni	0.0039	0.0038	0.0052	0.0050	0.0034	0.0033
O	0.0010	0.0008	0.0009	0.0008	0.0010	0.0010
k-inf.	1.3507	1.3616	1.4116	1.4254	1.3622	1.3732
± 1 Sigma		0.0005		0.0005		0.0005
Diff., %	-0.801		-0.968		-0.801	

The relative absorption rates and k-infinity comparisons are given in Tables VI and VII. The agreement for absorption rates is generally very good with the worst agreement for absorption of Zr in ZrH. The WIMS library has only data for elemen al Zr, while VIM has specific data for Zr in ZrH. Although the contribution is small, the addition of these data to the WIMS library would be an improvement. The largest bias is -1.2% for the LEU20 single rod cell. The four rod cell bias is less than 1.0% in all cases. The results for both types of TRIGA cells are very similar.

Tables VIII and IX provide a comparison of the spectra and selected microscopic cross-section data for both types of TRIGA cells. Again these results are very similar for the two cell types. The differences in pitch and rod size are apparently not a factor. The fuel to coolant ratios are very similar for the two cases. One could probably generate one set of microscopic data for use with both cell designs.

The spectra for the TRIGA cases are fairly hard. In this seven group structure, the resonance energy group for ^{238}U is group three. The two highest energy groups contain almost 60% of the neutrons, while the lowest groups (4-7) contain only about 13%. When these percentages are compared with the plate cases in Table III, one sees that the TRIGA spectra are considerably harder. This is largely due to the significant absorption in ^{167}Er over the resonance and lower energy range (see groups 3-7 in Table VIII and IX).

The microscopic cross-section data show more variation for the TRIGA cells with a larger number of energy groups, but the agreement is still fairly good. While the absorption in group 2 shows some significant variations for both ^{235}U and ^{238}U, the overall absorption rates in Tables VI and VII agree very well. The TRIGA cases also show WIMS with a lower resonance absorption for ^{238}U in the LEU fuels. The single rod cases are about 4% lower, while the four rod cells are less than 3% under the VIM values.

Conclusions

The WIMS data for both plate type and TRIGA type cells agree reasonably well with the corresponding VIM Monte Carlo ENDF/B-V data. Given that the cross-section libraries for the two codes are not based on the same evaluations, some differences should be expected. The k-infinities for the super-cells show a negative bias in all of the WIMS cases ranging from -0.4 to -1.2% with the plate cases showing a smaller bias.

The reaction rate data for absorption in the plate cases show excellent agreement. The TRIGA cases also show good agreement with the exception of Zr in ZrH. The WIMS library does not have data for Zr in ZrH corresponding to the VIM data. The absorption rate attributed to Zr is only about 2% of the total for the cell, and thus these differences are not a significant concern. The addition of these data to the WIMS library is still recommended.

