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IAEA Consultants' Meeting on

SELECTION OF BASIC EVALUATIONS FOR THE FENDL-2 LIBRARY

Karlsruhe, Germany 24 - 28 June 1996

hosted by the Forschungszentrum Karlsruhe, Germany

SUMMARY REPORT

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September 1996

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

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> Prepared by A.B. Pashchenko IAEA Nuclear Data Section Vienna, Austria

Abstract

FENDL-1 is the international reference nuclear data library for fusion design applications, available from the IAEA Nuclear Data Section. FENDL/E is the sublibrary for evaluated neutron reaction data. An updated version, FENDL-2, is being developed.

The present report contains the Summary of the IAEA Consultants' Meeting on "Selection of Basic Evaluations for the FENDL-2 Library", held at Karlsruhe, Germany, from 24 to 28 June 1996. This meeting was organized by the IAEA Nuclear Data Section (NDS) with the co-operation and assistance of local organizers of the Forschungszentrum Karlsruhe, Germany.

Summarised are the conclusions and recommendations for the selection of basic evaluations from candidates submitted by five national projects (JENDL-FF, BROND, EFF, ENDF/B-VI and CENDL) for FENDL/E-2.0 international reference data library.

September 1996



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Summary of the Meeting

FENDL-1 is the international reference nuclear data library for fusion design applications, available from the IAEA Nuclear Data Section. FENDL/E is the sublibrary for evaluated neutron reaction data. An updated version, FENDL-2, is being developed.

A Subgroup of the FENDL/E-2.0 selection committee, including several advisors, met in Karlsruhe, Germany, from 24 to 28 June 1996 in order to make recommendations for the selection of basic evaluations for the FENDL/E-2.0 library. The resulting conclusions and recommendations are given in <u>Attachment 1</u>. The meeting was attended by representatives of four evaluation projects: EU, Japan, Russia and the USA. The list of attendees with their affiliations is given in <u>Attachment 2</u>. U. Fischer of the Forschungszentrum Karlsruhe acted as Chairman of the meeting.

The committee followed the procedure agreed upon in Del Mar (see report INDC(NDS)-352, March 1996) which included the selection of candidate evaluations, organization of the schedule for submittal of evaluations and associated documentation, and the scheduling of data testing.

Five national projects, i.e. JENDL-FF (Japan), BROND (Russia), EFF (European Union), ENDF/B-VI (USA) and CENDL (China) submitted candidate evaluations and processed MCNP and multigroup working libraries supplemented by evaluation review kits and justifications outlining improvements over FENDL/E-1.0.

The committee judged each material on the selection list (see INDC(NDS)-352, page 51) through careful discussion. At the beginning, the submitters' representative made a brief presentation on the advantages of their new evaluation. The presentation was followed by discussion of the proposal led by the discussion leader. The responsibility of discussion leader was shared between all four representatives of the evaluation projects. The discussion leader was responsible for the development of a consensus during the discussion on the originally assigned materials and the preparation of conclusions and recommendations for each material. For more details see the meeting Agenda (Attachment 3).

The candidate evaluations were considered first with respect to microscopic data, using evaluation review kits distributed for most of the candidates before the meeting. In addition, the benchmark testing results reported by U. Fischer, FZK and Y. Oyama, JAERI, were considered in arriving at final recommendations.

The presence of the following information with assigned priorities was used in microscopic analysis as criteria for the selection of evaluations:

Priority	Selection Criteria
1	Isotopic vs Elemental Evaluations
1	Transport Cross Sections
1	Neutron Production
1	Gamma Production
1	Charged Particle Production
1	Resonance Region (A \leq 60)
3	Thermal Region
2	Covariance Information
3	Activation
1	Processibility
2	Documentation

The brief summary reviews as discussed and agreed at the meeting are given below in <u>Attachment 1</u>. Summaries were prepared by discussion leaders and present results of microscopic analyses and benchmark testing results as well as reasons for selection of evaluations. The recommendations from this meeting are summarized in the Table of <u>Attachment 1</u>.

Most of the selected evaluations were submitted from the JENDL-FF file (in some cases minor points should be checked by JENDL-FF evaluations for final selection), two evaluations were taken from BROND-2 (modified), the evaluations from EFF-3 were taken for ⁵⁶Fe and ²⁷Al (with some conditions) and ENDF/B-VI evaluations were recommended for isotopes of silicon.

