

Status of the ENDF Project

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Abstract

The present version of the library, ENDF/B-VI release 8, is frozen since October 2001. CSEWG is developing a new version of the library, ENDF/B-VII, scheduled for release in December 2005.

1. ENDF/B-VI release 8

The current version of the library, ENDF/B-VI release 8, was issued in October 2001. Since then, the library remains frozen. The library includes neutron cross-section evaluations for 328 materials (313 isotopic and 15 elemental).

The ENDF/B-VI.8 library, along with other ENDF-type libraries (JEFF-3.0, JENDL-3.3, BROND-2 and CENDL-2), was migrated into relational database software Sybase that runs under Linux operating system. The NNDC in collaboration with the IAEA Nuclear Data Section completed database migration, including powerful web interface and made it available in April 2004. One can retrieve variety of data, make comparison between various libraries and experimental data from CSISRS (EXFOR) as well as produce plots comparing evaluations and experimental data.

Fig. 1 shows title page of the new interface, www.nndc.bnl.gov/endl. As an example, it shows retrieval of MF=32 from ENDF/B-VI.8, with just 4 (four) materials with resonance covariance data, including 1 material using MLBW formalism and 3 materials using obsolete SLBW formalism.

2. Development of ENDF/B-VII


A. Meetings and timetable

The 53rd meeting of the Cross Section Evaluation Working Group was held at BNL, November 4-6, 2003. It fully focused on development of ENDF/B-VII and reviewed all new evaluations. A small 'mini-CSEWG' meeting was held on May 4, 2004 at LANL that addressed data validation.

CSEWG agreed on the following timetable for ENDF/B-VII:


- 2004: Validation, CSEWG meeting (November 2-4)
- 2005: Validation and final review, CSEWG meeting (November)
- 2005: Release of the library (December)

Fig. 1. New ENDF web interface is available at www.nndc.bnl.gov/endlf. As an example, request for MF=32 in ENDF/B-VI.8 retrieves all materials with resonance covariance data. These are just 4 materials, ^{23}Na , $^{240,242}\text{Pu}$ and ^{241}Am .



Evaluated Nuclear Data File (ENDF)

Database Version of February 09, 2004



Core nuclear reaction database containing evaluated (recommended) cross sections, spectra, angular distributions, fission product yields, photo-atomic and thermal scattering law data, with emphasis on neutron induced reactions. The data were analyzed by experienced nuclear physicists to produce recommended libraries for one of the national (USA, European, Japanese, Russian and Chinese) nuclear data projects. All data are stored in the internationally adopted format (ENDF-6) maintained by CSEWGW.

Advanced Request (example): [Go to: Standard Request](#)

Parameters:

NSUB (projectile)

Target nucleus

MF (quantity) # 32

MT (reaction) #

Product

Energy extends above MeV

Laboratory

Author(s)

Ranges:

	Target	Product
Z	<input type="checkbox"/> <input type="text"/>	<input type="checkbox"/> <input type="text"/>
A	<input type="checkbox"/> <input type="text"/>	<input type="checkbox"/> <input type="text"/>
Isomer	<input type="checkbox"/> <input type="text"/>	<input type="checkbox"/> <input type="text"/>

Libraries: All Selected

ENDF/B-VI.8 ENDF/B-VI.8 300 K

JENDL-3.3 JENDL-3.3 300 K

JEFF-3.0 JEF-2.2

CENDL-2 ENDF/HE-VI High Energy

BROND-2.2

Options:

Retrieve: Sections Sub-Sections

Display: Evaluations Sections/Sub-Sections

View: Details List Compact

Results: Evaluations: 4 Sections: 4 Output...

ENDF Data Selection

Data Selection: Selected Unselected All

Output Formats: ENDF

[@e](#) = Evaluation Summary

[@s](#) = Section Summary and Tabulated Data

[@i](#) = General Information Section (MF=1, MT=451)

++ Open all -- Close all

- @e	1)	MAT=1125 @i	11-NA-23	NSUB=10(N)	20MeV	ENDF/B-VI	ORNL	D. C. LARSON	2001
		MAT=1125 MF32 [COV/RES] Covariances of resonance parameters							
		MAT=1125 MF32 <input type="checkbox"/> 1 @s MT151 NA-23(N,RES),COV/RES Lines:62							
- @e	2)	MAT=9440 @i	94-PU-240	NSUB=10(N)	20MeV	ENDF/B-VI	ORNL	L.W. WESTON AND E. D. ARTHUR	1993
		MAT=9440 MF32 [COV/RES] Covariances of resonance parameters							
		MAT=9440 MF32 <input type="checkbox"/> 2 @s MT151 PU-240(N,RES),COV/RES Lines:33							
- @e	3)	MAT=9446 @i	94-PU-242	NSUB=10(N)	20MeV	ENDF/B-VI	HEDL, SRL, +	MANN, BENJAMIN, MADLAND, HOWERTON, +	1990
		MAT=9446 MF32 [COV/RES] Covariances of resonance parameters							
		MAT=9446 MF32 <input type="checkbox"/> 3 @s MT151 PU-242(N,RES),COV/RES Lines:210							
- @e	4)	MAT=9543 @i	95-AM-241	NSUB=10(N)	30MeV	ENDF/B-VI	LANL, CNDC	YOUNG, MADLAND, ZHOU ET AL.	1995
		MAT=9543 MF32 [COV/RES] Covariances of resonance parameters							
		MAT=9543 MF32 <input type="checkbox"/> 4 @s MT151 AM-241(N,RES),COV/RES Lines:591							

