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INTERNATIONAL NUCLEAR DATA COMMITTEE

IMPROVED EVALUATIONS AND INTEGRAL DATA TESTING FOR FENDL

Summary Report of the IAEA Advisory Group Meeting
organized by the International Atomic Energy Agency
in co-operation with the Max-Planck-Institut für Plasmaphysik
and held at the Max-Planck-Institut für Plasmaphysik, Garching near Munich, Germany,
12 to 16 September 1994

Prepared
by

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Vienna, Austria

December 1994

IAEA NUCLEAR DATA SECTION, WAGRAMERSTRASSE 5, A-1400 VIENNA

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Abstract

The IAEA Nuclear Data Section, in co-operation with several national nuclear data centres and research groups, has created the first version of an internationally available Fusion Evaluated Nuclear Data Library (FENDL-1). The FENDL library has been selected to serve as a comprehensive source of processed and tested nuclear data tailored to the requirements of the Engineering and Development Activities (EDA) of the International Thermonuclear Experimental Reactor (ITER) Project and other fusion-related development projects. Within the scope of the FENDL project, the International Atomic Energy Agency performs the task of coordinating the assembling, processing and testing of a comprehensive, fusion-relevant Fusion Evaluated Nuclear Data Library with unrestricted international distribution. The present report contains the summary of the IAEA Advisory Group Meeting on "Improved Evaluations and Integral Data Testing for FENDL," 12-16 September 1994 hosted by the Max-Planck-Institut fuer Plasmaphysik, Garching, Germany. The report presents the current status of the FENDL activity and the future work plans in the form of conclusions and recommendations of the four Working Groups of the Advisory Group Meeting on (1) Basic Evaluations towards FENDL/E-2.0 for ITER Design, (2) Experimental and Computational Benchmarks on Fusion Neutronics for FENDL Validation, (3) Production and Interfacing of FENDL Libraries to ITER Design, and, (4) Activation.

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FENDL SUMMARY

(See Neutron Nuclear Data Evaluation Newsletter #48 (1995))

FENDL, the evaluated nuclear database for fusion applications, has been completed. Its present version consists of the following sublibraries. At the ITER neutronics coordination meeting in San Diego, Feb. 1995, the ITER participants agreed to use **FENDL** in all design calculations.

1. **FENDL/A-1.1** (April 93): neutron activation cross-sections, selected from different available sources, for 636 nuclides, given in four representations:
 - "point data", i.e. cross-sections as function of energy in ENDF-6 format
 - "FENDL/G": VITAMIN-J 175 group data using a flat weighting spectrum
 - "FENDL/A-MCNP": processed into the format for input to the MCNP Monte-Carlo transport code
 - "FENDL/A-175G": VITAMIN-J 175 group data using the VITAMIN-E weighting spectrum for input to the code REAC*2/3
2. **FENDL/C-1.0** (Nov. 91): data for the fusion reactions D(d,n), D(d,p), T(d,n), T(t,2n), He-3(d,p) extracted from ENDF/B-6 and processed
3. **FENDL/D-1.0** (Jan. 92): nuclear decay data for 2900 nuclides in ENDF-6 format, extracted from ENDF/B-6 and ENSDF
4. **FENDL/DS-1.0** (Oct. 93): neutron activation data for dosimetry by foil activation. This is identical with file 1 (neutron activation cross-sections) of the International Reactor Dosimetry File IRDF-90 version 2 of Oct. 1993, given as multigroup data in 640 group extended SAND-2 format, without covariance data. FTP subdirectory: FENDLDS
5. **FENDL/E-1.0** (Nov. 94): data for coupled neutron-photon transport calculations, including
 - a data library for neutron interaction and photon production for 63 elements or isotopes, selected from ENDF/B-6, JENDL-3, or BROND-2
 - a photon-atom interaction data library for 34 elements taken from ENDF/B-6

These are available in three representations:

- original ENDF-6 format, as above, with resonance-parameters where applicable
- "FENDL/MG" (Nov. 94): processed by NJOY into multigroup data in MATXS format
- "FENDL/MC" (Nov. 94): processed into the format needed for input to the Monte Carlo code MCNP4A

FENDL BENCHMARK

The **FENDL/BENCHMARKS** file contains compiled fusion benchmark descriptions and data contributed by different institutes.

INTERNET/FTP online access to FENDL files

The **FENDL** data files can be electronically transferred to users from the IAEA Nuclear Data Section online system through INTERNET from NDS open area 'FENDL'.

Summary of the Meeting

1. Introduction

The IAEA Nuclear Data Section, in co-operation with several national nuclear data centres and research groups, has created the first version of an internationally available Fusion Evaluated Nuclear Data Library (FENDL-1). The FENDL library has been selected to serve as a comprehensive source of processed and tested nuclear data tailored to the requirements of the Engineering and Development Activities (EDA) of the International Thermonuclear Experimental Reactor (ITER) Project and other fusion-related development projects. Within the scope of the FENDL project, the International Atomic Energy Agency performs the task of coordinating the assembling, processing and testing of a comprehensive, fusion-relevant Fusion Evaluated Nuclear Data Library with unrestricted international distribution.

The specifications of the FENDL files, nomenclature and access to online services are presented in Appendix A.

The Agency, in cooperation with the Max-Planck-Institut fuer Plasmaphysik and the ITER Joint Central Team, Garching, Germany, organized an Advisory Group Meeting on "Improved Evaluations and Integral Data Testing for FENDL," during 12-16 September 1994 at the Max-Planck-Institut fuer Plasmaphysik, Garching, Germany. Thirty-three nuclear data experts from 11 countries (Austria, Bulgaria, France, Germany, Italy, Japan, The Netherlands, The Russian Federation, Switzerland, United Kingdom, and the U.S.A.) addressed several important nuclear data issues related to the immediate near term (1995-1996) requirements of the ITER project and to long term (beyond 1996). The experts also critically addressed issues related to further efforts which are urgently needed to complete FENDL-1 and test the library against existing experimental and calculational benchmarks. The plans and initiation of selections of basic nuclear data evaluations for FENDL-2 which will be a significant improvement over FENDL-1 were also performed at this meeting. Recommendations were made under the following titles: (1) Basic Evaluations towards FENDL/E-2.0 for ITER Design, (2) Experimental and Calculational Benchmarks on Fusion Neutronics for FENDL Validation, (3) Production and Interfacing of FENDL Libraries to ITER Design, and, (4) Activation. The report presents the current status of the FENDL activity and the future work plans.

The working nuclear data libraries in processed form for use by the ITER team in the early phase of ITER Engineering Design Activity (EDA) have been derived from FENDL-1 by R.E MacFarlane by processing the first version of FENDL/E, FENDL/E-1 using the NJOY code system. Dr. F.M. Mann performed the processing of the activation library and prepared the processed library of the activation data for use by the ITER design team. Some limited integral validation of derived libraries of FENDL-1 based on analysis of IAEA benchmarks was reported and discussed at this meeting. The task of validation of FENDL-1 as required by the customer, i.e. the ITER team is considered to be a task of high priority in the coming months.

The participants reminded that the well tested and validated nuclear data libraries in processed form of FENDL-2 are expected to be ready by mid 1996 for use by the ITER team in the final phase of ITER EDA after extensive benchmarking and integral validation studies in the 1994-96 period. In the next few months, efforts should be made with priority to make FENDL-1 available for use by the ITER team.

The detailed Agenda, the complete list of participants and the recommendations of the four Working Groups are presented in the appendices to this report.

The scope of the present AGM was considered at the previous AGM: "Review of Uncertainty Files and Improved Multigroup Cross Section Files for FENDL," Tokai Research Establishment, organized in cooperation with the Japan Atomic Energy Research Institute and held at the Tokai Research Establishment, JAERI, Tokai-mura, Japan during 8-12 November 1993. See summary report: INDC(NDS)-297, March 1994.

