Proposals for Nuclear Data Activities from PWR Core Design

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A direction of nuclear data activities and requirements are discussed in this paper. The discussions suggest actual guides to promote utilization of nuclear data.

1. Introduction and discussions

A nuclear data file of JENDL-3.3 was opened this year[1]. This is good news to those relating to atomic energy in Japan. But, I remember that Dr. Kimura pointed out that the Japanese evaluated nuclear data are seldom adopted in safety design and safety evaluation of light water reactors and hardly found in related safety regulatory guidelines and standards except the decay heat [2].

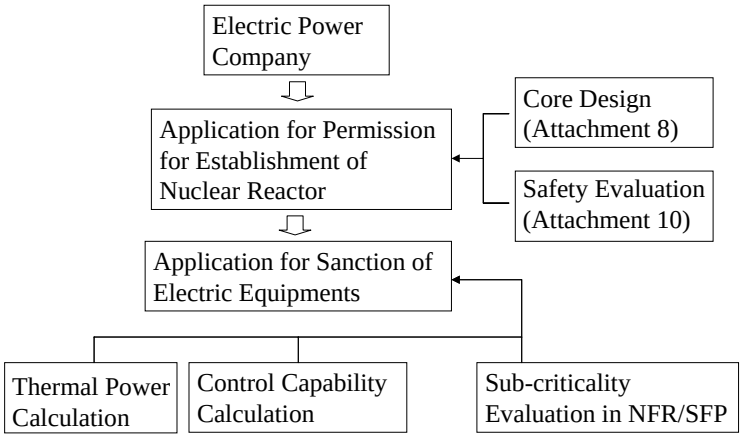

Fig. 1 Plant licensing application flow in Japan

Originally, nuclear data libraries were imported from U.S. with core design codes. However, Japan has already its own evaluated nuclear data. Although even the important nuclear data such as ^{235}U and ^{238}U are still being reevaluated and may be revised in future, now is the best time to begin using Japanese nuclear data. Plant licensing application flow is shown in Fig.1. Nuclear data are used in Core Design (Attachment 8), Control Capability Calculation and Sub-criticality Evaluation in New Fuel Rack (NFR)/ Spent Fuel Pit (SFP). Decay heat is used in Safety Evaluation (Attachment 10). It takes long time to validate nuclear data in core design and nuclear data can hardly changed from viewpoint of licensing. However, once Japanese nuclear data are used, the utilization will be accelerated and they will be widely used in reactor core design calculations and safety analyses. Therefore, Japanese nuclear data must be used first in plant licensing application to promote its use. To achieve this, I think the followings are needed: (a)

Establish a user support system; (b) Clarify the core parameter prediction uncertainty due to nuclear data uncertainties; (c) Assure activity of nuclear data evaluation and user support.

2. Proposals

I propose the following practical guides to reflect the above discussions.

(1) Nuclear data should be opened with its processing code

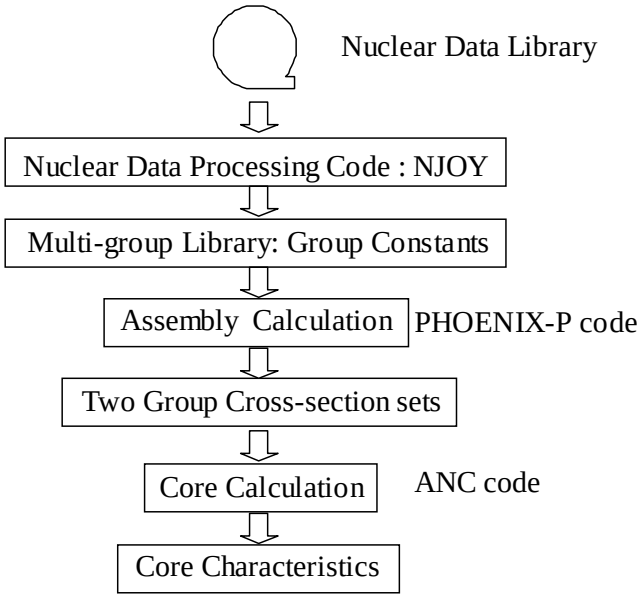

Fig. 2 Flow of Neutronics Calculation

The flow of neutronics calculation is shown in Fig.2. Multigroup library for assembly transport calculation code is generated using NJOY code. However, a lot of troubles have occurred in processing JENDL-3.3 nuclear data with the NJOY code. So, nuclear data processing code should be opened and maintained with nuclear data.

