2.3 Integral test of JENDL-3.3 for fast reactors

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An integral test of JENDL-3.3 was performed for fast reactors. Various types of fast reactors were analyzed. Calculation values of the nuclear characteristics were greatly especially affected by the revisions of the cross sections of U-235 capture and elastic scattering reactions. The C/E values were improved for ZPPR cores where plutonium is mainly fueled, but not for BFS cores where uranium is mainly fueled.

1. Introduction

The updated version of JENDL-3 nuclear data library, JENDL-3.3, was released. It is important to validate an application of JENDL-3.3 to the fast reactor analysis because a revision of nuclear data library affects accuracy of calculation values greatly.

This integral test was performed in several fast cores. These are ZPPR, FCA, JOYO, MOZART and BFS. Features of these cores are different to each other.

Analyzed nuclear characteristics are effective multiplication factor(k-eff), reaction rate distribution, reactivity of sodium void, Doppler and control rod insertion, and so on. The calculations were performed both with JENDL-3.3 and JENDL-3.2 and effects of the revision were evaluated.

2. Tested cores and its characteristics

Features of tested cores are summarized in Table 1. ZPPR cores are categorized into four “JUPITER” experiments. Many types of cores were used in this test. Small or large cores, uranium or plutonium fueled cores are there.

3. Calculation method

JUPITER standard calculation scheme[1] was adopted. The scheme has been used in many analyses of fast reactors. Figure 1 shows an outline of the scheme.

JFS-3-J3.3 was used as an application library to fast reactor analysis. JFS-3-J3.3 is the Bondarenko type library with 70-group structure. Effective cell-averaged cross sections are calculated by the cell calculation and condensed to smaller (18 or 7) energy groups. The condensed cross sections are used in the core calculation based on the diffusion or transport theory. After that, the value of the nuclear characteristics can be obtained.

In addition to the standard calculation scheme, the new group constant system was used. The system has been developed to improve an insufficient treatment of resonance self shielding effects[2]. Correction factors for the improvement were evaluated based on JENDL-3.2 and applied to some nuclear characteristics.

Table 1 Features of tested cores

	Core size	Feature	Fuel	Outer region*
JUPITER-I	Large, Medium	Homogeneous	Pu	Blanket
JUPITER-II		Radial haterogeneous	Pu	
JUPITER-III		Axial heterogeneous	Pu	
JUPITER-Io		Homogeneous	Pu,U	
BFS-62-1	Medium	Homogeneous	U	Blanket
BFS-62-2			U	Reflector, Blanket
BFS-62-3A			U,Pu	Reflector, Blanket
BFS-62-4			U,Pu	Blanket
JOYO MK-I	Small	Homogeneous	U,Pu	Blanket
JOYO MK-II				Reflector
FCA X-1	Small	Homogeneous	U,Pu	Blanket
FCA XVII-1				
MOZART MZA	Medium	Homogeneous	Pu	Blanket
MOZART MZB(1)				

*"Outer region" means the region adjacent to the fuel region.

4. Results

Figure 2 shows results of k-eff in ZPPR cores. k-eff increases about 0.2%dk/k by the revision and underestimations were slightly improved except for ZPPR-18, -19 cores, in which uranium is fueled partly. C/E values become similar to each other. Figure 3 shows results of sensitivity analyses. The revision of U-235 capture cross section causes the difference of the k-eff change. The revision of Fe capture cross section mainly contributes to the improvement of the underestimations.

