Working Party on International Nuclear Data Evaluation Cooperation, Subgroup 29

U-235 Capture Cross Section in the keV to MeV Energy Region

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Abstract

SG29 was established in May 2007. U-235 capture cross sections have been investigated from both of differential and integral points of view. The activities of the first year for SG29 are shown.

1. Introduction

SG29 was established in May 2007 to investigate U-235 capture cross section in the keV to MeV energy region. SG29 members are:

ENDF: T. A. Bredeweg (LANL) T. Kawano (LANL), R. McKnight (ANL, Monitor), L.C. Leal (ORNL), C. Lubitz (KAPL)
JEFF: R. Jacqmin (CEA)
JENDL: T. Nakagawa (JAEA), G. Chiba (JAEA), S. Okajima (JAEA), M. Ishikawa (JAEA), O. Iwamoto (JAEA, Coordinator)

Activities of SG29 are shown in the next section.

2. Activities

Control rod worth of ZPPR-18A

M. Ishikawa at JAEA looked for another independent integral experiment which can be used for survey U-235 capture effect, and found an experiment in the JUPITER project, control rod worth measurement in the ZPPR-18A core [1].

Figure 1 shows the configuration of the ZPPR-18A core. Since the inventory of total ZPPR-Pu fuel was not sufficient for this large FBR core construction, approx. 1,000kg of U-235 was loaded in the Y-axis direction of the outer core region (U-sector, hereafter). The X-axis direction of the outer core region (Pu-sector) and the whole inner core region were composed by normal ZPPR-Pu fuel, the effect of U-235 was quite different between X-axis and Y-axis. One of typical U-235 effect appeared in two cases of the control rod worth measurements. One is the case where four positions of CR worth were measured adjacent to Pu-sector (Case: Ring3X), the other measured adjacent to U-sector (Case: Ring3Y). The control rod positions of these cases are marked in Fig.1.

The control rod worth of the ZPPR-18A core was analyzed with the most-detailed deterministic method of JAEA, the features of which are: heterogeneous cell calculation by collision probability, 3-dimensional modeling of core, use of Benoist's anisotropic diffusion coefficient, transport correction, ultra-fine energy correction and reaction rate ratio preservation (RRRP) method for control rod modeling. The C/E values of all analytical results by JENDL-3.2 (with old U-235 resonance parameters) and JENDL-3.3 (with new resonance parameters) are depicted in Fig. 2. When JENDL-3.2 is used, The above two cases Ring3X and Ring3Y results in very similar C/E values which are consistent with those of other measured position patterns, but JENDL-3.3 clearly makes the C/E values of two cases worse. (Here he concentrates on not the absolute values of the C/Es, but the consistency of C/Es for various control rod position patterns, since the absolute values of reactivity C/Es may be systematically affected by many causes such as the isotope-wise delayed neutron data, neutron numbers per fission, analytical error of local neutron transport and gradient. These systematic errors would be considered as common in the two cases: Ring3X and Ring3Y.

Finally, he analyzed the nuclide- and reaction-wise contributions of C/E changes between JENDL-3.2 and JENDL-3.3 for the two cases, by multiplying the cross-section differences with the cross-section sensitivity coefficients. As seen in Fig.3, the C/E changes were effectively caused by the difference of U-235 capture cross-section only.