Table VIII. Few Group Spectra and Microscopic Cross-sections -Single Rod TRIGA

	HEU		LEU 20		LEU 30	
g	WIMS	VIM	WIMS	VIM	WIMS	VIM
Spectra Data						
1	0.3462	0.3554	0.3274	0.3363	0.3522	0.3687
2	0.2359	0.2323	0.2278	0.2240	0.2483	0.2489
3	0.2900	0.2778	0.2737	0.2681	0.2835	0.2825
4	0.0255	0.0246	0.0272	0.0274	0.0244	0.0251
5	0.0278	0.0299	0.0324	0.0336	0.0256	0.0270
6	0.0430	0.0498	0.0665	0.0675	0.0406	0.0417
7	0.0316	0.0302	0.0450	0.0430	0.0254	0.0245
U-235 Absorption Data						
1	1.361+0	1.332+0	1.363+0	1.333+0	1.363+0	1.333+0
2	2.416+0	2.143+0	2.417+0	2.145+0	1.918+0	2.143+0
3	3.258+1	3.314+1	3.318+1	3.365+1	3.095+1	3.168+1
4	7.541+1	7.481+1	7.881+1	7.992+1	7.589+1	7.709+1
5	2.004+2	1.988+2	2.067+2	2.080+2	1.985+2	1.998+2
6	2.972+2	2.976+2	3.118+2	3.116+2	2.889+2	2.897+2
7	4.502+2	4.604+2	4.985+2	5.094+2	4.255+2	4.355+2
U-235 Fission Data						
1	1.304+0	1.250+0	1.305+0	1.250+0	1.304+0	1.250+0
2	1.863+0	1.660+0	1.864+0	1.661+0	1.863+0	1.660+0
3	2.064+1	2.103+1	2.096+1	2.138+1	1.971+1	2.026+1
4	6.561+1	6.582+1	6.867+1	7.025+1	6.607+1	6.777+1
5	1.640+2	1.640+2	1.692+2	1.714+2	1.624+2	1.646+2
6	2.533+2	2.541+2	2.656+2	2.660+2	2.462+2	2.473+2
7	3.837+2	3.939+2	4.250+2	4.358+2	3.627+2	3.727+2
U-238 Absorption Data						
1	3.809-1	3.774-1	3.785-1	3.751-1	3.764-1	3.735-1
2	3.006-1	2.643-1	3.007-1	2.640-1	3.002-1	2.629-1
3	1.437+1	1.515+1	6.035+0	6.256+0	4.561+0	4.743+0
4	5.492-1	5.447-1	5.710-1	5.708-1	5.521-1	5.530-1
5	8.750-1	8.665-1	9.048-1	9.033-1	8.652-1	8.646-1
6	1.360+0	1.346+0	1.424+0	1.407+0	1.324+0	1.312+0
7	1.809+0	1.832+0	2.002+0	2.025+0	1.711+0	1.734+0
Er167 Absorption Data						
1	8.436-2	8.334-2	8.534-2	8.413-2	8.596-2	8.467-2
2	7.787-1	7.715-1	7.788-1	7.722-1	7.770-1	7.705-1
3	9.315+1	1.057+2	1.086+2	1.217+2	9.161+1	1.055+2
4	2.619+3	2.483+3	3.078+3	3.007+3	2.753+3	2.714+3
5	9.760+2	1.055+3	9.996+2	9.321+2	9.872+2	9.206+2
6	4.563+2	4.342+2	4.752+2	4.516+2	4.451+2	4.243+2
7	4.711+2	4.595+2	5.208+2	5.074+2	4.460+2	4.354+2
H in ZrH Absorption Data						
1	9.645-7	3.444-5	9.714-7	3.447-5	9.754-7	3.447-5
2	3.700-6	1.469-4	3.703-6	1.470-4	3.699-6	1.466-4
3	9.616-3	9.706-3	9.641-3	9.762-3	9.119-3	9.223-3
4	5.972-2	5.925-2	6.229-2	6.254-2	6.011-2	6.043-2
5	1.030-1	1.029-1	1.066-1	1.074-1	1.019-1	1.028-1
6	1.657-1	1.638-1	1.733-1	1.712-1	1.613-1	1.596-1
7	2.237-1	2.252-1	2.473-1	2.489-1	2.117-1	2.131-1
H in H2O Absorption Data						
1	8.837-7	3.145-5	8.871-7	3.141-5	8.917-7	3.143-5
2	3.557-6	1.448-4	3.551-6	1.444-4	3.550-6	1.443-4
3	1.012-2	1.034-2	1.013-2	1.037-2	9.852-3	1.008-2
4	7.255-2	7.200-2	6.946-2	7.008-2	7.255-2	7.297-2
5	1.282-1	1.285-1	1.219-1	1.236-1	1.294-1	1.310-1
6	2.247-1	2.250-1	2.110-1	2.116-1	2.330-1	2.326-1
7	6.117-1	6.076-1	5.615-1	5.570-1	6.371-1	6.332-1
Zr in ZrH Absorption Data						
1	1.320-2	9.994-3	1.314-2	1.003-2	1.310-2	1.004-2
2	8.544-3	1.945-2	8.551-3	1.951-2	8.556-3	1.945-2
3	9.726-2	6.892-2	9.728-2	6.902-2	9.962-2	7.085-2
4	3.304-2	3.232-2	3.449-2	3.412-2	3.325-2	3.296-2
5	5.702-2	5.618-2	5.905-2	5.863-2	5.635-2	5.609-2
6	9.095-2	8.946-2	9.526-2	9.351-2	8.841-2	8.717-2
7	1.215-1	1.230-1	1.346-1	1.360-1	1.147-1	1.164-1

