

The Present Status of CENDL-3

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CENDL-3 was started in 1996. According to the plan, CENDL-3 will be completed by the year 2000, and will contain about 200 nuclides. Among them, the data of following nuclides will be newly evaluated or reevaluated: fissile nuclides 15, structure materials 18, light nuclides 3, fission products 91.

Since then, the work has been continuously done at CNDC (Chinese Nuclear Data Center) and CNDN (Chinese Nuclear Data Network). Following institutes and universities are included in the CNDN now: China Institute of Atomic Energy (CIAE), Peking University (BJG), Sichuan University (SIU), Zhengzhou University (ZHN), Nankai University (NKU), Nanjing University (NJU), Northwest University (UNW), Jilin University and etc. Much effort has been made for general purpose file of CENDL-3 in last year, so more progress has been obtained. Following are the main aspects.

1. General Purpose File

So far, the present stage of CENDL-3 is shown in Table 1.

Table 1. The completed and planned nuclides of CENDL-3

Nuclides	Planned	Completed
Fissile nuclide	15	5($^{233,234,235,238}\text{U}$, ^{239}Pu)
Structure material	24	15($^{90,91,92,94,96,0}\text{Zr}$, $^{58,59,60,61,62,0}\text{Ni}$, $^{63,65,0}\text{Cu}$)
Fission products	91	73
Light nuclide	3	2(^6Li , ^9Be)
Total	133	95

The files 1,2,3,4,6,12-15 are included for all nuclides, except for fission nuclides, for which only files 1,2,3,4,5 are given.

Among above nuclides, most of them were completed in last year (from April of 1999 to now). They are $^{233,234,235}\text{U}$, ^{239}Pu , $^{90,91,92,94,96,0}\text{Zr}$, $^{65,0}\text{Cu}$, ^6Li , ^9Be and 44 fission product nuclides.

For structure material $^{90,91,92,94,96,0}\text{Zr}$, $^{63,65,0}\text{Cu}$, the data are given not only for the natural element but also for their all isotopes. The data were adjusted to making the consistent in physics not only for each nuclide itself, but also between natural element and their isotopes. For the latter, the data were not changed so much, if the measured data are more or less consistent before the adjusting; but they changed lot, if they are discrepant before adjusting. An example is given in Fig.1 for $^{90,0}\text{Zr}(n,2n)$ cross section. The double differential cross sections were calculated with code NUNF and the energy is in balance within 1.0% error without any artificially adjusting. Comparing with FENDL-2 (there is no DDX for other libraries), some of them were improved (Figs.2,3). Due to there are some new experimental data available, the some of cross section data were also improved, some example are given in Figs.4,5.

For light nuclides, the double differential cross section (file 6) was calculated with code LUNF in the frame of statistical theory. The key point is the description of the particle emissions from discrete level to discrete levels in pre-equilibrium states (it has been approved that the main process, more than 80%, is pre-equilibrium emission). In the whole reaction processes, the angular momentum and parity are kept conservation and the energy balance is taken into account. The level broadening effect and energy resolution is considered to fit experimental data. Comparing with the existing data in the evaluated libraries, the DDX data of ^9Be , ^7Li were considerably improved.

2. Special Purpose File

The evaluation was continuously done for special purpose file data. More progress has been made for fission yield, photonuclear reaction and prompt γ ray data.

1). Fission Yield

The work on fission yield evaluation has been done under the frame of IAEA's CRP on "Fission Product Yield Data Required for Transmutation of Minor Actinides Nuclear Waste".

a. Reference fission yield data

So far, the reference fission yield data of altogether 120 product nuclides have been evaluated since the CRP started. Among them, 65 product nuclides are for ^{235}U fission and 55 for ^{238}U fission. The evaluations were based on all available experimental data up to now. The data were corrected for standard yield, γ branch ratio and fission cross section. The error was also corrected to make them become "total" and to a reasonable level. The corrected experimental data with their errors were processed with codes AVERAG for averaging with weight and ZOTT for simultaneous evaluation. In the evaluation, the relatively measured data were not used, unless the standard used was just newly evaluated by us. This is special necessary for the evaluation of "reference yield data", the "standard data" could not be based on other standards, whose reliability are unknown.