The final approval of the full FENDL-2 library including final adoption of basic evaluations for FENDL/E-2.0 will be done at the closeout meeting at the IAEA/NDS in Vienna which is tentatively scheduled to be held in March 1997.

Attachment 1

IAEA Consultants' Meeting

on

"Selection of Basic Evaluations for the FENDL-2 Library"

Forschungszentrum Karlsruhe, Germany 24 - 28 June 1996

Conclusions and Recommendations

I. Summary by H.K. Vonach

Review of the evaluations of ^{28,29,30}Si submitted for FENDL-2

Candidate Evaluation: ENDF/B-VI, JENDL-FF FENDL-1: BROND-2 for natural silicon; not available for isotopes

Evaluations for the isotopes of Si for FENDL-2.0 were submitted by JENDL-FF and by ENDF/B projects. The ENDF/B evaluations, however, were first presented at the meeting and no MCNP library of these evaluations exists at present and therefore also no data testing could be performed on them before the meeting. In spite of this, the committee unanimously decided to consider these evaluations for the following reasons:

- 1) The evaluations are based on a new, accurate, high-resolution total cross section measurement, not available to all previous evaluations;
- 2) The late submission of the evaluations is caused by special circumstances outside of the influence of the evaluators. The committee appreciates the special effort of D. Larson and his colleagues to complete the evaluation before the meeting.

Detailed review of the submitted evaluations and the present FENDL-1 data showed that from the point of microscopic data the new ENDF/B evaluations seem the best choice for the following reasons:

- 1) They provide much improved total and elastic cross sections in the resonance range $(E_n < 1.75 \text{ MeV})$ due to the inclusion of the new high resolution total cross sections, σ_{tot} , measurements at ORNL and in addition better total cross sections in the whole range up to 20 MeV because of these new data;
- 2) They are more complete than any of the other evaluations. In addition to providing double-differential emission cross sections for all emitted particles and recoils, they provide covariance data for all cross sections in file 3 and used the existing discrete level information also in the (n,p) and (n,d) channels;

3) The evaluations are in excellent agreement with the existing γ -production data.

Comparison of the new evaluation from the JENDL-FF fusion file with FENDL-1 also showed that the JENDL-FF evaluations are much superior to FENDL-1 as they contain charged particle spectra not present in FENDL-1 and also provided a considerably better description of the double differential neutron emission cross sections at $E_n = 14$ MeV.

Comparison with the existing integral data also indicate a clear improvement by the use of JENDL-FF evaluations compared to FENDL-1. In this situation the following course of action is recommended.

- The new ENDF/B-VI evaluations will be subject to data testing before the next and final FENDL meeting. For this purpose the evaluation will be processed by J. White, RSIC, who will provide a MCNP library to the IAEA by 1 October 1996. This library will be used by U. Fischer and Y. Oyama for comparison with the existing integral data before the next FENDL meeting.
- 2) The committee recommends that the new ENDF/B-VI evaluations should be selected for FENDL-2, if the comparison with the integral experiments has given satisfactory results (that is at least comparable to the JENDL-FF results) otherwise the evaluations from the JENDL-FF fusion file should be selected for FENDL-2.

FENDL-2 - Selection for Oxygen

Candidate Evaluation: JENDL-FF **FENDL-1**: ENDF/B-VI

The ¹⁶O evaluation for oxygen from JENDL-FF has been submitted as candidate for FENDL-2; in addition there was also a late submission of a ¹⁶O evaluation from CENDL, however without any information on its performance in comparison with integral experiments. Therefore the committee unanimously decided not to consider this evaluation unless very serious deficiencies were detected in the other oxygen evaluation (which turned out not to be the case).

Detailed comparison of the new JENDL-FF evaluation with FENDL-1 showed that the JENDL-FF new evaluation provides some important improvements compared to FENDL-1:

- 1) JENDL-FF gives a better fit to the existing double-differential neutron emission cross sections at $E_n = 14$ MeV. This is probably due to the fact that the neutron spectrum from the $(n,\alpha n)$ reaction is not adequately described in FENDL-1, but somewhat artificially represented by enhancements of the inelastic cross sections leading to subsequent α -emission.
- 2) The capture cross-section is very much improved by adjusting to the new $\sigma_{n\gamma}$ data of Igashira in the energy range 10 100 keV.
- 3) The lower (n,α) cross-section of JENDL-FF at $E_n = 14$ MeV compared to FENDL-1 is also supported by new measurements of $(n,\alpha\gamma)$ cross sections performed within the IAEA CRP on photon production cross sections (S. Hlavać et al, 1994).