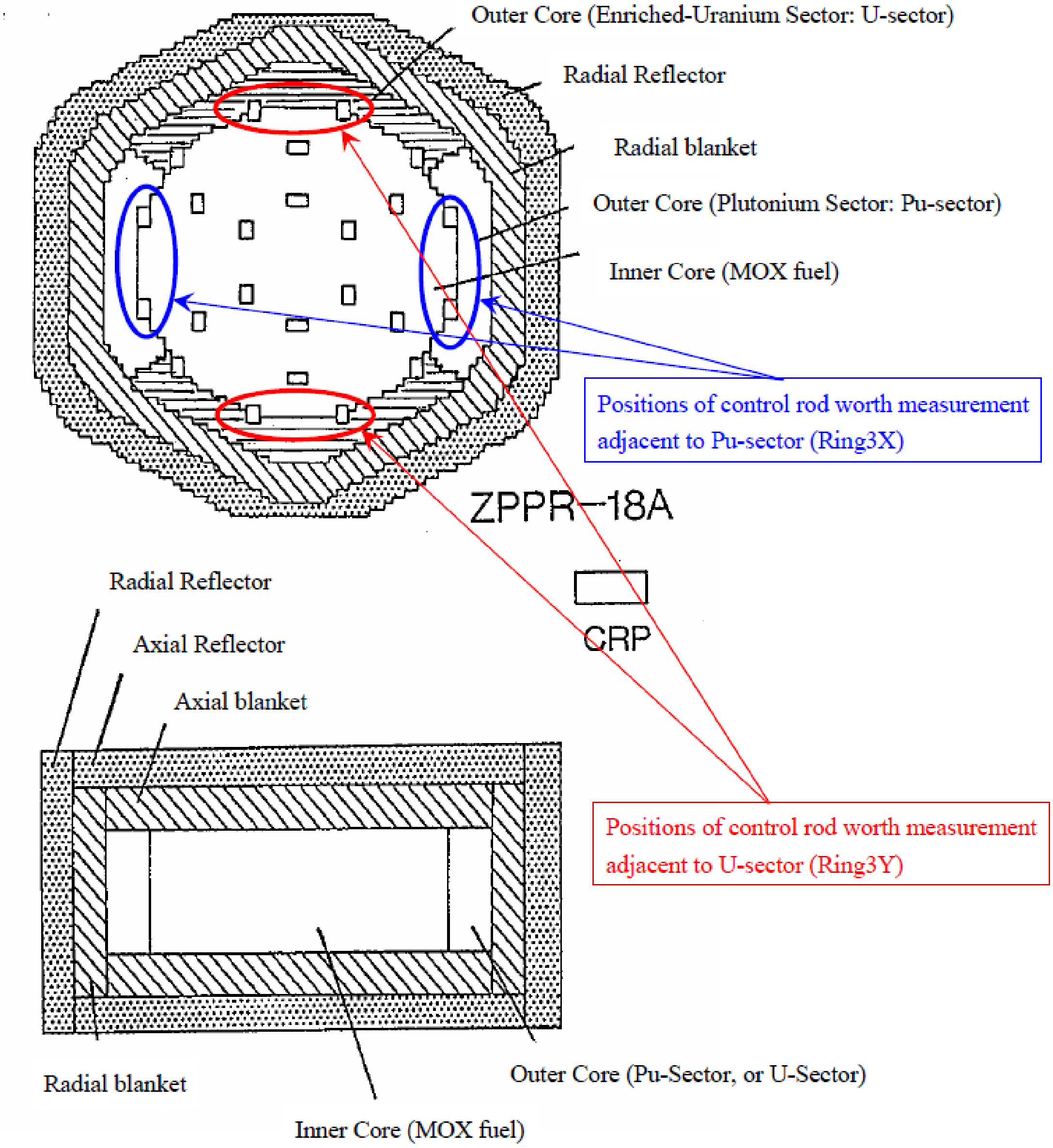

Fig.1. Core Configuration of ZPPR-18A (upper: Horizontal, lower: Vertical).

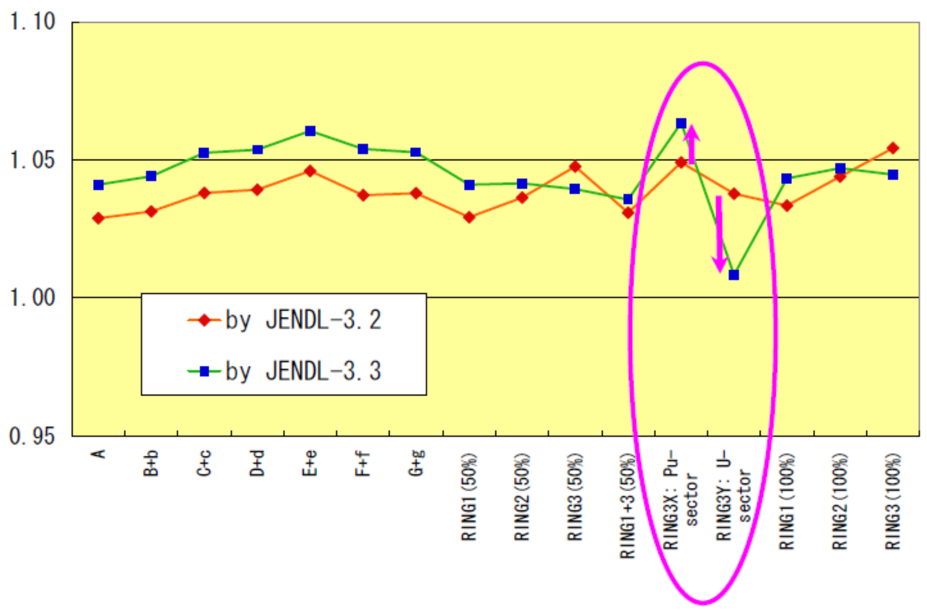

Fig. 2. C/E Values of Control Rod Worth in ZPPR-18A core.

