IAEA
International Atomic Energy Agency

INDC(NDS)-0525
Distr. FE

INDC International Nuclear Data Committee

IAEA Technical Meeting on

NUCLEAR DATA LIBRARY FOR ADVANCED SYSTEMS – FUSION DEVICES

International Atomic Energy Agency
Vienna, Austria

31 October – 2 November 2007

Prepared by

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April 2008

IAEA Nuclear Data Section, Wagramer Strasse 5, A-1400 Vienna, Austria

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Abstract

A Technical Meeting on "Nuclear Data Library for Advanced Systems - Fusion Devices" was held at the IAEA Headquarters in Vienna from 31 October to 2 November 2007. The main objective of the initiative has been to define a proposal and detailed plan of activities for a Co-ordinated Research Project on this subject. Details of the discussions which took place at the meeting, including a review of the current activities in the field, a list of recommendations and a proposed timeline schedule for the CRP are summarized in this report.

April 2008

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WELCOME

Participants were welcomed to the IAEA by A. Nichols (IAEA) and A. Mengoni (IAEA). Donald Smith was elected as a chairman and Robin Forrest as a rapporteur. The Agenda was adopted (Appendix 1)

1. INTRODUCTION

The current emphasis for fusion research is on ITER (International Thermonuclear Experimental Reactor), and the existing Fusion Evaluated Nuclear Data Library (FENDL-2.1) serves as a source of nuclear data for this work. The future of fusion is aimed at fusion power plants and will require detailed information on materials. Such information cannot be obtained from ITER but will require a dedicated materials test facility with a high intensity neutron source. The proposed International Fusion Materials Irradiation Facility (IFMIF) is the most suitable neutron source because of its very close match to the neutron spectrum in a fusion reactor. The project is considered to be an essential facility on the critical path to fusion power plants.

IFMIF will use a high energy, high intensity beam of deuterons striking a flowing lithium target to generate neutrons, and therefore nuclear data for the reactions of deuterons with materials are required. In addition, the neutron spectrum will have a high energy tail (up to 55 MeV), and thus neutron data for neutronics and activation calculations be extended above 20 MeV.

The objective of the present meeting is to define a Coordinated Research Project (CRP) that will address these nuclear data needs for advanced fusion devices. Given the amount of work carried out by the IAEA on the series of FENDL data libraries, it is also necessary to consider if this work can best be carried out by updating FENDL to contain the new data.

2. PRESENTATIONS

A series of presentations indicated the status of fusion and relevant nuclear data work in several countries, underlining the requirements for ITER and IFMIF, and reported various benchmarking studies with FENDL data libraries.

M. SUGIMOTO

Overview of fusion research activities in Japan

The Japanese strategy from ITER to DEMO was summarised including the Broader Approach. The "National Policy of Future Fusion R&D" report was endorsed by the Japan Atomic Energy Commission in November 2005. Main points of note were as follows:

- Standard Roadmap ITER/IFMIF/DEMO leading to commercial reactors
- Significant synergy between fission (Generation IV) and fusion which must be exploited.
- Focus on two DEMO concepts: SlimCS and CREST.
- Details of the ITER procurement process were given.
- Details of the key technology areas to be demonstrated by ITER, including superconducting magnets, remote operation, tritium processing, tokamak and plant control systems, and particle and heat rejection systems.
- Test Blanket Modules (TBM) are being designed by all the ITER partners. Japan is taking the lead in the Water-Cooled Solid Breeder TBM, fabrication is planned to begin in 2010.
- Broader Approach activities in collaboration with the EU focus on IFERC (simulation and DEMO studies), IFMIF-EVEDA and the JT60 super upgrade.
- Materials development: reduced activation ferritic steels, vanadium alloys and SiC/SiC composites.
- Complementary work on superconductors.

Discussion

R. Forrest noted that the presentation does not mention nuclear data and that the projects are not making their nuclear data needs clear. According to U. Fischer needs of IFMIF will be communicated directly with various parties. He also stated that although there is no official call from ITER for nuclear data, they do have significant needs.

Topics of discussion included damage energies, in particular MT=444 file which results from processing the basic data and could be different for the various libraries. U. Fischer noted that these derived files are available but probably have not been compared. There were no benchmarks, especially at higher energies.

Mengoni asked about Fischer's comment concerning ITER data needs; Fischer replied that although there is no official call from ITER for nuclear data, he feels that there are in fact needs.

