

A Brief Introduction to CENDL-3.2: Latest Release of Chinese Evaluated Nuclear Data Library

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As a general purpose evaluated nuclear database, Chinese Evaluated Nuclear Data Library (CENDL) is not only an output of more-than-forty-year domestic cooperation under the name of CENDL Library Project via China Nuclear Data Coordination Network (CNDCN), but also a product of international collaborations, especially under the multi-lateral framework of IAEA and OECD/NEA/WPEC.

Coordinated by China Nuclear Data Center (CNDC) during 2015-2019, CENDL-3.2 is the latest release of CENDL. With ENDF-6 formatted neutron reaction data for a total number of 272 materials, CENDL-3.2 is expected to meet general requirements for diversified scenarios of peaceful use of nuclear power and nuclear technology application.

Out of all 272 materials, the data for 135 materials are totally new or partly updated evaluations, while the other 137 materials were inherited and adopted as it was from previous version, CENDL-3.1. As shown in Table 1, major updates of the current version are: i) data set of 58 nuclides are brand newly evaluated on the basis of latest experimental information and model calculations from UNF codes, covering a broad spectrum of nuclides from n-1 to ^{241}Am ; ii) 14 nuclides are re-viewed and re-evaluated from previous version, with part of the data set modified, including ^2H , ^7Li , ^{93}Nb and major actinides isotopes Th, U, Np and Pu; iii) through an estimation of the uncertainties of theoretical model parameters within the generalized least square scheme, model dependent covariances for main reaction cross section data are added for 70 fission product nuclei.

In order to verify the physical rationality, systematic comparisons between CENDL-3.2 and other major evaluated libraries (e.g. ENDF, JENDL, BROND, JEFF and TENDL) as well as experimental data available have been implemented. Moreover, the benchmarking test of CENDL-3.2 was performed with ENDITS-1.0, an integrated benchmarking test system including 1233 criticality benchmark configurations. Figure 1~5 illustrates the benchmarking test results for CENDL-3.1 in various systems, as well as a comparison to ENDF/B-VIII.0, JENDL-4.0 and JEFF-3.2. As shown in Table 2, the χ^2 value implies that CENDL-3.2 has a potential remarkable improvement of predictions for ^{235}U and Pu systems.

Table 1. Nuclides List and Major Updates for CENDL-3.2^a

Newly Evaluated and Partly Updated (135 Nuclides)
Newly Evaluated (58 Nuclides): n-1, H-1, Na-23, Al-27, S-32, S-33, S-34, S-36, Ca-40, Fe-56, Ni-58, Zn-64, Zn-66, Zn-67, Zn-68, Zn-70, Se-74, Se-76, Se-77, Se-78, Se-79, Se-80, Se-82, Kr-87, Kr-88, Mo-93, Mo-99, Sn-126, Sn-128, Sb-124, Sb-127, I-130, I-131, Xe-123, Xe-124 ^b , Xe-129, Xe-131, Xe-132 ^b , Xe-133, Xe-134 ^b , Xe-135 ^b , Xe-136, La-139 ^b , Ce-140, Ce-141 ^b , Ce-142, Ce-144 ^b , Ho-165, W-180, W-182, W-183, W-184, W-186, U-236, U-240, Np-236, Pu-238, Am-241.
Partly Updated (77 Nuclides): H-2, Li-7, Ti-48, Ga-69 ^b , Ga-71 ^b , Ge-71 ^b , Ge-73 ^b , Ge-74 ^b , Ge-75 ^b , Ge-76 ^b , Ge-77 ^b , Ge-78 ^b , As-75 ^b , As-77 ^b , As-79 ^b , Sr-89 ^b , Y-89 ^b , Y-91 ^b , Zr-93 ^b , Zr-95 ^b , Nb-93, Nb-95 ^b , Tc-99 ^b , Ru-99 ^b , Ru-100 ^b , Ru-101 ^b , Ru-103 ^b , Ru-104 ^b , Ru-105 ^b , Rh-103 ^b , Rh-105 ^b , Pd-105 ^b , Pd-108 ^b , Cd-113 ^b , Sb-121 ^b , Sb-125 ^b , I-127 ^b , I-129 ^b , I-135 ^b ,

Cs-133^b, Cs-135^b, Cs-137^b, Ba-130^b, Ba-134^b, Ba-135^b, Ba-136^b, Ba-137^b, Ba-138^b, Pr-141^b, Nd-143^b, Nd-145^b, Nd-146^b, Nd-148^b, Pm-147^b, Pm-148^b, Pm-149^b, Sm-150^b, Sm-151^b, Eu-151^b, Eu-153^b, Eu-155^b, Gd-154^b, Gd-155^b, Gd-156^b, Gd-157^b, Gd-158^b, Gd-160^b, Th-232, U-233, U-235^c, U-237, U-238^c, U-239, Np-237, Np-239, Pu-240, Pu-241^c.