Considering the urgent needs of engineering design activity of International Thermonuclear Experimental Reactor (ITER) reported at the previous AGM, it was considered very timely to convene the present AGM in order to facilitate international co-operation with the purpose to review the current status of production and integral testing of functional working libraries derived from version 1 of Fusion Evaluated Nuclear Data Library (FENDL-1) for ITER applications against existing experimental and calculational benchmarks. The present AGM also assigned priorities and finalized plans of activities for the generation of FENDL-2 which would be an improvement over FENDL-1.

2. Organization of Advisory Group Meeting and Meeting Proceedings

The above Advisory Group Meeting was organized in co-operation with the Max-Planck-Institut fuer Plasmaphysik, Garching, Germany and the ITER Joint Central Team, Garching, Germany. The local organizers did an excellent job in providing all the necessary arrangements which greatly contributed to the success of the meeting. The co-operation of Dr. W. Dänner and Dr. Y. Gohar and their colleagues deserves a special mention in this respect. On Tuesday evening, 13 September 1994, the participants of the meeting were presented with a short presentation, and guided visit of the IPP Plasma Physics Experiments ASDEX-Upgrade, and W-VII-AS facilities. In the inaugural session, the welcome address was delivered by Dr. Ronald Richard Parker, Deputy Director and Head of site, ITER Joint Central Team, Garching. After the opening remarks by Dr. Y. Gohar, the local organizer, S. Ganesan, the IAEA Scientific Secretary, delivered an address on behalf of the Director General of the IAEA.

The Meeting was convened mainly to discuss the current status, bottlenecks, problem areas, tasks, goals, time schedule, information sharing, formulation of future strategy in the light of past experience, etc. Oral presentation of papers covered the following subject areas, items 1 to 6:

1. Checking and validation of FENDL/MG-1.0, the coupled neutron-photon multigroup cross section libraries, by analysis of selected fusion benchmarks.
2. Checking of consistency, validation, and use of libraries to be adopted for FENDL/MC-1.0 for coupled neutron photon Monte Carlo calculations.
3. Review of improved evaluations for FENDL based on procedures recommended in report INDC(NDS)-297 (March 1994). Recommendations on improved evaluations for FENDL.
4. Status of experimental and calculational benchmarks in electronic format in the compilation of IAEA benchmark problems for validation of methods and nuclear data in fusion neutronics. Review of the current benchmarking activity and discussion on needs of improved benchmarking.
5. Define methods and plans for preparation of FENDL-2 and processing, and, system integration, of the transport, activation and decay data files of FENDL-2 for ITER applications.
6. Assessment of present status and role of uncertainty files, their processing and sensitivity studies related to FENDL.

The main focus in this Advisory Group Meeting was on reviewing, in detail:

- a. The present status of production and integral validation of coupled neutron-photon multigroup cross section library, FENDL/MG-1.0. The FENDL/MG-1.0 was created by R.E. MacFarlane by processing FENDL/E-1.0 using the NJOY code system. The FENDL/MG library is directed towards use in discrete ordinates - neutronics calculations of fusion machines with emphasis to the urgent needs of engineering design activity phase of ITER.
- b. The current status of production and integral validation of point libraries FENDL/MC-1.0, derived by R.E. MacFarlane by processing FENDL/E-1.0 for use in Monte Carlo calculations.
- c. Selections of basic nuclear data evaluations for improving FENDL-2. The selection procedure, general rules and time schedule for improving FENDL-2 have been set at the previous AGM.
- d. Further improvements and benchmark validation of FENDL Activation Library.

3. Meeting Attendance

The Meeting was attended by thirty-three nuclear data experts from 11 countries (Austria, Bulgaria, France, Germany, Italy, Japan, The Netherlands, The Russian Federation, Switzerland, United Kingdom, and the U.S.A.) including two participants from the ITER team and one from the NET team. Dr. S. Ganesan served as the Scientific Secretary of the IAEA Advisory Group Meeting and Dr. A.B. Pashchenko attended the meeting during 15-16 September 1994. In all, twenty experts were awarded by the Agency limited financial support in the form of lump sum grant to defray partially the travel and subsistence expenses. The complete list of participants is presented in Appendix D.

The meeting was held in conjunction with two other meetings as shown below to enable participation of the experts in more than one meeting where appropriate.

1. September 07-09, 1994, IAEA Specialists Meeting on "Comparison of Activation Cross Section Measurements and Experimental Techniques", St. Petersburg, Russia (Scientific Secretary, Dr. A.B. Pashchenko, IAEA Nuclear Data Section).
2. September 19-23, 1994, IAEA Research Co-ordination Meeting on "Development of Reference Input Parameter Library for Nuclear Model Calculations of Nuclear Data" (Phase I: Starter File), Ravenna, Italy (Scientific Secretary, Dr. P. Obložinský, IAEA Nuclear Data Section).

4. Results of the Meeting

The Meeting was smoothly conducted by the respective chairman of each session as shown in the Agenda presented in Appendix B. After formal presentation of papers, during the meeting, four Working Groups (WGs) were organized: WG I on "Basic Evaluations towards FENDL/E-2.0 for ITER Design," WG II on "Experimental and Computational Benchmarks on Fusion Neutronics for FENDL Validation," WG III on "Production and Interfacing of FENDL Libraries to ITER Design" and, WG IV on "Activation". The summary reports of the four WGs are presented in Appendix C. The main points of interest to the Agency are summarized below:

4.1. Status of FENDL-1 and FENDL in general:

Presently, the data files, FENDL/E, FENDL/A, FENDL/DS, FENDL/MG, FENDL/MC, FENDL/D, FENDL/C and FENDL/BENCHMARKS are complete and ready for full data testing activities except for minor problems as discussed in the summary report of WG I. The documentation for all the FENDL sublibraries, FENDL/E, FENDL/A, FENDL/DS, FENDL/MG, FENDL/MC, FENDL/D, FENDL/C and FENDL/BENCHMARKS should be prepared with QA considerations. Since 1994, the data can be accessed by the user from the Agency Nuclear Data Section online system over international computer networks as described in Appendix A. The well tested and validated nuclear data libraries in processed form of FENDL-2 are expected to be ready by mid 1996 for use by the ITER team in the final phase of ITER EDA after extensive benchmarking and integral validation studies in the 1994-1996 period. In the next few months, efforts should be made with priority to make FENDL-1 available for use by the ITER team. The experts expressed the concern that the present manpower in the Nuclear Data Section is not being maintained until 1996 in order that the tasks can be completed. In the 1995-1996 period, as the budgetary situation stands, the activities on FENDL will be limited to the online services of various sub-libraries of FENDL and to the organization of the Advisory Group Meeting in 1995 and in 1996.

4.2. Plans for 1995-1996:

The Agency has plans to organize an Advisory Group Meeting on "Development of Improved Nuclear Data Library for Fusion (FENDL-2)" in San Diego, U.S.A. for 5 days during September 1995. The final Advisory Group Meeting on "Processing and Testing of the FENDL-2 Library" has been planned for 1996 in Vienna. Based upon identified needs, one or two consultants meetings may be organized by the Agency to address specific problem areas in FENDL.

4.3. Reports on Integral Tests of FENDL-1:

Many experts reported successful experiences of the use of FENDL-1 distributed by the Agency. This initial testing phase proved to be very important and valuable in performing higher level physics checking on the evaluations and in clearing the basic evaluations. The processed files (the results of production runs with the use of the processing code system NJOY), supplied by Dr. R.E MacFarlane, FENDL/MG, in multigroup form were scrutinized and several errors detected in the period December 1993 - August 1994. The derived files FENDL/MG and FENDL/MC were revised as a result and were made available at the Los Alamos Machine by Dr. R.E. MacFarlane issued in the last week of August. At the time of writing these reports, the revised FENDL/MG and FENDL/MC files have also been made available in the Nuclear Data Section online system.

4.4. ITER Team's Viewpoint:

The ITER team (Dr. Y. Gohar and Dr. R.T. Santoro) appreciated the efforts of various teams and the successful international co-ordination efforts by the Agency to bring out the best possible product for use by the ITER team. Dr. Gohar stated that **the FENDL-1 will be considered as complete only when it is available as functional working libraries compatible with neutronic codes** used by the fusion community. It was stressed that documentation, QA studies and data testing of FENDL-1 should assume high priority to create confidence in the use of FENDL-1 files by the designers of fusion blankets. Integral validation of the FENDL-1 files by analyses of the IAEA fusion benchmarks should be performed to increase confidence in the use of the FENDL-1 by the ITER design teams. The tasks of co-ordination of activities in FENDL relating to processing, post-processing and integral benchmarking needs attention with priority.

