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The International Scope of Data Evaluation

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Introduction

This paper summarizes the principal national and international evaluation activities that contributed to the widespread use of evaluated data files. Emphasis is placed on those efforts that have become best known through the availability of data, documentation, and computer codes.

Early attempts at nuclear data evaluation consisted of improving communication among measurers of similar information. As reactor methodology proceeded from a four factor formula to multi-group theory the demand for detailed representation of nuclear data increased. The systematic access to large volumes of data required placing the information in computer readable formats.

Data Formatting

The first data evaluation efforts were not internationally coordinated. Except for the few instances of cooperation among defense laboratories within a country a large number of different formats were developed for storing evaluated data. Two formats became well known when the contents and formats of the United Kingdom Nuclear Data Library (UKNDL)[1] and the Karlsruhe library (KFK)[2] were publicized. However, a new format similar to those in existence was devised for the Evaluated Nuclear Data File (ENDF)[3] expressly for the purpose of intercomparing data available in widely different formats.

Today, although prior investment in code links between evaluated data and reactor design methods has made it difficult to adopt new formats, the availability of evaluated data and codes using ENDF formats have made ENDF a popular choice. Several national and international efforts have adopted the ENDF format.

Data Evaluation

The first comprehensive evaluations of cross sections that appeared in the UKNDL (to 15 MeV) and KFK (to 10 MeV) formats from their respective countries emphasized the materials and reactions needed for fast reactor design. Later, extensive libraries appeared from Sweden,[4] Japan,[5] and the U.S.[3] Some countries emphasized special purpose libraries, such as for dosimetry or fission products, as a corollary to their measurement programs or nuclear model development.

The principle objectives for evaluated data are to assemble a complete evaluation for each material and validate the data in the calculation of benchmark experiments related to specific applications. Evaluated nuclear data such as the U-235 fission cross section as a function of energy and angle is called differential data and a carefully performed and documented experiment such as a critical assembly that measures reactivity for a mixture of fissionable, structural, and moderator materials is called an integral experiment.

Agreement between integral experiment and neutronics calculations was often not as good as desired. Sometimes the changes in multi-group data to improve agreement between calculations and experiments were so rapid and unsystematic that the correspondence between group averaged data and evaluated data was lost. An alternative approach was to observe whether the bias

between unadjusted calculations and experiments followed a consistent pattern that could be related to certain data. The situation is further complicated by the fact that not all discrepancies were necessarily caused by differential data since results could depend on the algorithms, numerical techniques, and computers used in the group cross-section and neutronics calculations as well as uncertainties in the integral experiments. Coefficients could be obtained of the sensitivity of the integral benchmark calculations to each component of evaluated data.

Data Improvement

The sensitivity coefficients were used extensively to improve the agreement between calculation and experiment. Reactor design groups of most countries used the sensitivity coefficients to determine what adjustments to the group cross-sections derived from evaluated data would minimize the discrepancies between calculations and experiments. Adjustment methods used least squares fitting techniques and assumed the results depended linearly on cross-section data.

Since design organizations that adjusted data primarily used only benchmark experiments relating to their application the adjusted data were expected to be application dependent, i.e. data adjusted for large breeder reactor designs might not be valid for smaller fast reactors, thermal reactors or fusion devices. The urgent need for design data that could predict the performance of reactors overshadowed the need for reconciling differences between adjusted and evaluated data. Furthermore, data adjustments were tied to a particular procedure that included the specified algorithms, numerical methods, etc. mentioned earlier. While most evaluated data became generally available the application dependent adjusted multi-group data sets used in

reactor design were considered to have commercial value and were not freely available. Example of these adjusted libraries were the Fast Group Library (FGL) set developed by the U.K. and the Carnaval set developed by France.

On the other hand, the U.S. effort developed ENDF/B to be the basis for both evaluated data and design data. Because the developers of ENDF/B included thermal, fast, and fusion reactor and shielding physicists there was much interest in related benchmark testing but not in adjusted data that would be application dependent. The continued use of feedback from the calculation of benchmark experiments spurred selected measurements of differential data and revised evaluations for successive versions of ENDF/B. With ENDF/B-V, issued in 1979, the results were comparable with those using adjusted data in most applications. Because of the commercial value of this success, special purpose ENDF/B-V files were released, but a limited distribution policy similar to that followed by some countries for adjusted group sets was applied to the general purpose ENDF/B-V data.

There have been several conferences attended by world data evaluation experts to exchange information on evaluation techniques. Many of these conferences are sponsored or cosponsored by the International Atomic Energy Agency. The most recent conference was held at Brookhaven.[6]

Current Availability of Evaluated Data

The major libraries available from international data centers[7] are listed in Table 1. In addition to these libraries there are many other selected evaluations contributed by other countries. Newsletters issued by each center list related processing codes and additional evaluations available. Comparisons will be given by the author during his presentation of evaluations obtained from different sources.

Recently, several countries of western Europe and Japan that are members of the Organization for Economic Cooperation and Development (OECD) started development of a Joint Evaluated File (JEF). New evaluations were to be collected in the ENDF/B-V formats for review and benchmark testing. The JEF development program is still in progress. The JEF evaluations are not available for general distribution.

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Table I

Library	General Date	Country	Format
General Purpose			
UKNDL-2	1981	U.K.	UKNDL
KEDAK-4	1983	F.R. Germany	KEDAK
ENDF/B-IV	1974	U.S.	ENDF
JENDL-2	1983	Japan	ENDF
ENDL-82	1982	U.S. (LLNL)	ENDF
Special Purpose			
ACTL-82	1978 Activation	U.S. (LLNL)	
ENDF/B-V	1979 Activation	U.S.	ENDF
INDL/A	1982 Actinides	I.A.E.A.	ENDF
ENDF/B-V	1979 Actinide	U.S.	ENDF
IRDF-82	1982 Dosimetry	I.A.E.A.	ENDF
ENDF/B-V	1979 Fission Products and Decay Data	U.S.	ENDF
INDL/F-83	1983 Fusion	I.A.E.A.	ENDF
ENDF/B-V	1979 Standards	U.S.	ENDF

References

1. K. Parker, "United Kingdom Nuclear Data Library", 1963, AWRE-O-70163.

2. D. Woll, "Card Image Format of the Karlsruhe Evaluated Nuclear Data File", 1968, KFK 880.

3. H. Honeck, "Specifications for an Evaluated Nuclear Data File for Reactor Applications", 1966, BNL 50066 (ENDF-102) and subsequent revisions.

4. "SPENG, Swedish Neutron Data Library", 1972, AE-RD-45.

5. S. Igarasi et al. "Japanese Evaluated Nuclear Data Library, Version-1", 1979, JAERI 1261; JENDL-2, 1984 is described in JAERI 59-066.

6. B. A. Magurno and S. Pearlstein, Editors, "Proceedings of the Conference on Nuclear Data Evaluation Methods and Procedures", Brookhaven National Laboratory, 1981, BNL-NCS-51363.

7. National Nuclear Data Center, Brookhaven National Laboratory, Upton, New York 11973, U.S.A. 516-282-2901, Services U.S.A. and Canada.

   Center PO Jademum Dannym, Institute of Physics and Energy, Obninsk, U.S.S.R., Services U.S.S.R.

Nuclear Energy Agency Data Bank, P.O. No. 9, 91191 Gif-Sur-Yvette, France, Services sponsoring NEA countries.

Nuclear Data Section, International Atomic Energy Agency, Wagramerstrasse 5, A1400 Vienna, Austria, Services most other countries not included above.