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STATUS OF JAPANESE EVALUATED NUCLEAR DATA LIBRARY VERSION 3

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Abstract: The compilation of the Japanese Evaluated Nuclear Data Library, Version 3 (JENDL-3) has been made in the Japanese Nuclear Data Committee and is now in a final stage. JENDL-3 has been planned so as to meet requirements from fields of fusion researches and radiation shieldings as well as designs of thermal- and fast reactors. In JENDL -3, much emphasis was placed on improvement of high-energy neutron data, inclusion of photon production data and consideration of measured double differential neutron emission cross sections. Much efforts were also made in full revisions of JENDL-2 data for fissile nuclides and structural materials. This paper gives an outline of JENDL-3 project and the present status of its compilation.

(Evaluated Data, Neutron Data, Evaluated Nuclear Data Library, JENDL-3)

Introduction

The compilation of the Japanese Evaluated Nuclear Data Library (JENDL) has been made at the JAERI Nuclear Data Center in cooperation with the working groups in the Japanese Nuclear Data Committee (JNDC). The first version of JENDL, JENDL-1/1,2/ was compiled in 1977 to use for design calculations of fast breeder following JENDL-0 which was a starter file of JENDL. The second version (JENDL-2)/3,4/ was released in 1982 intending to use widely for shielding designs and fusion researches as well as thermal- and fast reactors. In JENDL-2, the range of neutron energy was extended from 15 to 20 MeV, and the number of nuclides stored was increased fairly. The evaluated data were also improved mainly for structural and fissile materials. However, the JENDL-2 data of some nuclides important for fusion researches had not been compiled, and some data for high energies around 14 MeV were not satisfactory for the use in fusion neutronics.

The version 3 of JENDL has been planned so as to meet requirements from fields of fusion researches and shielding designs. In this paper an outline of the JENDL-3 plan and the status of the compilation are summarized. An invited talk by Hasegawa/5/ at this conference also will cover the present situation of JENDL-3 as well as the details of the benchmark tests for JENDL-3.

Outline of JENDL-3 Plan

To overcome the drawbacks of the JENDL-2 data described above, JNDC set up an ad-hoc committee in 1980 to make a draft of the plan for the new version of JENDL although JENDL-2 was under the compilation at that time. The ad-hoc committee firstly made an inquiry about the demands for the new version by questionnaires among data users in various fields, and in the basis of these requirements gave a frame of the JENDL-3 plan, taking account of the manpower and costs needed for the data evaluation as well as the uses in wide fields for nuclear-energy researches.

The points of the plans are mainly divided into the three items as follows: 1) to improve the data on high-energy neutrons. 2) to adopt newly the nuclear data for photon production and 3) to revise fully the JENDL-2 data for major nuclides. In the data compilation the ENDF/B-V format was adopted. The energy range of the data was set up from 10^{-5} eV to 20 MeV, being the same as that of JENDL-2, though there were strong demands for future uses to expand the energy range. For the number of new nuclides the committee decided initially to limit only a few nuclides of N, Mg, S, W and so on, which were strongly requested, by considering the amount of evaluation work. Later, however, we had to increase the number of nuclides stored in JENDL-3 in opposition to the above original idea, in order to meet additional demands from wider fields, firstly fusion researches.

Data Evaluation for JENDL-3

The data evaluation for JENDL-3 has been performed by sharing between thirty-odd members of the working groups in JNDC. The examination of evaluated data and the discussion on evaluation method were made in the JNDC working groups. In particular, a task force was organized in JNDC to discuss the uses of several computer codes in a common base and gave a guideline for the consistent uses of computer codes and the choice of nuclear model parameters.

One of the major tasks in the JENDL-3 plan was the improvement on the data for high-energy neutrons, as described above. In the data evaluation for JENDL-3, much emphases have been placed on the improvement of high-energy neutron data including double differential neutron emission cross sections and threshold-reaction cross sections. The data evaluation for double differential neutron emission cross section was made mainly by referring to the recent experimental data due to both groups of Osaka University/6, 7, 8/ and Tohoku University/9, 10/. For threshold reactions all the cross-section data significant below 20 MeV were evaluated in taking account of precompound effects. For structural materials such as Cr, Fe, Ni, Cu, Pb etc., in particular, emphases have also been put on the gas (hydrogen and helium) production cross sections/11/.

We also have made much efforts on the new evaluation of the nuclear data for photon production. The secondary gamma-ray spectra were cautiously evaluated mainly with theoretical calculations as well as the photon-production cross sections and the photon multiplicities.