Table IX **Few Group Spectra and Microscopic Cross-sections -Four Rod TRIGA**

	HEU		LEU 20		LEU 30	
g	WIMS	VIM	WIMS	VIM	WIMS	VIM
Spectra Data						
1	0.3440	0.3503	0.3225	0.3297	0.3494	0.3578
2	0.2315	0.2271	0.2226	0.2177	0.2440	0.2391
3	0.2805	0.2735	0.2700	0.2626	0.2811	0.2732
4	0.0259	0.0248	0.0275	0.0262	0.0249	0.0238
5	0.0278	0.0310	0.0334	0.0360	0.0267	0.0288
6	0.0531	0.0559	0.0723	0.0755	0.0443	0.0466
7	0.0362	0.0374	0.0517	0.0523	0.0296	0.0307
U-235 Absorption Data						
1	1.368+0	1.343+0	1.370+0	1.345+0	1.370+0	1.345+0
2	2.422+0	2.152+0	2.424+0	2.153+0	2.420+0	2.151+0
3	3.270+1	3.313+1	3.329+1	3.362+1	3.101+1	3.158+1
4	7.510+1	7.390+1	7.875+1	7.739+1	7.556+1	7.424+1
5	1.985+2	1.941+2	2.057+2	2.017+2	1.964+2	1.918+2
6	2.927+2	2.824+2	3.092+2	3.010+2	2.836+2	2.724+2
7	4.296+2	4.033+2	4.814+2	4.610+2	4.041+2	3.738+2
U-235 Fission Data						
1	1.311+0	1.262+0	1.313+0	1.262+0	1.311+0	1.262+0
2	1.868+0	1.667+0	1.870+0	1.668+0	1.867+0	1.667+0
3	2.062+1	2.101+1	2.102+1	2.136+1	1.974+1	2.021+1
4	6.533+1	6.506+1	6.863+1	6.811+1	6.579+1	6.533+1
5	1.625+2	1.601+2	1.684+2	1.665+2	1.607+2	1.582+2
6	2.494+2	2.411+2	2.635+2	2.570+2	2.416+2	2.325+2
7	3.662+2	3.481+2	4.103+2	3.944+2	3.445+2	3.199+2
U-238 Absorption Data						
1	3.846-1	3.822-1	3.817-1	3.804-1	3.796-1	3.784-1
2	3.013-1	2.655-1	3.015-1	2.647-1	3.009-1	2.638-1
3	1.444+1	1.523+1	6.173+0	6.345+0	4.593+0	4.739+0
4	5.465-1	5.382-1	5.703-1	5.619-1	5.494-1	5.402-1
5	8.672-1	8.466-1	9.012-1	8.827-1	8.566-1	8.361-1
6	1.339+0	1.277+0	1.412+0	1.359+0	1.298+0	1.232+0
7	1.726+0	1.605+0	1.932+0	1.833+0	1.625+0	1.489+0
Er167 Absorption Data						
1	8.420-2	8.370-2	8.547-2	8.448-2	8.601-2	8.506-2
2	7.800-1	7.750-1	7.808-1	7.744-1	7.788-1	7.729-1
3	9.433+1	1.063+2	1.126+2	1.237+2	9.322+1	1.065+2
4	2.643+3	2.487+3	3.111+3	2.916+3	2.776+3	2.600+3
5	9.644+2	1.027+3	9.905+2	1.070+3	9.741+2	1.048+3
6	4.483+2	4.111+2	4.703+2	4.356+2	4.357+2	3.979+2
7	4.496+2	4.027+2	5.027+2	4.592+2	4.235+2	3.738+2
H in ZrH Absorption Data						
1	9.650-7	3.477-5	9.743-7	3.481-5	9.776-7	3.481-5
2	3.710-6	1.474-4	3.716-6	1.474-4	3.711-6	1.471-4
3	9.654-3	9.709-3	9.690-3	9.769-3	9.163-3	9.232-3
4	5.946-2	5.857-2	6.224-2	6.138-2	5.984-2	5.886-2
5	1.021-1	1.006-1	1.062-1	1.049-1	1.009-1	9.928-2
6	1.631-1	1.553-1	1.719-1	1.653-1	1.582-1	1.499-1
