New ENDF/B-VII Library

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Abstract

We describe the current status of work on the new version of the U.S. Evaluated Nuclear Data File, ENDF/B-VII. The library, organized into 14 sublibraries, has number of improvements and extensions. In particular, there are new neutron cross section standards, considerably improved neutron cross sections for actinides, entirely new fission product neutron cross sections, improved thermal neutron scattering sublibrary, new photonuclear sublibrary, improved charged particle cross section sublibraries and other. Preliminary results of integral data testing & validation are very encouraging and it is expected that ENDF/B-VII.0 will be officially released later in 2006.

KEYWORDS: *Evaluated nuclear data file, nuclear reactions, nuclear data evaluations, nuclear data library*

1. Introduction

The Cross Section Evaluation Working Group (CSEWG) has been established in 1966 and charged to produce and maintain the U.S. Evaluated Nuclear Data File. The first version of the library, ENDF/B-I, was released in 1968 and other versions followed as summarized in Tab. 1. The current ENDF/B-VI was initially released in 1990 and had numerous updates, the last being ENDF/B-VI.8 completed in October 2001.

Table 1. Releases of the ENDF/B library

ENDF/B	I	II	III	IV	V	VI	VII
Year	1968	1970	1972	1974	1978	1990	(2006)

Since the end of 2001, the CSEWG has been working on a new release of the library, ENDF/B-VII. Three preliminary versions were distributed for testing and validation, beta0 in March 2005, beta1 in October 2005 and the current beta2 in April 2006. The library is currently under extensive benchmarking and testing. Considering encouraging performance of the library reported so far, it is expected that official release of ENDF/B-VII.0 will follow later in 2006.

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2. ENDF/B-VII beta2 Library

Testing version of the library, ENDF/B-VII beta2, was released on April 25, 2006 as shown on Fig.1 [1]. The library was issued in the ENDF-6 format, the same format as used for ENDF/B-VI. This format will be used also for the official release of the ENDF/B-VII.0 library.

Figure 1: The top web page of the National Nuclear Data Center, **www.nndc.bnl.gov**, announcing release of the ENDF/B-VII beta2 library for testing on April 25, 2006.
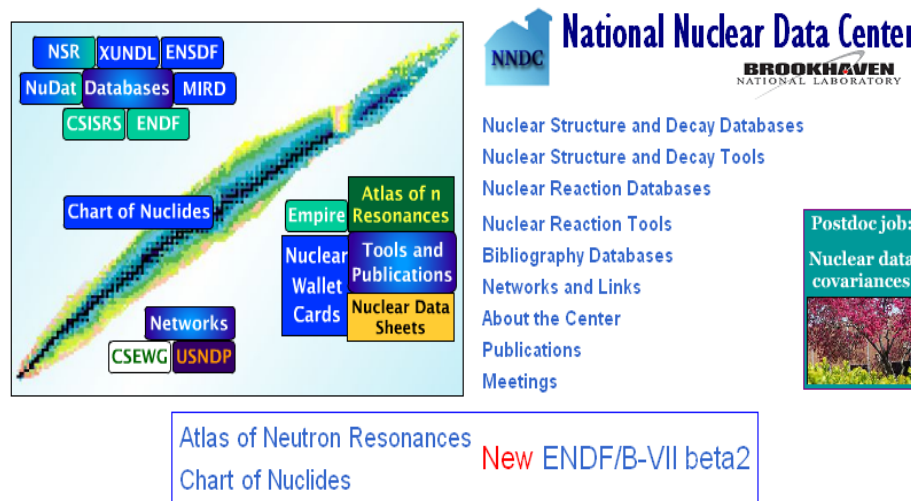
The ENDF/B-VII beta2 library contains 14 sublibraries as summarized in Table 2. Since ENDF/B-VII is no more stored on tapes, the tape containing standards had to be replaced by newly created Standards Sublibrary (NSUB=19). Two sublibraries (photonuclear, standards) can be considered as new. In 7 other sublibraries considerable updates and extensions were made, while remaining 2 fission yield and 3 atomic sublibraries were taken without any change from the current ENDF/B-VI.8.

Table 2. Sublibraries in the ENDF/B-VII beta2 library

No.	NSUB	Sublibrary	Short name	Materials in b2	Materials in VI.8	Comment
1	0	Photonuclear	g	**163**	-	**New sublibrary**
2	3	Photo-atomic	photo	**100**	100	Taken from VI.8
3	4	Radioactive decay	decay	**3830**	979	**New evaluations**
4	5	Spontan. fission yields	s/fpy	**9**	9	Taken from VI.8
5	6	Atomic relaxation	ard	**100**	100	Taken from VI.8
6	10	Neutron	n	**393**	328	**Many new evaluations**
7	11	Neutron fission yields	n/fpy	**31**	31	Taken from VI.8
8	12	Thermal scattering	tsl	**20**	15	**Some new evaluations**
9	19	Standards	std	**8**	8	**New evaluations**
10	113	Electro-atomic	e	**100**	100	Taken from VI.8
11	10010	Proton	p	**48**	35	Updated and extended
12	10020	Deuteron	d	**5**	2	Updated and extended
13	10030	Triton	t	**3**	1	Updated and extended
14	20030	He-3	he3	**2**	1	Updated and extended

Neutron cross-section standards are given in the new Standards Sublibrary (NSUB=19). These are 9 standards reactions organized in 8 files that, with the exception of C(n,n), represent new evaluations, see Table 3. Full files for these 8 materials can be found in the neutron sublibrary, all of them were adjusted to new standards.