B. New features of the library

The ENDF/B-VII library should have the following new features:

- New version of standard cross sections
- Energies up to 150 MeV for selected materials
- Photonuclear data
- Improved evaluations for major actinides
- Improved evaluations for criticality safety
- Improved evaluations for fission products
- New and improved charged particle evaluations relevant to astrophysics
- Evaluations relevant to RIA, ADS and next generation reactors.

It should be pointed out that ENDF/B-VII library continues to use the current ENDF-6 format. There is no ENDF-7 format.

C. New evaluations

So far, 231 new/improved evaluations have been submitted for inclusion into the ENDF/B-VII library. These include the following number of materials:

- 51 materials for neutrons (mostly actinides and fission products),
- 20 materials for charged particles (10 for protons; 10 for D, T and He3), and
- 160 materials for photonuclear, that is,
- **231 materials in total.**

Three laboratories contributed new evaluations, namely, LANL, ORNL and BNL as explained below.

Los Alamos. LANL is major contributor of new evaluations, focusing on actinides, with many detailed improvements as illustrated in Fig.2.

- 16 materials for neutrons
 - ^{236, 237, 239, 240, 241}U, ²³⁷Np, ²³⁹Pu, ²⁴¹Am
 - ^{196, 198, 199, 200, 201, 202, 204}Hg (up to 150 MeV)
 - ²⁷Al
- 160 materials for photonuclear, mostly up to 150 MeV, includes considerable international input (IAEA CRP project)
- 20 materials for light charged-particle reactions
 - 10 materials for protons (3-H, 6,7-Li, 196,198,199,200,201,202,204-Hg)
 - 10 materials for D (2,3-H, 3-He, 6,7-Li), tritons (3-H, 3-He, 6-Li) and 3-He (3-He, 6-Li)
- Expected: 240, 242, 242m, 243-Am, Cm isotopes

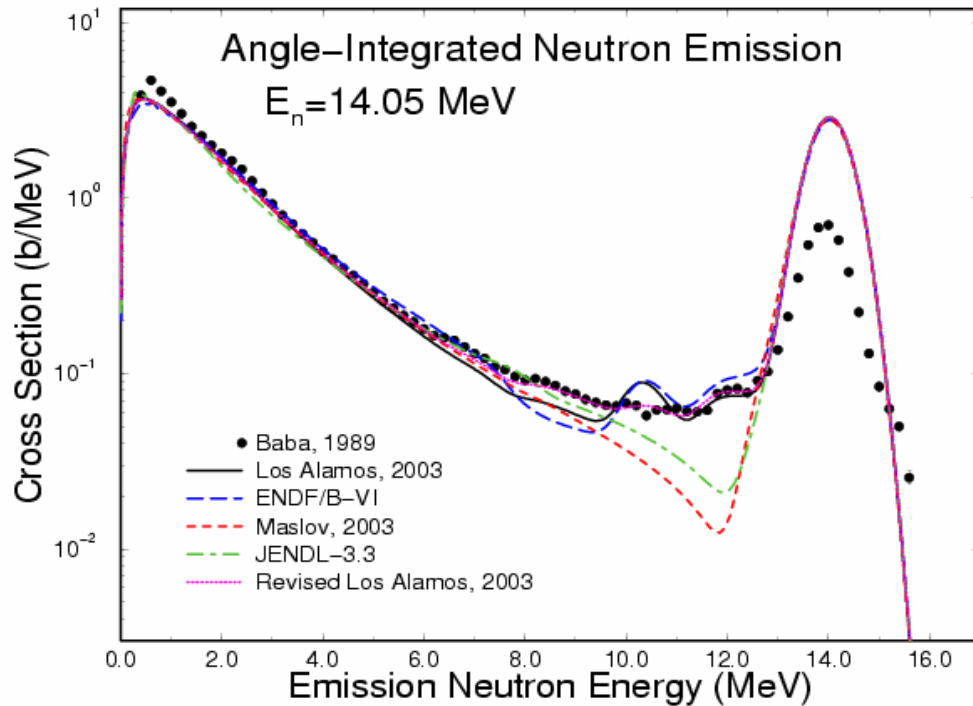


Fig. 2. Recent improvement in ^{238}U evaluation performed by LANL. New evaluation is supported by LLNL integral pulsed sphere benchmark.

