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Generation and Verification of ENDF/B-VII.0 Cross section Libraries for Monte Carlo Calculations

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1. Introduction

For Monte Carlo neutronics calculations, a continuous energy nuclear data library is needed. It can be generated from various evaluated nuclear data files such as ENDF/B using the ACER routine of the NJOY.code[1] after a series of prior processing involving various other NJOY routines. Recently, a utility code, which generates the NJOY input decks in an automated mode, named ANJOYMC[2] became available. The use of this code greatly reduces the user's effort and the possibility of input errors.
In December 2006, the initial version of the ENDF/B-VII nuclear data library was released. It was reported that the new data files have much better data which reduces the errors noted in the previous versions.[3] Thus it is worthwhile to examine the performance of the new data files particularly using an independent Monte Carlo code, MCCARD[4] and the ANJOYMC utility code. The verification of the newly generated library can be readily performed by analyzing numerous standard criticality benchmark problems.

2. Library Generation

Based on a simple user input, ANJOYMC can generate NJOY input decks and a batch file needed to run the NJOY code. The library generation procedure is shown in Figure 1. Note that this cross section is not only for MCCARD but also for the MCNP code.

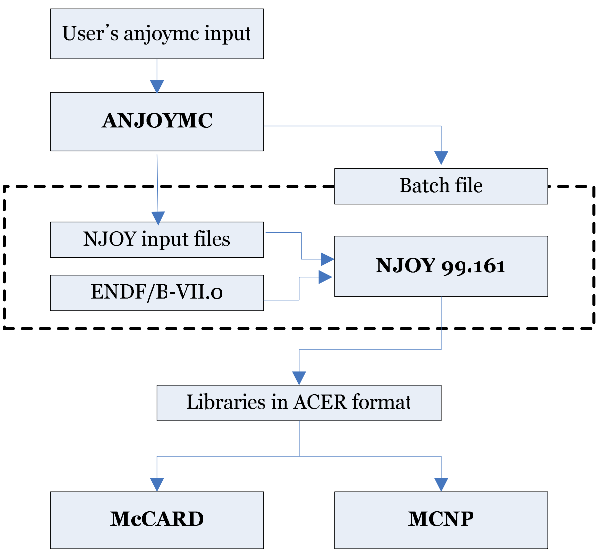

Figure1. Flow chart of the ANJOYMC calculations

The ACE files generated encompass about 350 nuclides at 300K, 600K, and 900K. These files as well as a generation record are available at the following URL:
http:/neutron.snu.ac.kr/data/ENDF/Endf7pack.tar.gz

3. Benchmark Calculations

In order to examine the newly generated ACE files, MCCARD analyses of the selected criticality benchmarks were performed. Among the examined benchmarks, Godiva, Jezebel, Jezebel240, Jezebel233, U233-MF-002, and Fllatop-25. Godiva and Flattop-25 are highly enriched uranium (HEU) criticals while Jezebel and Jezebel240 are Plutonium criticals. Jezebel233 and U233-MF-002 are U-233 criticals. These are all the room temperature criticals. The benchmark specifications were taken from Reference 5. All the McCARD Monte Carlo calculations were performed employing 100,000 neutron histories per a cycle, 200 active cycles, and 50 inactive cycles. The complexity of each problem is briefly described in Table 1.

Table1. Brief description of 6 benchmarks

Case	Handbook ID	Description
Godiva	HEU-MET-FAST-001	Bare HEU sphere
Jezebel	PU-MET-FAST-001	Bare Pu sphere (Pu-240 4.5%)
Jezebel240	PU-MET-FAST-002	Bare Pu sphere (Pu-240 20%)
Jezebel233	U233-MET-FAST-001	Bare U-233 sphere
U233-MF-002	U233-MET-FAST-002	U-233 sphere reflected by U
Flattop-25	HEU-MET-FAST-028	HEU sphere reflected by U

The k_{eff} values of the 6 cases are listed in Table 2 and Figure 2 shows the difference between the result of benchmark calculation and experimental value (=1.0). For comparison with other sources, the results based on JENDL-3.3 and JEFF-3.0 files which are taken from the Reference 6.

In general, MCCARD cases based on the ENDF/B-VII.0 libraries predicts the critically very well. Considering the experimental uncertainty (shown within the parenthesis in pcm), the k-eff's of the ENDF/B-VII.0 cases agree within a single standard deviation with the measurement except Flattop-25. In contrast, three of the results of ENDF/B-VI.8 and JEFF-3.0 differ from the corresponding benchmark value by more than two standard deviations. And four of the results of JENDL-3.3 differ from the corresponding benchmark value by more than two standard deviations. This confirmed partially the better quality of the ENDF/B-VII.0 as well as the accuracy of the MCCARD modeling.

Table2. McCARD Results for ENDF/B-VII.0 Benchmarks

Calculated Keff		
Case	Godiva	Jezebel
Experiment	1.00000(100)	1.00000(200)
ENDF/B-VII.0	1.00006(15)	1.00000(14)
ENDF/B-VI.8	0.99631(15)	0.99809(15)
JENDL-3.3	1.00330(15)	0.99660(30)
JEFF-3.0	0.99640(9)	1.00000(30)
Case	Jezebel240	Jezebel233
Experiment	1.00000(200)	1.00000(100)
ENDF/B-VII.0	1.00022(14)	0.99959(15)
ENDF/B-VI.8	0.99857(15)	0.99337(15)
JENDL-3.3	1.00090(30)	1.00426(15)
JEFF-3.0	1.00430(30)	1.01353(14)
Case	U233-MF-002	Fllatop-25
Experiment	1.00000 (100)	1.00000(300)
ENDF/B-VII.0	0.99992 (16)	1.00326(16)
ENDF/B-VI.8	0.99672 (16)	1.00249(18)
JENDL-3.3	1.00394 (15)	0.99849(17)
JEFF-3.0	1.01074 (16)	0.99489(17)

* Values in the parenthesis are experimental uncertainty or the standard devation of the calculated value

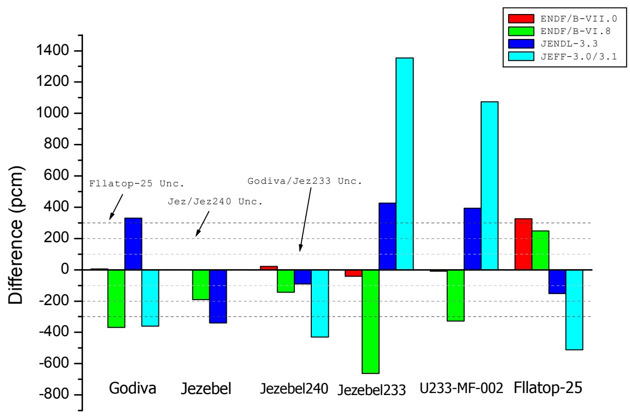

Figure2. Comparisons of calculated k_{eff} with experiments

4. Conclusion

The continuous energy cross section libraries in the ACE format were generated from the ENDF/B-VII.0 files using the ANJOYMC utility and the NJOY processing codes. The MCCARD analysis results for the 6 criticality benchmark problems proves the superior accuracy of the ENDF/B-VII.0 compared with the previous versions or the other source of evaluated data files. From this verification, it is also concluded that the automated generation procedure using the ANJOYMC code and the MCACRD models themselves work properly. The library files generated for ~350 nuclides at three temperatures of 300, 600, and 900K were made available through an internet access.

Acknowledgments

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