Inherited from CENDL-3.1 (137 Nuclides):

H-3, He-3, He-4, Li-6, Be-9, B-10, B-11, C-12, N-14, O-16, F-19, Mg-24, Mg-25, Mg-26, Si-28, Si-29, Si-30, P-31, Cl-0, K-0, Ca-0, Ti-46, Ti-47, Ti-49, Ti-50, V-0, Cr-50, Cr-52, Cr-53, Cr-54, Mn-55, Fe-54, Fe-57, Fe-58, Co-59, Ni-60, Ni-61, Ni-62, Ni-64, Cu-0, Cu-63, Cu-65, Ge-0, Ge-70, Ge-72, Kr-83, Kr-84, Kr-85, Kr-86, Rb-85, Rb-87, Sr-88, Sr-90, Zr-90, Zr-91, Zr-92, Zr-94, Zr-96, Mo-92, Mo-94, Mo-95, Mo-96, Mo-97, Mo-98, Mo-100, Ru-102, Ag-0, Ag-107, Ag-109, Cd-0, In-113, In-115, Sn-0, Sn-112, Sn-114, Sn-115, Sn-116, Sn-117, Sn-118, Sn-119, Sn-120, Sn-122, Sn-124, Sb-123, Te-130, Cs-134, Ba-132, Ce-136, Ce-138, Nd-142, Nd-144, Nd-147, Nd-150, Pm-148m, Sm-144, Sm-147, Sm-148, Sm-149, Sm-152, Sm-154, Eu-154, Gd-152, Dy-164, Hf-174, Hf-176, Hf-177, Hf-178, Hf-179, Hf-180, Ta-181, Au-197, Hg-0, Tl-0, Pb-204, Pb-206, Pb-207, Pb-208, Bi-209, U-232, U-234, U-241, Np-238, Pu-236, Pu-237, Pu-239, Pu-242, Pu-243, Pu-244, Pu-245, Pu-246, Am-240, Am-242, Am-242m, Am-243, Am-244, Bk-249, Cf-249.

a. Total data size of CENDL-3.2: 392MB.

b. Covariance added.

c. Beta-delayed fission gamma spectrum (MT=460) added.