Scope and project plan of the IFMIF/EVEDA

This presentation introduced various phases of IFMIF including the present one (EVEDA - Engineering Validation, Engineering Design Activity) and the one that will follow – CODA (Construction and Commissioning, Operation and Maintenance and Decommissioning).

IFMIF has a very small testing region and high energy tail in the neutron spectrum, which would mean that there is a need for nuclear data above 20 MeV. It is expected that the EVEDA phase will last 6 years (until 2013) and after that construction will take 6 years. The EVEDA work is being carried out at Rokkasho, Japan.

Details of the IFMIF project schedule, organization, staffing levels, participating organisations, procurement arrangements and the project plan were given (see presentation). There are three main parts – the test facility, target facility and accelerator facility.

Discussion
A. Mengoni enquired about the connection between IFMIF and ITER – connection exists since the EVEDA phase of IFMIF is funded through the EU/Japanese Broader Approach part of ITER.

Status of nuclear data above 20 MeV

The composition of the JENDL/HE file was given. There was an initial release in 2004 which will be expanded by the JENDL/HE-2007 release expected in December 2007. This contains data up to 3 GeV for 132 targets. The theoretical methods used for calculation and evaluation were outlined. It was noted that there had been improvements in the cluster-particle emission spectra and production cross-sections. Results of some analyses using JENDL/HE were also summarized for benchmark calculations (TIARA experiment). The calculations using JENDL/HE have shown good performance. For the integral experiment at RCNP, Osaka University, neither JENDL 3.1 nor JENDL/HE gave adequate agreement.

R. FORREST

Status and needs of activation data for fusion

The current activation libraries such as EAF-2007 were summarised. This differs from EAF-2003 because energies up to 60 MeV are covered and data for deuteron- and proton-induced reactions are also included. Validation and testing of such large datasets are based on integral measurements and the statistical approach (SACS). In determining all the activation properties of the stable elements, only a minority of the reactions are important. The technique of Importance Diagrams was described, and results for the important reactions from EAF-2003 were presented. Similar analyses are underway for EAF-2007. The neutron-induced data in EAF contain uncertainty information for all reactions; however, this is simplified and options for improvements were described. There are still issues of format for activation files, especially for energies > 20 MeV, which need to be addressed. Several questions that need to be considered concerning the FENDL activation file were raised - need to decide how much additional information could be added to an improved FENDL file.

In addition to the presentation by R. Forrest, R. Capote-Noy presented the IAEA work on dosimetry reactions at E > 20 MeV. A series of ten new reactions will be included in the IRDF library up to 40 MeV. It is expected that this work will be carried out over a period of two years. He also noted that work on a tungsten evaluation including covariances may be of relevance to activation data files.

U. FISCHER

Development needs of nuclear data for fusion technology

An overview of the nuclear data required for nuclear design analyses of fusion technology focusing on ITER and IFMIF was presented. The status of the available data evaluations and libraries concerning the required materials/nuclides and data types was reviewed, stressing their quality as compared to differential and integral experimental data. Concerning nuclear data evaluations for neutron and photon transport simulations, activation cross-sections and covariance data for uncertainty analyses, future development needs were identified.

Significant progress in developing qualified nuclear data for fusion technology such as the FENDL nuclear data library has been achieved in the past. A complete general-purpose nuclear data library in particular for neutronics calculations of the IFMIF neutron source facility needs to be developed. A variety of intermediate energy data evaluations is already available from JEFF, ENDF/B and the JENDL/HE data library including many of the IFMIF high priority nuclides. These evaluations need to be qualified and complemented for the remaining isotopes.

Activation data libraries have been developed for neutron-, proton- and deuteron-induced reactions according to IFMIF needs. They are mainly based on nuclear model calculations, in particular with regard to the high energy range. Thus, there is a strong need for measuring IFMIF relevant activation cross-section data in the neutron energy range 20 – 50 MeV including elements such as Cr, Co, V, W, Ta, Pb, Bi, Tm, Fe, Au and Mn as well as others. Some of the data are required for application to the dosimetry foil activation technique for neutron flux monitoring. The primary focus for deuteron-induced cross-sections is on Cu, Al and Nb. Analogous data are required for proton-induced activation reactions when operating the IFMIF prototype accelerator. This will include materials such as Ta, W, Pt, Au and Pb that may be used for the proton beam dump.

