Analyses of Benchmark Experiments at FNS with Recent Nuclear Data Libraries

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Integral benchmark experiments for nuclear data verification carried out at JAEA FNS have been analyzed with MCNP-4C and the recent nuclear data libraries; JENDL-3.3, FENDL-2.1, JEFF-3.1 and ENDF/B-VII.0. In this paper the results for the experiments for SiC and Iron were discussed and compared each other.

1. Introduction

For a few years several nuclear data libraries, JENDL-3.3 [1], FENDL-2.1 [2], JEFF-3.1 [3] and ENDF/B-VII.0 [4], have been newly released.

- JENDL-3.3 was released in May, 2002.
- FENDL-2.1 was released in December, 2004.
- JEFF-3.1 was released in May, 2005.
- ENDF/B-VII.0 was released in December, 2006.

It is essential to verify these libraries through analyses of integral benchmark experiments. Many integral benchmark experiments for nuclear data verification have been carried out at JAEA/FNS [5-7]. Thus we analyzed these experiments with JENDL-3.3, FENDL-2.1, JEFF-3.1 and ENDF/B-VII.0 and the results were compared each other.

2. Overview of integral benchmark experiments at JAEA/FNS

Two types of integral benchmark experiments for nuclear data verification with DT neutrons have been performed for long time at JAEA/FNS. One is a Time-of-flight (TOF) experiment, the other is an in-situ measurement experiment.

In the TOF experiments angular neutron spectra above ~ 50 keV leaking from slabs were measured at several angles. So far they were done for lithium oxide, beryllium, graphite, nitrogen, oxygen, iron, copper and lead slabs changing the slab thickness.

In the in-situ measurement experiments neutron spectra over almost the whole energy region, reaction rates for several dosimetry reactions, fission rates, gamma-ray spectra, gamma-ray heating, etc. were measured inside slabs. So far they were done for lithium oxide, lithum aluminate, lithium titanate, lithium zirconate, beryllium, graphite, SiC, vanadium, iron, SS316, copper, tungsten.

3. Calculation method

The Monte Carlo code MCNP-4C [8] was used for this analysis. The following ACE files were adopted for the present analyses.

- JENDL-3.3 : ACE files supplied from JAEA Nuclear Data Center processed with NJOY99.67 [9] and local patch [10].
- FENDL-2.1 : ACE files supplied from IAEA Nuclear Data Services processed with NJOY99.90 and local patch [11].
- JEFF-3.1 and ENDF/B-VII.0 : ACE files processed with NJOY99.161 for ourselves.

4. Results and discussions

We have too many results of the analyses for integral benchmark experiments at JAEA/FNS to show all of them in this symposium. The results of the in-situ measurement experiments only for SiC and iron, where differences among the results with recent nuclear data libraries are rather large, are described here. All the results will be published in JAEA-Data/Code or so.

1) In-situ measurement experiment for SiC

Figure 1 shows ratios of calculation value to experimental one (C/E) for the reaction rate of ^{93}Nb(n,2n)^{92m}Nb which is sensitive to neutrons above 10 MeV. The calculations with JENDL-3.3 and ENDF/B-VII.0 agree with the measurement within 5 %, while that with JEFF-3.1 overestimates the measurement and that with FENDL-2.1 tends to underestimate the measurement slightly. Figure 2 plots C/E distributions for the gamma-ray heating rate. The calculation with FENDL-2.1 underestimates the measurement by around 30 %m while those with the other libraries overestimate by 20 – 30 %.

2) In-situ measurement experiment for iron

Figures 3 and 4 show neutron spectra at the depths of 310 and 810 mm. Generally all the calculations agree with the measurements well. The calculation with JENDL-3.3

slightly overestimates the measurements below ~ 10 keV at the depth of 310 mm, if you check them in detail. This is clearly indicated in Fig. 5, which plots C/E distributions for the neutron flux from 0.1 keV to 1 keV. Figure 6 shows the C/E distribution for the reaction rate of ^{115}In(n,n')^{115m}In, which is sensitive to neutrons above 300 keV. Note that the four calculations show a different tendency each other, though the difference is not so large.

