Present Status of the JENDL Project (May 2011)
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General

The highlight of the recent work is the completion of JENDL-4.0 project. The compilation of JENDL-4.0 library was completed in March 2010. After the JAEA internal procedure for public release, JENDL-4.0 was released in May 2010.

Organization of Japanese Nuclear Data Committee

The Japanese Nuclear Data Committee (JNDC) is a research committee for JAEA research activities. Prof. T. Yoshida of Tokyo City University chairs the committee. The committee has two subcommittees: Subcommittee on Nuclear Data and Subcommittee on Reactor Constants. The organization of the committee has been changed a little after the completion of JENDL-4.0. The following listed working groups are those of the last fiscal year (2010.4 - 2011.3).

Subcommittee on Nuclear Data (chaired by K. Shibata, JAEA)
High Energy Nuclear Data Evaluation WG (chaired by Y. Watanabe, Kyushu Univ.)
ENSDF Group (chaired by H. Iimura, JAEA)

Subcommittee on Reactor Constants (chaired by N. Yamano, Fukui Univ.)
Reactor Integral Test WG (chaired by M. Ishikawa, JAEA)
Shielding Integral Test WG (chaired by N. Yamano, Fukui Univ.)
Decay Heat Evaluation WG (chaired by T. Yoshida, Tokyo City Univ.)
WG on Evaluation of Nuclide Generation (chaired by K. Okumura, JAEA)

The activities for covariances, evaluation methodology, fostering, nuclear data needs and dissemination will be considered.

Nuclear Data Evaluation

Aftercare of JENDL-4.0

The compilation of the new Japanese Evaluated Nuclear Data Library, JENDL-4.0 was completed in March 2010. After the internal procedure for public release, the JENDL-4.0 was released in May 2010. The DVD-ROM including the original data, point-wise data (0, 300K) and plots also has been published. The Maxwellian average cross sections of neutron capture reactions and JENDL-4 merged version of JENDL/HE-2007 were prepared for nuclear astrophysics applications and IAEA/CRP on FENDL-3, respectively.

The reference papers have been published as followings;

JENDL-4.0 original:
- K. Shibata, O. Iwamoto, T. Nakagawa, N. Iwamoto, A. Ichihara, S. Kunieda, S. Chiba, K. Furutaka, N. Otuka, T. Ohsawa, T. Murata, H. Matsunobu, A. Zukeran, S. Kamada, and J. Katakura, "JENDL-4.0: A New Library for Nuclear Science and Engineering", *J. Nucl. Sci. Technol.* **48**, 1-30 (2011).

Benchmark tests:
- G. Chiba, K. Okumura, K. Sugino, Y. Nagaya, K. Yokoyama, T. Kugo, M. Ishikawa, and S. Okajima, "JENDL-4.0 Benchmarking for Fission Reactor Applications", *J. Nucl. Sci. Technol.* **48**, 172-187 (2011).

Evaluations:
- K. Shibata, "Evaluation of Neutron Nuclear Data on Hafnium Isotopes for JENDL-4" J. Nucl. Sci. Technol. **47**, 160-168 (2010).
- S. Kamada, K. Shibata, A. Ichihara, S. Kunieda, "Evaluation of Neutron Nuclear Data on Selenium Isotopes for JENDL-4", *J. Nucl. Sci. Technol.* **47**, 329-339 (2010).
- K. Shibata, A. Ichihara, S. Kunieda, "Evaluation of Neutron Nuclear Data on Rubidium and Strontium Isotopes for JENDL-4", *J. Nucl. Sci. Technol.* **47**, 1055-1064 (2010).
- K. Shibata, A. Ichihara, S. Kunieda, "Evaluation of Neutron Nuclear Data on Bromine and Krypton Isotopes for JENDL-4.0", *J. Nucl. Sci. Technol.* **48**, 429-439 (2011).

For the treatment of bugs, the collection of the deficiencies in JENDL-4.0 has been started. Following it, updated files for
- Elastic scattering cross section of ^{10}B
- Comment file of ^{109}Ag
- Fission product yields for ^{241}Pu and ^{242m}Am

have been prepared. The original FPY for ^{242}Am should have been the FPY for ^{242m}Am. Therefore, the wrong MAT number was changed to the correct one.

Preparation of Libraries Based on JENDL-4.0
The following libraries based on JENDL-4.0 were prepared and released to public by JAEA in September 2010:
1) 'SRACLIB-JDL40' for neutronics analysis system for thermal reactors SRAC2006 with 107-energy structure,
2) 'MVPlib-nj40' for continuous-energy Monte Carlo code MVP,
3) 'FSXLIB-J40' for continuous-energy Monte Carlo code MCNP and PHITS,
4) 'MATXSLIB-J40' for shielding calculation codes such as ANISN,
5) 'JFS-3-J4.0' for fast reactor analysis code SLAROM with 70-energy structure, and
6) 'UFLIB-J4.0' for fast reactor analysis code SLAROM-UF with ultra-fine energy structure.