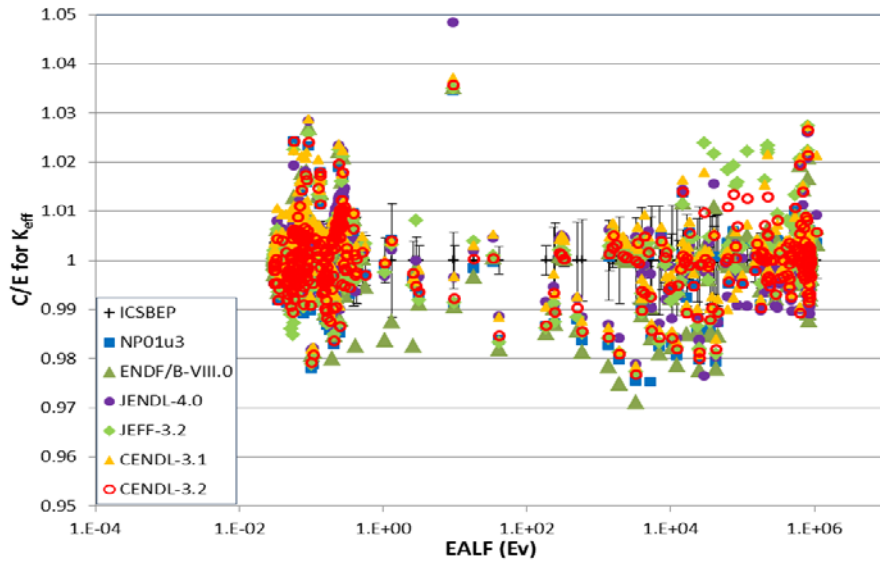


Figure 1 Results for HEU systems

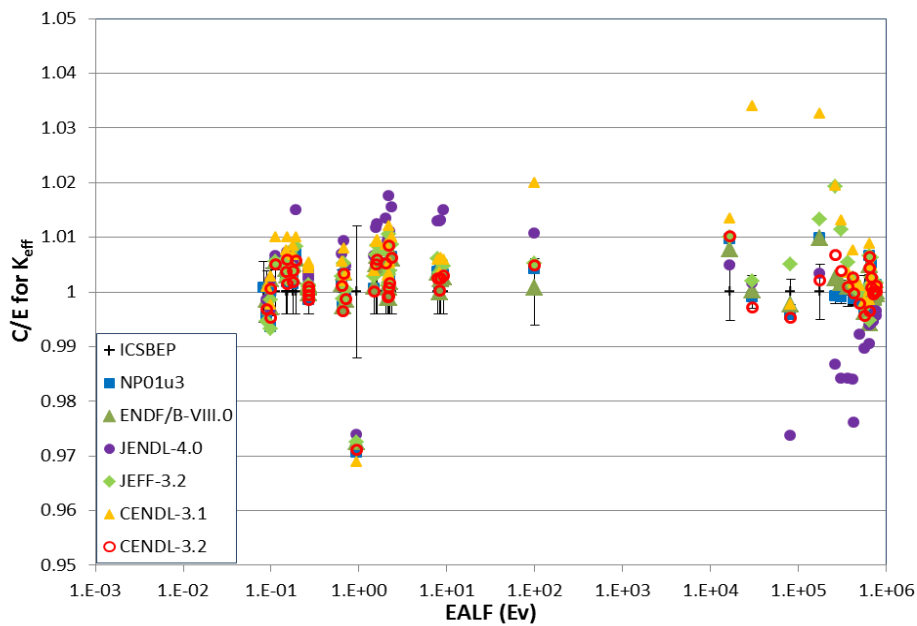
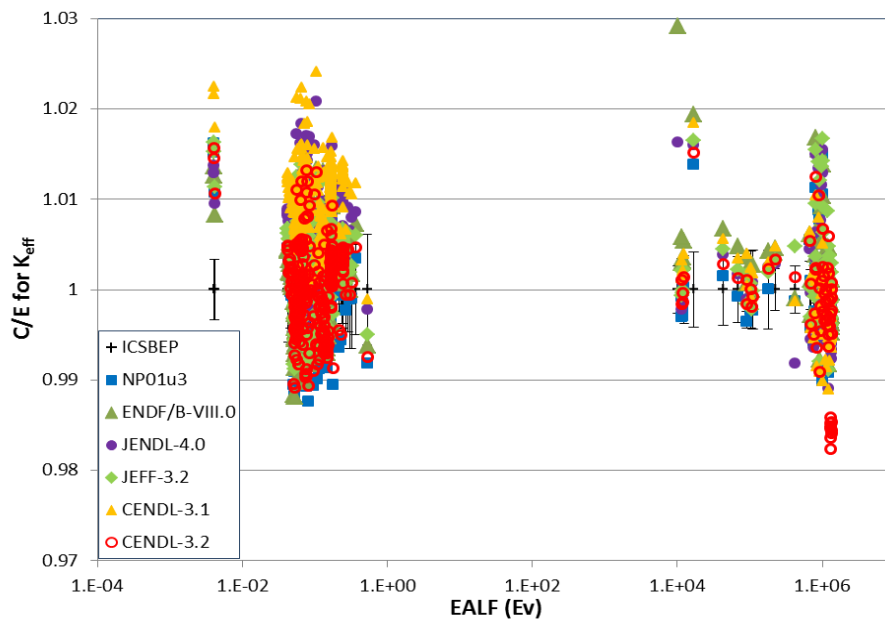
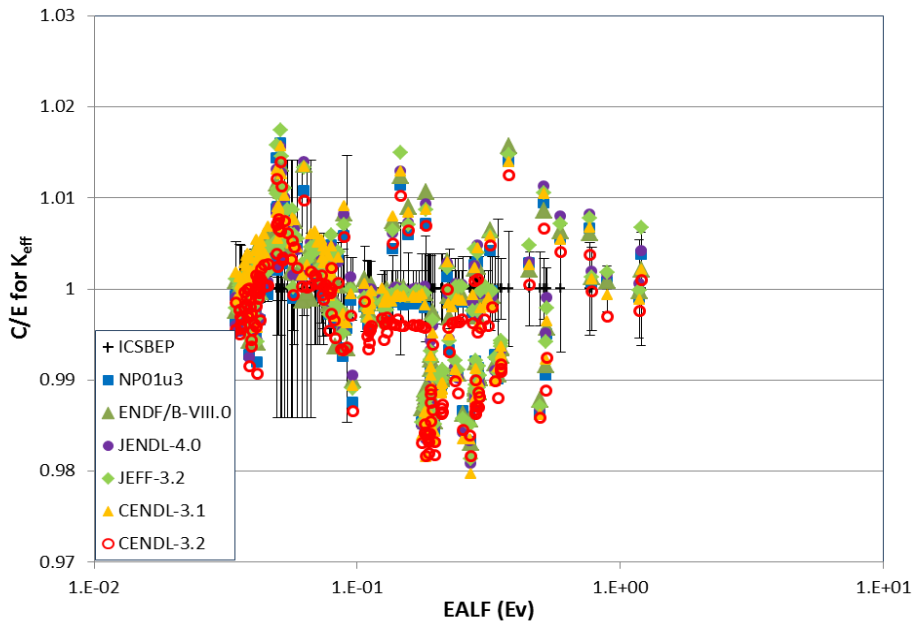