5. Concluding remarks

We analyzed integral benchmark experiments at JAEA FNS with the recent nuclear data libraries (JENDL-3.3, FENDL-2.1, JEFF-3.1 and ENDF/B-VII.0) and MCNP-4C in order to verify these libraries. The results of the in-situ measurement experiments only for SiC and iron were discussed here. Differences among the results with recent nuclear data libraries were rather large. In the future we will investigate origins of the differences among the calculation results.

References

[1] K. Shibata, et al. : J. Nucl. Sci. Tech. 39, 1125 (2002).

[2] D. Lopez Al-dama and A. Trokov : "FENDL-2.1Update of an evaluated nuclear data library for fusion applications," IAEA Report INDC(NDS)-467 (2004).

[3] A. Koning, et al. (Ed.) : "The JEFF-3.1 Nuclear Data Library," JEFF Report 21, OECD Nuclear Energy Agency (2006).

[4] M.B. Chadwick, et al. : Nuclear Data Sheets 107, 2931 (2006).

[5] Sub working group of fusion reactor physics subcommittee (Ed.) : "Collection of Experimental Data for Fusion Neutronics Benchmark," JAERI-M 94-014 (1994).

[6] F. Maekawa, et al. : "Data Collection of Fusion Neutronics Benchmark Experiment Conducted at FNS/JAEA," JAERI-Data/Code 98-021 (1998).

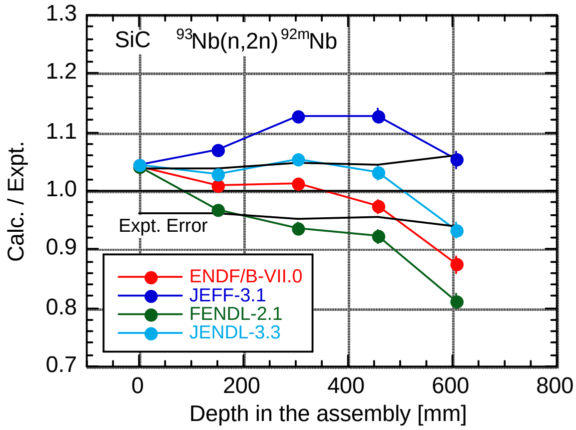
[7] F. Maekawa, et al. : "Benchmark Experments on Advanced Breeding Blanket Materials and SiC with 14-MeV Neutrons, " JAERI-Conf 2001-006, p.311 (2001).

[8] J.F. Briesmeister (Ed.) : "MCNP - A General Monte Carlo N-Particle Transport Code, Version 4C," LA-13709-M (2000).

[9] R.E. MacFarlane and D.W. Muir : "The NJOY Nuclear Data Processing System, Version 91, " LA-12740-M (1994).

[10] K. Kosako, et al. : "The libraries FSXLIB and MATXSLIB based on JENDL-3.3," JAERI-Data/Code 2003-011 (2003).

[11] http://www-nds.iaea.org/fendl21/index.html.



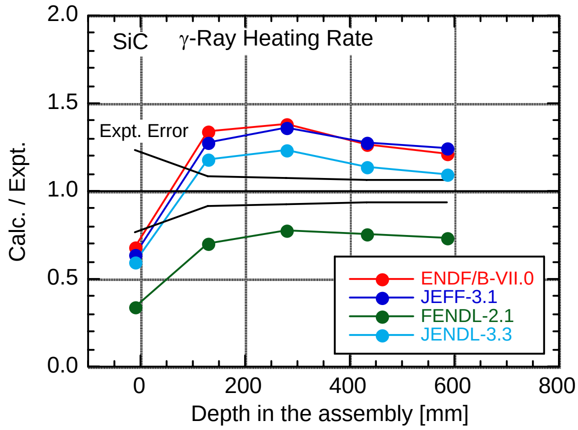


Fig. 1 C/E for reaction rate of ^{93}Nb(n,2n)^{92m}Nb. in SiC experiment.

Fig. 2 C/E for gamma-heating rate in SiC experiment.