(Ref. http://wwwndc.jaea.go.jp/jendl/j40/j40appli/j40appli_lib.html)

Benchmarking for fission reactor applications
Benchmark testing for the newly developed Japanese evaluated nuclear data

library JENDL-4.0 is carried out by using a huge amount of integral data. Benchmark calculations are performed with a continuous-energy Monte Carlo code and with the deterministic procedure, which has been developed for fast reactor analyses in Japan. Through the present benchmark testing using a wide range of benchmark data, significant improvement in the performance of JENDL-4.0 for fission reactor applications is clearly demonstrated in comparison with the former library JENDL-3.3. Much more accurate and reliable prediction for neutronic parameters for both thermal and fast reactors becomes possible by using the library JENDL-4.0:

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1) Criticality for thermal systems:

Figure 1 shows C/E values of 18 criticality data of uranium-fueled light-water-moderated systems. The error bars in this figure indicate the uncertainties of the benchmark keff 's given in the ICSBEP handbook. Uranium-235 enrichment dependence of the C/E values is observed in both the JENDL-3.3 and JENDL-4.0 results. JENDL-4.0 results in slightly larger criticalities than JENDL-3.3. As a result, JENDL-4.0 improves underestimations for low-enriched uranium systems observed in the JENDL-3.3 results. JENDL-4.0 reproduces the experimental values of these criticalities within about 0.5%dk/kk' differences.

2) Criticality of middle- and large-sized fast systems:

Figure 2 shows C/E values of criticalities of these systems. The deterministic procedure is employed for the Monju and BFS-2 calculations. In this figure, systems are ordered with a small contribution of Pu-239 to fission reaction at the left side. JENDL-3.3 systematically underestimates the criticalities of the MOX-fueled cores of about 0.3%dk/kk', and significantly underestimates the criticalities of uranium-fueled cores, especially for BFS-62-1, which does not include any plutonium nuclides. On the other hand, JENDL-4.0 improves these underestimations and yields good agreements between calculation and experimental values, regardless of reactor size and fuel composition.

3) Sodium void reactivity worths of BFS-2:

The sodium void reactivity worths of BFS-2 are defined as zone-wise reactivities, and the reactivity worths are given for each fuel region: a low-enriched uranium, intermediate-enriched uranium, high-enriched uranium, or mixed-oxide region. These worths are calculated using the deterministic procedure. Figure 3 shows the results of the sodium void reactivity worths of BFS-2. For the MOX-fueled zone voiding case, both JENDL-3.3 and JENDL-4.0 predict the reactivity worths well. JENDL-3.3, however, significantly underestimates the reactivity worths of the uranium-fueled zone voiding. This problem is also observed when other modern nuclear data libraries, such as JEFF-3.1 and ENDF/B-VII.0, are employed. JENDL-4.0 solves this problem by the reevaluation of the U-235 capture cross section.

4) Postirradiation examination for fast reactors, Joyo MK-II:

C/E values of number density ratios of two actinoids after irradiation are shown in Fig. 4 for the Joyo data. For example, 'Am-241 sample/Pu-238' indicates the number density ratio of Pu-239 to Pu-238, which is sensitive to the Pu-238 capture cross section,

in the Am-241 sample. These results show that C/E values are considerably improved in JENDL-4.0. Therefore, it is considered that the MA data in JENDL-4.0 is quite applicable to the MA-loaded fast reactor core analyses with high accuracy.

New Evaluations

The data which are not updated in JENDL-4.0 are continuously considered, especially for FP region nuclides. Among them, full evaluation for ^{17,18}O, ^{99}Tc and ^{165,166m}Ho has been done. The evaluation for Ga, Ru, Rh, Sb, Te, I, La, Ce, Pr and Er is being planned in near future.

The activation cross sections are getting more important for the down-stream of fuel cycle and replacements of power reactors. For this purpose, the thermal capture cross sections of ^{2}H, ^{59}Co, ^{58,62}Ni and ^{93}Nb have been reviewed and those of ^{2}H and ^{58,62}Ni have been revised. Some new data for the medical RI production, the reactions of ^{90}Zr, ^{100}Mo+n up to 40 MeV were evaluated.

Covariances

The covariance data were considered for all reactions of ^{52,53}Cr. Those for resolved resonance parameters of ^{233,235,238}U and ^{239}Pu were also investigated and stored in MF=33, not in MF=32.