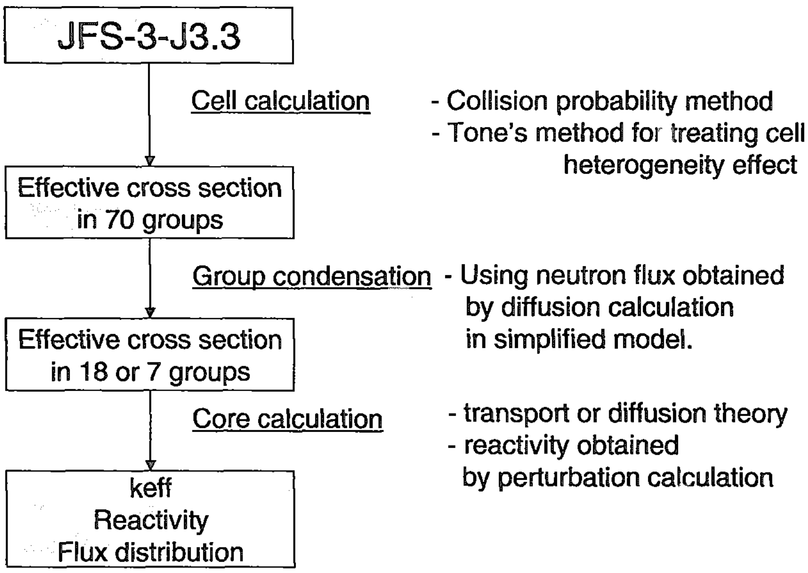

Fig. 1 Outline of the JUPTIER standard calculation scheme

Figure 4 shows results in other cores. It can be seen that C/E values become worse in BFS cores while MOZART cores have better results. The changes of k-eff in BFS cores were caused by the revision of U-235 capture cross section. Improvements in MOZART cores were mainly contributed by the revision of Fe capture and elastic scattering cross sections.

It can be said in general, improvements were observed in k-eff of most of the tested cores when JENDL-3.3 was used. However, k-eff of all cores were still underestimated.

Control rod worth was affected by the revision only in uranium fueled cores. Figure 5 shows results of ZPPR-18, -19 cores. Decreases were observed in control rod worth for uranium fueled regions. As the result, discrepancy of C/E values becomes smaller. This is due

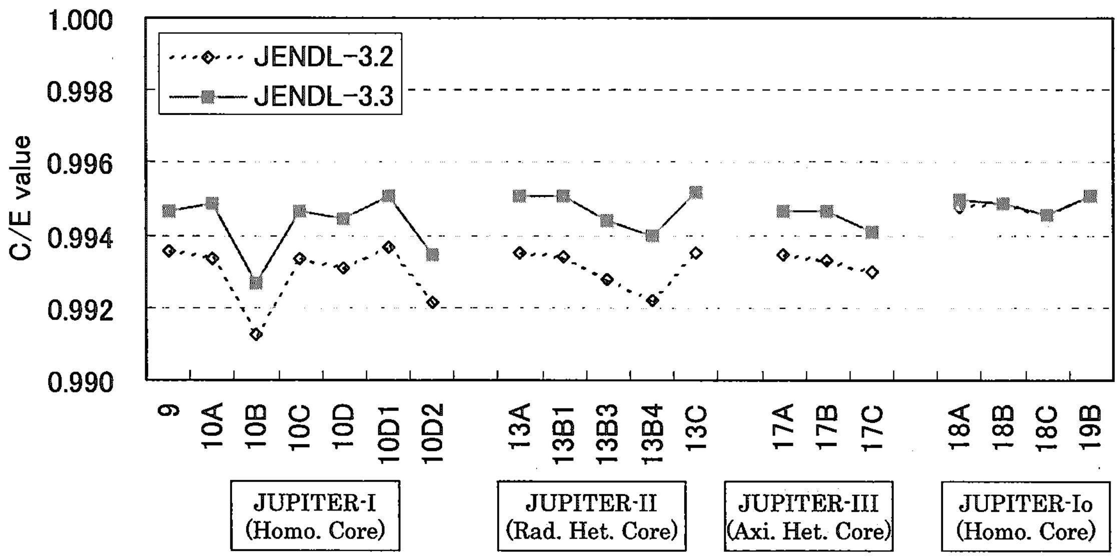

Fig.2 Results of k-eff in ZPPR cores

to the revision of U-235 capture cross section. However, in BFS cores, C/E values are not improved by the revision. The results are shown in Fig. 6.

Small sample worth analysis was also performed in ZPPR-9 cores. A significant effect was observed when sample is a stainless steel. The result is shown in Fig. 7. The average of C/E values changed from 1.095 to 1.046. Overestimations were improved about 5% by using JENDL-3.3. It is due to the revision of Fe capture cross section.