The JENDL-2 data for fissile nuclides and structural materials were fully revised. The JENDL-2 data were largely improved for inelastic scattering and threshold reactions. In the JENDL-2 data the direct process in inelastic scattering was ignored for almost nuclides. This has caused trouble for some cases concerning with high-energy neutrons. For most of the all nuclides in JENDL-3 direct process is considered in inelastic scattering cross section and angular distribution based on either DWBA or coupled-channel calculations. In the data for medium and heavy nuclei systematic and consistent evaluations have been intended. For major fissile nuclides a simultaneous evaluation has been made to obtain the consistent data of the fission cross sections for major fissile nuclides/12,13/. The data on their fission spectra were evaluated mainly based on the recommendation of Madllund and Nix/14/.

For the data evaluations of the nuclides relevant to fusion researches, special emphases were placed on tritium production cross sections, inelastic scattering cross sections including double differential neutron emission cross sections. The evaluation of neutron emission spectra for very light nuclides was performed with special caution, because there exists a strong angle-energy correlation in the secondary neutron spectra. For fission products the data evaluation of the new nuclides in JENDL-3 was made systematically including the revision of almost the fission-product data in JENDL-2.

The summaries on the data evaluation for JENDL-3 have been partly given elsewhere by several authors/15, 16, 17, 18/.

Status of the Compilation for JENDL-3

The compilation of the JENDL-3 data have been carried out by the JENDL Compilation Group of JAERI Nuclear Data Center. Before the compilation of JENDL-3, the preliminary small files called JENDL-3PR1 and -3PR2/19/ were prepared in 1984 and 1985, respectively, for an urgent use in fusion neutronics. These files included the tentative data only for a few nuclides relevant to fusion neutronics, such as ^{6}Li, ^{7}Li, ^{9}Be, structural materials etc. The real compilation for JENDL-3 started in 1986 and is now in a final stage. The evaluated data for main nuclides have been already stored in a temporary file called JENDL-3T/20/ to examine their applicabilities for several systems in detail.

Table 1 shows the numbers of nuclides to be stored in JENDL-3 in comparing with those of JENDL-1 and -2. Finally a total of 311 nuclides will be stored in JENDL-3, including 178 fission product nuclides. The evaluated data on photon production are to be given for 42 nuclides. Table 2 shows a list of the nuclides stored in JENDL-3.

In JENDL-3 the data on fission-product yields and decays in File 8 will be taken from a new version of the JNDC Decay Data File/21/. The scattering law data for thermal neutrons used in File 7 will be taken from the evaluation due to the Subworking group on thermal neutron scattering law in JNDC/22/.

In the course of the JENDL-3T compilation we have faced several problems on the file-

Table 1 The Comparison of the Numbers of Nuclides in JENDL-3T with Those in JENDL-1, -2 and -3. The figures in the parenthesis stand for the number of nuclides with photon-production data.

	JENDL-1 (1977)	JENDL-2 (1982)	(JENDL-3)
light nuclides (z= 1 ~ 19)	7	11	37(12)
structural materials nuclides (z= 20 ~ 30)	20	30	37(15)
FP nuclides (z= 31 ~ 69)	34	101	178(3)
medium weight nuclides (z= 70 ~ 89)	1	12	20(9)
heavy nuclides (z= 90 ~ 94)	9	19	21(3)
transplutonium (z= 95 ~ 98)	1	8	18(0)
TOTAL	72(0)	181(0)	311(42)

Table 2. Nuclides in the General Purpose File of JENDL-3
The underlines denote the nuclides stored newly in JENDL-3.
The asterisks show the nuclides with the evaluated data for photon production.