Evaluation Tools

The 5 year period from 2010 to 2014 is the second period of mid-term research plan of JAEA. According the mid-term plan, the objective of nuclear data research is "incident energy expansion of JENDL". For this purpose, the nuclear reaction model code, CCONE is planned to be expanded to higher energy region. The considered improvements are;
- to add the multi-particle emission from the pre-equilibrium stage,
- to add the complex-particle emission from the pre-equilibrium stage, and
- to add the function of calculating photo-induced reactions.

FP Decay Data File

The version up of FP Decay Data File 2000 is now planned to include recent measured and compiled data. The sensitivity analysis of FP decay heat and the error of fission energy were studied. The blanching ratios of delayed neutron were reviewed and recompilation was done by using ENSDF and/or Pfeiffer & Kratz. The decay data of 1263 nuclides have been recompiled for FP Decay Data File with considering the latest ENSDF, Yoshida's TAGS data (including the "pandemonium" effect) and delayed neutron data. The test calculation was done for the decay heat after the ^{235}U fission, and gave good agreement with the experimental data.

The further check is planned to be done. After that, data for nuclides other than FPs will be compiled.

Other Activities

2010 Symposium on Nuclear Data

The symposium was held on 25 and 26, November, 2010 at the Chikushi campus of Kyushu university. There were 61 participants. The symposium was hosted by nuclear data division, Atomic Energy Society of Japan. The topics related to the

JENDL-4, nuclear data measurements and light charged-particle emission reactions were presented. Totally 40 papers including poster presentations were presented and will be summarized into the proceedings.
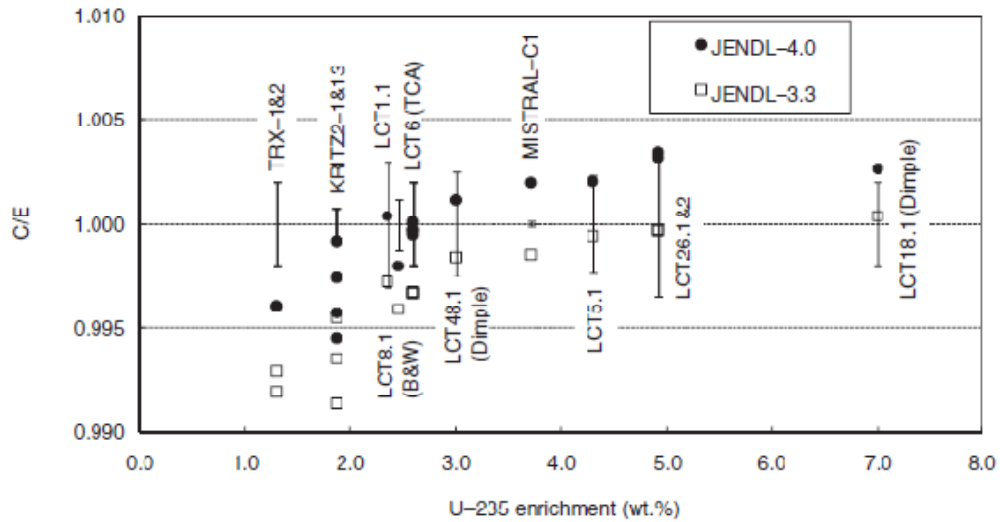

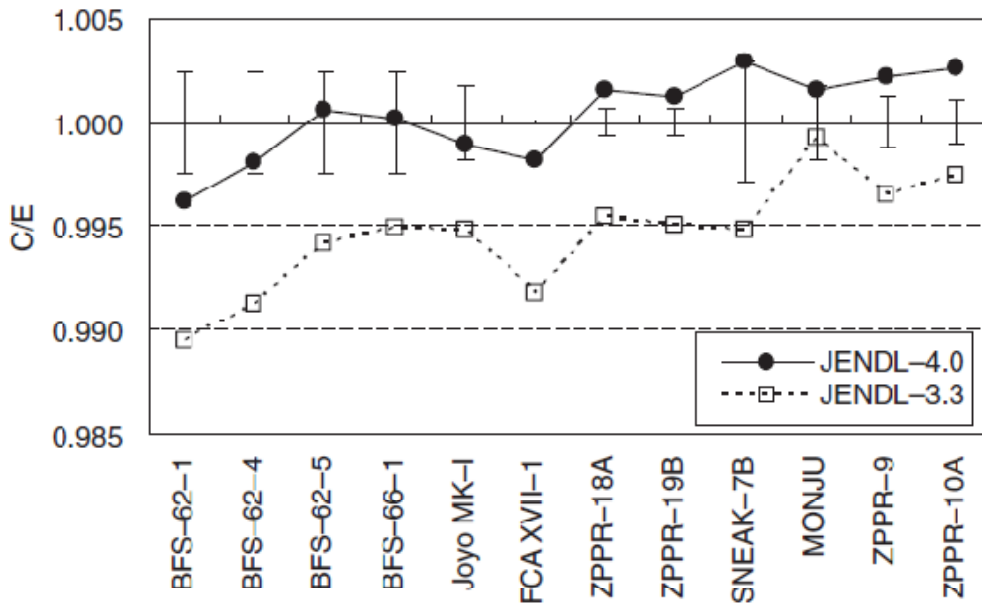**Fig. 1** C/E values of criticalities of uranium-fueled light-water-moderated systems