Figure 8 shows results of high Pu-240 zone substitution reactivity analysis in

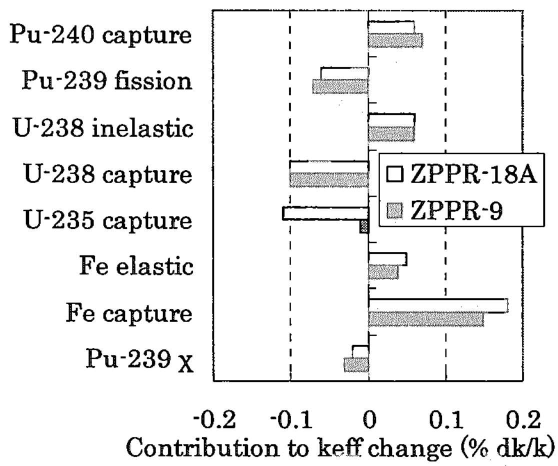

Fig.3 Results of sensitivity analyses of k-eff in ZPPR cores

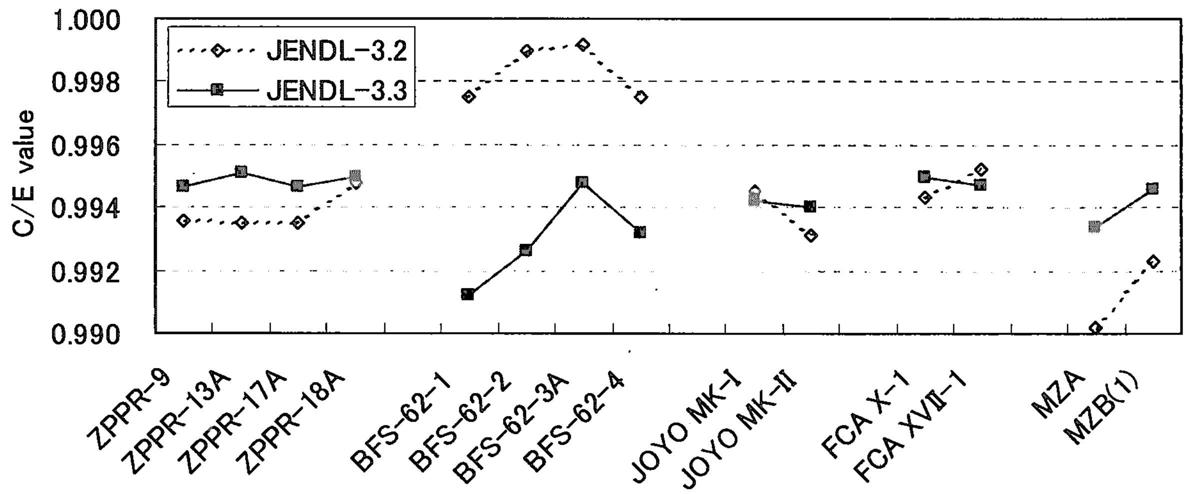

Fig. 4 Results of k-eff in other cores

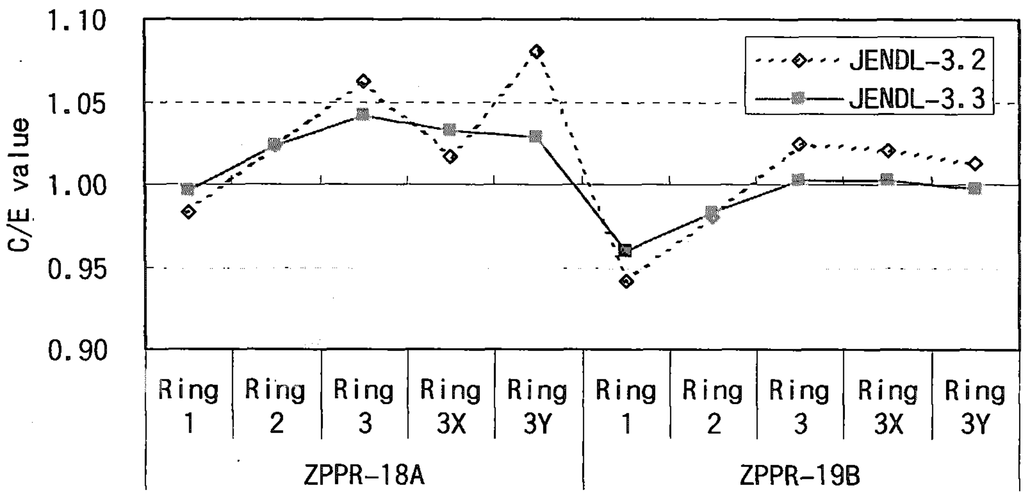

Fig.5 Results of control rod worth in ZPPR cores

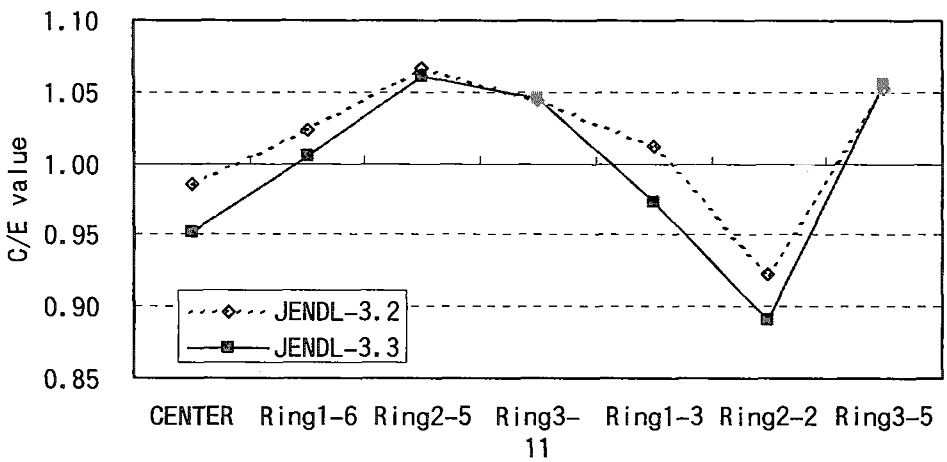

Fig.6 Results of control rod worth in BFS cores