Special attention needs to be given to the gas production cross-section data of the major IFMIF irradiation materials such as Fe, Cr, Mn, W, Ta and others. Recent measurements of the helium and hydrogen production cross-sections by R. Haight et al. have shown large disagreements between the experimental data and the nuclear model calculations in the neutron energy range from 20 to 100 MeV.

With regard to ITER neutronics, the most urgent need is to continue with the improvement of data evaluations required for the neutronics analyses of the Test Blanket Modules (TBM) such as Li, Be, Pb and O. A major challenge in this field is to provide the covariance data required for assessing the uncertainties of the nuclear responses in the TBM. This requires revisiting older evaluations without any uncertainty information in the data files. Covariance data can be obtained either from analyses of experimental data or, in cases where the experimental data are limited, by means of simulation calculations following new theoretical approaches.

P. RULLHUSEN

Nuclear data for fusion applications - an experimentalist's view

Developments and design studies for large facilities such as ITER, IFMIF and DEMO require careful revision of the present nuclear database. Data for a range of nuclear reactions are needed, e.g. for reactions used for diagnostic purposes, shielding calculations and for assessing the radiation damage in structural materials. Examples were presented on recent measurements carried out at the HADES underground laboratory operated by IRMM for diagnostics at the JET facility. Also, recent cross-section measurements on several W isotopes were presented: total absorption, capture, and charged-particle production (via the activation technique). Concerning the availability of experimental facilities, there are only a few places where measurements at neutron energies above 20 MeV can be performed, as needed for IFMIF. In addition, the database for charged-particle induced reactions (d, t, ^{3}He, α) is less complete than the database for neutron-induced reactions.

Rullhusen noted that any data needs for fusion applications should be put in the High Priority Request List (HPRL) of the NEA.

U. FISCHER

Status of neutronics tools and data for IFMIF-EVEDA

The status of the computational tools developed for IFMIF neutronics analyses and the available nuclear data were presented with respect to the EVEDA phase to be conducted 2007-2012 within the Broader Approach agreement of the EU and Japan.

The McDeLicious Monte Carlo code has been developed to simulate the neutron generation on the basis of evaluated d + ^{6,7}Li cross-sections. A complete new evaluation of the d + ^{6,7}Li interaction cross-sections up to 50-MeV deuteron energy has been performed, applying a new methodology which takes into account compound nucleus reactions, pre-equilibrium processes, stripping and other direct reactions. A series of benchmark calculations were conducted to test the data against experimental neutron yields of thick lithium targets. The comparison showed that McDeLicious with the updated d-Li cross-section data is able to reproduce the experimental results over the entire deuteron energy range from threshold up to 40 MeV.

With regard to the general purpose neutron cross-section data, a variety of 150-MeV data evaluations are available from various sources including LANL and NRG. Most of these evaluations are contained in the general purpose data libraries of ENDF/B-VI, -VII and JEFF-3.1, respectively. New 150-MeV data evaluations have been prepared for $^{180,182\text{-}184,186}$W, ^{181}Ta and ^{55}Mn for the EFF project. However, the most comprehensive data library for high energy applications has been produced by JAEA. The JENDL High Energy data file extends up to 3 GeV and comprises both neutron- and proton-induced cross-section data. The first JENDL-HE release of 2004 comprised 66 nuclides. In the meantime, another set of 37 nuclides has been evaluated, and is expected to be released in 2007. In addition, JAEA has generated a special PKA/Kerma data file JENDL/PK with PKA spectra for 29 elements with 78 isotopes for radiation damage calculations.

With regard to activation data, a major evaluation effort has been conducted on the production of a qualified activation data library for fusion inventory calculations in EU fusion technology programme. This has led to various versions of the European Activation File (EAF), with the current version (EAF-2007) having an extended energy range up to 60 MeV. The EAF-2007 activation file satisfies the needs for activation calculations of the IFMIF neutron source and contains cross-section data for 65,565 neutron-induced reactions on 816 targets. EAF-2007 includes also deuteron- and proton-induced activation data libraries. These libraries are mainly based on model calculations with the TALYS code using global parameters. They were produced to enable activation calculations for the IFMIF accelerator components caused by beam losses.

A dedicated Intermediate Energy Activation File (IEAF-2001), was previously developed for neutron-induced activation cross-sections up to 150 MeV. An update of this data file is underway at FZK (Forschungszentrum Karlsruhe). A complementary data file for proton-induced reactions (Proton Activation Data File (PADF)) has already been produced, and is available from the IAEA/NDS website.