For last year, the evaluation work has been continuously done, and the data of 18 product nuclides for ^{235}U fission and 16 product nuclides for ^{238}U fission were evaluated.

b. Covariance Matrix

A method and code have been developed for constructing covariance matrix of absolute fission yield measurement. So-called parameter analysis method was studied, the calculation formulas were derived and some examples were calculated. The correlation coefficients of each

directly measurable parameter was given based on the general case of the experiments and included in the code, which is the key point in the covariance construction. By using the code, the correlation can be calculated for same nuclide at different energy points or for different nuclides at same energy point.

2). Photonuclear reaction data

In last year, the complete data of photonuclear reaction up to 30 MeV have been continuously evaluated and calculated by using code GUNF as the task of IAEA's CRP. So far, the evaluations have been completed for 24 nuclides ^9Be , ^{27}Al , ^{51}V , $^{50,52,53,54}\text{Cr}$, $^{54,56,57,58}\text{Fe}$, $^{63,65}\text{Cu}$, $^{90,91,92,94,96}\text{Zr}$, $^{180,182,183,184,186}\text{W}$, and ^{209}Bi . The evaluated data include $(\gamma,1n)$, $(\gamma,1p)$, $(\gamma,1\alpha)$, $(\gamma,1^3\text{He})$, $(\gamma,1d)$, $(\gamma,1t)$, $(\gamma,2n)$, (γ,np) , $(\gamma,n\alpha)$, $(\gamma,2p)$, $(\gamma,3n)$ cross sections and corresponding outgoing particle spectra. Some typical results are shown in Figs.6-8.

3). Prompt γ -ray data

Under the supporting by the IAEA and as a part of the CRP, the evaluation of prompt γ -ray data of thermal neutron capture, including the energy, intensity and decay scheme, was started in April of 1999, and so far the data for nuclides $A=1\sim 35$ have been performed.

3. Validation of CENDL

In last year, CENDL-2.1 was tested for heavy water benchmark assemblies ZEEP-1,2,3 with comparing with newly released version 5 of ENDF/B-6 and old WIMS library. Firstly, the WIMS-69 group libraries were generated with CENDL-2.1 and ENDF/B-6 respectively, and then k_{eff} (effective multiplication factor), ρ^{28} (epithermal/thermal captures for ^{235}U), δ^{25} (epithermal/thermal fission for ^{235}U), δ^{28} ($^{238}\text{U}/^{235}\text{U}$ fission), C^* (^{238}U capture/ ^{235}U fission), and $RCR(C^*_{\text{lattice}}/C^*_{\text{Maxwell}})$ etc. integral

parameters were calculated with code WIMSD5A and compared with experimental ones. The results are shown in Table 2.

Table 2. The calculated integral parameters for heavy water reactor benchmarks

Lattices	Integral parameter	Experiment	WIMS/D4	CENDL-2.1	ENDF/B-6.5
ZEEP-1	k_{eff}	1.0000	0.99398	1.0032	0.99790
	ρ^{28}	----	0.26026	0.28687	0.28488
	δ^{25}	----	0.0258	0.0256	0.02557
	δ^{28}	0.0675	0.06804	0.06785	0.06892
	RCH	1.16	1.279	1.274	1.29226
ZEEP-2	k_{eff}	1.0000	0.9993	0.99993	0.99465
	ρ^{28}	----	0.4688	0.52713	0.52368
	δ^{25}	----	0.04891	0.048715	0.04849
	δ^{28}	----	0.07261	0.07192	0.07332
	RCR	----	1.464	1.489	1.50807
ZEEP-3	k_{eff}	1.0000	1.00384	0.99752	0.99237
	ρ^{28}	----	0.62021	0.70397	0.69603
	δ^{25}	----	0.06539	0.06538	0.06504
	δ^{28}	----	0.07672	0.07583	0.07748
	RCR	----	1.5968	1.6424	1.66292

It can be seen from the table that CENDL-2.1 is better than old WIMS library for the heavy water reactor calculation, and is in good agreement with the experimental data for k_{eff} , δ^{28} .

The newly evaluated data of ^{238}U , ^{239}Pu , ^{233}U , and natural Zr etc. for CENDL-3 have been tested after they were primary completed. The problems found in the testing are being improved now.