4) The total photon production cross section (especially at the highest energies) in FENDL-1 seem to be too small; probably also in this respect JENDL-FF gives a better description.

For these reasons the committee recommends to choose the JENDL-FF evaluation of oxygen for FENDL-2. This recommendation is also supported by the data testing results reported at the meeting.

It is further recommended that two minor points should be checked by the JENDL-FF evaluation:

- 1) As a number of the discrete levels of ¹⁶O, which can be excited by inelastic scattering, decay by subsequent α -emission, the corresponding part of the (n,n α) cross section may be contained already in MT 51 91 sections and only the (n, α n) should then be described in MT 22 section. This situation should be checked in order to avoid any double counting.
- 2) There are a number of rather accurate measurements of the total nonelastic cross section, σ_{non} , around 14 MeV; therefore the evaluation should be checked concerning the agreement with these data.

FENDL-2 Selection for Carbon

Candidate Evaluation: JENDL-FF **FENDL-1**: ENDF/B-VI

The JENDL Fusion File evaluation for ¹²C submitted for FENDL-2 was compared in detail with the FENDL-1 evaluation. From this it was concluded that both evaluations have their specific strengths and weaknesses.

The ENDF/B-VI evaluation took special care to describe the low energy region (below the first excited level of ¹²C at 4.42 MeV) as the elastic scattering cross section of carbon in the low energy range is an important cross section standard. Therefore in this energy range the FENDL-1 evaluation is probably more accurate than the JENDL-FF evaluation. On the other hand the JENDL-FF evaluation gives a considerably better description of the cross sections for higher neutron energies especially at 14 MeV. The double-differential neutron emission cross section at 14 MeV is much improved in JENDL-FF compared to FENDL-1 especially in the low energy range by a better description of the neutron spectrum from the important (n,n'3 α) reaction.

The committee therefore concluded that the best solution would be to merge the two files keeping the low energy part from FENDL-1 and combine it with the high-energy part of JENDL-FF. In addition it was recommended that the existing data on the nonelastic cross section especially at 14 MeV should be used to check the evaluation.

S. Chiba agreed to perform this task. After modification of JENDL-FF data, to be completed by 1 October 1996, the data testing will be repeated.

FENDL-2 Selection of Nitrogen

Candidate Evaluation: JENDL-FF **FENDL-1**: BROND-2 (ENDF/B-VI)^{*})

The JENDL-Fusion File for ¹⁴N submitted for FENDL-2 was compared in detail with the FENDL-1 evaluation (ENDF/B-VI). The main results of this comparison are the following:

- The JENDL-FF file gives a better description of the double-differential neutron-emission spectrum at 14 MeV, whereas the neutron-emission cross sections are seriously underestimated in FENDL-1 at all emission angles. This is also reflected in the better performance of the JENDL-FF in the data testing.
- 2) The (n,γ) , (n,p) and (n,α) cross sections, however, are better described in FENDL-1. The structure present in the capture cross section in the energy range 0.4 10 MeV is neglected in JENDL-FF. The (n,p) and (n,α) cross sections of FENDL-1, especially at 14 MeV, are in much better agreement with the existing experimental data (see for example H. Felber et al., Z. Phys. A276, 75 (1976) and M. Mörike et al., Z. Phys. A287, 211 (1978)).

For these reasons it is recommended that the JENDL-FF file be modified by changing for the (n,p), (n,α) and (n,γ) cross sections to the FENDL-1 description. It was recognized that the practical consequences of the deficiencies of the present (n,γ) cross sections in JENDL-FF are probably small and the inclusion of the structure into this cross section may not be absolutely necessary. In addition it is recommended that the agreement of the modified evaluation with the existing data on the total nonelastic cross section should be checked.

S. Chiba agreed to perform this task by 1 October 1996, which is gratefully acknowledged by the committee. After modification of the JENDL-FF evaluation, the data testing will be repeated. It is recommended that the revised JENDL-FF file - after data testing - be adopted as FENDL-2 at the final FENDL meeting.

^{*) &}lt;sup>14</sup>N from BROND-2 was adopted for the FENDL/E-1.0 library. However, BROND-2 evaluation does not allow for processing into ACE format. Therefore, the ENDF/B-VI version of the basic evaluation and processed ENDF/B-VI files are available in FENDL-1.