Discussion

(*All*) There is a wide range of quality in the uncertainty data of the current libraries. The low fidelity covariance set prepared by NNDC extending to 20 MeV would be useful here. The tools for using the existing covariances are available but according to Mengoni this approach would involve a complete evaluation. Smith noted that while it is strictly not possible to add the covariance data to FENDL, this might be a useful first step. The long-term goal would include new evaluations, but in the mean time a shadow library calculated purely by model codes and containing covariance data would be useful. It was acknowledged that the data of 180 deg backscattering of deuterons are poor.

U. FISCHER

ITER computational shield benchmark

The FENDL-2.1 nuclear data library for fusion applications has been tested on the basis of a computational ITER shielding benchmark in one-dimensional geometry. The benchmark calculations have been performed with the MCNP Monte Carlo code, version 5, using the FENDL-2.1/MC data processed by the Nuclear Data Section (IAEA/NDS) in the ACE format. Comparison calculations were performed for FENDL-2.0 and 1.0 /MC data. The considered nuclear responses include the neutron and gamma fluxes, the nuclear heating, and the helium and hydrogen gas productions.

No significant differences were observed when comparing FENDL-2.1 and 2.0 based Monte Carlo calculations for the neutron fluxes except for the region of the TF coil where FENDL-2.1 results are higher by 10 – 12 %. These differences are attributed to the error propagation associated with the neutron radiation transport through the thick bulk shield. A similar trend was observed for the photon flux and the nuclear heating. Thus, no significant effects are expected for these responses in ITER design calculations when switching from FENDL-2.0 to FENDL-2.1.

Significant discrepancies have been found for the helium and hydrogen gas production data. These were attributed to non-reliable FENDL-2.0 gas production data. FENDL-2.1 provides a significant improvement over FENDL-2.0. However, the FENDL-2.1 data need to be checked against experimental data.

P. BATISTONI

FENDL-2.1 benchmark analysis - validation of FENDL-2.1 and JEFF-3.1 libraries for fusion technology (presented by U. Fischer)

A variety of integral 14-MeV neutron benchmark experiments, suitable for checking fusion relevant neutron transport calculations, are available and have been used for benchmarking the FENDL-2.1 general purpose data. In such experiments, material assemblies are irradiated with 14-MeV neutrons, and nuclear responses of interest are measured and compared to calculations which simulate the experiment by modelling the experimental set-up as close as possible. The following benchmark experiments, performed in the European Fusion Technology Programme at the Frascati Neutron Generator (FNG), were considered for benchmark analyses of the FENDL-2.1 data library:

- ITER bulk shield experiment with measurements of neutron/photon flux spectra by the experimental team of the Technical University of Dresden (TUD).
- ITER streaming experiment with measurements of neutron/photon flux spectra by the experimental TUD team.
- W bulk shield experiment with measurement of neutron/ photon flux spectra by the experimental TUD team.
- HCPB (Helium Cooled Pebble Bed) breeder mock-up experiment with measurements of the tritium generated in Li_2CO_3 pellets and the neutron/photon flux spectra in the back of the assembly.

All of these benchmark experiments had been previously analysed with FENDL-1.0/2.0, EFF-3.0/JEFF-3.1 and other data evaluations, and were now re-analysed with FENDL-2.1 data. The results can be summarized as follows:

- **ITER bulk shield and streaming experiments:** No significant differences were obtained for the calculated neutron and photon flux spectra when comparing FENDL-2.0/2.1 and JEFF-3.1 data.
- **Tungsten benchmark experiment:** FENDL-2.1, coming from ENDF-B/VI-8, performs better than FENDL-2.0 (origin: JENDL-FF) and JEFF-3.1 (origin: JENDL-3.3), in particular the neutron flux spectrum distribution across the assembly is reproduced significantly better.
- **HCPB breeder blanket mock-up experiment:** Again no significant differences were found between FENDL-2.0/2.1 and JEFF-3.1 based calculations. However, that the tritium generated in the Li_2CO_3 pellets is underestimated for all calculations by 5 to 10% on average.

Discussion
R. Forrest asked why the variation in C/E was the same for all the libraries tested, and whether it reflects inadequacies with the IRDF library used for the activation data. This effect has not been seen in tungsten, so it may be due to the layers of iron and polyethylene. ^{6}Li abundance has not been measured. Kopecky noticed that the experimental error estimates were not included on the graphs.