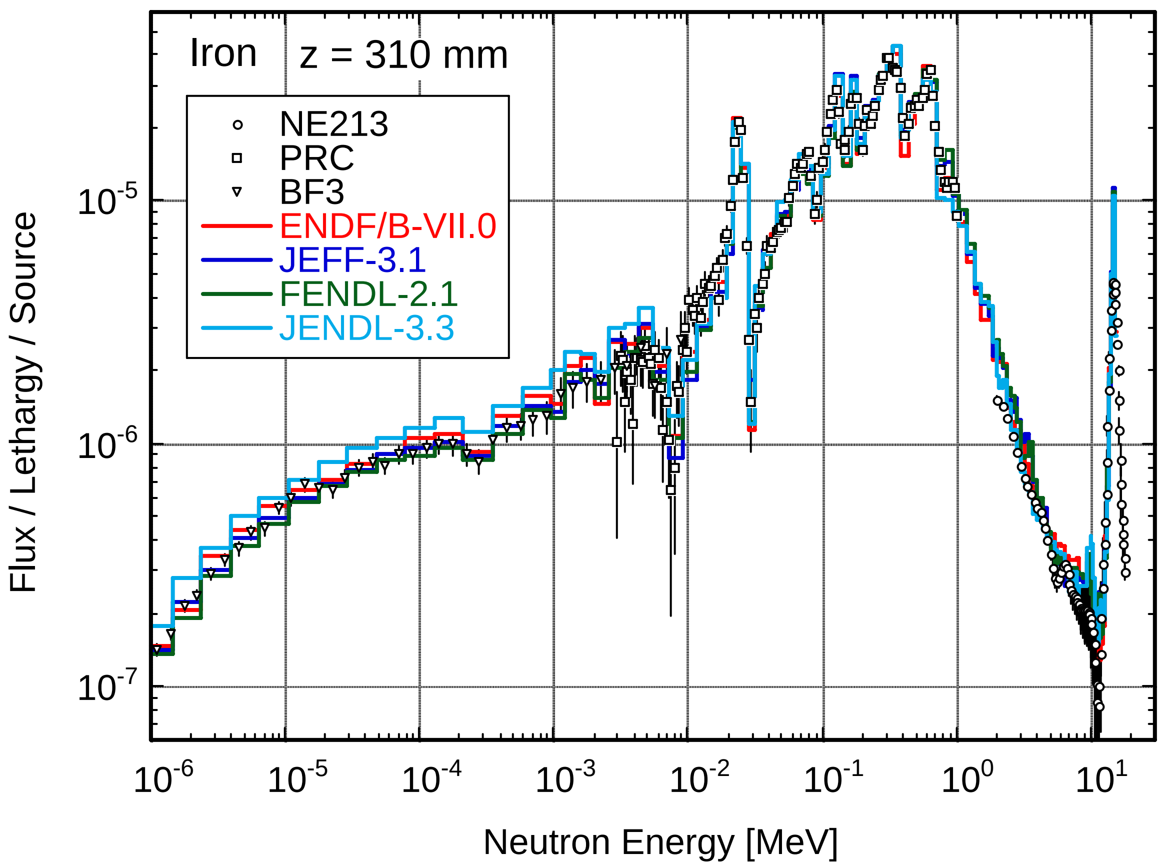


Fig. 3 Measured and calculated neutron spectra at depth of 310 mm in iron experiment.