4.5. Online Access:

The participants stated that the data transfer by online access from the Nuclear Data Section is too slow due to limitation on the hardware at the Nuclear Data Section which limits data transfer to 64 Kilo bits per second as compared to 1 Mega bits/second available in many other centres. The downloading of all the files of FENDL via internet takes a couple of weeks or more, while limited data can be downloaded in a day.

4.6. Report of Working Group III on Production and Interfacing of FENDL Libraries to ITER Design:

The working group discussed issues and concerns related to the production and interfacing of the FENDL libraries to ITER design. The issues discussed and conclusions made are presented in the report of WG3 (see Appendix C.3).

The original plan was to start work on processing FENDL-2 (to clear the evaluations as processable by first runs with the NJOY code system, perform higher level physics checking and finally to perform production runs to produce multigroup and Monte Carlo libraries) as soon as possible to make it available in 1997 when it is expected that the ITER licensing and siting process will start. Y. Gohar and R. Santoro from the ITER JCT expressed the opinion that while the work on FENDL-2 is encouraged and welcomed, **the highest priority is to finish the work on FENDL-1 to make it available for use in ITER.** There is an immediate need of FENDL-1 for use in the interim ITER design which should be finished in Mid 1995.

4.7. FENDL Benchmarking and Data Testing:

Most benchmarks identified at the November 1993 meeting in Japan have been received and placed on the on-line system in the subdirectory [FENDL.BENCHMARKS]. The current contents of the on-line Benchmark Data are summarized in Table 1 of the WGII report. A diskette containing the current benchmark data base was made available at the meeting. The IAEA-Nuclear Data Section arranged a consultancy visit to the IAEA-Nuclear Data Section by U. von Möllendorff, Karlsruhe, Germany, during October 17-22, 1994 as informed at the meeting to carry out a critical review of the fusion benchmarks. The completion of the task of FENDL-1 from the view point of ITER customer as mentioned in the previous paragraph is best accomplished by performing analysis of as many experimental and calculational fusion benchmarks as possible using FENDL-1.

4.8. Longer Range Evaluation Activities:

Because of the time scale required for finalizing the FENDL/E-2.0 library, the working group recognizes that some problems and areas of concern will still exist after the FENDL/E-2.0 file is established. Some areas of weakness that the experts anticipate the Nuclear Data Section will need to address in the 1997-1998 period after the issue of FENDL/E-2.0 in 1996 are summarized in the detailed report.

4.9. General Recommendation:

The Experts of the Advisory Group Meeting expressed their Concern on the following:

Because of significant decline in several national nuclear data programs, this Advisory Group recommends that the IAEA-Nuclear Data Section inform the ITER Joint Central Team and Home Teams that further progress with FENDL will only be achieved with their strong support. Many of the facilities and much of the technical expertise used in developing FENDL to its present state are disappearing. As the ITER project advances toward its final goals, safety and licensing issues will place more stringent demands on the FENDL nuclear data base. New requirements for general purpose, activation, dosimetry, and decay data evaluated libraries are inevitable and will not be met without adequate support of the FENDL activity.

APPENDIX A**SPECIFICATIONS AND ACCESS TO ONLINE FUSION EVALUATED NUCLEAR DATA FILES:**

The FENDL project of the International Atomic Energy Agency has the task of coordinating the assembly, processing and testing of a comprehensive, fusion-relevant Fusion Evaluated Nuclear Data Library (FENDL) with unrestricted international distribution. The FENDL project has made significant progress in the last one year. Well tested and validated nuclear data library in processed form are expected to be ready by mid 1996 for use by the ITER team in the final phase of ITER EDA, after iterative feedback to the evaluators through extensive benchmarking and integral validation studies of FENDL-2 in 1994-1996 period.

The FENDL library is composed of the several sublibraries describing the transport of both the plasma-source neutrons and secondary gamma rays through fusion reactor components, as well as the resulting radiation effects, such as nuclear heating, tritium breeding activation and material damage. Also included are cross sections for fusion and other important charged-particle nuclear reactions of the plasma constituents, as well as data for fusion-relevant neutron dosimetry.

The FENDL files are specified as follows:

FENDL/E for General Purpose Evaluation Library,

FENDL/A for Activation Library,

FENDL/DS for Dosimetry Library,

FENDL/D for Decay Data Library,

FENDL/C for Incident Charged-Particle Library,

FENDL/MC for Processed Monte Carlo Library,

FENDL/MG for Processed Multigroup Library, and,

FENDL/BENCHMARKS for Compiled Information on Fusion Neutronics Benchmarks.

FENDL/U Processed Uncertainty Library (Not available at present).

Note that 'FENDL' represents a system of data libraries. FENDL-1 represents a system of sublibraries with the suffix '-1' denoting the first version and '-2' the second version. For the individual sublibraries again the same convention will be followed. FENDL/E-1.0 stands for the first version of FENDL/E library. Note also that FENDL/MG-1.0 and FENDL/MC-1.0 are processed libraries derived from FENDL/E-1.0. The point activation library of FENDL/A is denoted by FENDL/PA-1.1 with '-1.1' indicating the version 1.1 and FENDL/PA-1.1-MCNP stands for the FENDL/PA-1.1 in format for use by the Monte Carlo code MCNP. The data library designated by FENDL/PA-1.1_175G is the multigroup library in 175 energy groups derived from FENDL/PA-1.1 for use by the transmutation code REAC*2/3.

Presently, most of the FENDL-1 files are available online from the IAEA's Nuclear Data Section. The data can be accessed by the user over international computer networks as described below. In the Nuclear Data Section open area 'FENDL', a subdirectory has been created for each file, for example, "FENDLE" for the FENDL/E file. There are 'AAREADME.TXT' files in the subdirectories providing explanatory notes.

The file transfer via internet can be performed by ftp command to the address:

iaeand.iaea.or.at or 161.5.2.2.

The user should logon with the user name "FENDL". No password is required. After having logged on, the user can set the default to any required subdirectory using 'cd' and transfer files as desired.

A grand total of 46 directories with 791 files with a total size of 1640676 blocks (one block=512 bytes) constituting FENDL-1 has been made available online before the commencement of the meeting. At the time of writing this report, the FENDL/MC-1 and FENDL/MG-1 were revised in the online system. In addition, several additions were made to the integral benchmark data base. At the time of writing this report, a grand total of 47 directories with 840 files with a total size of 1977843 blocks has been made available online.

Note: Appendix A reflects the status of the FENDL on-line structure and access at the time of writing the present report. The Nuclear Data Section is currently preparing an improved version of the FENDL on-line structure. Information about this development should be made available also through the ITER EDA Newsletter.