II. Summary by S. Chiba

Review summary of Deuterium Data

Candidate Evaluation: BROND-2 (modified), CENDL-2 **FENDL-1**: BROND-2 (ENDF/B-VI)^{*)}

- 1) There are two candidates, one from BROND-2 (modified) and the other from CENDL-2. The FENDL/E-1 came from BROND-2.
- 2) The CENDL-2 data could not show any remarkable improvements compared with FENDL/E-1. Therefore it was decided not to consider CENDL-2 further.
- 3) The NJOY/MCNP processing difficulties caused by discrete lines for direct interactions in the BROND-2 (n,2n) evaluation still persist, so a simple, phase-space approximation was substituted in BROND-2 for the Faddeev theory treatment.
- 4) However, this modified (phase-space) BROND-2 evaluation did not show any improvements when compared with the ENDF/B-VI evaluation processed by MacFarlane for FENDL-1 data testing.
- 5) Therefore, the JENDL-FF project was asked to see whether they could supply a laboratory system distribution based on the Faddeev theory. If this is not possible, then the simple phase approximation as submitted should be adopted. It has been agreed that JAERI will supply File-6 formatted data to Obninsk by 1 September 1996.
- 6) There is a fluctuation in the (n,γ) reaction cross section as observed in the review kit. This should be smoothed out.
- 7) The unphysical peaks in the Legendre coefficients as shown on page 14 of the review kit should be modified.
- 8) After all these modifications the new evaluation and MCNP library should be submitted to NDS by 1 November 1996.

^{*) &}lt;sup>2</sup>H from BROND-2 has not been included in FENDL/E-1.0 because the discrete lines for direct interactions in the (n,2n) reactions doesn't allow for processing into ACE format. Therefore the ENDF/B-VI version has been processed by R.E. MacFarlane (see p. 25 of INDC(NDS)-312 and remarks in IAEA-NDS-169). However, FENDL/MG-1.1 contains the BROND-2.0 version processed into GENDF and MATXS format.

Review summary of ⁵⁶Fe data in EFF-3

Candidate Evaluation: EFF-3 **FENDL-1**: ENDF/B-VI

- 1) Significant improvements have been found compared with FENDL/E-1 in the following items:
 - a) the ultra-high resolution data measured by Weigmann were taken into consideration in the unresolved region;
 - b) new (n, α) and $(n, x\alpha)$ data were considered;
 - c) new elastic and inelastic angular distribution data measured at PTB in 8-14 MeV range were considered; and
 - d) simultaneous update of the EFF-2 data as a prior has been carried out on the basis of the Bayesian approach. This procedure has yielded the covariance information not only in a single reaction but also between different type of reactions. It also resulted in a much reduced uncertainty compared with FENDL/E-1.
- 2) Through preliminary benchmark tests, it was found that the nonelastic cross section data in the MCNP library is about 10% lower than the data given in the basic evaluation. It turned out that the reactions given in MT=103 and 107 were ignored when the MCNP library was generated. This will account for the problems found in the benchmark test.
- 3) Therefore, it was agreed that the European party will re-process the data and send the properly processed MCNP library to NDS for further distribution by 1 October 1996.
- 4) At the same time, the European party should investigate a possibility to reduce the number of cross section data points to a more reasonable amount without loosing accuracy of information. The re-submission, as described in item 3, should be done after the consideration of this problem.
- 5) We recommend that the EFF-3 data be adopted for FENDL/E-2 because it is definitely superior to FENDL/E-1 from microscopic point of view provided that the properly processed library is available by 1 October 1996 and it is verified by the benchmark tests that the EFF-3 data is at least as good as those given in FENDL/E-1.

III. Summary by C.L. Dunford

Tungsten

Candidate Evaluation: JENDL-FF **FENDL-1**: ENDF/B-VI

The natural tungsten evaluation submitted by the JENDL project was constructed from separate evaluations of the tungsten isotopes of natural tungsten. The evaluation contains all required data in ENDF-6 format. In particular, the evaluation contains secondary γ , proton, deuteron and α emission and recoil spectra. The natural element evaluation including recoil spectra should be adequate for heating calculations.

The γ -spectra show significant improvement compared to FENDL-1 for hard gamma rays. Secondary neutron spectra at 14 MeV are also improved except for a limited energy range at 90 degrees.

The inelastic cross section between 600 keV and 3 MeV is considerably lower than measured data from Obninsk. Also, the evaluation does not exhibit the direct capture peak at energies above 10 MeV. Available benchmark test results for the interior of a slab show improved calculation of spectra and reaction rate indices with the JENDL-FF data.

