

## **Progress report on the Fusion Evaluated Nuclear Data Library (FENDL)**

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### **ABSTRACT**

The complete FENDL-2.0 library was released on 15 May 1998. Since then, the main emphasis of the FENDL project has changed from library development to validation and maintenance. In support of this goal, the IAEA intends to hold small Consultants' Meetings annually to stimulate and monitor data testing activities and to permit the incorporation of improved evaluations. The first such Meeting, dedicated to the validation of the transport sublibrary (FENDL/E-2.0) was held in Vienna in October 1998. The second in the series has been held in Obninsk (Russia) in June 1999, and was devoted to the results of testing and improvements of the activation sublibrary (FENDL/A-2.0). Findings and recommendations of the latter Meeting are reported below.

### **INTRODUCTION**

The IAEA Nuclear Data Section (NDS), in cooperation with several major national nuclear data projects, has created the Fusion Evaluated Nuclear Data Library (FENDL). The goal of the effort is to provide a comprehensive and high quality data library in support of various fusion related projects. FENDL is a collection of nuclear data selected from various national libraries and contains: activation cross sections, decay data, dosimetry data, fusion reaction cross sections, and general purpose data for transport calculations. The basic and processed data are provided. The FENDL-2.0 was completed on 15 May 1998 with the release of the transport sublibrary (FENDL/E-2.0). Other sublibraries had been released earlier (14 March 1998). Since then, the IAEA Nuclear Data Section has been involved in the coordination of testing and validation of the FENDL library in order to maintain its usefulness to the fusion community. To this end, Consultants' Meetings have been organized approximately annually to stimulate and monitor data testing activities and to permit the incorporation of improved evaluations as they become available.

The first of these Meetings was held in Vienna in October 1998 to review results of testing and validation of the basic and derived transport sublibrary (see the report INDC(NDS)-395, Vienna, March 1999). The Meeting has concluded that FENDL-2.0 is currently the best and most comprehensive nuclear data library available for fusion applications and should be adopted as a reference library in fusion reactor design calculations.

The second Meeting, held in Obninsk (Russia) in June 1999, concentrated on the

activation, decay, and dosimetry sublibraries. The objectives of the Meeting were:

- review recent testing, validation and applications of the FENDL/A/D/DS-2.0 sublibraries,
- identify needs for improvements and extensions,
- establish procedures for updating/revisions of the current evaluations,
- review Web-access tools for FENDL-2.0.

The Meeting was attended by five internationally recognized experts (Cheng (USA), Forrest (UK), Kopecky (The Netherlands), Maekawa (Japan), and Pashchenko (Russia)), the IAEA representative (Herman) and 7 local observers. Main results and recommendations are reported below (for details see the report INDC(NDS)-406, Vienna, November 1999).

## **VALIDATION OF FENDL/A/D/DS-2.0**

The decay heat experiment, performed at the JAERI Fusion Neutronics Source, proved to be a very valuable source of information. A comprehensive database of decay heat has been obtained for 32 fusion related materials in a wide range of cooling times. It was found that in most cases the FENDL/A-2.0 sublibrary predicts adequately the decay heat power, indicating high precision of cross sections and complementary data. In particular, good agreement was found for SS316, F82H and Zr. Independent analysis of the same experiment was performed by Forrest. About 130 reactions were validated. It turned out that about 50% of the calculated values are in excellent agreement (better than 10%) with the experiment. Additional 15% are in good agreement (better than 20%). Some cross sections needing improvements were identified.

Another integral experiment was conducted using a 19 MeV deuteron and beryllium neutron source available at FZK Karlsruhe. As a result, all major radioactivities were predicted adequately by FENDL/A-2.0 while some minor ones indicate the necessity of cross section modifications.

116 reactions and 16 isomeric ratios were measured in the energy range between 13.4 and 14.9 MeV at Khlopin Institute with accuracy between 1.2 and 30% but generally better than 5%. The comparison with the FENDL/A-2.0 data shows that in 72 cases the new experiments agree with the evaluated ones within experimental errors. Strong deviations were observed in 10 cases.

A few serious differences between half-lives in FENDL/D-2.0 and other data sources (e.g., Wallet cards) were noted.

## **CONCLUSIONS**

The reports presented at the Consultants' Meeting (CM) gave evidence that many of the reactions tested by the integral experiments were well represented in FENDL/A-2.0. Thus, the library is capable of giving accurate predictions of activation for many materials.

The same reports also indicated that there are a small number of reactions that could be improved. Some of these will be investigated and will lead to the improved sublibrary FENDL/A-2.1. Such a maintenance update is necessary to ensure that the sublibrary remains relevant to the users.

The participants stressed the role of experimental measurements, both differential and integral, in validating FENDL and providing corrections for updates. Work at Khlopin Institute and at JAERI-FNS has been especially useful and should be continued. In addition, use of the reactor based facilities should be encouraged to validate non-threshold reactions.

It was recommended that the IAEA investigate the possibility of substantially improving the capabilities of the FENDL activation sublibrary by including data at energies greater than 20 MeV for applications other than fusion (e.g., accelerator driven systems).

The IAEA-NDS plans to release the improved version of the library (FENDL-2.1) in spring 2001.

## Appendix A. "FENDL in Pictures" V.Zerkin, NDS-IAEA

"FENDL in Pictures" is a pictorial representation (Fig.1) of the technical quality of the data contained in the Fusion Evaluated Nuclear Data Library. This product is an example of integration of EXFOR retrieval system based on ACCESS-97 with the ZVVIEW graphics utility for production of an interactive Web Atlas of nuclear data.

FENDL-2.0 Activation file including more than ten thousand reactions is made into Web pages with summary table of materials, reaction codes, values of the deviation ( $\chi^2$  per point) between evaluations and experiments, and plots of evaluated curves in comparison with experimental data points.

All HTML pages and GIF pictures were generated automatically on a PC (ZVVIEW is used in non-interactive mode). These were then transferred to the NDS Web Server and could be copied to a CD-ROM for distribution. Users can call interactive plotting program ZVVIEW with chosen data on local computer and retrieve original experimental data from NDS Web EXFOR Service by clicking the appropriate hyperlinks.

The total number of materials is 667, reactions (plots): 11805, experiments found: 4688.

Fig. 1 Example of Web pages from "FENDL in Pictures"