IAEA Advisory Group Meeting on
"Improved Evaluations and Integral data testing for FENDL"
12-16 September 1994
hosted by Max-Plank Institute fuer Plasma Physik, Garching,
Germany
Scientific Secretary: S. Ganesan

DETAILED AGENDA

MONDAY, 12 September 1994

- 9.30-10.30 Inaugural session
Welcome address:
Dr. Ronald Richard Parker (Deputy Director and
Head of site, ITER JCT, Garching)
Opening remarks: Y. Gohar
Statement by the IAEA
Scientific Secretary, S. Ganesan
Discussion on Agenda and adoption
Announcements by local organizers: Dr. W. Daenner
- 10.30-10.45 Coffee break
- 10.45-11.15 Session I NUCLEAR DATA REQUIREMENTS, PRIORITIES
FOR ITER AND ROLE OF FENDL

CHAIRMAN: DR. W. DAENNER

Y. GOHAR:
Nuclear Data Requirements and priorities for
ITER (15 mins)
Discussions
- 11.15-1230 SESSION II: BASIC EVALUATIONS

CHAIRMAN: DR. W. DAENNER

S. GANESAN: Online services, Present status and
future plans of FENDL (15 minutes)
Y. KIKUCHI: JENDL Fusion File
(20 minutes)
J.KOPECKY: Status of the EFF-2.4 library
(20 minutes)
P.G. YOUNG: Status of the ENDF/B-VI data file
(15 minutes)
Discussions
- 12.30-13.30 Lunch break

MONDAY, 12 September 1994

13.30-15.30 **SESSION III: PREPARATION OF PROCESSED LIBRARIES**

CHAIRMAN: DR. F.M. MANN

R.E MACFARLANE:

Status of multigroup and Monte Carlo files for FENDL/MG-1.0 and FENDL/MC-1.0 (60 minutes)

G.C. PANINI

Status of NET group libraries (20 minutes)

A. HOGENBIRK

Using EFF-2.4 data for MCNP calculations (20 minutes)

Discussions

15.30-15.45 **Coffee break**

15.45-17.30 **SESSION IV: Testing the performance of processed libraries of FENDL by analyses of fusion neutronics benchmarks**

CHAIRMAN: DR. Y. KIKUCHI

A. SANTAMARINA

Development of Gamma Heating Measurements Techniques. Experimental Results and EFF1 Qualification from the FNG SS Shield Benchmarks (20 minutes)

M. E. SAWAN

FENDL application to ITER neutronics (30 minutes)

U. FISCHER

Status of FENDL data test analyses at KfK (20 minutes)

Discussions

TUESDAY, 13 September 1994

9.00-9.45 **SESSION IV: Testing the performance of processed libraries of FENDL by analyses of fusion neutronics benchmarks**

CHAIRMAN: DR. Y. KIKUCHI

K. ILIEVA

Benchmark on neutron leakage from beryllium slabs and iron sphere (15 minutes)

M. YOUSSEF

Neutronics R & D Pathways- Status of benchmarking FENDL-1 data using JAERI's 316 SS and 316SS/water bulk shield experiments (20 minutes)

Discussions

TUESDAY, 13 September 1994

- 9.45-10.30 SESSION V: EXPERIMENTAL BENCHMARKS AND ANALYSES**
CHAIRMAN: Dr. E. MENAPACE
- A.I. BLOKHIN:**
Analyses of neutron and gamma-ray leakage spectra for 14 MeV incident neutrons (20 minutes)
- R.W. ROUSSIN:**
The SINBAD database for storage and retrieval of integral benchmarks. (20 minutes)
- 10.30-10.45 Coffee break**
- 10.45-11.35 SESSION V (continued)**
- P. BATISTONI**
Nuclear heating benchmark experiment at FNG (25 minutes)
- A. TAKAHASHI**
Integral testing of JENDL-3 and ENDF/B-VI by analyses of leakage neutron spectra from spheres
- D.V. MARKOVSKIJ**
Some results of fusion shielding experiments and analyses in Russia. (20 minutes)
- Y. OYAMA:** Integral Data Test of JENDL-3 and FENDL-1 with FNS Benchmark Experiments (20 minutes)
- Discussions**
- 11.35-12.30 SESSION VI: CHARACTERIZATION OF UNCERTAINTIES IN NUCLEAR DATA**
CHAIRMAN: H. VONACH
- D.W. MUIR**
Current Status of Fusion relevant covariance data (Presented by R.E. MacFarlane) (10 minutes)
- A. HOGENBIRK**
Uncertainty calculations made easier (30 minutes)
- Discussions**
- 12.30-13.30 Lunch break**
- 13.30-14.15 SESSION VI: CHARACTERIZATION OF UNCERTAINTIES IN NUCLEAR DATA**
CHAIRMAN: H. VONACH
- 14.15-15.30 ORGANIZATION OF THE WORKING GROUPS**
- Working group (I) on basic evaluations towards FENDL-2 for ITER design.**
D. Larson, Chairman
P. Young, Secretary

TUESDAY, 13 September 1994**14.15-15.30 ORGANIZATION OF THE WORKING GROUPS (continued)**

Working group (II) on experimental and calculational benchmarks on fusion neutronics for ITER

Y. Oyama, Chairman,
R. Roussin, Secretary

Working Group (III) on production and interfacing of FENDL/MG, FENDL/MC, FENDL/PA, FENDL/D and FENDL/DS to ITER design

(processing, post-processing and consistent integration of all functional sub-libraries)

R. MacFarlane, Chairman
M. E. Sawan, Secretary

Working group (IV) on selection of activation library of FENDL, FENDL/A-2.

FM Mann, Chairman
RA Forrest, Secretary

15.30-15.40 Coffee break**15.40-17.15 Short presentation, and guided visit of the IPP Plasma Physics Experiments ASDEX-Upgrade, and W-VII-AS****WEDNESDAY, 14 September 1994****9.00-10.30 SESSION VII: ACTIVATION LIBRARY FOR ITER
CHAIRMAN: R.W. ROUSSIN**

H.M.ATTAYA

Computational Methods for Continuous and Pulsed Activation(15 minutes)

H.M.ATTAYA

Activation Calculations for ITER Designs (15 minutes)

A.V.IGNATYUK

Benchmark validations of the FENDL Activation Data Library and proposals for the second version of FENDL/A-2 (15 minutes)

Y. KIKUCHI

JENDL Activation File (15 minutes)

J.KOPECKY

Status of EAF-4 library (15 minutes)

Y. IKEDA

Integral tests of current activation libraries based on induced radioactivity benchmark experiments at FNS (15 minutes)

Discussions

WEDNESDAY, 14 September 1994

- 10.30-10.45 Coffee break
- 10.45-12.30 Working group (I) on basic evaluations towards FENDL-2 for ITER design.
- 12.30-13.30 Lunch break
- 13.30-15.30 Working group (II) on experimental and calculational benchmarks on fusion neutronics for ITER
- 15.30-15.40 Coffee break
- 15.40-17.30 Working group (II) on experimental and calculational benchmarks on fusion neutronics for ITER
- 18.00-20.00 Joint IAEA/ITER/NET Reception (Buffet) at IPP Gastecasio

THURSDAY, 15 September 1994

- 9.00-10.00 Additional Presentations:
 S.PELLONI
 Experience with the processed libraries of FENDL (10 minutes)
 R.A. FORREST
 Comparison of USDOE/JAERI experimental data with calculations using EASY-2 (15 minutes)
 R.A. FORREST
 Status of work to include sequential charged particle reactions within FISPACT(10 minutes)
- 10.00-10.15 Coffee break
- 10.15-12.30 Working Group (III) on production and interfacing of FENDL/MG, FENDL/MC, FENDL/PA, FENDL/D and FENDL/DS to ITER design (processing, post-processing and consistent integration of all functional sub-libraries)
- 12.30-13.30 Lunch break
- 13.30-15.30 Working Group (III) on production and interfacing of FENDL/MG, FENDL/MC, FENDL/PA, FENDL/D and FENDL/DS to ITER design (processing, post-processing and consistent integration of all functional sub-libraries)
- 15.30-15.45 Coffee break

THURSDAY, 15 September 1994

15.45-17.45 Working group (IV) on the selection of activation libraries for FENDL/A-2. Summary, conclusions and recommendations

FRIDAY, 16 September 1994

9.00-12.30 Working group (IV) on the selection of activation
and libraries for FENDL/A-2 Continued. Summary,
conclusions and Final session: Summary, conclusions
13.30-15.00 and recommendations, adoption of final
report of the Advisory Group Meeting.

APPENDIX C: Conclusions and Recommendations

- Working Group I: Basic Evaluations towards FENDL/E-2.0 for ITER Design
- Working Group II: Experimental and Computational Benchmarks on Fusion Neutronics for FENDL Validation
- Working Group III: Production and Interfacing of FENDL Libraries to ITER Design
- Working Group IV: Report of Working Group IV on Activation

Working Group 1

Basic Evaluations towards FENDL/E-2.0 for ITER Design

D. Larson, Chairman
P. Young, Secretary

Working Group 1 met to assess the status of the FENDL/E-1.0 evaluated data library and to complete any additional planning required for the FENDL/E-2.0 library. The working group noted that recommendations from the previous Advisory Group meeting concerning FENDL/E-1.0 have been followed and the file has been successfully processed by R. MacFarlane at Los Alamos. In the course of processing the file a number of questions and problems have been resolved by MacFarlane working with the various evaluators, and the file is now available for use online at the IAEA Nuclear Data Section. Except for minor questions that are discussed and resolved below, the data file is complete and ready for full data testing activities.

