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Comparative Study Of Generated WIMSD-5B Multigroup Constants Library Based On JENDL-3.2 With JEFF-3.1.1,CENDL-3.0 And Original WIMS And Validation Ofgenerated Library Through Some Benchmark Experiments Analysis.

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Abstract: *This research work deals with the "Comparative Study of Generated WIMSD-5B Multigroup Constants Library Based on JENDL-3.2 with JEFF-3.1.1, CENDL-3.0 and Original WIMS and Validation of Generated Library through Some Benchmark Experiments Analysis". The basic evaluated nuclear data file JENDL-3.2 was selected for the generation of problem dependent few group neutron macroscopic cross section libraries for all of the materials in the core and its immediate neighborhood of TRIGA thermal reactor. The task of updating working libraries involves the use of the nuclear data processing systems NJOY99.0. Cell calculation code WIMSD-5B is used for benchmark lattices. The integral parameters such as* k_{eff}, ρ^{28}, δ^{25}, δ^{28} *and* C^{*} *have been investigated for the Cross-Section Evaluation Working Group (CSEWG) benchmark lattices TRX-1, TRX-2, BAPL-1, BAPL-2 and BAPL-3 and the results were compared to JEFF-3.1.1, CENDL-3.0 & original WIMS and also with the experimental values. All the integral parameters are in good agreement with some uncertainties.*

Keywords: *ENDF, Integral Parameters, JENDL-3.2, NJOY99.0, TRX and BAPL Benchmark Lattices, and WIMSD-5B*

I. Introduction

The WIMS code is a freely available thermal reactor physics lattice-cell code used widely especially by scientists in developing countries for thermal research and power reactor applications. The recently released basic evaluated nuclear data files such as ENDF/B-VII (The US Evaluated Nuclear Data Library), JENDL-3.2 (Japanese Evaluated Nuclear Data library), JEFF-3.1.1[1](Joint European Fission Fusion), BROND-2(Russian Evaluated Nuclear Data Library), and CENDL-3.0(Chinese Evaluated Nuclear Data Library) are not directly used as input to neutronics or other applied calculations but are first converted to pre-processed files which are post-processed into multigroup files and then cast into specially formatted working libraries that are compatible with neutronic codes. Very few codes are available in the public domain that can handle processing of the new data with dependable accuracy. Cullen's work [2] proved many of the data processing codes to be obsolete. After careful analysis of these facts NJOY99.0 [3] was chosen since it includes sophisticated methods of correct reconstruction using multi-level Breit-Wigner resonance parameters, Doppler broadening by accurate point kernel method, group to group thermal scattering matrices and special thermal law treatment, flux weighted fission fraction vectors, and a weighting flux produced by a point solution of the slowing down problem that accurately accounts for broad and intermediate resonance effects. The NJOY Nuclear Data Processing System [4-8] is a modular computer code designed to read evaluated nuclear data in ENDF format [9] , transform the data in various ways, and output the results as libraries designed to be used in various applications.

In this study, the 69-group cross section libraries were generated for the lattice code WIMS based on basic evaluated data files JENDL-3.2 using nuclear data processing code NJOY99.0. This cross section library was used to benchmark the integral parameters of the TRX [9] (two-region physics critical experiment) and BAPL [10] (Bettis Atomic Power Laboratory) Lattices calculated by WIMSD-5B [11] reactor lattice code. These integral parameters were compared to JEFF-3.1.1, CENDL-3.0 & original WIMS and also with the experimental values. It has been found that this study shows a good performance of JENDL-3.2 data file and also the validation of the generated 69-group cross section library for the lattice transport code WIMS. The results of such analysis are presented in this paper.

II. New Executable Njoy99.0

The version NJOY99.0 of NJOY has the capability to process data in ENDF/B-6 (Rose and Dunford, 1990) format, which is used in ENDF/B-VI, 1993), JEF-2.2 (Nordberg and Salvatore's, 1994), JENDL-3.2 and some evaluations in the ENDF-2 data library. Some modifications are necessary in the "WIMSR" module of

Nuclear Data Processing System NJOY99.0 developed in USA to incorporate compatibility with the WIMSD code and ENDF/B-6 format requirements. For this purpose the modifications suggested by IJS [12] in the WIMSR module were considered to be important development that may be incorporated to make a new executable of NJOY.

