Analysis of OKTAVIAN Shielding Benchmark Experiments by ENDF/B-VII, JEFF-3.1, and JENDL-3.3

Do Heon Kim, Choong-Sup Gil, Young-Ouk Lee
Korea Atomic Energy Research Institute, P.O. Box 105, Yuseong, Daejeon, 305-600, Korea
kimdh@kaeri.re.kr

1. Introduction

International collaborations for the ITER Project and other fusion-related development projects have been conducted to create a reference fusion nuclear data library such as FENDL, which was a collection of the best cross section data from national nuclear data libraries.[1] Recent release of newly evaluated nuclear data libraries requires an extensive and intensive benchmarking of the updated transport libraries to become a candidate for the future collection.

In this study, the pulsed sphere experiments for leakage neutron and gamma-ray spectra at the D-T neutron source facility of Osaka University, OKTAVIAN [2] were employed to test the ENDF/B-VII beta 1, JEFF-3.1, and JENDL-3.3 libraries. The continuous energy Monte Carlo transport code MCNPX-2.5 [3] was used along with the ACE format libraries processed by a modified version of the NJOY99.90 code [4].

2. Benchmark Calculations and Results

A series of pulsed sphere experiments for a 14 MeV neutron transmission has been performed at the OKTAVIAN facility using spherical piles made of a variety of materials. Nickel, iron, aluminum, silicon, and tungsten spheres among them were chosen for our benchmark analyses, because they are well described as fusion neutronics shielding experiments in Shielding Integral Benchmark Archive Database (SINBAD) [5].

The leakage neutron and/or gamma-ray spectra from a sphere with 14 MeV neutrons were calculated and compared with the measured one. Especially for Al, Si, and W spheres, another series of calculations was carried out starting with the secondary gamma-rays produced by the interactions of the source neutrons with the structural materials of the target. The MCPLIB02 and EL03 libraries in the MCNPX code package [3] were used for the gamma and electron transport calculations, respectively.

Figures 1 and 2 show the comparisons of the MCNPX results with the neutron leakage spectra of the high and low energy measurements, respectively. The leakage spectra generally agree well with the measured one. Slight disagreements among the three libraries are shown at around 10 MeV in Fig. 1.

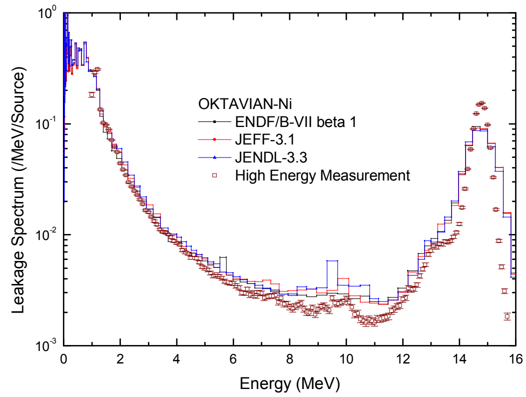

Figure 1. Neutron leakage spectrum from OKTAVIAN-Ni sphere compared with high energy measurements.

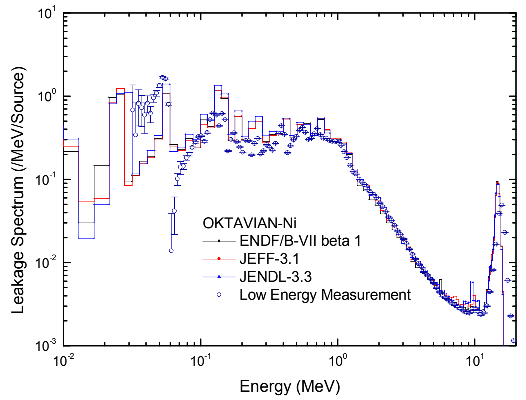

Figure 2. Neutron leakage spectrum from OKTAVIAN-Ni sphere compared with low energy measurements.