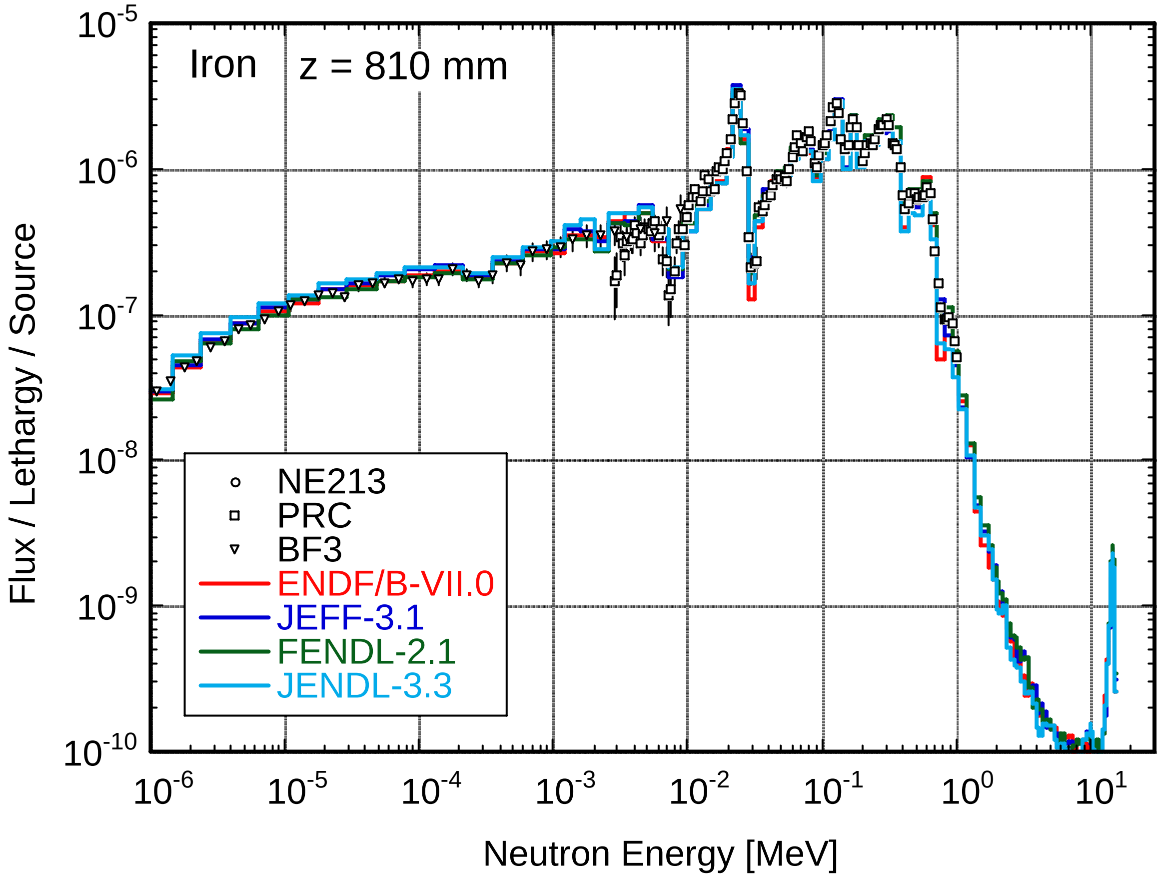


Fig. 4 Measured and calculated neutron spectra at depth of 810 mm in iron experiment.

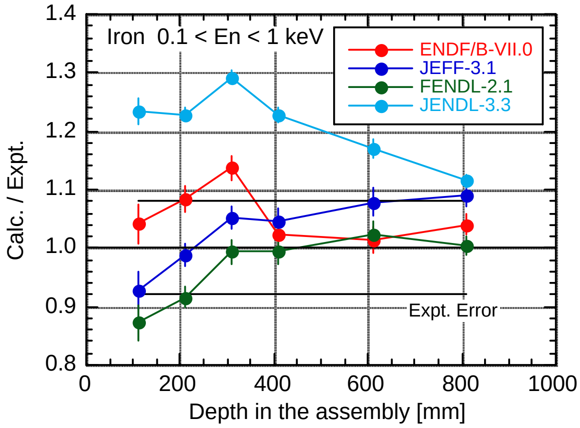


Fig. 5 C/E for neutron flux from 0.1 keV to 1 keV in iron experiment.

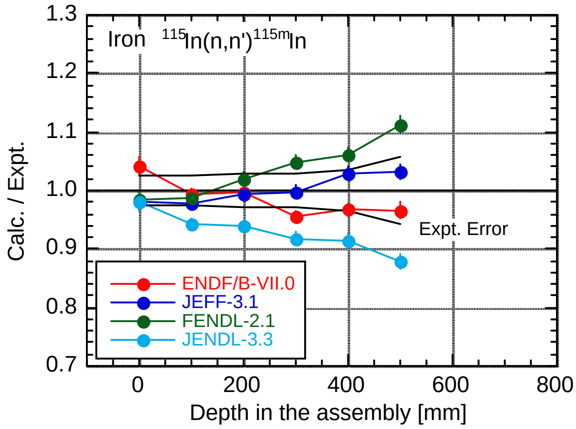


Fig. 6 C/E for reaction rate of ^{115}In(n,n')^{115m}In in iron experiment.