III. Generation Of Gendf Data

The NJOY Modules used to generate the WIMSD cross section library are schematically in Fig. 1. The JENDL-3.2 data were attractive considering its success for various applications in the present years. The data types were processed using NJOY, which can handle the new features of the data library. The used elements have been processed in the PC in RECONR-BROADR-UNRESR-THERMR-GROUR sequence. In this exercise it was necessary to validate the JENDL data processed by NJOY99.0. The group constants in WIMS format from the JENDL files have been directly compared. The isotopes present in the TRIGA Mark -II research reactor added with the original WIMS library from JENDL-3.2 data processed through NJOY99.0, and the respective IDs are shown in Table I.

Table 1**:** List of the Isotopes from JENDL-**3.2** data processed Through NJOY99.0 Added with the Original WIMS Library with the Respective IDs.

SL. No	Isotope	ID
01	H-1	125
02	B-10	525
03	C-12	625
04	N-14	725
05	O-16	825
06	Al-27	1325
07	Cr-52	2431
08	Mn-55	2525
09	Fe-56	2631
10	Ni-58	2825
11	Pb-207	8234
12	U-235	9228
13	U-238	9237

IV. Benchmark Name And Type

There are two types of systems: (i) TRX system and (ii) BAPL system. Their system descriptions are given below:

4.1 System description of TRX

These benchmarks are water moderated uranium critical lattices of slightly enriched (1.3 wt.%) uranium rods with diameters of 0.98297 cm in a triangular pattern [13] . Measured lattice parameters include ρ^{28}, δ^{25}, δ^{28} and C*. These lattices directly test the U-235 resonance fission integral and thermal fission cross section. They also test U-238 shielded resonance capture and the thermal capture cross section. They are sensitive to the U-238 fast fission cross-section, U-238 inelastic scattering and U-235 fission spectrum. The scattering and thermal absorption cross sections of H_2O are very important also.

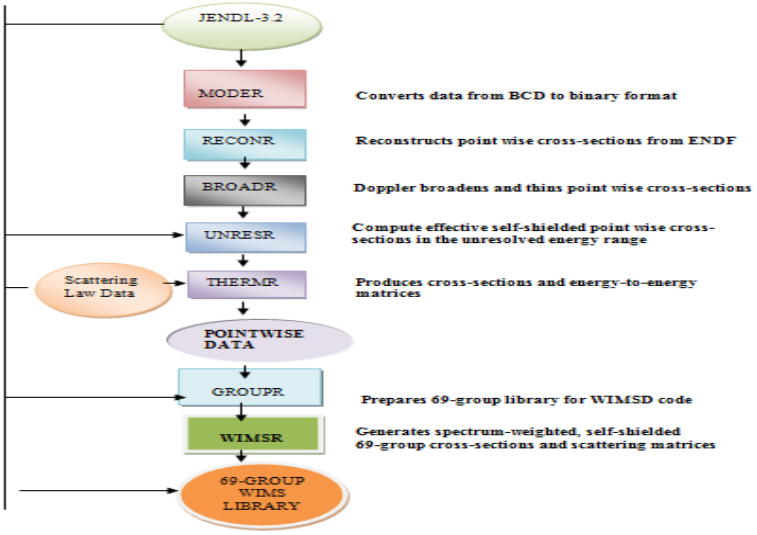

Fig.1: flow diagram for generating 69-group WIMS library

4.2 system description of BAPL

These experiments consist of H_2O moderated uranium oxide critical lattices of 1.311 wt. % enriched uranium oxide rods with diameters of 0.9728 cm in a triangular pattern. The measured parameters include ρ^{28},δ^{25}, δ^{28} and C*. Three lattices with moderator to fuel volume ratios of 1.43, 1.78 and 2.40 are specified.

V. Integral Parameters

The integral parameters analyzed are defined as below.