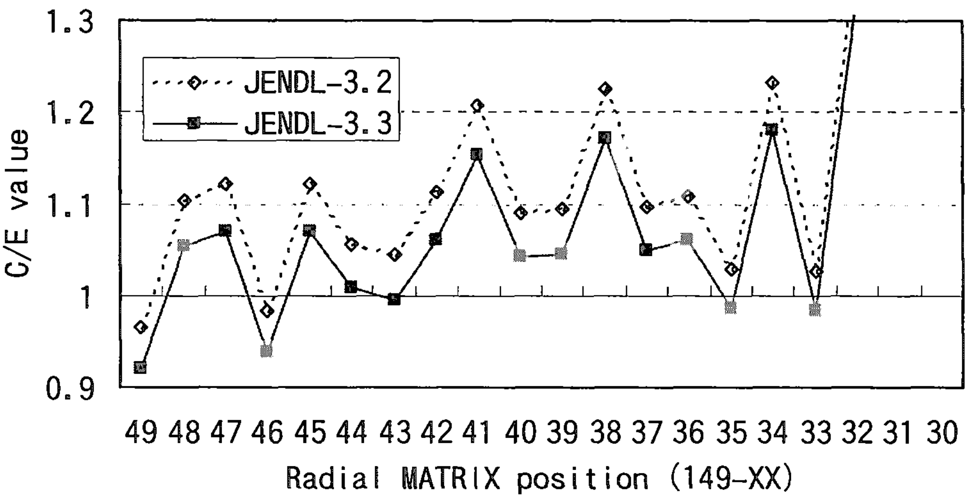

Fig.7 Results of small sample reactivity (ZPPR-9)

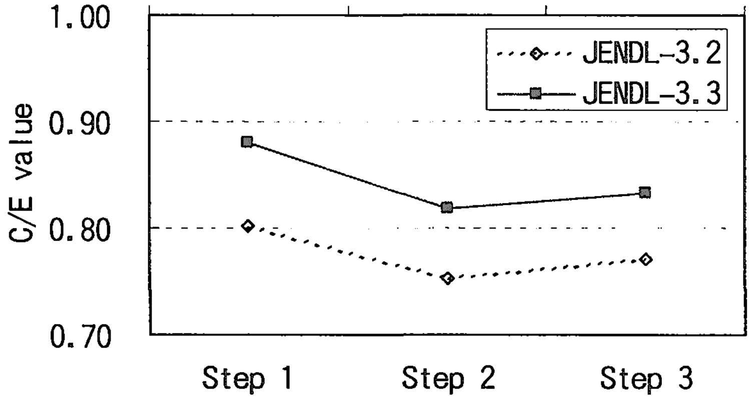

Fig.8 Results of high Pu-240 substitution reactivity

ZPPR-13C. In this experiment, the ordinary fuel(Pu-240 enrichment is 12%) was substituted to high Pu-240 fuel(enrichment is 26%) and the reactivity was measured. Underestimation was improved by the revision of Pu-240 capture cross section.