R. HAIGHT

Nuclear data research at LANSCE with possible relevance to IFMIF

The Los Alamos Neutron Science Center (LANSCE) offers intense, pulsed sources of neutrons, continuous in energy, for nuclear data measurements from thermal to over 100 MeV, i.e. over the full energy range relevant for IFMIF. Instruments available for measurements include the Germanium Array for Neutron-Induced Excitations (GEANIE), the Fast-Neutron-Induced Gamma-ray and Neutron Observer (FIGARO), the Detector for Advanced Neutron Capture Experiments (DANCE), an array for detecting charged particles (NZ) and several instruments for studying fission. Each instrument is located at a station 8 to 22 meters from the pulsed neutron source. The energy of the incident neutron inducing a reaction is deduced from the time of flight of the neutrons from the source. The facilities of most relevance to IFMIF are GEANIE, FIGARO and NZ, which are briefly described below:

GEANIE is an array of 26 high-resolution gamma-ray detectors that measure prompt gamma-rays in the residual nuclei produced in neutron-induced reactions. The yield of specific gamma-rays as a function of neutron energy can be related to the channel reaction cross section in one of two ways. The most direct procedure is to measure the cross sections for all (or nearly all) of the gamma rays for transitions that go to the ground state of the residual nucleus and then sum these contributions. The other approach is to measure as many of the individual gamma-ray transitions as possible and then use these results to normalize nuclear model calculations. Both of these approaches are also valid for excitation functions for producing isomers. Cross sections determined this way could be very useful data for activation cross sections as a function of incident energy. In many cases there are no experimental data on these activation cross sections for neutron energies above 20 or 25 MeV because of the lack of purely mono-energetic neutron sources in this energy range. An example of a dosimetry reaction sensitive to neutrons of a few MeV was given. Although the this particular reaction is important for these relatively low energy neutrons, the cross section needs to be known at higher energies as well as for applications such as IFMIF, where there are abundant higher energy neutrons.

FIGARO is an array of 20 liquid scintillator neutron detectors and two or three gamma-ray detectors centred 22 meters from the fast neutron source. The gamma-ray signal serves both as the stop signal for the neutron time of flight from the source and the start signal for neutron emission from the reaction. The energy of the emitted neutrons is determined from time of flight to the neutron detectors located approximately 1 meter from the sample. An example of neutron emission from nickel was shown as a function of incident neutron energy.

"**NZ**" is an array of charged-particle detectors used for measuring protons, deuterons, tritons, ^{3}He and alpha particles from neutron-induced reactions. By integrating these results over emission angle and energy, the hydrogen and helium production cross-sections can be obtained. At present, a measurement programme is underway to support the Global Nuclear Energy Partnership (GNEP) programme in the USA. Results for chromium, iron, molybdenum and tantalum were presented.

Another issue of importance to radiation damage is the damage energy as described in the file MT=444, in the ENDF system. This file is not specifically part of the evaluated data files but rather is a file derived from the basic data by the NJOY code. Several questions were raised:

- What is the quality of MT=444 data?
- Have the MT=444 data derived from different basic data files (ENDF, FENDL, JENDL, EFF, BROND, etc.) been compared? How different are these data, and what is the neutron-energy dependence of the differences?
- Are there any benchmark tests of the MT=444 data? As there are few imaginable absolute benchmark tests, experiments at different energies could give "relative benchmark data". For example, if irradiations with fission neutrons and with 14-MeV neutrons are carried out to the same values of displacements per atom, "dpa", *as calculated with MT=444 data*, are responses of the materials the same?

Discussion

J. Kopecky asked if specific requests for measurements would be necessary for implementing an experimental plan - R. Haight answered positively. There is also a possibility to measure total cross-sections.

3. DISCUSSIONS AND RECOMMENDATIONS

Discussions

A discussion document "A proposed approach for a CRP to produce a FENDL upgrade library" has been prepared by D. Smith. He spent some time explaining the main points of the document. D. Smith noted that it might be necessary to do some work in processing the "shadow" library; to which M. Williams at ORNL may be able to contribute. It was noted that a theorist might need to be included in the CRP, especially for the low mass targets. D. Smith asked about correlations between the various reactions since they all use the same model parameters. D. Smith asked who in Japan is calculating deuteron-induced reactions – they are mainly nuclear physicists linked to experimental groups.