Figure 2 Results for IEU systems



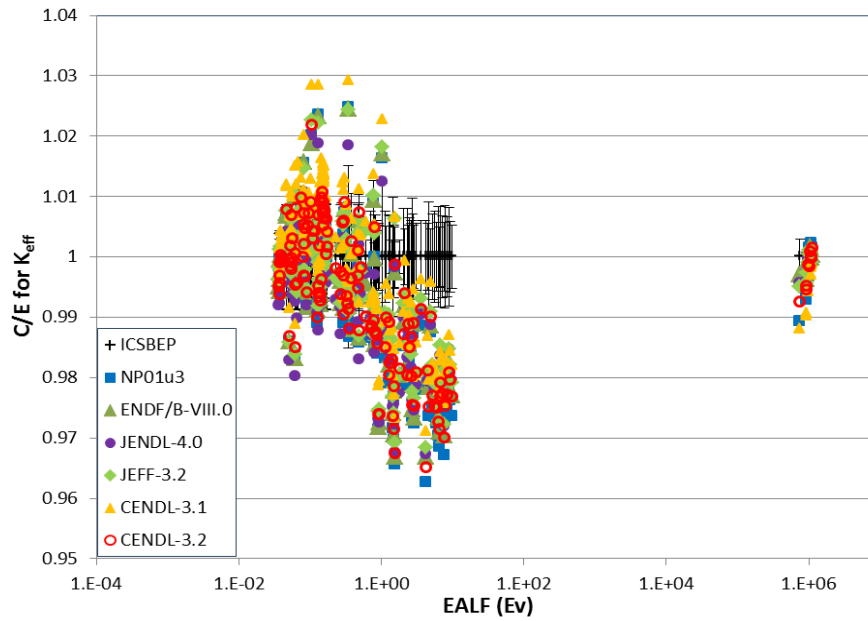


Figure 5 Results for U-233 systems

Table 2. The average values of C/E-1, standard deviation and χ^2

Type	Cases	Quantity	ENDF/B-VIII.0	JENDL-4.0	JEFF-3.2	CENDL-3.1	CENDL-3.2
U-235	686	C/E-1 (pcm)	-20	26	62	182	-84
		STDEV	703	772	750	779	758
		χ^2	12.32	13.56	12.41	23.94	9.66
U-Pu	7	C/E-1 (pcm)	-170	-1233	122	-36	88
		STDEV	225	572	414	285	283
		χ^2	5.89	249.26	35.51	11.89	16.81
Pu	376	C/E-1 (pcm)	93	554	210	764	4
		STDEV	488	561	504	769	554
		χ^2	2.26	4.91	2.80	9.05	3.27
U-233	164	C/E-1 (pcm)	-547	-653	-378	-42	-579
		STDEV	1127	1031	1091	1197	1139
		χ^2	4.81	4.77	4.27	6.49	5.30
All	1233	C/E-1 (pcm)	-56	89	49	328	-119
		STDEV	745	849	762	892	782
		χ^2	8.21	11.09	8.53	17.01	7.17