Requests on Domestic Nuclear Data Library from BWR Design

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Requests on the domestic nuclear data library JENDL and activities of the Nuclear Data Center have been presented from the perspective of BWR design and design code development. The requests include a standard multi-group cross section library, technical supports, and clarification of advantage of JENDL as well as requests from physical aspects.

1 Introduction

The domestic nuclear data library JENDL3.3 [1] was released in May 2002. In order that the efforts made for the domestic nuclear data library development may not end up being a waste, it is important to prepare a way for use of the domestic nuclear data library in design works. User’s opinions will be informative for this purpose. This paper summarizes requests on the domestic nuclear data library and activities of the Nuclear Data Center from various viewpoints of BWR design; requests from the viewpoint of physical aspects in BWR fuel/core designs are described in Chapter 2, those from the standpoint of design code development in Chapter 3, and those from the angle of the domestic nuclear data library utilization in Chapter 4.

2 Physical Aspects in BWR Fuel and Core Design

2.1 Improvement of Current BWR

Recent BWR core designs are characterized with

- high burn-up,
- plutonium utilization in thermal reactors,
- long-cycle operation, and
- up-rate of reactor power

in the extension of a current BWR design.

High burn-up design is effective for reducing the amount of spent fuel disposal and fuel cycle cost. High burn-up BWR fuel designs [2] are proceeding step by step; a target discharge exposure of conventional 8x8 fuel was 28GWd/t, and those of high burn-up fuels Step-I, Step-II, Step-III were 33GWd/t, 39.5GWd/t, and 45GWd/t, respectively, as shown in Fig.1. From Step-I to Step-III fuel, various items such as reliability and thermal margin were improved so as to keep fuel integrity. The fuel cycle cost of Step-III was reduced by 30% compared with conventional 8x8 fuel.

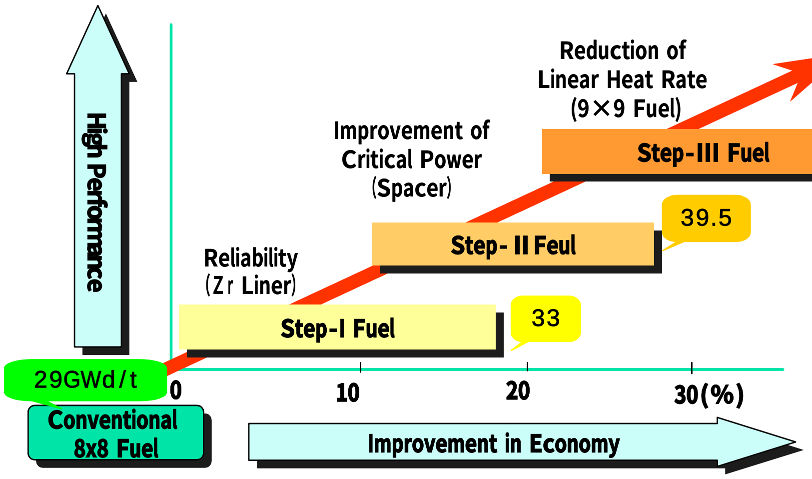

Fig. 1　High Burn-Up Fuels Used in BWR

Figure 2 shows the FP contribution to total absorption rate in a fuel rod as a function of discharge exposure. The FP absorption contribution increases with exposure; for example, the FP contribution increases by 50% when discharge exposure increases from 30GWd/t to 60GWd/t. Therefore, accurate evaluation of the FP absorption contribution is important for the high burn-up designs.

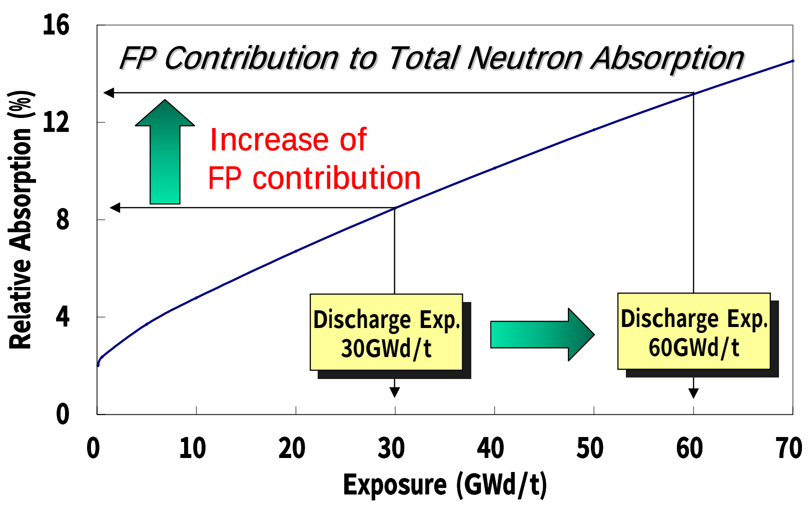

Fig. 2　FP Contribution to Total Neutron Absorption in UO_2 Fuel

In the plutonium utilization in thermal reactors (Pu thermal utilization), the higher actinide contribution to the total absorption rate increases as shown in Fig. 3. This figure shows that this contribution is more significant in MOX fuel than in UO_2 fuel. Hence, more attention should be paid to the accuracy of higher actinide cross sections in MOX fuel design than in UO2 fuel design.