In addition to addressing final actions for the FENDL/E-1.0 library, the working group reviewed the status of plans and procedures for developing the FENDL/E-2.0 library, and considered longer range questions for FENDL/E. Recommendations from Working Group 1 are given below.

1. Final issues to be resolved for FENDL/E-1.0

- A. Except for ^{138}Ba , the Ba isotope evaluations in FENDL/E-1.0 do not include photon production and therefore do not satisfy the rules established for selection of FENDL/E-1.0 evaluations. Because natural barium is 72 % ^{138}Ba and we do not know of a transport requirement for Ba, we assume that the need for the Ba isotopes is for absorption purposes only, and the existing evaluations are adequate for that activity.
- B. Because of the inclusion of discrete (direct) neutrons with the continuous phase-space distributions of neutrons in ^2H (n, 2n) reactions, it is not possible to utilise the FENDL/E-1.0 ^2H evaluation (from the BROND-2 data file) for MCNP continuous energy calculations. A new version of the MCNP code is required to remedy this situation, but this will not happen for several years. A. Ignatyuk and co-workers will investigate whether the direct component can be ignored or if some other improvement can be made to the ^2H data file that will permit it to be used in MCNP calculations. It was agreed that this work should be completed by 10 Nov. 1994. After that time, if no solution has been reached concerning the BROND-2 evaluation, R. E. MacFarlane will adopt the ENDF/B-VI evaluation for FENDL/E-1.0.

- C. In the course of processing the FENDL/E-1.0 data files, R. MacFarlane inadvertently included the ENDF/B-VI evaluations for ^3He , ^4He , and ^{89}Y . Members of WG-1 decided to add the ENDF/B-VI evaluations for ^3He and ^4He to the official FENDL/E-1.0 data file, but to remove the ^{89}Y evaluation.

2. Do we need to add any new materials for FENDL/E-2.0?

The FENDL/E-1.0 is a comprehensive and complete data file. However, the working group recommends that the list of materials be reviewed to make sure that any new materials required by the fusion community for inclusion in FENDL/E-2.0. Because this question requires input from a broader group than is present at this meeting, Dr. Ganesan was asked to survey the fusion project community to see if evaluations for additional materials need to be identified as part of the upgrade to FENDL/E-2.0. E. Cheng agreed to cooperate with S. Ganesan in this assessment, which should be completed by 10 Nov. 1994. Dr. Ganesan was asked to inform members of Working Group 1 of the results of this assessment.

3. Do we need to modify any of the procedures we set up at the 1993 FENDL meeting for FENDL/E-2.0 candidate evaluations?

The procedures set up at the last meeting for FENDL/E-2.0 candidate evaluations were reviewed and found to be satisfactory. It was decided that evaluations sent to R. MacFarlane by 28 February 1995 will be considered for FENDL/E-2.0. Evaluations sent later than that date will only be considered if time is available. Graphical materials illustrating comparisons between available evaluations and experimental data should be provided to MacFarlane by the evaluators. The procedures are spelled out in Appendix B.3 of the proceedings from the Tokai FENDL meeting [INDC (NDS) - 297, 1994].

4. Oversight of the FENDL activity

Working Group 1 recommends that the IAEA/NDS appoint an oversight committee to coordinate scientific activities in the interim period between now and the next FENDL meeting. Membership of the committee should be from the nuclear data community of the participating partners in ITER. The committee should cover the areas of expertise included in the various working groups at this meeting. The membership of the committee should be about six in number. One person from the IAEA/NDS should be included in the membership.

5. Longer range evaluation activities

Because of the time scale required for finalizing the FENDL/E-2.0 library, the working group recognizes that some problems and areas of concern will still exist after the FENDL/E-2.0 file is established. Some areas of weakness that we anticipate the NDS will need to address in the 1997-98 period after the issue of FENDL/E-2.0 in 1996 are summarized below.

- a. New material requirements - we anticipate evaluation needs for new materials as fusion technology progresses toward design of an operating power reactor.
- b. Higher energy data - As material irradiation test facilities are designed and built, needs for evaluated data at higher energies will occur.
- c. Covariance data - A number of evaluations will not have covariance data or the covariance data will be inadequate.
- d. Energy-angle correlated data - It is expected that full representation of particle and recoil spectra in MF6 format will not be present for all materials, for example, light elements.
- e. Cross sections for (n,alpha) reactions - Both an IAEA CRP and a subgroup of NEANSC Working Party on International Evaluation Cooperation have been organized to study the problem of measuring/calculating the magnitude and shape of (n,alpha) cross sections in the structural materials. Results of these activities will not be available in time to impact FENDL/E-2.0 submissions.
- f. Problems in low-energy region - Development of improved treatment of KERMA from keV capture reactions, improved data on capture gamma-ray spectra at keV energies, and improved level-spacing data are needed in many evaluations.
- g. Correction of problems - In the event that data testing activities identify problems in the data files, some mechanism needs to be in place to address these deficiencies.
- h. Long-term file maintenance - A procedure for maintaining the FENDL/E file and incorporating improvements should be established.

Working Group (II) on Experimental and Calculational Benchmarks on Fusion Neutronics for FENDL Validation

Y. Oyama (JAERI) Chairman, R. Roussin (ORNL-RSIC) Secretary

A. Status of Experimental Benchmark Data Base at IAEA

1. Summary of Benchmarks submitted to IAEA

Most benchmarks identified at the November 1993 meeting in Japan have been received and placed on the on-line system in the subdirectory [FENDL.BENCHMARKS]. The IAEA/NDS has plans to arrange for U. v. Möllendorff to spend some time at the Agency to do a critical review of the fusion benchmarks. Suggestions for changes would be communicated to the contributors. The current contents of the on-line Benchmark Data are summarized in Table 1. A diskette containing the current Benchmark Data Base was made available at the meeting.

2. Status of Benchmarks not yet submitted

Candidates from China and ORNL have not yet been received. The ORNL shielding and streaming benchmarks are now being entered into the SINBAD Data Base at RSIC and will be provided to IAEA when that process is complete.

3. New candidates

Gamma-ray heating in stainless steel measured by CEA/ENEA at the FNG will be submitted to the Data Base. Additional experiments will be submitted from Russia in the multiplication category for total neutron leakage from Be, Pb, and Bi spheres (KIAE) and in the bulk/streaming shield category in-system reaction rates and gamma-heating for Fe slabs (KIAE/MEPhi).

A request was made to obtain the LLNL pulsed spheres and Roussin will attempt to do this. The need to have these data in enough detail for complete analysis was stressed. New candidates should be submitted in the recommended format (INDC-NDS-298) by Nov. 10, 1994.

It was pointed out that benchmarks using vanadium are needed and such measurements are encouraged.

4. Future Maintenance

It was reported that the IAEA NDS will continue to maintain the Benchmark Data Base.

B. Expected Participants:

Participants in data testing are expected from many

countries, including Bulgaria, China, Italy, India, France, Germany, Japan, Russia, and the United States. A list of individuals are is given below:

Bulgaria	K. Ilieva	Japan	Y. Oyama A. Takahashi C. Ichihara
Italy	P. Batistoni	Russia	A. Blokhin D.V. Markovskij
India	Basu	USA	M.Z. Youssef E. Cheng H. Hunter
France	A. Santamarina		
Germany	U. Fischer, K. Seidel		

All codes needed for data testing of FENDL will be provided by the Radiation Shielding Information Center (RSIC, ORNL) without charge. Requests can be made by e-mail to pdcc@ornl.gov or Fax (615) 574-6182. Requestors are required to complete a registration form.

C. Versions for Testing FENDL/1.0

Ganesan will notify all the participants of the AGM and expected data testing participants when the updated and corrected processed data is ready. Files which have been changed from earlier versions should be identified clearly by name on the on-line system. Earlier versions should be retained in the archives.

