Introduction

An IAEA Consultants' Meeting on "Preparation of Processed Nuclear Data Libraries for Thermal, Fast and Fusion Research and Power Reactor Applications" was held during 8-10 December 1993 at the IAEA Headquarters, Vienna. The main purpose of the meeting was to review the current status of work in the subject of interfacing nuclear data banks to application calculations of thermal, fast and fusion research and power reactors, and, to assist the Agency in identifying appropriate IAEA activities related to nuclear data processing. This report contains the texts of the invited presentations delivered at this meeting. Since the meeting there have been many requests to make the texts of the presentations available in printed form. The texts are reproduced here, directly from the authors' manuscripts with little or no editing, in the order in which the presentations were made at the meeting. The summary report containing the agenda, conclusions and recommendations of the meeting has been separately published as document INDC(NDS)-299.

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THE ROLE OF IAEA IN FULFILLING NUCLEAR DATA NEEDS

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Abstract

The role of the Nuclear Data Section of IAEA has been unique and significant in India's nuclear data related work. Experience at Indira Gandhi Centre for Atomic Research Centre (IGCAR) has shown that the services of NDS-IAEA have been vital in building a capability at our centre, towards preparation of multigroup constants for application in fast reactor physics calculations, starting from the basic evaluated nuclear data libraries. However, bottlenecks exist in realising completeness in the benefits due to non-availability of certain data or codes to our country. Problems also exist due to lack of manpower and computer resources. In this presentation, our experiences with nuclear data processing, the problems faced etc. are outlined. Some suggestions to NDS-IAEA are also given towards removing some of the problems.

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I. Introduction

India has a programme on nuclear data related work, which is limited to meeting the needs of the design and operation of thermal and fast reactor applications. Basic nuclear data measurements and creation of evaluated nuclear data files are not part of our programme. We consequently rely upon the data made available from International Nuclear Data Centres like IAEA. The Nuclear Data Section of IAEA, in particular, has been playing a unique and significant role in meeting our nuclear data requirements. In fact, planning of our nuclear data programme, including allocation of manpower and other resources, takes into account what is available through IAEA. Our experience at the Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam, India, reported below, clearly shows the important role played by IAEA in the development of a code system for the preparation of multigroup constants. IAEA has been effectively distributing evaluated data files, their updates, the available processing codes and so on along with the well formatted documents. In recent years IAEA has been making available preprocessed or even multigrouped data. The Code Verification Project and the WIMS Library Update Project are good examples of IAEA's initiative

towards ensuring correctness and consistency in the codes and the data used by the nuclear data user community. This forum gives us an opportunity to express our appreciation of the commendable services NDS-IAEA has been rendering to its member countries. As the nuclear data teams in the developing countries like ours continue to include the NDS-IAEA contribution in their development plans, its services in the future would remain essential.

However, some bottlenecks remain to be cleared such as non-availability of specific data or some processing codes. As far as our Centre is concerned, our programme on nuclear data for reactor physics purposes, includes updating our information with newer data and better processing, if feasible. It is felt the latest version of NJOY could help us appreciably in our efforts to create a new multigroup library for core physics applications and a neutron - gamma coupled library for shielding applications from the ENDF/B-VI data file supplied by IAEA. At present, we do not have the recent version of this code. IAEA processing codes (Dr. Cullen's LRSG system of codes) do not deal with coupled neutron-gamma library. They also are inadequate in treating the unresolved resonance region at elevated temperatures. They do not have the capability to extract $\bar{\mu}_L(E)$ from angular distribution data of ENDF/B-VI. Though the IAEA preprocessing codes by themselves are excellent tools for obtaining linearised point data, we at IGCAR, have had to supplement them with our own codes REX1/1/, REX2/2/ and REX3/3/ for obtaining group cross sections and self-shielding factors. NJOY on the other hand, has

all the advantages of IAEA codes in giving reconstructed point data, in addition to giving multigroup constants conforming to various definitions and formats used in several popular neutronic codes including ANISN and WIMS. NJOY's capability to process thermal scattering law data, to calculate displacement cross sections and kerma factors, to process gamma interaction cross sections etc. are also attractive for our immediate applications. In the absence of NJOY, though we have been able to prepare neutron multigroup cross sections from ENDF/B-VI using Cullen's codes, complemented by our own, we are unable to use ENDF/B-VI for creating neutron - gamma coupled library, displacement cross sections etc. The details of our nuclear data requirements, our experiences, problems faced etc. will be discussed in brief below.

II.Requirements of nuclear data at IGCAR

We require the following nuclear data for our research activities:

(1). Neutron multigroup cross sections for fast and thermal reactor core physics neutronics calculations.

(2). Neutron - Gamma coupled multigroup cross sections for fast reactor shield calculations.

(3). Neutron activation multigroup cross sections for activation studies.