The consultants recommend that the tungsten submitted from the JENDL Fusion file be adopted for FENDL-2 with the following conditions:

- the adequacy of the natural tungsten evaluation for heating calculations must be confirmed. Otherwise it is requested that the γ-spectra be added to the separate isotope evaluations before inclusion in the FENDL-2 library;
- 2) the capture cross section above 8 MeV be revised to include the direct capture component;
- 3) the inelastic cross section between 600 keV and 3 MeV be reviewed in the light of the Russian measurement and revised if necessary.

Niobium

Candidate Evaluation: BROND-2 (modified), JENDL-FF FENDL-1: BROND-2

The two submitted evaluations are in ENDF-6 format. Both contain γ and neutron emission spectra. Only the JENDL-FF evaluation contains proton, deuteron and α emission spectra. The BROND niobium evaluation contains covariance date for file 3.

The calculated (n,p), (n,n'p), (n,α) and $(n,n'\alpha)$ cross sections differ significantly between the candidates. The neutron emission spectra in JENDL-FF shows good agreement with measured data; no plots from BROND were supplied. The gamma spectrum from JENDL-FF are in agreement with measured data at 8 and 14 MeV but not at 11 MeV. The BROND spectra show good agreement for soft gamma rays, but no conclusion could be drawn for hard gamma rays

from the linear scale plots supplied. The total cross section from JENDL-FF appears to be too high from about 800 keV up to 2 MeV; the BROND too low below 800 keV. Also the BROND capture cross section does not have the correct shape between 5 and 15 MeV.

No definitive conclusions about the two candidate evaluations can be drawn from the data testing results. They do however indicate that the gamma production may be too low in both evaluations.

The consultants recommend that the JENDL-FF evaluation for niobium be adopted for FENDL-2 because it contains charged particle emission spectra and because of the good agreement of the neutron and γ emission spectra with measured values. This recommendation is made on the condition that

- 1) the total cross section between 800 keV and 2 MeV be re-evaluated;
- 2) the (n,α) cross section be reviewed and updated if necessary.

Molybdenum

Candidate evaluation: JENDL-FF **FENDL-1**: JENDL

The natural molybdenum evaluation submitted by the JENDL project was constructed from the separate evaluations of the molybdenum isotopes. The evaluation contains all of the required data in ENDF-6 format. In particular, the evaluation contains secondary γ , proton, deuteron, triton, helium-3 and α emission and recoil spectra. The natural element evaluation including recoil spectra should be adequate for heating calculations.

The neutron emission spectra show significant improvement in the proposed evaluation compared to FENDL-1. In addition, the inelastic and the (n,2n) cross sections better agree with measurements. Gamma spectra are generally in better agreement with measured data except for 5 to 8 MeV secondary energy range at 8 MeV. The evaluated capture cross section is higher than the experimental data above the resonance region.

The EFF evaluation for molybdenum was also reviewed and found to be roughly equivalent. Available benchmark testing results show no significant differences when using either FENDL-1 or the JENDL-FF evaluation and agree within the experimental error.

The consultants recommend that the JENDL fusion file evaluation for molybdenum be adopted for FENDL-2 with the following conditions:

- 1) The adequacy of the natural molybdenum evaluation for heating calculations must be confirmed. Otherwise it is requested that the γ -spectra be added to the separate isotope evaluations before inclusion in the FENDL-2 library.
- 2) The capture cross section above the resonance region be re-evaluated.
- 3) The charged-particle emission spectra be checked against the experimental measurements of R. Haight et al.

Tin

Candidate Evaluation: BROND-2 (modified) FENDL-1: BROND-2

The improved natural tin evaluation from the BROND library contains all of the required data in ENDF-6 format. Proton and α emission spectra are given as are cross section covariances (File 33).

The gamma production spectra looks good. The total and capture cross sections above 100 keV look better than the equivalent data in the ENDL library.

It was noted that:

- 1) the elastic cross section is not smooth above 2 MeV;
- 2) the capture cross section is discontinuous at 200 keV;
- 3) there is coarse structure in the total cross section, 200 600 keV.

No data testing benchmarks are available.