The gamma-ray leakage spectrum from the Al sphere is shown in Fig. 3. The JENDL-3.3 results tend to dramatically increase the gamma-ray leakage in the energy range of more than about 7 MeV. For JENDL-3.3, the production of neutron capture gammas is increased by about 10% in the fast energy region when compared to other libraries, which is caused by the increase of the neutron capture cross sections of Al-27 in the energy range of more than about 200 keV. It is recommended that the neutron capture cross section of Al-27 should be examined in the fast energy regions.

Figure 4 shows the neutron leakage spectrum for the W sphere. The JEFF-3.1 results agree well with the JENDL-3.3 results. But the ENDF/B-VII results show relatively large differences with other libraries for a given energy range. In order to clarify the main causes of the differences, it is required to thoroughly investigate the W data of the ENDF/B-VII by comparing the major reaction rates with other libraries.

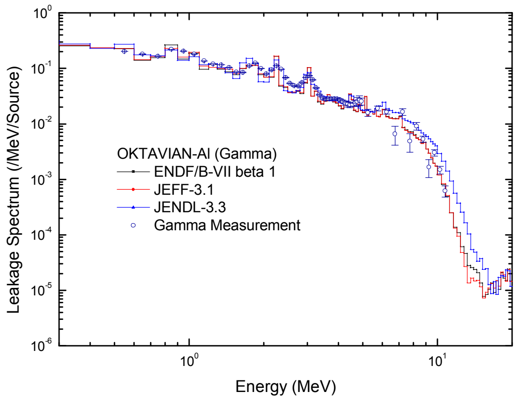

Figure 3. Gamma leakage spectrum from OKTAVIAN-Al sphere.

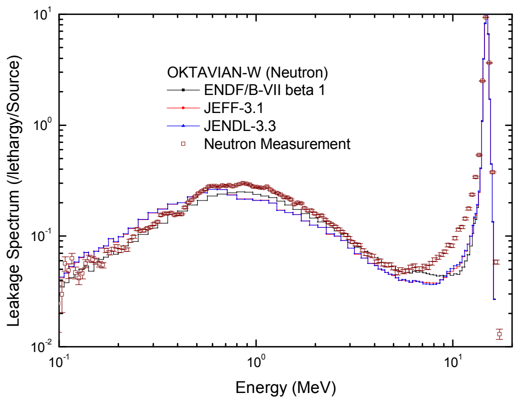

Figure 4. Neutron leakage spectrum from OKTAVIAN-W sphere.

3. Summary

As a first step for the fusion neutronics shielding benchmarks, the ENDF/B-VII beta 1, JEFF-3.1, and JENDL-3.3 have been tested for 5 pulsed sphere experiments performed at the OKTAVIAN facility. The leakage neutron and/or gamma spectra calculated by the MCNPX code have been compared with the measurements.

Other latest evaluated nuclear data libraries such as ENDF/B-VII.0, FENDL-2.1, etc. will be used for further investigations. And also other fusion neutronics shielding benchmarks performed at the FNS/JAEA, FNG/ENEA, etc. [5] will be analyzed.

ACKNOWLEDGEMENT

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REFERENCES

[1] L.L. Aldama, "FENDL-2.1: Update of an Evaluated Nuclear Data Library for Fusion Applications," INDC(NDS)-467, International Atomic Energy Agency, Austria (2004).

[2] F. Maekawa, etc., "Compilation of Benchmark Results for Fusion Related Nuclear Data," JAERI-Data/Code 98-024, Japan Atomic Energy Research Institute, Japan (1998).

[3] D.B. Pelowitz, "MCNPX User's Manual Version 2.5.0," LA-CP-05-0369, Los Alamos National Laboratory, USA (2005).

[4] R.E. MacFarlane and D.W. Muir, "The NJOY Nuclear Data Processing System, Version 91," LA-12740-M, Los Alamos National Laboratory (1994).

[5] I. Kodeli, E. Sartori, and B. Kirk, "SINBAD Shielding Benchmark Experiments Status and Planned Activities," The American Nuclear Society's 14th Biennial Topical Meeting of the Radiation Protection and Shielding Division, Carlsbad, New Mexico, USA (2006).