(4). Neutron multigroup displacement cross sections for calculating the damage in the structural materials in a fast reactor environment.

(5). Multigroup cross sections for the important fission

products and higher actinides.

III. Experiences and problems of ENDF/B nuclear data processing

It has been our interest to create our own multigroup (non-adjusted) cross section sets in format suitable for neutronics codes for performing LMFBR core calculations from the latest ENDF/B type files to study the impact of recent revisions in the basic data. The Nuclear Data Section of IGCAR has developed the capability to generate the neutron multigroup cross sections from the differential neutron cross section data in ENDF/B format for the fast reactor core physics neutronics calculations. For this, we have used various IAEA preprocessing codes (LINEAR, RECENT, and SIGMA1) , our own multigrouping codes (REX1, REX2 and REX3) and some interfacing programs (LCAT/4/ and TOXIC/5/). A flowchart for the preparation of multigroup cross section set at IGCAR from a basic evaluated nuclear data file is given in Fig.1. Using the above code system, we have created earlier a 25 group neutron multigroup cross section set (IGCENDF4) /6/in format of French adjusted Cadarache Version 2 (1969) set/7/, available at IGCAR. The performance of IGCENDF4 set in predicting the reactor integral parameters was found to be similar to the Cadarache Version 2 set. Its creation gave us confidence and motivation for generating multigroup cross section sets from other more recent files.

We have recently completed creating a 25 group neutron cross section set (IGCJENDL)/8/ for nuclides of interest to LMFBR from the Japanese Evaluated Nuclear Data Library - Version 2 (JENDL-2) (1984) in the format of Cadarache Version 2 set. Since we do not

have a programme of critical experiments, the only way to check the predictional capability of the generated multigroup cross section set is through the analyses of the critical assemblies whose informations are published by the Cross Section Evaluation Working Group. The integral validation of IGCJENDL set /9/ was done by analysing nine fast critical assemblies having a wide range of core size, neutron energy spectrum, fuel composition etc. We had calculated effective multiplication factors, central reaction rate ratios and the reactivity coefficients for these assemblies and good agreement with the reported values was obtained.

So far the adjusted Cadarache Version 2 set has been used for the small LMFBR core physics calculations, at IGCAR. But, this set has been found inadequate for the core physics studies of the planned 500 MWe Prototype Fast Breeder Reactor (PFBR), mainly due to its overprediction (about 3%) of k-eff's of two theoretical LMFBR benchmarks of 1200 and 500 MWe capacity respectively, compared to the reported predictions by the adjusted French cross section set, CARNAVAL-IV (1977) or the Russian set BNAB-78, for the same assemblies. Analyses of the above theoretical benchmarks with IGCJENDL/10/ showed that this set could predict the integral parameters, k-eff in particular, close to that predicted by the CARNAVAL-IV or the BNAB-78 set, and hence could be used for large LMFBR analysis. Interestingly, we had found, after a detailed study, that the replacement of Pu-241 data in Cadarache Version 2 set by Pu-241 data taken from IGCJENDL set removes the 3% overprediction of k-eff in the above

benchmarks. We also propose this set, called ' Modified Cadarache set', for the design analysis of PFBR.

In most of the fast reactor core physics calculations, we make use of the 1969 version of the adjusted Cadarache Version 2 set (modified as above when necessary). But, this set contains the data for only 38 nuclides. So, it was planned to expand this set by adding multigroup data from ENDF/B-VI library for nuclides which are absent in the above set and are often required for reactor calculations. Since ENDF/B-VI does not explicitly give elastic scattering angle cosine data in the laboratory system, required to calculate transport cross sections, a program AMUL-4 /11/ was written to calculate this quantity from the Secondary Neutron Angular Distribution (SNAD) data. By employing the AMUL-4 code in our code system (see Fig. 1), the ENDF/B-VI data for several important nuclides which are absent in the Cadarache Version 2 set were processed and added. The fission products from ENDF/B-VI could also be processed this way.

For fast reactor shield calculations, a neutron-gamma coupled multigroup (100 n, 21 gamma) cross section library called DLC-37, procured from RSIC, is extensively being used. This library was generated from ENDF/B-IV and is meant for fusion reactor applications as reported. So, we have taken up the task of creating a coupled library from the latest evaluated data files. Even though the ENDF/B-VI library is available here, a code system to process this library for the above purpose is not available, like the new NJOY system (NJOY91). For the same

reason , we are, at present, unable to process the improved data in ENDF/B-VI related to displacement cross sections.