The consultants recommend that the BROND-2 evaluation for tin be adopted for FENDL-2. Separate isotope evaluations were not believed to be important or necessary. The meeting requests that:

- 1) the elastic cross section above 2 MeV be modified to be a smooth curve;
- 2) the discontinuity at 200 keV in the capture (and perhaps other) cross sections be removed;
- 3) the evaluated total cross section between 200 and 600 keV be reviewed.

Gallium

It was verified by E. Cheng that gallium may be used as a coolant in fusion reactors. No gallium candidates were submitted for consideration before the meeting. However a natural gallium evaluation is available in JENDL-3.2 (isotopes also available). This evaluation does not contain either γ -production or charged particle spectra. However the meeting felt that it was important to include a gallium evaluation in the FENDL-2 library. Therefore the consultants recommend that the natural gallium evaluation from JENDL-3.2 be adopted for inclusion in the FENDL-2 library.

IV. Summary by A. Blokhin

Beryllium

Candidate Evaluation: JENDL-FF **FENDL-1**: ENDF/B-VI

The submitted evaluation contains all of the required data in ENDF-6 format. The cross sections from JENDL-FF and FENDL-1 files are in agreement with measured data. Otherwise, the double-differential cross section for (n,xn) reaction differ significantly between FENDL-1 and candidate at the neutron energy lower than 10 MeV.

Available benchmark testing results, presented by Y.Oyama, show similar results in calculation of the slab time-of-flight and internal experiments. Based on improvement of DDX data the consultants recommend that JENDL-FF be adopted for the FENDL/E-2.0 library. It was advised also to include the available spherical shell experiments in the analysis of JENDL-FF data.

Zirconium

Candidate Evaluation: JENDL-FF **FENDL-1**: BROND-2 (isotopes)

The natural zirconium evaluation submitted by the JENDL-FF project was constructed from the separate evaluations of the zirconium isotopes. The JENDL-FF evaluation contains all of the required data in ENDF-6 format. In particular, secondary gamma, proton, deutron, triton, ³He and α -emission and recoil spectra. The natural element evaluation including recoil spectra should be adequate for heating calculations.

The available OKTAVIAN benchmark testing results for spherical shells show better agreement when the JENDL-FF data is used.

The consultants recommend that the zirconium evaluation submitted from JENDL-FF file be adopted with the following conditions:

- the adequacy of the natural zirconium evaluation for the heating calculations must be confirmed. If not confirmed, it is requested that the γ -spectra be added to the separate isotope evaluations before inclusion in the FENDL-2 library.

Vanadium

Candidate Evaluation: JENDL-FF **FENDL-1**: ENDF/B-VI

The submitted evaluation from JENDL-FF library contains all of the required data in ENDF-6 format.

The main improvements in candidate evaluation are the following:

- data for double-differential cross section for secondary emission neutrons are presented:
- data for double-differential cross section for secondary charge-particles are presented;
- data for recoil nuclei spectrum is added into file;
- there is a complete evaluation for the gamma-ray production cross section;

There are no integral benchmark experiments for vanadium material. However, the benchmark experiment for spherical shells is underway in Obninsk in the framework of the collaboration between IPPE, Obninsk, and FZK Karlsruhe. If experimental results are available in time, it is recommended that analysis be done before the close-out FENDL meeting.

The consultants recommend that the JENDL-FF evaluation be adopted for the FENDL-2 library.

Aluminium

Candidate Evaluation: JENDL-FF, EFF-3 **FENDL-1**: JENDL

The two submitted evaluations are in the ENDF-6 format and both files contain all of the required data.

The main improvements in JENDL-FF candidate evaluation are the following:

- data for double-differential cross section for secondary emission neutrons are presented;
- data for double-differential cross section for secondary charge-particles are presented;
- data for recoil nuclei spectrum is added into file;
- there is a complete evaluation for the gamma-ray production cross section.

Main improvements in EFF-3 candidate evaluation are the following:

- data for double-differential cross section for secondary emission neutrons are presented;
- data for double-differential cross section for secondary charge-particles are presented;
- there is a complete evaluation for the gamma-ray production cross section;

The benchmark testing, presented by Y.Oyama, shows improved calculations of shell-sphere experiment with JENDL-FF data in comparison with FENDL-1. A similar analysis with EFF, however, has not been done yet.

The consultants recommend that the EFF-3 file may be adopted for FENDL-2 with the following conditions:

- 1) European party to prepare the intercomparision plots (EFF-3 vs FENDL-l) to be sent to IAEA/NDS before 1 October 1996 for further distribution.
- EFF-3 data processed by NJOY for MCNP and ANISN should be sent to IAEA/NDS before 15 October 1996.