The organisation of IAEA CRPs on nuclear data was outlined by A. Mengoni. Approximately ten participants are expected to become involved whose attendance at meetings is supported. In addition, it is usually possible to place up to three or four research contracts with funding of about 4 kEUR each. These research contracts are usually placed with groups from developing countries to perform a specific agreed task (*e.g.* data processing, or a specific measurement, etc.).

The work scope of a possible CRP was discussed and a need for a general purpose file for deuteron interactions suitable for transport calculations (except for lithium) was underlined. A deuteron activation library is also required. Sugimoto said that MCNPX calculations in Japan could be undertaken to work out where in the beam line prior to the target the neutrons are produced. This means neutron production from various deuteron-material interactions is needed. Mengoni asked what library is used for this –just the built-in data of the MCNPX code.

After discussion, the main scope of the CRP was outlined. The basic objectives would include, for the neutron general purpose library, extension of the energy above 20 MeV. Deuteron general purpose data are only required for Li in full detail, and the rest need double differential cross-sections. Neutron- and deuteron-induced data libraries including uncertainties are required for activation of neutrons and possibly deuterons. Kopecky said that in his experience it was difficult to start completely new work in a CRP, but this might be possible if research contracts were used.

Proposal

The general layout of the CRP proposal would be based on the descriptions and highlights described below.

While the FENDL-2.1 library can be considered sufficient for ITER calculations, advanced systems such as IFMIF require data above 20 MeV. IFMIF will require data at least up to 60 MeV. However, if data at higher energies were available, the upper limit should be extended above 60 MeV, possibly up to 150 MeV. In particular, it has been stressed that the data above 20 MeV could be used to help improve model parameterizations above this energy limit.

Production of FENDL-3 general purpose neutron library:

- Look at FENDL-2.1 and where the data source has been superseded by an update from the same source then replace
- Develop software to enable all sections of ENDF file to be merged from two libraries around 20 MeV
- Produce a complete file above 20 MeV using the merging software
- Develop tools for producing covariance data in ENDF format
- Produce a “shadow” library based completely on model calculations containing relative covariances; extract the covariance data and add to FENDL-3.
- Run through checking code

Production of FENDL-3 general purpose proton library:

- Select from existing evaluations for energies up to 150 MeV and assemble
- Run through checking code

Production of FENDL-3 general purpose deuteron library:

- Produce a library up to 150 MeV containing covariances, based completely on model calculations but guided by experimental data,
- Run through checking code

Experimental activities:

- Survey and assess the experimental database critically for deuteron-induced reactions
- Suggest measurements to address deficiencies – such requests could be included in the NEA HPRL

For all libraries:

- Initial testing with NJOY to ensure they can be processed, but no production of application libraries

Production of FENDL-3 activation neutron library:

- Use of existing EAF library *e.g.* EAF-2007
- Develop a methodology for conversion of high energy EAF library to ENDF
- Produce the ENDF library
- Produce a FENDL-3 uncertainty library in correct format using existing EAF uncertainty data

Production of FENDL-3 activation proton library:

- Use existing EAF library e.g. EAF-2007 with conversion tool to produce ENDF library in correct format

Production of FENDL-3 activation deuteron library:

- Use existing EAF library e.g. EAF-2007 with conversion tool to produce ENDF library in correct format
-

These ideas are summarised in tabular form below.

FENDL General Purpose file:

	Available	To do
n-induced	Evaluations up to 20 MeV	1. Update evaluations with existing new evaluations 2. Extend energy up to 150 MeV 3. Tools for generating uncertainties in ENDF format 4. Produce a calculation based library which includes covariances (‘shadow library’)
p-induced	-	Assemble existing evaluations for energies up to 150 MeV
d-induced	-	Produce a library based on model calculations guided by experimental data (for cross-sections and angular distributions), including covariances
Application libraries	Available for FENDL-2.1	Produce full application library based on the updated FENDL in future (not for CRP)

FENDL/A

	Available	To do
n-induced	Evaluations up to 20 MeV	1. Develop a methodology for converting EAF-2007 into ENDF format and produce ENDF version of EAF-2007 2. Include uncertainties in proper format
p-induced	-	Assemble existing evaluations
d-induced	-	Assemble existing evaluations

Experimental activities

	Available	To do
d-induced	EXFOR, CINDA, NSR, scientific literature	Survey and critical assessment of existing data Identify needs for new experimental measurements