Table 3. Neutron cross section standards (9 reactions in 8 files)

No.	Reaction	Energy range	Evaluation	Comment
1	H(n,n)	1 keV to 200 MeV	New	
2	3-He(n,p)	Thermal to 50 keV	New	
3	6-Li(n,t)	Thermal to 1 MeV	New	
4	10-B(n,α)	Thermal to 1 MeV	New	
5	10-B(n,α$_1$γ)	Thermal to 1 MeV	New	
6	C(n,n)	Thermal to 1.8 MeV	Old	Taken from VI.8
7	197-Au(n,γ	Thermal, 0.2 to 2.5 MeV	New	
8	235-U(n,f)	Thermal, 0.15 to 200 MeV	New	
9	238-U(n,f)	2 to 200 MeV	New	

The earlier testing version of the library, ENDF/B-VII beta1, still contained almost all covariance data that were in ENDF/B-VI.8. Then, in November 2005, CSEWG decided to review these covariances and take over quality data only. As a consequence, only small amount of old covariance files were migrated to ENDF/B-VII beta2, namely 26 MT files out of 371, see Table 4 [2]. A limited amount of new covariances were included in ENDF/B-VII beta2 library. The list includes 9 materials, each of which contains covariance resonance data file MF=32 that is based on Reich-Moore resonance representation:

- ^{152,153,154,155,156,157,158,160}Gd with MF = 32, 33
- ^{232}Th with MF = 31, 32, 33

Table 4. Summary of covariance files in ENDF/B-VII beta1, only small part of which migrated to ENDF/B-VII beta2 library.

MF	Quantity	Materials in ENDF/B-VII b1	Number of MT Covariance Files that migrated to ENDF/B-VII b2
31	Nu-bar	4	2 out of 7 total
32	Resonance Parameters	4	1 out of 4 total
33	Cross Sections	36	21 out of 358 total
35	Neutron Emission Spectra	1	1 out 1 total
40	Activation Cross Sections	1	1 out 1 total
	Totals	**39**	**26 out of 371 total**

2. Quality Assurance

Quality assurance represents an important feature in the development of the library. QA includes Phase 1 testing (data verification), followed by extensive Phase 2 testing

(integral data testing and validation). Data verification, as done by the NNDC and summarized in Table 4, consisted of checking, followed by processing and use of processed ACE files in basic neutronics application calculation. In addition to standard ENDF checking codes, the following codes were used:

- Processing code NJOY-99.125
- Processing code for new covariances ERRORJ (version 2006)
- Monte Carlo codes MCNP5 and MCNPX.

Table 5. Data verification of the ENDF/B-VII b2 library as performed by the National Nuclear Data Center.

No.	Sublibrary	Checking	Processing	Application
1	Photonuclear	Yes	NJOY-99.125	MCNP5
2	Photo-atomic	Yes		
3	Radioactive decay	Yes		
4	Spontaneous fission yields	Yes		
5	Atomic relaxation	Yes		
6	Neutron	Yes	NJOY-99.125	MCNP5
7	Neutron fission yields	Yes		
8	Thermal scattering	Yes	NJOY-99.125	MCNP5
9	Standards	Yes		
10	Electro-atomic	Yes		
11	Proton	Yes	NJOY-99.125	MCNPX
12	Deuteron	Yes		
13	Triton	Yes		
14	He-3	Yes		

At the time of writing the present paper (June 8, 2006), data validation of ENDF/B-VII beta2 was still underway and only preliminary results, not authorized for publication, were available.

In order to illustrate overall feelings about performance of the library we reproduce several typical statements from the testing of beta0 and beta1 versions, reported to the CSEWG meeting in November 2005 [3]:

- A.C. (Skip) Kahler and R.E. MacFarlane (LANL): "ENDF/B-VII beta1 cross-section eigenvalues for homogeneous solution systems **remain very good**."

- A.C. (Skip) Kahler and R.E. MacFarlane (LANL): "Water moderated and reflected LEU-COMP-THERM eigenvalues are **significantly improved** with ENDF/B-VII beta1 cross sections."

- C. Lubitz (KAPL): "For the ICSBEP benchmarks we examined, ENDF/B-VII beta0 performs **better than any previous** data set we are aware of."

- R. Mosteller and R. Little (LANL): "Overall, initial ENDF/B-VII produces **major improvements** relative to ENDF/B-VI and JENDL-3.3."

3. Conclusions

The five-year dedicated effort of the Cross Section Evaluation Working Group devoted to the development of the new U.S. library ENDF/B-VII.0 is nearing successful completion. Results from integral testing and validation reported so far look very encouraging. Official release of the library is expected in 2006.

Acknowledgements

References

1) CSEWG, Evaluated Nuclear Data File ENDF/B-VII beta2 test release, April 2006, see www.nndc.bnl.gov/exfor2/emdf00.htm.

2) D. Smith, Survey of Covariance Data, unpublished report, January 2006, see www.nndc.bnl.gov/csewg.

3) Minutes of the CSEWG Meeting, November 2005, see www.nndc.bnl.gov/csewg.