(2) Benchmark problems with detailed specifications and information should be opened

To verify the adequacy of nuclear data, Benchmark calculations were performed using TCA, TRX critical experiments. However, recalculation and confirmation of adequacy of nuclear data were never done and reported by any plant makers or software companies because the details of the benchmark calculations were not opened. To promote use of Japanese nuclear data, confirmation is needed and benchmark problems and reference solutions should be opened with detailed input lists for the codes used in the reference calculations.

Moreover, the benchmark calculations were done at cold conditions (20°C), but commercial reactor cores are operating at higher temperatures, therefore, benchmark analyses should be done using high temperature experiments for instance KRITZ performed at 20°C to 245°C.

Such analyses are beneficial to evaluation of Doppler effect from cold to hot conditions. In addition to critical experiments, PIE analyses and Core analyses should be performed to verify nuclear data of higher actinides and fission products during fuel depletion. These tasks should be shared in nuclear data committee and done by working groups. The results should be integrated and opened as an evaluation result of nuclear data.

(3) Establish a user support system

To avoid the difficulties as described above (1), users are hoping that a user support sys-

tem will be established in Nuclear Data Center. They will feel rather strongly that the nuclear data is reliable and that they are supported if the benchmark problems described above (2) are discussed and communication with the support center is maintained.

(4) Uncertainty should be evaluated using benchmark problems

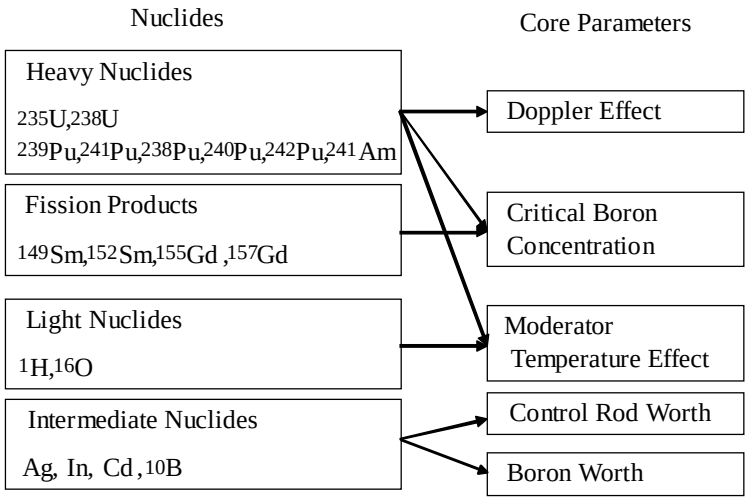

Fig. 3 Nuclides affecting core parameters

The relation of core parameters and nuclides that affect them are shown in Fig.3. In actual core design, critical boron concentration is one of the most important parameters from safety and economical efficiency viewpoint. That is, the core reactivity with fuel depletion must be predicted accurately. Therefore, uncertainty of keff due to nuclear data uncertainty should be evaluated and opened with nuclear data. For this purpose, benchmark problems should be established first. Nuclear parameters to be evaluated (keff, Doppler effect etc.) should be also determined. These benchmark problems may be critical experiments, unit pin cell calculation, unit assembly calculation or core calculation.

(5) Standard nuclear data libraries should be prepared for common use

When developing or comparing calculation methods, and clarify the calculation accuracy, standard or common libraries will play a very important role and produce useful and beneficial results. Multigroup libraries and continuous energy libraries should be prepared based on the same nuclear data. For multgroup libraries, energy shielding methods of F-table method (SRAC type library) and resonance integral table method (WIMS type library) should be prepared for extended use of the libraries. ORIGEN is widely used for simple and extensive study. So, ORIGEN libraries should be also prepared.

(6) Assure activity of nuclear data evaluation and user support

Nuclear data are basis of neutronics calculations and used in plant licensing applications. Therefore they must be reliable and valid and maintained for some period. In order to continue to improve nuclear data quality and keep user support, activity of nuclear data must be assured to Nuclear Data Center.

References

[1] JENDL HP: http://wwwndc.tokai.jaeri.go.jp/jendl/jendl_J.html

[2] Kimura I.: JAERI-Conf 2000-005 p.9 (2000).