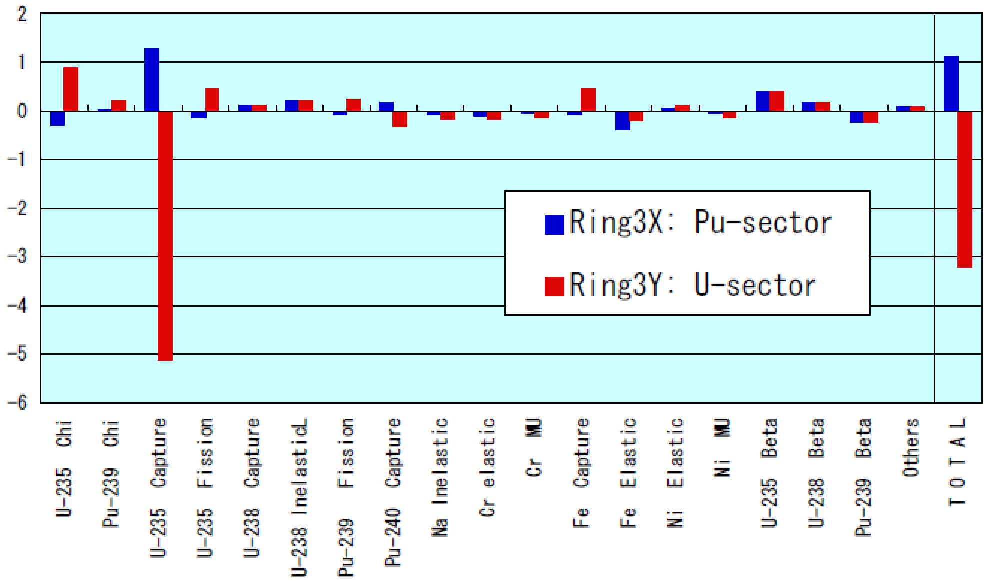

Fig. 3. Nuclide- and Reaction-wise Contribution to C/E Changes of Control Rod Worth in ZPPR-18A core.

FCA-IX benchmark problem

G. Chiba and S. Okajima have prepared a FCA-IX benchmark problem, which is easy to calculate with Monte-Carlo or deterministic neutron transport codes [2].

Cores of the benchmark problem are expressed as simple two-dimensional cylinder. Each core model is composed of two material regions, *i.e.*, a fuel region and a blanket region. Lattice heterogeneity effect of each region is ignored in these models. Geometrical specifications of the core models and region-wise number densities are shown.

Experimental values of this problem are obtained from the experimental data of the 'as built' assemblies and the correction factors for model simplification. These correction factors are determined as a difference between Monte-Carlo solution of the benchmark model and that of the 'as built' model. They have surveyed these correction factors with several nuclear data files and consequently confirmed that the dependence of these factors on nuclear data is small.

Impact of JENDL-3.2 and ENDF/B-VII.0 Resonance Region

O. Iwamoto *et al.* investigated the source of the biases in intermediate energy benchmark calculations [3]. The work consists of calculations of intermediate benchmark using JENDL-3.2 and ENDF/B-VII.0 and sensitivity calculations.

It can be seen that ENDF/B-VII.0 capture cross section is much larger than JENDL-3.2 and statistical model calculations in the range of about 100eV to 3keV. Discrepancies are found also in the elastic scattering cross sections below 30 keV. The total and fission cross sections have no such noticeable discrepancies.

The ENDF/B-VII.0 capture/fission ratio, α, is in the upper part of the experimental results. However, JENDL-3.2 agrees well with the experimental results.

Difference between ENDF/B-VII.0 and JENDL-3.2 from 500eV to 2.25keV has a large impact on both the FCA-IX and Zeus calculations while difference below 500eV has an impact only on the Zeus calculations.

Replacement of the ENDF/B-VII.0 resonance parameters by JENDL-3.2 for uranium-235 makes the C/E dependence on spectrum hardness smaller. However, this also results in unacceptable high C/E values. This can be an indication that there exists other energy region which also contributes to the multiplication factor. These cases need further investigation.

A simple decrease in the capture cross section, i.e. in Γ_γ, reduces the C/E dependence on spectrum hardness. However, it scales the k_{eff} up. These results may indicate that other cross section or combinations of effects may be causing the biases.

Detailed neutron balance analyses indicate that the leakages for the ZEUS benchmark experiments are on the average of 28 % whereas in the FCA it is about 4 %. The contribution of each component to k_{eff} for the ZEUS and FCA benchmark experiments are different from each other.

Through cross section adjustment with the integral data and the covariance information for uranium-235 cross sections, it is indicated that capture cross section in resonance range is overestimated.

3. Conclusions

M. Ishikawa suggested that U-235 capture cross section affected the control rod worth measurement in the ZPPR-18A core. G. Chiba and S. Okajima have prepared a FCA-IX benchmark problem, which is easy to calculate with Monte-Carlo or deterministic neutron transport codes. O. Iwamoto et al. investigated the source of the biases in intermediate energy benchmark calculations.

References

[1] M. Ishikawa, *“Effect of U-235 capture-cross section to control rod worth of ZPPR-18A”*, Report, Sep. 2007, http://wwwndc.jaea.go.jp/iwamoto/sg29/.

[2] Go CHIBA, Shigeaki OKAJIMA, *“FCA-IX benchmark problem for WPEC/SG-29”* , Report, 2007, http://wwwndc.jaea.go.jp/iwamoto/sg29/.

[3] O. Iwamoto, G. Chiba, T. Nakagawa, and L. Leal, “*Impact of JENDL-3.2 and ENDF/B-VII.0 Resonance Region (resolved and unresolved) in Intermediate Energy Benchmark Calculations*”, Report, 2008, http://wwwndc.jaea.go.jp/iwamoto/sg29/.