D. Initial Recommendations on use of FENDL/MG - 1.0 and FENDL/MC -1.0

It is expected that initial tests during the final processing of FENDL/E -1.0 will attest to the completeness of FENDL/MG - 1.0 and FENDL/MC -1.0. U. Fischer will contact the expected participants in data testing to exchange information on how to proceed. Results of some initial calculations by data testers will be communicated to U. Fischer of KfK by December 31,1994. He will summarize these results and reports this early experience to ITER. Success in this initial phase will give confidence to ITER that the processed data based on FENDL/E - 1.0 has the blessing of the FENDL group as a first-round tool for fusion neutronics analyses.

E. Mechanism for Feedback to FENDL

U. Fischer will collect results of data testing over the

next few months. These will be forwarded to the executive committee, if it is established, for guidance in the improvement of the next version of FENDL by February 28, 1995. It is anticipated that a meeting will be held in the Spring of 1995 to review data testing results.

F. Sensitivity/Uncertainty Analysis

These are expected to have an impact down the road. A. Santamarina (CEA, Cadarache) will calculate sensitivity coefficients of measured responses to the cross sections, and from the C/E information will carry out a trend analysis. The results will be available as a guide for recommendations for improvement to evaluations by the next FENDL meeting. Furthermore, safety factors for bulk shield calculations will be derived from the observed trends of C/E's by M. Youssef (UCLA, USA) and A. Santamarina.

G. Calculational Benchmarks

M. Sawan (U. Wisconsin) will provide to the NDS, by October 31, 1994, a detailed description for a representative of ITER calculational benchmark as well as of the responses to be calculated. He will collect and summarize contributions from participants and report results at the next FENDL meeting. The calculational benchmark will be added to the NDS on-line system.

H. Effects of Self-Shielding Methods:

A. Blokhin and co-workers at IPPE, Obninsk will study the effect of self-shielding methods on the neutron and gamma emission leakage spectra for thick iron spheres. Results will be sent to U. Fischer by the end of February, 1995.

TABLE 1 IAEA COMPILATION OF FUSION BENCHMARKS

(Prepared by S. Ganesan)

FENDL/BENCHMARKS, the compiled information on fusion neutronics benchmarks can be accessed by the user over international computer networks as described below. In the NDS open area 'FENDL', a subdirectory has been created for each file, for example, "FENDLE" for the FENDL/E file and FENDL.BENCHMARKS for the benchmarks. The file transfer via internet can be performed by ftp command to the address: `iaeand.iaea.or.at` or `161.5.2.2`. The user should logon with the user name "FENDL". No password is required. After having logged on, the user can enter any required subdirectory using 'cd' and transfer files as desired.

Directory UD6:[FENDL.BENCHMARKS] contains the following 8 subdirectories at the time of writing this report:

1. ACTIVATION.DIR;1
2. BOMBAY.DIR;1
3. DRESDEN.DIR;1
4. ENEACEA.DIR;1
5. JAERIM94014.DIR;1
6. OKTAVIANFENI.DIR;1
7. RUSSIA.DIR;1
8. WISCONSIN.DIR

1. Directory UD6:[FENDL.BENCHMARKS.ACTIVATION] provides the Activation Benchmark Data of the USDOE/JAERI collaboration in the form as it was received from Dr.Ikeda.
2. Directory UD6:[FENDL.BENCHMARKS.BOMBAY] provides details of "Neutron Multiplication Measurements in beryllium, beryllium oxide and lead with 14-MeV neutrons" (submitted by Dr. Tejen Kumar Basu)
3. Directory UD6:[FENDL.BENCHMARKS.DRESDEN] contains three subdirectories
 - 3.1. Directory UD6:[FENDL.BENCHMARKS.DRESDEN.FESLAB] contains the data of the TUD Iron Slab Benchmark (submitted by K. Seidel)
 - 3.2. Directory UD6:[FENDL.BENCHMARKS.DRESDEN.PB] contains files describing the IAEA Benchmark Problem Based on the Lead Sphere Experiment at TU Dresden performed within the framework of a collaboration between IAE Moscow, ZfK Rossendorf and TU Dresden. (submitted by K. Seidel)
 - 3.3. Directory UD6:[FENDL.BENCHMARKS.DRESDEN.U] contains the IAEA Benchmark Problem Based on the Uranium Sphere Experiment performed at TU Dresden within the framework of a collaboration between IAE Moscow, ZfK Rossendorf and TU Dresden. (submitted by K. Seidel)

4. Directory UD6:[FENDL.BENCHMARKS.ENEACEA] contains the details of the experiment carried out at FNG (Frascati Neutron Generator) facility which consists of the irradiation of a stainless steel (SS) block by 14-MeV neutrons. (Submitted by P. Batistoni)
5. Directory UD6:[FENDL.BENCHMARKS.JAERIM94014] consists of 9 subdirectories:
 - 5.1 BE.DIR;1
 - 5.2 C.DIR;1
 - 5.3 COPPER.DIR;1
 - 5.4 FNS-TOF1.DIR;1
 - 5.5 FNS-TOF2.DIR;1
 - 5.6 IRON.DIR;1
 - 5.7 LI20.DIR;1
 - 5.8 OKTAVIAN.DIR;1
 - 5.9 SS316L.DIR;1

These 9 subdirectories contain benchmark data submitted by JAERI.

- 5.1 The directory UD6:[FENDL.BENCHMARKS.JAERIM94014.BE] contains the details of Integral Experiment on Beryllium Cylindrical Assembly (Version 1.0 compiled on March 8, 1994) (H. Maekawa et al.,)
- 5.2 The directory UD6:[FENDL.BENCHMARKS.JAERIM94014.C] contains the details of Integral Experiment on Graphite Cylindrical Assembly. Version 1.0 compiled on March 8, 1994) (H. Maekawa et al.,)
- 5.3 The directory UD6:[FENDL.BENCHMARKS.JAERIM94014.COPPER] contains the details of Integral Experiment on Copper Cylindrical Assembly Version 1.0 compiled on March 25, 1994 (H. Maekawa et al.,)
- 5.4 Directory UD6:[FENDL.BENCHMARKS.JAERIM94014.FNS-TOF1] (note: Items 5.4 and 5.5: FNS-TOF1 and FNS-TOF2 are two directories containing the following subdirectories: BE.10, C.10, Li2O.10, FE.10, PB.10, LQ-N.10, LQ-O.10)
 - 5.4.1 The directory UD6:[FENDL.BENCHMARKS.JAERIM94014.FNS-TOF1.BE] contains the following: Version 1.0 Revised on Nov. 19, 1992 IAEA Benchmark Problem Based on the Time-of-Flight Experiment on beryllium Slabs at FNS/JAERI. Submitted by: Yukio OYAMA and Hiroshi MAEKAWA