IV. Suggestions to Nuclear Data Section, IAEA

In developing countries, like India, the needs of nuclear data for the nuclear energy programme, are met with a considerable dependence on International Centres, and NDS-IAEA in particular. These countries would find it difficult to expand their teams and resources to keep pace with the advances made by the highly developed contributing countries. It is felt that NDS-IAEA's endeavour in distributing the latest cross section information in the most sophisticated formalisms and formats, would be made much more useful if IAEA itself takes the responsibility of distributing the necessary processing codes, that are fully compatible with the data it distributes. This may probably be achieved by forming a team under NDS-IAEA, with personnel selected from both advanced and developing countries, for preparing such codes and their updates whenever needed. Such a team, after the teething problems are over, could serve all the IAEA member countries for their nuclear data processing needs, of course, limited to the data supplied by IAEA. The areas requiring immediate attention are:

(1) Supplementing IAEA preprocessing codes systems with correct treatment for the unresolved resonance region at higher temperatures.

(2) Preparation of neutron - gamma coupled library using ENDF6 formatted libraries.

(3) Processing thermal scattering law data from ENDF6

(4) Calculation of radiation damage related parameters

(5) Preparation of interfaces to give the outputs in conformity with definitions and formats of most widely used neutronic application codes.

V. References

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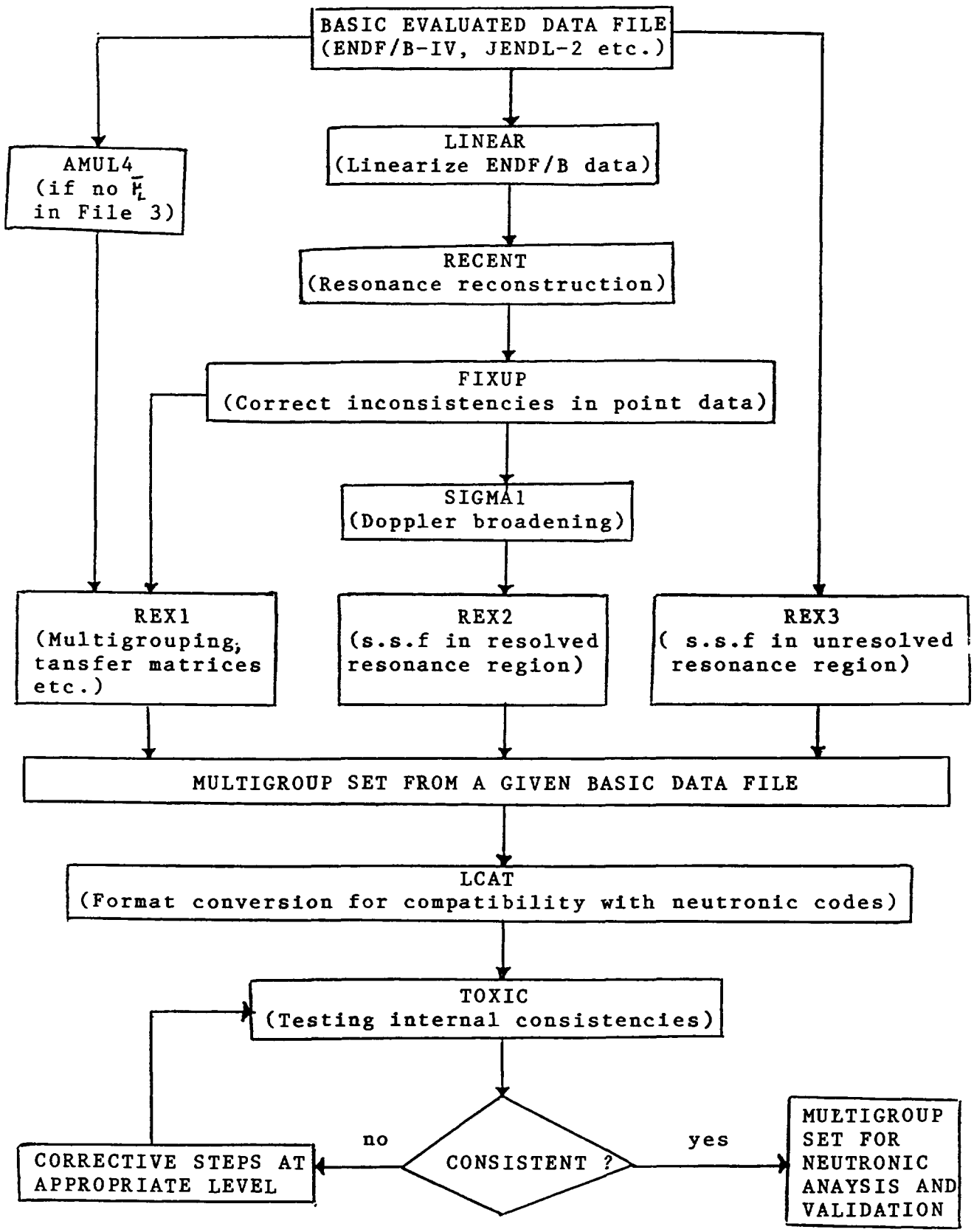

Fig.1 Flowchart for the preparation of multigroup neutron cross section set at IGCAR