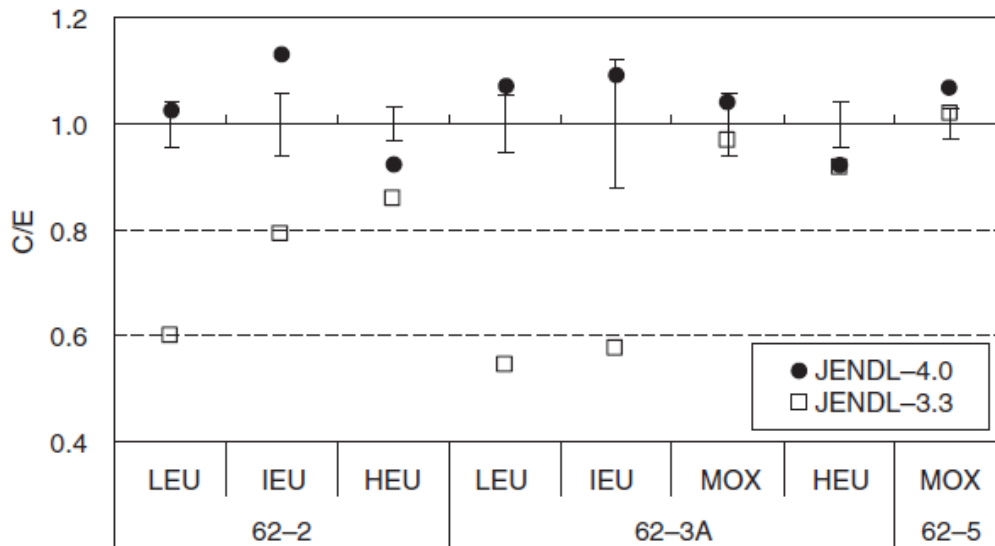**Fig. 2** C/E values of criticalities of middle- and large-sized fast systems

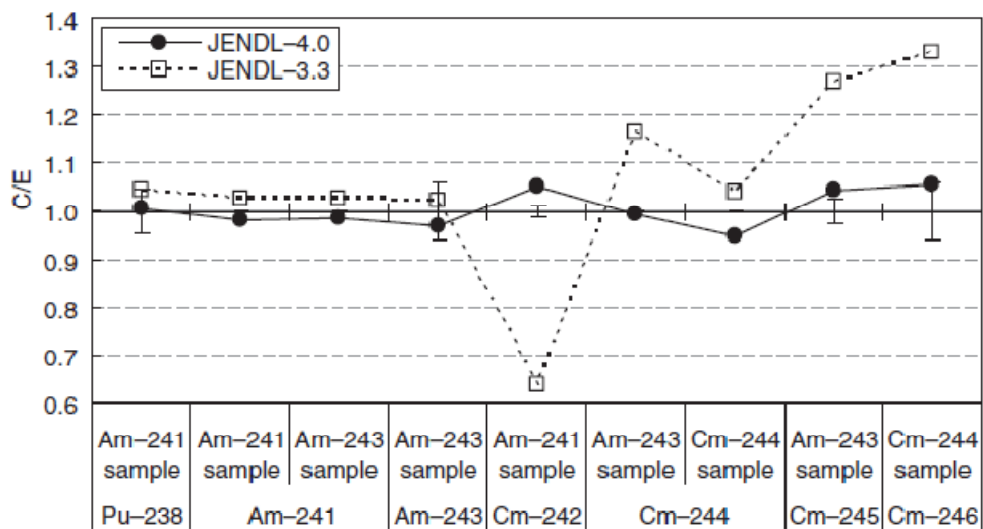**Fig. 3** C/E values of sodium void reactivity worths of BFS-2

Fig. 4 Result of calculations related to the capture cross sections of ^{238}Pu, ^{241}Am, ^{243}Am, ^{242}Cm, ^{244}Cm, ^{245}Cm, and ^{246}Cm for the MA sample irradiation tests in Joyo MK-II