- 5.4.2 **The directory**
UD6:[FENDL.BENCHMARKS.JAERIM94014.FNS-TOF1.C]
contains the following data: Version 1.0 Revised
on Nov. 19, 1992 IAEA Benchmark Problem Based on
the Time-of-Flight Experiment on Graphite Slabs at
FNS/JAERI Submitted by: Yukio OYAMA and Hiroshi
MAEKAWA
- 5.4.3 **The directory**
UD6:[FENDL.BENCHMARKS.JAERIM94014.FNS-TOF1.LI2]
contains the following: Version 1.0 Revised on
Nov. 19, 1992 IAEA Benchmark Problem Based on the
Time-of-Flight Experiment on Lithium Oxide Slabs at
FNS/JAERI Submitted by: Yukio OYAMA and Hiroshi
MAEKAWA
- 5.5.1 **The subdirectory**
UD6:[FENDL.BENCHMARKS.JAERIM94014.FNS-TOF2.FE]
contains the following data: Version 1.0 Nov. 20,
1992 IAEA Benchmark Problem Based on the
Time-of-Flight Experiment on Iron Slabs at
FNS/JAERI Submitted by: Yukio OYAMA and Hiroshi
MAEKAWA
- 5.5.2 **The subdirectory**
UD6:[FENDL.BENCHMARKS.JAERIM94014.FNS-TOF2.LQ-N]
contains the following data: Version 1.0 Mar. 8,
1994 IAEA Benchmark Problem Based on the
Time-of-Flight Experiment on Liquid Nitrogen Slabs
at FNS/JAERI Submitted by: Yukio OYAMA and Hiroshi
MAEKAWA
- 5.5.3 **The subdirectory**
UD6:[FENDL.BENCHMARKS.JAERIM94014.FNS-TOF2.LQ-O]
contains the following data: Version 1.0 Mar. 8,
1994 IAEA Benchmark Problem Based on the Time-of-
Flight Experiment on Liquid Oxygen Slabs at
FNS/JAERI Submitted by: Yukio OYAMA and Hiroshi
MAEKAWA
- 5.5.4 **The subdirectory**
UD6:[FENDL.BENCHMARKS.JAERIM94014.FNS-TOF2.PB]
contains the following data: Version 1.0 Nov. 20,
1992 IAEA Benchmark Problem Based on the
Time-of-Flight Experiment on Lead Slabs at
FNS/JAERI Submitted by: Hiroshi MAEKAWA and Yukio
OYAMA
- 5.6 **The directory**
UD6:[FENDL.BENCHMARKS.JAERIM94014.LI20] contains
the following data: Integral Experiment on Li2O
Cylindrical Assembly Version 1.0 compiled on March
8, 1994 (Submitted by H. Maekawa et al.,)

- 5.7 **The directory**
 UD6:[FENDL.BENCHMARKS.JAERIM94014.OKTAVIAN]
 consists of two subdirectories:
 BELI.DIR;1 and TPR.DIR;1
- 5.7.1 **The directory**
 UD6:[FENDL.BENCHMARKS.JAERIM94014.OKTAVIAN.BELI]
 contains the following: Leakage Neutron Spectra
 from Beryllium Sphere and Beryllium-Lithium Sphere
 Version 1.0 compiled on March 8, 1994 (Submitted by
 A. Takahashi et al.,)
- 5.7.2 **The Directory**
 UD6:[FENDL.BENCHMARKS.JAERIM94014.OKTAVIAN.TPR]
 contains the following: Tritium Breeding Ratio in
 Li, Pb-Li, Pb-Li-C, Be-Li, Be-Li-C, Spheres
 Measured with Li²CO₃ Pellets and/or LiF TLDs
 Version 1.0 compiled on March 8, 1994 (Submitted by
 A. Takahashi et al.,)
- 5.8 **The Directory**
 UD6:[FENDL.BENCHMARKS.JAERIM94014.SS316L] contains
 the following: Fast Neutron Spectrum and Secondary
 Gamma-Ray Heating in a Type 316L Stainless Steel
 Assembly Irradiated by 14 MeV Neutrons. Submitted
 by: H. Nakashima, S. Tanaka and Y. Oyama
6. **The Directory** UD6:[FENDL.BENCHMARKS.OKTAVIANFENI]
 contains details of the following:
- 1.IAEA Benchmark Problem Based on the
 Time-of-Flight Experiment on Iron Sphere at
 OKTAVIAN/Osaka University
 - 2.IAEA Benchmark Problem Based on the
 Time-of-Flight Experiment on Nickel Sphere at
 OKTAVIAN/Osaka University.
- Both these were submitted by Yo Makita and Akito
 Takahashi
7. **The Directory** UD6:[FENDL.BENCHMARKS.RUSSIAN]
 contains 17 files of data describing the following
 experiments: Neutron leakage spectra from Be, Fe,
 Pb, PbLi Shells with 14 MeV Neutron Source.
 Submitted by:S.P.Simakov, B.V.Devkin, M.G.Kobozev,
 V.A.Talalaev, Obninsk, The Russian Federation.
8. **The directory** UD6:[FENDL.BENCHMARKS.WISCONSIN]
 contains two calculational benchmarks submitted by
 Prof. M. SAWAN: 1. The neutronics and shielding
 benchmark with description of the reference steel /
 water blanket design in the ITER outline design.
 2. A calculational activation benchmark
 representative of the ITER design.

Report of Working Group III on Production and Interfacing of FENDL Libraries to ITER Design

R. MacFarlane (LASL) - Chairman

M. Sawan (Univ. of Wisconsin-Madison) - Scientific Secretary

The working group discussed issues and concerns related to the production and interfacing of the FENDL libraries to ITER design. A list of issues discussed and conclusions made is given below.

I. Dosimetry Library

The dosimetry data are based on IRDF-90 version 2 data provided in multigroup form with 640 energy groups. The question of providing the data in continuous energy format was addressed. If the data are available in pointwise form from the original source (e.g. ^{197}Au from ENDF/B-VI), they will be processed from the pointwise data. Otherwise, they will be processed from histogram representation.

2. Gas Production Data

Based on the request of ITER JCT and FENDL library users, it was recommended that the gas production cross sections will be added. The preferred option is to add the data in the materials data files in the general purpose library rather than providing them in special purpose files. R. MacFarlane will generate and add the five gas production (^1H , ^2H , ^3H , ^3He , ^4He) data in the FENDL/E library and the processed multigroup and continuous energy files. The modified FENDL/E files will be returned to the IAEA/NDS for use as version 1.1.

3. Neutron Damage Data

The option of providing the atomic displacement cross sections (dpa) for the different elements in the libraries was discussed. It was decided to keep the current approach in which the damage energy cross sections are provided for the elements leaving it to the user to calculate the dpa cross section, which depends on values of efficiency and displacement energy recommended for the different metals and alloys.

4. Heating Data

R. MacFarlane will modify the KERMA factors to include the decay energy carried by the beta particles emitted from decay of short lived ($T_{1/2} < 1$ day) radionuclides. This energy will be added to the neutron KERMA factor and is assumed to be deposited locally. On the other hand, the gamma photons associated with the radioactive decay will be accounted for by modifying the gamma

production matrix. This allows for transporting these gamma photons which will end up depositing their energy somewhere else. R. MacFarlane will provide an algorithm that users can include in the TRANSX input. Two separate continuous energy files will be provided for cases where decay heat is included or not. For several materials where only elemental evaluations are available in FENDL, it will be necessary to use isotopic evaluations outside FENDL to provide the necessary decay energy data for modification of KERMA factors. The KERMA data will be generated using energy balance although kinematic KERMA will be available for the multigroup library.

5. Need for higher scattering order

Y. Gohar confirmed the need to extend the gamma transport data up to P_8 to account for large scattering anisotropy. R. MacFarlane will extend the libraries to scattering order P_8 for gamma. The neutron scattering matrices for orders larger than P_6 will simply be filled with zeros.

6. Need for higher temperatures

There was no strong feeling among the participants regarding adding data at temperatures other than the 300K used in the FENDL library.

7. Need for Thermal Upscatter

No strong need for thermal upscatter data for FENDL-2 was expressed.

8. Plans for FENDL-2

The original plan was to start work on processing FENDL-2 as soon as possible to make it available in 1997 when it is expected that the ITER licensing and siting process will start. Y. Gohar and R. Santoro from the ITER JCT expressed the opinion that while the work on FENDL-2 is encouraged and welcomed, the highest priority is to finish the work on FENDL-1 to make it available for use in ITER. There is an immediate need of FENDL-1 for use in the interim ITER design which should be finished in Mid 1995. The participants agreed on giving FENDL-1 the highest short term priority.

9. Revision Control

A need for detailed information on the history of changes to the files was expressed, both at the library and at the material levels.

10. Other Formats

The need to have FENDL-1 data available in other formats, such as

AMPX, was discussed briefly. Several laboratories would like to use AMPX data. The need for careful cross validation between the AMPX and MATXS data was stressed and ORNL and ENEA/Bologna agreed to carry out this validation. These data will be stored under FENDL/MG with a ".ampx" suffix.

Report of Working Group IV on Activation

Chairman: FM Mann
Secretary: RA Forrest

Introduction

The agenda shown below was agreed by the Working Group. The FENDL/A-1.1 file is complete and is ready and endorsed for use by ITER. The purpose of the Working Group is focused on the selection process for the individual evaluation for FENDL/A-2, the FENDL-2 activation (cross section) library.