The committee recommends that the new EFF-3 evaluation be selected for FENDL-2 if the comparison with the integral experiments gives satisfactory results (that is at least comparable to the JENDL-FF results) otherwise the evaluations from the JENDL-FF fusion file should be selected for FENDL-2.

Gadolinium

Gadolinium was proposed as addition to the FENDL file after the Garching 1994 meeting. However, as it was verified by E. Cheng, there are not any proposals for using gadolinium in a fusion reactor. It was agreed to exclude gadolinium from the list of FENDL-2 materials.

				FENDL/E-2.0 Selection				
Material	Priority	FENDL-1	BROND	EFF	ENDF/B	JENDL	CENDL	1
² H	3	BROND-2/ ENDF/B-VI.1	X				X	BROND-2
°Be	1	ENDF/B-VI.0		х		X		JENDL-FF
¹² C	2	ENDF/B-VI.1				x		JENDL-FF
¹⁴ N	3	BROND-2/ ENDF/B-VI.1				x		JENDL-FF
¹⁶ O	2	ENDF/B-VI.0				X	x	JENDL-FF
²⁷ Al	2	JENDL		Х		X		EFF-3
²⁸ Si	2			X	X	X		ENDF/B-VI
²⁹ Si	2			· · · · · · · · · · · · · · · · · · ·	X	X		ENDF/B-VI
³⁰ Si	2				X	X		ENDF/B-VI
^{nat} Si	2	BROND-2				x		-
⁵¹ V	1	ENDF/B-VI.1		X		X		JENDL-FF
⁵⁶ Fe	1	ENDF/B-VI.1		X				EFF-3
Ga	3				X			JENDL-FF
^{nat} Zr	2					x		JENDL-FF
⁹³ Nb	3	BROND-2	X			X		JENDL-FF

Table: Results of Selection for FENDL/E-2.0 reached at theConsultants' Meeting in Forschungszentrum Karlsruhe, June 1996

Table (cont'd): Results of Selection for FENDL/E-2.0 reached at	i the
Consultants'	Meeting in Forschungszentrum Karlsruhe, June 19	96

		FENDL-1		FENDL/E-2.0 Selection				
Material	Priority		BROND	EFF	ENDF/B	JENDL	CENDL	
⁹² Mo	3			X		x		JENDL-FF
⁹⁴ Mo	3			x		x		JENDL-FF
⁹⁵ Mo	3			X		X		JENDL-FF
[%] Mo	3			x		х		JENDL-FF
⁹⁷ Mo	3			x		X		JENDL-FF
⁹⁸ Mo	3			x		x		JENDL-FF
¹⁰⁰ Mo	3			x		X		JENDL-FF
^{nat} Mo	3	JENDL				x		JENDL-FF
^{nat} Sn	3	BROND-2	x					BROND-2
Gd	3					Х		-
natW	1					x		JENDL-FF

Attachment 2

IAEA Consultants' Meeting on "Selection of Basic Evaluations for FENDL-2 Library" Forschungszentrum, Karlsruhe, Germany 24 - 28 June 1996

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Attachment 3

INTERNATIONAL ATOMIC ENERGY AGENCY

IAEA Consultants' Meeting on

Selection of Basic Evaluations for FENDL-2 Library

Karlsruhe, Germany 24 - 28 June 1996

In co-operation with Forschungszentrum Karlsruhe Technik und Umwelt D-76021 Karlsruhe, Germany

<u>Agenda</u>

Monday, June 24

- 08:00 Pick-up at hotels
- 08:30 Opening of the meeting
 Welcome & administrative announcements (U. Fischer)
 Welcome address by IAEA representative (A.B. Pashchenko)
 Discussion of Agenda & adoption

08:45 Session 1: Review of evaluations based on the submitted review kit data

- (i) General discussion on selection criteria Discussion leader: C.L. Dunford
- (ii) First priority materials: Be, V, Fe, W <u>Discussion leaders</u>: S. Chiba (Fe) A. Blokhin (Be, V) C. Dunford (W)

10:30 Coffee break

10:45 Session 1: Review of evaluations based on the submitted review kit data (cont'd)

 (ii) First priority materials: Be, V, Fe, W (cont'd) <u>Discussion leaders</u>: S. Chiba (Fe) A. Blokhin (Be, V) C. Dunford (W)