K_{eff} = finite medium effective multiplication factor

ρ^{28} = Ratio of epithermal to thermal ^{238}U captures

$= (\sum_c)^{38}_{epth} / (\sum_c)^{38}_{th}$

$= (\sum_a - \sum_f)^{38}_{epth} / (\sum_a - \sum_f)^{38}_{th}$

δ^{25} = Ratio of epithermal to thermal ^{235}U fission

$= (\sum_f)^{35}_{epth} / (\sum_f)^{35}_{th}$

δ^{28} = Ratio of ^{238}U fission to ^{235}U fission

$= (\sum^t_f)^{38} / (\sum^t_f)^{35}$

C^* = Ratio of ^{238}U Captures to ^{235}U fission

$= (\sum^t_c)^{38} / (\sum^t_f)^{35}$

$= (\sum^t_a - \sum^t_f)^{38} / (\sum^t_f)^{35}$

VI. Results And Discussions

The analyses for TRX and BAPL lattices have been performed by the lattice code WIMSD-5B. This code uses the JENDL-3.2 library. The calculated values of effective multiplication factor (k_{eff}) and other integral parameters for TRX and BAPL lattices and their comparison with some other libraries are shown in Table II and III respectively.

Table 2 **:** Integral Parameters Calculated by WIMSD-5B for TRX Benchmark Lattices

Lattices	Integral Parameters	Experiment (CSEWG,1986)	JENDL-3.2	JEFF-3.1.1[14] (WIMSD-5B)	CENDL-3.0[15] (MCNP)	WIMS[16]
TRX-1	k_{eff}	1.0000 (0.30)	0.98663 (-1.33602)	0.9885 (-1.15)$^{\$}$	0.9975 (-0.25)$^{\$}$	1.0023 (0.23)$^{\$}$
	ρ^{28}	1.3200 (1.60)	1.33225 (0.928)	1.3285 (0.64)	1.3608 (3.09)	1.2631 (-4.31)
	δ^{25}	0.0987 (1.00)	0.096163 (-2.5695)	0.0975 (-1.21)	0.0980 (-0.71)	0.0990 (0.31)
	δ^{28}	0.0946 (4.30)	0.09820 (3.8060)	0.0915 (-3.27)	0.0962 (1.69)	0.0965 (2.02)
	C^*	0.7970 (1.00)	0.79094 (-0.759)	0.7926 (-0.55)	0.7922 (-0.60)	0.7745 (2.82)
TRX-2	k_{eff}	1.0000 (0.10)	0.9882 (-1.177)	0.9895 (-1.05)	0.9982 (-0.18)	0.9966 (-0.34)
	ρ^{28}	0.8370 (1.90)	0.82754 (-1.123)	0.8273 (-1.16)	0.8530 (1.91)	0.7967 (-4.81)
	δ^{25}	0.0614 (1.30)	0.0590 (-3.8587)	0.0603 (-1.79)	0.0620 (0.98)	0.0610 (-0.64)
	δ^{28}	0.0693 (5.10)	0.070085 (1.1332)	0.0685 (1.15)	0.0681 (-1.73)	0.0695 (0.30)
	C^*	0.6470 (0.93)	0.63680 (-1.575)	0.6388 (-1.27)	0.6387 (-1.28)	0.6321 (-2.31)

$(Error in %) = [(Calculated value–Experimental value)/ Experimental value] x 100

Comparison of the results with experiment shows that in case of TRX-1, the calculated value of k_{eff} using JENDL-3.2 obtained from the WIMS is 1.336 % less where as the same value based on JEFF-3.1.1 library is 1.15 % less, based on CENDL-3.0 library is 0.25% less and based on original WIMS is 0.23% over than the experimental value. Thus original WIMS gives the best result for k_{eff} . The deviations from the experimental value for the other parameters namely ρ^{28}, δ^{25}, δ^{28} and $C^*$are 0.928%, -2.56%, 3.80% and –0.75% in case of JENDL-3.2 and 0.64%,- 1.21% ,-3.27% and -0.55% in case of JEFF-3.1.1 and 3.09%,-0.71%,1.69% and-0.60% in case of CENDL-3.0 and -4.31% , 0.31%,2.02% and 2.82% in case of original WIMS respectively. The similar tendency is observed in case of TRX-2 as well. It can be said that the results are in good agreement with the experimental values.