Agenda

1. Selection of list of important reactions
2. Detailed requirements for 'Review Kit'
3. Adoption of review process and time scale
4. Activation code requirements
5. Consistency with General Purpose Files
6. Leadership of FENDL activation process
7. Membership of Selection Panel
8. Access of FENDL data files
9. Decay data files
10. Future activities
11. Official documentation

1. Selection of list of important reactions

As an action item from the previous FENDL meeting, a revised list of reactions important for fusion applications has been produced by four members of the Working Group after discussions carried out by e-mail. This list has been published as an ECN Petten report, and copies of this report were available at the current meeting. This list containing 386 reactions was adopted by the Working Group without amendment.

2. Detailed requirements for "Review Kit"

The "Review Kit" is the set of information that will be supplied to members of the Selection Panel to aid in the choice between the various candidate evaluations for each reaction in the library. It was agreed that this will consist of two parts: the first for the important reactions and the second for the remainder of the library (the "base library"). The inputs required to produce each of these are listed below:

A Input for Review Kit for important reactions

- (i) Electronic copy of the evaluation in the FENDL-A format.
- (ii) Electronic copy of the reasons for using the evaluation (in English).

- (iii) Electronic copy of the results of using the evaluation in a comparison with the UCLA/JAERI benchmark. This must consist of the cross section averaged (collapsed) in spectra A and B. If possible the C/E value for activity should also be calculated.
- (iv) Electronic copy of the evaluation in VITAMIN-J format.

All information will be sent to Mann who will distribute as required. JAERI volunteered to process the FENDL-A format file to produce (iii) and to collate all candidates of a particular reaction and produce a single graph showing the evaluations and experimental data (where available). Note that if (iv) cannot be produced then Mann will process (i) before forwarding to JAERI .

B Input for Review Kit for the base library

- (i) Electronic copy of the library in the FENDL-A format.
- (ii) Supporting documentation consisting of summary (in electronic form) and what ever reports or documents are considered necessary to describe the library construction and testing.
- (iii) Results of the UCLA/JAERI benchmark using the complete library and results from any other validation exercise.

3. Adoption of review process and time scale

The following review process was adopted:

Important reactions

- a. All candidate evaluations to be submitted to Mann.
- b. Mann will forward item 2a(iv) to JAERI to produce graphical comparisons and benchmark comparisons.
- c. JAERI will return completed comparisons to Mann who will add other items and distribute to members of selection panel.
- d. Selection panel will review data and through discussion between its members (via e-mail) reach consensus, wherever possible, about the choice of evaluation for each reaction. If no final agreement can be reached, the number of choices will be reduced if possible.
- e. The full results of the selection panel will be distributed.
- f. A reduced set of reactions will be discussed at the next FENDL meeting by the full Working Group.

The time scale for each of these actions was agreed based on the date of the next FENDL meeting being set for 1 October 1995.

- a. 15 February 1995
- b. 1 March 1995
- c. 1 June 1995
- d. 15 July 1995
- e. 1 August 1995
- f. 1 October 1995

Base library

- a. All candidate evaluations to be submitted to Mann.
- b. Mann will distribute the support documentation to members of the Selection Panel, and make the full library available by electronic means.
- c. Selection Panel will review libraries and through discussion between its members (via e-mail) reach consensus if possible about the choice of library. If no final agreement can be reached, the number of choices will be reduced if possible.
- d. A reduced set of library choices will be discussed at the next FENDL meeting by the full Working Group.

The time scale for each of these actions was agreed based on the date of the next FENDL meeting being set for 1 October 1995.

- a. 1 June 1995
- b. 1 July 1995
- c. 1 September 1995
- d. 1 October 1995

4. Activation code requirements

The requirements for activation codes were specified at the last FENDL meeting, these are listed in the report of that meeting², and it was agreed that all the nine code specifications and the requirements for a User Manual and results of the calculational benchmarks should remain. It was further agreed to give all nine criteria equal importance and not divide them into three levels of priority as before.

There was discussion about the importance of interfacing to transport codes, it was noted that no recommendation for particular transport codes (apart from MCNP) had been made by ITER. It was proposed that ITER be again asked if any recommendations were now possible.

There was a proposal for a further calculational benchmark focused on the ITER design activity. This was agreed and the following procedure was adopted:

- a. Sawan will provide data corresponding to a series of zones in a 1D representation of an ITER design. These data are:
 - (i) A set of neutron fluxes for each zone
 - (ii) Irradiation history
 - (iii) Material compositions
 - (iv) Adjoint g fluxes corresponding to a point at the rear of the shield to enable contact g doses to be calculated (that include g transport).
- b. Participants will use FENDL-A1.1 cross sections and FENDL

- decay data library to do the calculation.
- c. Reported data to include the inventory of the 'top ten' contributing nuclides and the decay heat in each zone and the point g dose rate; all of these at the various cooling times defined.
 - d. Results will be collated, inter-compared, and conclusions drawn, with Roussin as the contact point.

Sawan agreed to finish the design of the benchmark and distribute to IAEA NDS who will make it available to interested parties for comments by 31 October 1994. When agreed the data will be made available by the IAEA NDS.

Preliminary interested participants are: M Sawan, M Youssef, H Attaya, E Cheng and RA Forrest.

5. Consistency with General Purpose Files

It was agreed that the present policy of allowing evaluations chosen for the activation library to be from a different source than in the General Purpose Files would continue.

6. Leadership of FENDL activation process

It was agreed that Pashchenko would assume the leadership role in the period before the next FENDL meeting. He accepts responsibility for reminding members of the Working Group of forthcoming milestones and attempting to ensure that tasks are completed on time. Mann will distribute to the IAEA NDS all pointwise activation candidates at the same time as the files are distributed to the Selection Panel.

All contact points will keep IAEA NDS fully informed of the status of activities.

7. Membership of Selection Panel

It was agreed that no more than two people from each region expected to submit full libraries (China, Europe, Japan, Russia and USA) would be nominated, by each organisation responsible for the full library, to be members of the Selection Panel. Nominations must be sent to Mann by 1 March 1995.

It was agreed that an Information Group would be formed and that Mann would send via e-mail regular progress reports during the selection process.

It was asked if there was a need for a supplementary archive of the FENDL data files (General Purpose in addition to activation) as some people had experienced delays in obtaining files on-line from the IAEA NDS. It was agreed that this was sensible; there are no problems with distribution policy as all are unrestricted. It was proposed that the NDS should contact the other three Data Centres

and RSIC to see if they are willing also to distribute the FENDL files.

9. Decay data files

It was noted that the FENDL decay data library was supplied by Mann and contains information (only some of which is fully evaluated) for over 2800 nuclides. This library is in ENDF-B/VI format. There is no standardised processed file, largely because the needs of each inventory code are rather different. It was proposed that Cheng should organise a subgroup to consider the feasibility of preparing processed files and should look at ways of comparing the existing libraries. Cheng agreed to investigate and to give a status report by 1 January 1995.

10. Future activities

It was agreed that future activities for consideration by the Working Group would include:

- a. Improvements to the decay data library.
- b. Possible inclusion of parameters derived from the decay library (e.g. biological hazard coefficients) within the FENDL libraries.
- c. More consideration of calculational benchmarks.
- d. Further consideration of present and future experimental benchmarks.

It was agreed that the Working Group cannot give more concrete advice on future NDS activities until the next FENDL meeting because deficiencies in the FENDL 1.1 library will not be apparent until then.

11. Official documentation

The Working Group noted that the report IAEA-NDS-148 ("JONACS") is not the official documentation of the FENDL/A and FENDL/D activities.

APPENDIX D

334-F4-AG-758.3

(1994-09-12)

**IAEA Advisory Group Meeting on
"Improved Evaluations and Integral Data Testing for FENDL"**

12-16 September 1994

**hosted jointly by the Max-Planck-Institut fuer Plasmaphysik
and the ITER Joint Central Team
at Garching near Munich, Germany**

(Scientific Secretary: S. Ganesan)

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