12:30 Lunch break

13:30 Session 1: Review of evaluations based on the submitted review kit data (cont'd) (ii) First priority materials: Be, V, Fe, W (cont'd)

- Discussion leaders: S. Chiba (Fe)
 - A. Blokhin (Be, V)
 - C. Dunford (W)

Discussion

- 15:30 Coffee break
- 15:45 Session 1: Review of evaluations based on the submitted review kit data (cont'd)
 (iii) Second priority materials: C, O, Al, Si, Zr
 <u>Discussion leaders</u>: A. Blokhin (Al, Zr)
 H. Vonach (C, O, Si)

17:30 **Departure to hotels**

Tuesday, June 25

- 08:00 Pick-up at hotels
- 08:30 Session 1: Review of evaluations based on the submitted review kit data (cont'd)
 (iii) Second priority materials: C, O, Al, Si, Zr (cont'd)
 <u>Discussion leaders</u>: A. Blokhin (Al, Zr)

H. Vonach (C, O, Si)

Discussion

10:30 Coffee break

10:45 Session 1: Review of evaluations based on the submitted review kit data (cont'd) (iii) Second priority materials: C, O, Al, Si, Zr (cont'd)

> Discussion leaders: A. Blokhin (Al, Zr) H.Vonach (C, O, Si)

Discussion

12:30 Lunch break

13:30 Session 1: Review of evaluations based on the submitted review kit data (cont'd)

 (iv) Third priority materials: D, N, Ga, Nb, Mo, Sn, Gd <u>Discussion leaders</u>: A. Blokhin (Gd) S. Chiba (D, Ga) Ch. Dunford (Nb, Mo, Sn) H. Vonach (N)

15:30 Coffee break

15:45 Session 1: Review of evaluations based on the submitted review kit data (cont'd)

(iv) Third priority materials: D, N, Ga, Nb, Mo, Sn, Gd

Discussion leaders: A. Blokhin (Gd) S. Chiba (D, Ga) Ch. Dunford (Nb, Mo, Sn) H. Vonach (N)

17:30 **Departure to hotels**

- 26 -

Wednesday, June 26

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08:00	Pick-up at hotels
08:30	Session 2: Data testing results (i) JAERI-results - Y. Oyama
10:30	Coffee break
10:45	(i) JAERI-results - Y. Oyama (cont'd) Discussion
12:30	Lunch break
13:30	 (ii) EU-results FZK - U. Fischer, Y. Wu Analyses for Fe benchmarks (EFF-2, -3, JENDL-FF, FENDL data) IPPE spherical shells (n-spectra) TUD slab transmission experiment (n- + gamma-spectra) FNS iron slab experiment - TOF angular n-spectra FNS iron slab experiment - in-system n-spectra + reaction rates
15:30	Coffee break
15:45	 (ii) EU-results (cont'd) FZK - U. Fischer, Y. Wu Spherical shell experiments on: Be (KANT, Oktavian, IPPE-experiments) Al (Oktavian, IPPE), Si (Oktavian), Mo (Oktavian) Some results on FNS Be-slab (TOF-experiment) Discussion
17:30	Departure to hotels
20:00	Dinner at Gastdozentenhaus
Thursda	y, June 27
 08:00	Pick-up at hotels

- 08:30 Session 2: Data testing results (cont'd)
 - (ii) EU-results (cont'd)
 ENEA Frascati L. Petrizzi
 Analyses of SS-316 bulk shield and nuclear heating experiment: EFF-1,-2, -3 & FENDL-1 data

Discussion

10:30	Coffee break
10:45	Session 3: Selection of evaluations based on findings/discussions
12:30	Lunch break
13:30	Session 3: Selection of evaluations based on findings/discussions (cont'd)
15:30	Coffee break
15:45	Session 3: Selection of evaluations based on findings/discussions (cont'd) Discussion
17:30	Departure to hotels

Friday, June 28 _____

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08:00	Pick-up at hotels
08:30	Session 4: Draft/approval of the summary report for the FENDL-2 close-out meeting
10:30	Coffee break
10:45	Session 4: Draft/approval of the summary report for the FENDL-2 close-out meeting (cont'd)
12:30	Lunch break
13:30	Session 4: Draft/approval of the summary report for the FENDL-2 close-out meeting (cont'd)
15:30	Coffee break
15:45	Session 4: Draft/approval of the summary report for the FENDL-2 close-out meeting (cont'd) Summary discussion & adoption of recommendations

17:30 Departure to hotels -

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