7	2.135-1	1.973-1	2.388-1	2.253-1	2.011-1	1.830-1
H in H2O Absorption Data						
1	8.780-7	3.110-5	8.825-7	3.106-5	8.868-7	3.108-5
2	3.550-6	1.440-4	3.547-6	1.441-4	3.547-6	1.437-4
3	1.018-2	1.043-2	1.020-2	1.046-2	9.927-3	1.019-2
4	7.220-2	7.260-2	6.918-2	6.930-2	7.221-2	7.261-2
5	1.277-1	1.311-1	1.217-1	1.246-1	1.290-1	1.324-1
6	2.253-1	2.384-1	2.115-1	2.214-1	2.333-1	2.475-1
7	5.974-1	6.360-1	5.508-1	5.821-1	6.204-1	6.640-1
Zr in ZrH Absorption Data						
1	1.330-2	1.007-2	1.325-2	1.010-2	1.321-2	1.012-2
2	8.560-3	1.956-2	8.571-3	1.954-2	8.575-3	1.952-2
3	9.694-2	6.887-2	9.689-2	6.881-2	9.915-2	7.020-2
4	3.292-2	3.195-2	3.447-2	3.348-2	3.312-2	3.211-2
5	5.657-2	5.480-2	5.886-2	5.725-2	5.987-2	5.420-2
6	8.967-2	8.485-2	9.457-2	9.032-2	8.692-2	8.190-2
7	1.166-1	1.078-1	1.307-1	1.231-1	1.097-1	9.995-2

The WIMS microscopic absorption cross-sections for ^{238}U in the resonance range are lower by more than 5% for the LEU plate cases and by about 4% for the TRIGA cases. The addition of ENDF/B-V data to correspond to that in VIM may resolve some of the differences noted. The overall absorption rate does not seem to be strongly affected by the differences observed in the microscopic data.

This improved version of the WIMS-D4 code gives a respectable set of data with the current library for both plate and rod type fuel. The code provides and option for generating microscopic cross-sections in the ISOTXS format to interface with neutronics codes using this format. The code is also capable of generating macroscopic data averaged over selected regions. Further improvements in the code are in progress including 2D transport and treatments for non-lattice heterogeneities (experiments, control rods, reflectors, etc.). A new all ENDF/B-V library will be generated in the near future with the inclusion of additional desired materials.

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4. "Standard Interface Files and Procedures for Reactor Physics Codes, Version III," Compiled by B. M. Carmichael, LA-5486-MS, pp. 8-13, Feb. 1974

5. "Research Reactor Core Conversion from the Use of Highly Enriched Uranium to the Use of Low Enriched Uranium Fuels - Guidbook," IAEA-TECDOC-233, pp. 60-71 and pp. 447-628, 1980

6. IAEA-TECDOC-233, p. 264

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