Z	Nuclide
1	*^{1}H, ^{2}H
2	^{3}He, ^{4}He
3	*^{6}Li, *^{7}Li
4	*^{9}Be
5	^{10}B, ^{11}B
6	*^{12}C
7	*^{14}N
8	*^{16}O
9	^{19}F
11	*^{23}Na
12	*Mg, ^{24}Mg, ^{25}Mg, ^{26}Mg
13	*^{27}Al
14	*Si, ^{28}Si, ^{29}Si, ^{30}Si
15	^{31}P
16	S, ^{32}S, ^{33}S, ^{34}S, ^{36}S
17	Cl, ^{35}Cl, ^{37}Cl
18	^{40}Ar
19	K, ^{39}K, ^{40}K, ^{41}K
20	*Ca, ^{40}Ca, ^{42}Ca, ^{43}Ca, ^{44}Ca, ^{46}Ca, ^{48}Ca
21	^{45}Sc
22	*Ti, ^{40}Ti, ^{47}Ti, ^{48}Ti, ^{49}Ti, ^{50}Ti
23	^{51}V
24	*Cr, ^{50}Cr, ^{52}Cr, ^{53}Cr, ^{54}Cr
25	*^{55}Mn
26	*Fe, ^{54}Fe, ^{56}Fe, ^{57}Fe, ^{58}Fe
27	^{59}Co
28	*Ni, ^{58}Ni, (^{59}Ni), ^{60}Ni, ^{61}Ni, ^{62}Ni, ^{64}Ni
29	*Cu, ^{63}Cu, ^{65}Cu
30	*Zr, ^{90}Zr, ^{91}Zr, ^{92}Zr, ^{94}Zr, ^{96}Zr
41	*^{93}Nb, (^{94}Nb)
42	*Mo, ^{92}Mo, ^{94}Mo, ^{95}Mo, ^{96}Mo, ^{97}Mo, ^{98}Mo, ^{100}Mo
47	*Ag, ^{107}Ag, ^{109}Ag
48	Cd
51	Sb, ^{121}Sb, ^{123}Sb
63	*Eu, ^{151}Eu, ^{153}Eu
72	*Hf, ^{174}Hf, ^{176}Hf, ^{177}Hf, ^{178}Hf, ^{179}Hf, ^{180}Hf
73	*^{181}Ta
74	*W, ^{180}W, ^{182}W, ^{183}W, ^{184}W, ^{186}W
82	*Pb, ^{204}Pb, ^{206}Pb, ^{207}Pb, ^{208}Pb
83	*^{209}Bi
90	^{228}Th, ^{230}Th, ^{232}Th, ^{233}Th, ^{234}Th
91	^{231}Pa, ^{233}Pa
92	^{232}U, ^{233}U, ^{234}U, *^{235}U, ^{236}U, *^{238}U
93	^{237}Np, ^{239}Np
94	^{236}Pu, ^{238}Pu, *^{239}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu
95	^{241}Am, ^{242g}Am, ^{242m}Am, ^{243}Am
96	^{242}Cm, ^{243}Cm, ^{244}Cm, ^{245}Cm, ^{246}Cm, ^{247}Cm, ^{248}Cm, ^{249}Cm
97	^{249}Bk, ^{250}Bk
98	^{249}Cf, ^{250}Cf, ^{251}Cf, ^{252}Cf

making. Athough all the evaluated data for JENDL-3 were compiled in the ENDF/B-V format as described above. the main problems were on the data processing in this format and these format rules, and on the relation with user's processing codes as well as on the vast laborious work in the file making. The first was on the use of the File 6 data. For the data evaluations for the secondary neutrons of ^{6}Li and ^{7}Li, for example, the use of File 6 was essential to represent the actual physical process more precisely. The use of File 6, however, is not permitted in the ENDF/B-V format though the ENDF/B-VI format which is now available permits to use File 6. Considering the relation of user's processing codes, therefore, we converted the data in File 6 for JENDL-3T to File 4 and File 5. After the completion of JENDL-3, we will have an another auxiliary file used File 6, in taking account of that the ENDF/B-VI format would be adopted in the major libraries in the world in near future.

The another was on the formalism of resonance parameters. The resolved resonance parameters of ^{239}Pu were evaluated with the formalism of Reich-Moore which is not permitted in the ENDF/B-V format. However, since the use of the Reich-Moore formalism was unavoidable in this case, we decided to use this formalism in JENDL-3 in spite of the violation for the format rule.

In some cases the JENDL-3T data were not accepted some processing codes due to the existence of the subsections in the File 5 and File 15. At least the subsection in File 15 is not permitted in the ENDF/B-V format. In JENDL-3, therefore, all the subsections in File 5 and File 15 will be removed.

Further Programme on JENDL-3 Compilation

The various benchmark tests for JENDL-3T have been carried out for applications to the several benchmark systems, namely thermal reactors (light water reactor and high conversion light water reactor)/23/, fast breeder reactors/24/, shielding assemblies/25/, experiments on dosimetry /26/ and on fusion neutronics /27/. The details on the benchmark tests will be presented in this conference by several authors separately/5, 28, 29, 30, 31/.

After detailed examinations of the benchmark results, the JENDL-3T data will be partly revised before JENDL-3 is finally compiled. In some cases another tests for the revised data would be necessary. The completion of the file-making for JENDL-3 is expected in the end of 1988.