Figure 9 shows results of sodium void reactivity analysis in ZPPR cores. C/E values decrease and were not improved by the revision. Figure 10 shows

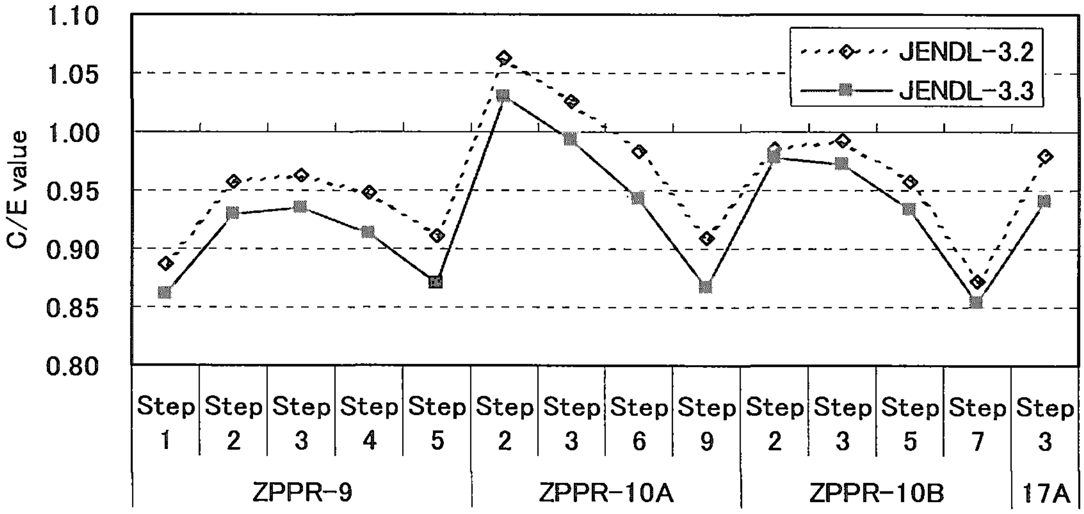

Fig.9 Results of sodium void reactivity in ZPPR cores

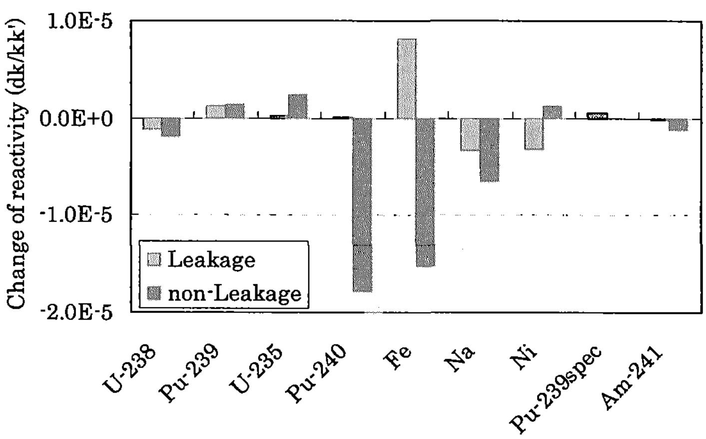

Fig.10 Result of sensitivity analysis of sodium void reactivity (ZPPR-9 void step 5)

results of sensitivity analysis. The revision of Pu-240 and sodium cross section made the C/E values smaller. The revision of Fe affects a little because a cancel of effects was occurred between the leakage term and the non-leakage term. Figure 11 shows C/E values in BFS cores. The revision of U-235 capture cross section mainly contributed to the changes of C/E values, which did not lead to an improvement.