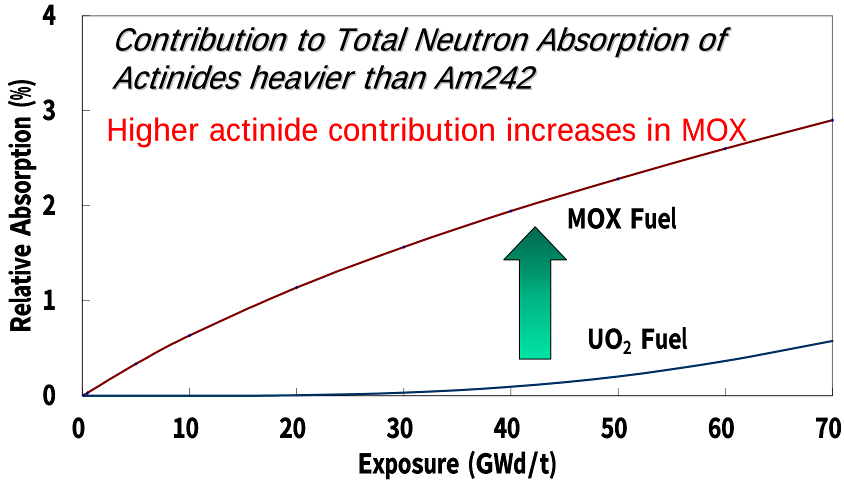

Fig. 3 Higher Actinide Contribution to Total Neutron Absorption

Long-cycle operation improves the plant utilization factor. In this operation, a control of excess reactivity is a key technique, and new kinds of burnable absorber might be adopted in place of gadolinia. Therefore, the cross section of various absorber materials must be prepared for the long-cycle operation design. Accurate thermal margin evaluation is important for up-rate of reactor power. For this purpose, every type of cross sections must be prepared with sufficient accuracy as basic data of the design works.

2.2 Next Generation BWR

New core concepts for next generation BWR [3] are investigated these days in order to maintain stable energy supply in the future. Some of these designs improve a conversion ratio up to 1.0 or more, using tight-pitch lattices with low H/HM ratios. Others [4] aim at an effective use of Pu for saving uranium resources, in which design high moderation MOX core is used. Further refinement in resonance treatment is required for evaluations of core performances such as conversion (or breeding) ratio in the former design. In the latter design, higher actinide and FP contributions are important as in Pu thermal utilization. These new designs also require various cross-sections and chain data for a sufficient number of nuclides.

3 Design Code Development

We are concerned about the decreasing number of nuclear data specialists in the BWR fuel/plant makers. The fact that very few nuclear data specialists are in the analysis method development staff makes it difficult to get various kinds of information on nuclear data and to investigate group constants processing methods. The design codes use the processed group constants, instead of nuclear data themselves given in the nuclear data library such as

JENDL. Therefore, even if the nuclear data were accurate and elaborate, the group constants processed incorrectly from the nuclear data library would result in poor design codes. Accuracy of nuclear data library strongly links with group constant processing methods in design use.

We request that the nuclear data center should provide the following technical supports in this field:

- To provide nuclear data information,
- To provide a standard multi-group cross-section library, and
- To provide handling techniques for effective cross-sections and kinetic parameters.

It is desirable that the standard multi-group cross-section library with 200 or more energy groups is commonly used for fast and thermal reactors. Standardization of the cross-section library and its handling technique makes open environments and make it easy to accumulate experience of nuclear data library usage, leading to a highly accurate nuclear data library.

4 Domestic Nuclear Data Library Utilization

A merit of maintaining the domestic nuclear data library is that it can reflect our design activities such as critical experiments and reactor operation tracking. A good example is Am241 absorption cross section reflected in JENDL3.3, which was thought to be a primary cause of a critical eigenvalue overprediction in the MISTRAL full MOX critical experiments conducted by NUPEC. In the future, when Japan must select its original reactor such as the next generation BWR described above in its particular resource situation, the domestic nuclear data library will play a more important role than now.

However, the fact is that very few design codes adopt JENDL in the official design procedures even in Japan. Why?

Japanese design codes have something to do with foreign companies as their developers or users. Moreover, chances to collaborate in design work or method development with foreign companies are increasing recently. In these collaborations, common nuclear data such as cross-sections, nuclide chain data and kinetic data are required, because differences in such fundamental data make essential discussion difficult. However, the choice of nuclear data library is not so easy because the accuracy of the nuclear data library is not clear. As a result, we are apt to select a well-known nuclear data library such as ENDF.

The request on the use of the domestic nuclear data library is that the advantage of JENDL should be clarified compared with other libraries such as ENDF and JEF through international benchmark analysis, including operating reactor cases, for nuclear data library comparison. It is more preferable that the domestic nuclear data library provides cross-sections, nuclide chain data, and kinetic parameters consistent with those of other libraries.

5 Conclusion

The requests on the domestic nuclear data library from the standpoint of BWR design and design method development are summarized as follows:

(1) To provide the neutron and photon cross-sections for a sufficient number of higher actinides, FP nuclides and burnable absorbers with sufficient accuracy,

(2) To provide technical support related to nuclear data use, such as standard multi-group cross-section libraries and their handling methods, and

(3) To clarify the advantage of JENDL nuclear data compared with other nuclear data files such as ENDF and JEF, or to provide cross-sections, kinetic-related data and nuclide chain data consistent with those files.

Reference

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