The ad-hoc committee above described gave no definite conclusions for both covariance data and special purpose file, because of being not able to catch future demands for these data precisely and of their enormous amounts of the work. However, JAERI Nuclear Data Center has been planning the compilation of special purpose files for activation cross section and so on, as the supplementary files of JENDL.

REFERENCES

1. S. Igarasi, T. Nakagawa, Y. Kikuchi, T. Asami and T. Narita : JAERI 1261 (1979).
2. Y. Kikuchi, T. Nakagawa, H. Matsunobu, M. Kawai, S. Igarasi and S. Iijima : JAERI 1268 (1981).
3. T. Nakagawa (ed.) : JAERI-M 84-103 (1984).
4. T. Asami and T. Narita (ed.) : JAERI-M 84-052 (1984).
5. A. Hasegawa :"Benchmark Testing of Evaluated Data File on Fission Reactors and Shielding Problems", contribution to this conference (IDO3) (1988).
6. A. Takahashi, E. Ichimura, Y. Sasaki and H. Sugimoto: J. Nucl. Sci. Tech. 25, 215 (1988).
7. A. Takahashi, Y. Sasaki and H. Sugimoto : JAERI-M 88-065, p.279 (1988).
8. A. Takahashi, Y. Sasaki and H. Sugimoto : "Double Differential Neutron Emission Cross Sections at 14.1 MeV for Be, V and Fe", contribution this conference (AB04) (1988).
9. M. Baba, M. Ishikawa, T. Kikuchi, H. Wakabayashi and N. Hirakawa : "Double-differential Neutron Scattering Cross Sections of Beryllium, Carbon and Oxygen", contribution to this conference (AB05) (1988).
10. S. Chiba et al. : J. Nucl. Sci. Eng. 22, 10 (1985).
11. S. Iijima, T. Asami, K. Shibata and H. Yamakoshi : "Evaluation of Neutron-Induced Cross Sections of Chromium, Iron and Nickel for JENDL-3", contribution to this conference (DD32) (1988).
12. Y. Uenohara and Y. Kanda : Proc. Intern. Conf. on Nuclear Data for Science and Technology, 1982 Antwerp, 639 (1983).
13. Y. Uenohara and Y. Kanda : Proc. Intern. Conf. on Nuclear Data for Science and Technology, 1985 SantaFe, 1567 (1986).
14. D.G. Madlund and J.R. Nix : Nucl. Sci. Eng. 81, 213 (1982).
15. S. Chiba: JAERI-M 88-065 (1988) p.75.
16. M. Kawai et al.: ibid. p.57.
17. M. Mizumoto : ibid. p.29.
18. T. Nakagawa : ibid. p.10.
19. T. Asami : JAERI-M 86-029 (1986) p.15.
20. T. Asami: JAERI-M 88-065 (1988) p.4.
21. K. Tasaka, J. Katakura, H. Ihara, T. Yoshida, M. Akiyama and R. Nakasima : Proc. Specialists' Meeting on Data for Decay Heat Predictions, 1987 Studsvik, 277 (1987).
22. Y. Nakahara : private communication (1988).
23. H. Takano and K. Kaneko: JAERI-M 88-065 (1988) p.119.
24. T. Takeda, M. Takamoto, H. Takano and A. Hasegawa : ibid. p.135.
25. A. Hasegawa : ibid. p.162.
26. M. Nakazawa : ibid. p.191.
27. H. Maekawa : ibid. p.198.
28. H. Takano and K. Kaneko :"Thermal and Fast Reactor Benchmark Tests of JENDL-3", conribution to this conference (DD05) (1988).
29. M. Kawai, A. Hasegawa, K. Sakurai, K. Ueki, N. Yamano, K. Sasaki, Y. Matsumoto, K. Tsunoda, Y. Itoh, M. Uematsu and Y. Oka :"Shielding Benchmark Test of Iron and Sodium Cross Sections in JENDL-3", contribution to this conference (DD02) (1988).
30. T. Takeda, M. Takamoto, H. Takano and A. Hasegawa :"Sensitivity Analysis of JENDL-3", contribution to this conference (DD06) (1988).
31. H. Maekawa, K. Kosako, Y. Ikeda, Y. Oyama, S. Yamaguchi, K. Tsuda and T. Nakamura : "Integral test of JENDL-3T Through Benchamrk Experiments Using FNS", contribution to this conference (CB02) (1988).