Overestimation was observed in Pu-239 fission reaction rate distribution on the reflector region in

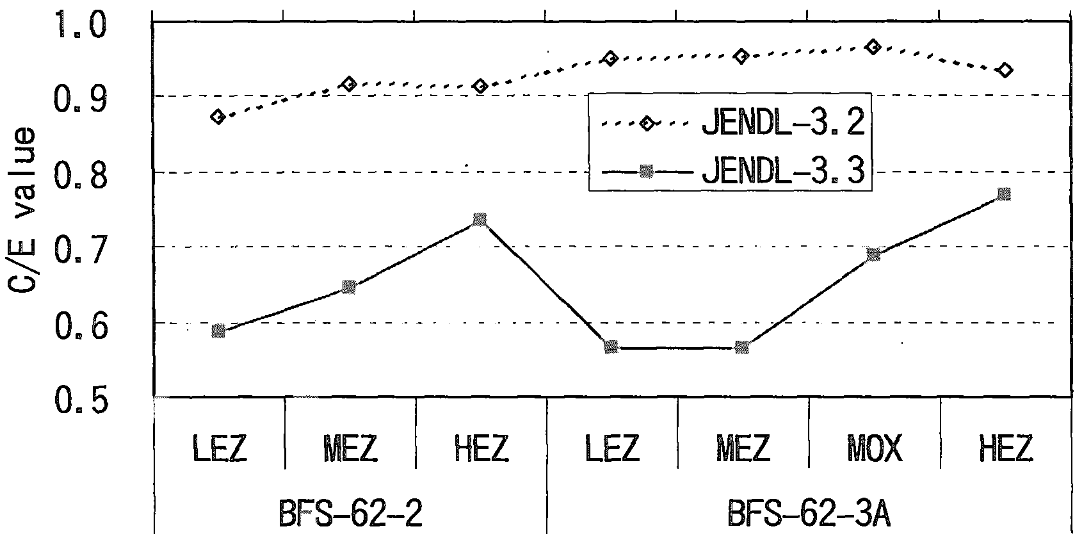

Fig.11 Results of sodium void reactivity in BFS cores

BFS cores when JENDL-3.2 was used. It have been pointed out by many researchers that the overestimation was originated from an error of the nuclear data because Monte Carlo methods can not improve the problem. Figure 12 shows results obtained by using JENDL-3.3. There is no improvement.

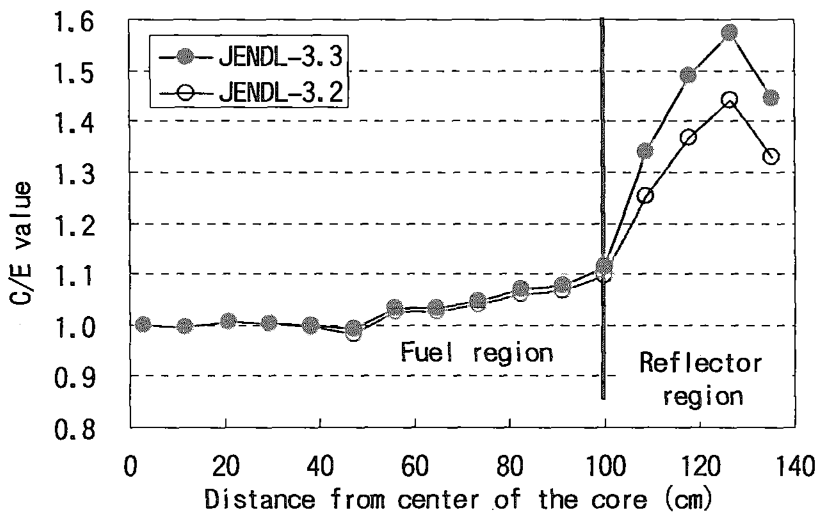

Fig.12 Results of Pu-239 fission reaction rate distribution(BFS-62-2)

5. Conclusion

An integral test of JENDL-3.3 was performed for fast reactors. The nuclear characteristics were mainly affected by the revision of U-235 capture cross section, Fe capture cross section, Fe elastic scattering cross section and Pu-240 capture cross section. In ZPPR cores, C/E values of many characteristics were improved by using JENDL-3.3. However, C/E values deteriorate in BFS cores which have strong sensitivity to U-235 cross section.

References

[1] Ishikawa, M. : "Consistency Evaluation of JUPITER Experiment and Analysis for Large FBR Cores," *Proc. of Int. Conf. on the Physics of Reacotrs(PHYSOR96)*, Mito, Japan, Vol.2, p.E-36 (1996).

[2] Sugino, K. : "JUPITER Experiment Analyses Using a New Constant Set Based on JENDL-3.2," *J. of.Nucl. Technol. Supp.* 2 p.1002 (2002).