Table 3**:** Integral Parameters Calculated by WIMSD-5B for BAPL Benchmark Lattices

Lattices	Integral parameter	Experiment	JENDL-3.2	JEFF3.1.1[14] (WIMSD-5B)	CENDL-3.0[15] (MCNP)	WIMS[16]
BAPL-1	k_{eff}	1.0000 (0.10)	0.99790 (-0.2090)	0.9970 (-0.30)$^{\$}$	1.0023(0.23)$^{\$}$	1.0030 (-0.30)
	ρ^{28}	1.3900 (0.72)	1.34442 (-3.278)	1.3851 (-0.35)	1.3923(0.16)	1.3454 (-3.21)
	δ^{25}	0.0840 2.40)	0.08092 (-3.662)	0.0815 (-2.98)	0.08199(-2.39)	0.8040 (0.05)
	δ^{28}	0.0780 (5.10)	0.07591 (-2.672)	0.0753 (-3.46)	0.07362(-5.61)	0.0755 (-3.23)
	C*	.....	0.7894	0.7919	0.7972	0.7960
BAPL-2	k_{eff}	1.0000 (0.10)	0.99706 (-0.2937)	0.9967 (-0.33)	1.0021(0.21)	1.0006 (0.06)
	ρ^{28}	1.1200 (0.89)	1.1129 (-0.62)	1.1187 (0.12)	1.1602(3.59)	1.1227 (0.24)
	δ^{25}	0.0680 (1.50)	0.0660 (-2.842)	0.0667 (-1.91)	0.0669(-1.61)	0.0687 (1)
	δ^{28}	0.0700 (5.70)	0.06546 (-6.481)	0.0650 (-7.14)	0.0633(-9.57)	0.0652 (-6.8)
	C*	.....	0.71902	0.7223	0.7274	0.7282
BAPL-3	k_{eff}	1.0000 (0.10)	0.99668 (-0.331)	0.9975 -0.25)	1.0021(0.21)	0.9982 (-0.18)
	ρ28	0.9060 (1.10)	0.86969 (-4.102)	0.8996 (-0.71)	0.9130(0.77)	0.8849 (-2.32)
	δ^{25}	0.0520 (1.90)	0.0508 (-2.23)	0.0512 (-1.54)	0.0515(-0.96)	0.0529 (1.73)
	δ^{28}	0.0570 (5.30)	0.05385 (-5.509)	0.0535 (-6.14)	0.0518(-9.12)	0.0538 (-5.56)
	C*	.....	0.64314	0.6468	0.6511	0.653

$(Error in %) = [(Calculated value–Experimental value)/ Experimental value] x 100

Comparison in case of BAPL-1, the WIMS code based on JENDL-3.2 gives a calculated value of k_{eff} which is 0.209% less whereas the same value obtained based on JEFF-3.1.1 is 0.30% less, based on CENDL-3.0 is 0.23% over and based on original WIMS is 0.30% less than the experimental value. Thus in case of BAPL-1, JENDL-3.2 gives the best result for $k_{eff.}$. The discrepancies of the other parameters namely ρ^{28}, δ^{25}, δ^{28} and $C^{*}$are -3.278%, -3.662% -2.672% & 0.7894 in case of JENDL-3.2 and –0.35%, -2.98% –3.46% & 0.7919 in case of JEFF-3.1.1 and 0.16%,-2.39%,-5.61% & 0.7972 in case of CENDL-3.0 and -3.21%,0.05% ,-3.23% & 0.7960 in case of original WIMS respectively. Experimental value of C* is not available for comparison. The similar tendencies are observed in case of BAPL-2 and 3 as well. This is why it can be said that the results are in good agreement with the experimental values.

VII. Conclusion

The comparative study shows consistency between the data libraries generated from JENDL-3.2, JEFF-3.1.1, CENDL-3.0 and original WIMS. By comparing the calculated results for the benchmark lattices with the measured values, good agreement is observed with negligible differences in some points. It is obvious that different evaluated nuclear data library is the cause of the difference between the calculated results. From the analyses of the results it is concluded that almost all of the calculated parameters lie within the uncertainty limit of the measurements. Therefore, it may be said that library JENDL-3.2 is sufficiently reliable for thermal reactor calculations.

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