Possible participants

CIAE, Chen	Evaluator, light nuclides, covariances
CEA, J-Ch Sublet	Data processing
IPPE, A Ignatyuk	Evaluator, theory
JSI, A Trkov	Evaluator, data processing
NRG, A Koning	Theory, evaluation
UKAEA, R Forrest	Evaluation
FZK, Fischer	Evaluation, data processing
JAEA, T Fukahori	Evaluation, data processing
JAEA, IFMIF/PT M Sugimoto	Evaluation
Kyushu Univ, Y Watanabe	Theory, evaluation
JUKO, J Kopecky	Evaluation
IFN, M Avrigeanu	Theory, evaluation
ENEA, P Batistoni	Data processing, benchmarking
CEA/Spiral2, S Hilaire	Theory, evaluation, covariances
Vienna, H Vonach/ S Targesen	Theory, evaluation, covariances
ANL, D Smith	Evaluation, covariances
ORNL, M Williams	Evaluations (resonance region)
LANL T Kawano	Theory, evaluation
LLNL, J Escher	Theory
NNDC, M Pigni/ M Herman	Theory, covariances
ATOMKI, F Tarkanyi	Experiment
PTB, R Nolte	Experiment
Tohoku /JAEA/RCNP, *Varii*	Experiment
Rez, P Bem	Experiment

Recommendations

TM work was concluded by formulating the following recommendations:

1. The participants converged on the idea of requesting an upgrade of the FENDL library in several areas, motivated by the fact that the present status of the library is not adequate for current or advanced fusion applications. The new FENDL library should contain extensions to cover:
   a) wider energy range for the neutron-induced library (above the present limit of 20 MeV);
   b) inclusion of charged-particle induced reactions, in particular proton- and deuteron-induced reactions for IFMIF;
   c) inclusion of covariances;
   d) update and extension of the activation library in the same fashion as for the General Purpose library.

2. The extensions mentioned above should not invalidate past extensive work in constructing FENDL-2.1. A complete re-evaluation for all targets is not feasible, and it will be necessary to extend the current library in a pragmatic fashion.

3. A by-product of the production of covariances will be the generation of a library based on nuclear model calculations (”shadow” library) which can be used for sensitivity studies.

4. Although the main focus of the proposed CRP will be to generate a new evaluated library, we recognize that several technical tasks will need to be addressed:
   a) critical assessment of relevant existing experimental data,
   b) examination of how existing nuclear modelling and processing codes can be effectively applied to generate and process improved libraries

5. It will not be within the scope of the CRP to generate application libraries. To obtain full benefit from the updated libraries, it is required that the user community (e.g. ITER and IFMIF) supports the timely generation of application libraries following completion of the CRP.

6. It is recommended that the CRP activities commence as soon as possible so that the upgraded libraries will be ready for the IFMIF design activities now in progress.

4. CLOSE

The chairman thanked the Committee for their work during the meeting and thanked the IAEA for organising and hosting the meeting. The chairman closed the meeting.

APPENDIX A

Technical Meeting on

Nuclear Data Library for Advanced Systems – Fusion Devices

IAEA Headquarters, Vienna, Austria

31 Oct – 2 Nov 2007

Meeting Room A2313

AGENDA

<u>Wednesday, 31 October</u>

08:30 - 09:30	**Registration** (IAEA Registration desk, Gate 1)
09:30 - 10:30	**Opening Session**
	Welcome and introduction
11:00 – 11:30	**Administrative and Financial Matters related to participants**
	Coffee break
13:00- 14:00	**Lunch**
14:00 - 17:30	**Presentations**
	(Coffee break as appropriate)

<u>Thursday, 1 November</u>

09:30 – 12:30	**Presentations (cont.)**
	(Coffee break as appropriate)
12:30 – 14:00	**Lunch**
14:00 – 17:30	**Discussion**
	Start draft report of the Meeting
	(Coffee break as appropriate)
19:00 – 23:00	**Dinner at Restaurant**

<u>Friday, 2 November</u>

09:30 – 12:30	**Discussion (cont.)**
	Draft report of the Meeting
	(Coffee break as appropriate)
12:30 – 14:00	**Lunch**
14:00 – 17:30	**Finalize report**
	Close
	(Coffee break as appropriate)

APPENDIX B

Technical Meeting on
Nuclear Data Library for Advanced Systems – Fusion Devices
IAEA Headquarters, Vienna, Austria
31 Oct – 2 Nov 2007

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