Oak Ridge. ORNL is focusing on materials important for criticality safety, in particular in resolved resonance region & unresolved resonance region.

- 4 materials for neutrons: ^{19}F , $^{35,37}\text{Cl}$, ^{241}Pu
- 7 materials for neutrons together with LANL: ^{28}Si , ^{208}Pb , $^{232,233,234,235,238}\text{U}$
- Expected: 7 isotopes of Gd with covariances (in collaboration with LANL)?

Brookhaven. NNDC is focusing on fission products evaluations.

- 24 materials for neutrons (resonance + fast region), in collaboration with KAERI:
 - ^{95}Mo , ^{99}Tc , ^{101}Ru , ^{103}Rh , ^{105}Pd , ^{109}Ag , ^{131}Xe , ^{133}Cs , ^{141}Pr , $^{143,145}\text{Nd}$, $^{147,149,150,151,152}\text{Sm}$, ^{153}Eu , $^{155,157}\text{Gd}$ and $^{160,161,162,163,164}\text{Dy}$
- New BNL-325, systematic re-evaluation of resonance region by S. Mughabghab
- Recommendations for bulk of FPs (WPEC Subgroup 21 collaboration)
- Expected 5 materials: $^{70,72,73,74,76}\text{Ge}$ (for homeland security, focus on photon production, in collaboration with JAERI and IAEA)

D. Data testing

To facilitate review of new evaluations, the NNDC has setup 'Preliminary ENDF/B-VII Webpage', available for CSEWG members only. This page provides an easy access to all files, including output of checking codes, and in many cases also plots that compare evaluations with experimental data.

The last CSEWG meeting reviewed all new evaluations and addressed validation as well. In general, many promising validation results were shown primarily by LANL. Some recent results are summarized in Figs. 3,4.

Fast Critical Assembly Data Testing of ENDF Pre-VII

	Old ENDF/B-VI	New ENDF6++	k-eff C/E shown
Godiva (235U)	0.9961	0.9993	
Flattop-235U	1.0018 (bias)	1.0024	
Jezebel (239Pu)	0.9978	1.0004	
Flattop-Pu	1.0033 (bias)	1.0019	
Jezebel-23 (233U)	0.9925 (v. bad!)	0.9987	
Flattop-233U	1.0024 (bias)	0.9999	
BigTen (lots of 238)	1.0127 (v. bad!)	0.9985	

Notes:

ENDF6++ more reactive with better k-eff

233U greatly improved

238U reflection problem largely improved (flattop versus unreflected k-eff)

BigTen now much better (due to 238 inelas)

BUT: Godiva spectral index 238f/238f C/E=0.961 (calc = too soft)



Fig. 3. Fast critical assembly data testing performed by LANL.

Examples of Improved Criticality: Fast, and LEU

Fast Criticals: for 14 ICSBEP and CSEWG models of Godiva, Jezebel-Pu, Jezebel-23, Flattop-25, Flattop-Pu, Flattop-23, Bigten, only one case is outside experimental uncertainty.

Good examples HMF001 (Godiva): 0.99942 PMF001 (Jezebel): 1.00024
(Conflicting models for Flattop-25 should be reviewed)

LEU Lattices: there was a long-standing problem thought to result from U-238. For the LCT006 series, ENDF/B-VI Rel.8 gives av. value of 0.9936 with some bias vs lattice pitch.

Our new evaluations give an average of 0.9991 with very little bias. LCT001 series gives an improved average of .9982, which is within the uncertainty. The LCT002 series with a 4.31% enrichment gives an average of .9970, which may indicate some enrichment bias. *(Half of this improvement is from better high-energy data in U-238, and half comes from resonance-range & thermal capture changes).*



Fig. 4. Examples of improved criticality performed by LANL.

Plans for validation work in near future expect pretty extensive activity. In the next 6 months the evaluations will change and be 'improved' and LANL will be continually testing them in integral assembly simulations to ensure continued good performance. Main changes we will be including are:

- New standards for fission cross-sections. Impact small, because the LANL interim values now in use were a good starting point.
- New 14 MeV neutron inelastic scattering data for $^{238,235}\text{U}$ and ^{239}Pu . This should better model LLNL pulsed-spheres.
- New ^{238}U capture from the standards project (approximately 1keV - MeV energies). Again, impact modest, because our starting point is good. ORNL may change their resolved resonances for ^{238}U . We like their preliminary values, now in use.

The goal for LANL is to have these capabilities in place and tested by the next CSEWG (November 2-4, 2004).

3. Conclusions

In summary, CSEWG is actively working on validation of new ENDF/B-VII library. The current schedule assumes that the library will be released in December 2005.

There are topics of high interest such as covariance data. Covariance data were discussed at last two CSEWG meetings, though mostly as formatting issue (compact resonance Reich-Moore format). It seems that the time has come to open a broader discussion on this important topic, including recent results from WPEC SG20 on resonance covariance data and possible implications for ENDF/B-VII.