

# ENDF/B-VII.0 Covariances

**Donald L. Smith**

*Nuclear Engineering Division  
Argonne National Laboratory*

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# Evolution from ENDF/B-VI.8 to ENDF/B-VII.0

## ENDF/B-VI.8

Transferred most earlier-version covariance files to the ENDF/B-VII development library.

## ENDF/B-VII (Beta1)

Inspected covariances. Categorized according to perceived quality. Severely pruned existing content with intent to improve quality of ENDF/B covariances (controversial?). Added new covariances (Gd, Th, Standards ...). Bookkeeping.

## ENDF/B-VII (Beta2)

Added more new covariances (Li, Y, Tc, Ir, ...). Processed covariances with ERRORJ and PUFF. Visualized covariances. Some modifications made to new covariances (mostly in RR and URR energy regions). More bookkeeping.

## ENDF/B-VII (Beta3)

Final bookkeeping.

## ENDF/B-VII.0 !!

# Criteria for Covariances Included in ENDF/B-VII.0

- Errors and correlations had to be reasonable and to adequately represent the information upon which the evaluations were based.  
--- The accepted covariances satisfied a visualization “reality test”.
- Covariances constructed from *ad hoc* estimates of errors and correlations decoupled from core evaluation processes have been mostly eliminated and strong preference has been given to covariances generated using contemporary evaluation procedures.  
--- *Evaluation methodologies have matured beyond the subjective stage.*
- Accepted covariance matrices had to demonstrate that they could be processed and therefore would be usable for applications.
- Covariances that are represented in the files using the simplest allowable ENDF formats, consistent with the need to adequately express the uncertainty information, have been favored in order to facilitate user access, visualization, and file processing.

# Covariance File Types

<b>MF</b>	<b>Description</b>
31	Fission Neutron Multiplicity ( $\bar{\nu}$ )
32	Resonance Parameters
33	Neutron Cross Sections
34	Particle Emission Angular Distributions
35	Secondary Particle Energy Spectra
40	Production of Radioactive Nuclei

# Summary of Covariance Files

MF	<u>ENDF/B Libraries</u>				
	VI.8	VII(Beta1)	VII(Beta2)	VII(Beta3)	VII.0
31	9	9	3	3	3
32	4	4	10	10	10
33	739	739	146	218	218
34	0	0	0	0	0
35	1	1	0	1	1
40	2	1	1	1	1
Totals	755	754	160	233	233

**Note:** The file counts seen on this and other slides for MF=33 may exceed the actual number of covariance files found in ENDF/B-VII.0 because of the way that some covariance data for more than one reaction channel have been “lumped”, e.g., for Li-7 and Th-232.

# Inventory of ENDF/B-VII.0 Covariance Files (1)

**MF = 31**

**Fission Neutron Multiplicity**

Isotope	ENDF/B-VII.0 Covariance Files by MT Number
Th-232	452
U-235	452,456
Cf-252	452

**MF = 32**

**Resonance Parameters**

Isotope	ENDF/B-VII.0 Covariance Files by MT Number
Na-23	151
Gd-152	151
Gd-153	151
Gd-154	151
Gd-155	151
Gd-156	151
Gd-157	151
Gd-158	151
Gd-160	151
Th-232	151

# Inventory of ENDF/B-VII.0 Covariance Files (2)

**MF = 33**

**Neutron Cross Sections (A = 1 to 100)**

Isotope	ENDF/B-VII.0 Covariance Files by MT Number
Li-6	105,105(Std)
Li-7	1,2,4,16,24,25,51-82(All),102,104,851-859(All)
B-10	107,107(Std),800,800(Std),801,801(Std)
C-nat	2(Std)
F-19	4,16,22,28
Ti-48	1,4,16,28,102,103,107
V-nat	1
Co-59	1,16,103,107
Ni-58	16
Y-89	1,2,4,16,102,103,107
Nb-93	1
Tc-99	1,2,4,16,102,103

# Inventory of ENDF/B-VII.0 Covariance Files (3)

**MF = 33**

**Neutron Cross Sections ( $A > 100$ )**

Isotope	ENDF/B-VII.0 Covariance Files by MT Number
Gd-152	1,2,4,16,102,103
Gd-153	1,2,4,16,102,103
Gd-154	1,2,4,16,102,103,107
Gd-155	1,2,4,16,102,103
Gd-156	1,2,4,16,102,103,107
Gd-157	1,2,4,16,102,103
Gd-158	1,2,4,16,102,103,107
Gd-160	1,2,4,16,102,103,107
Ir-191	1,2,4,16,102,103
Ir-193	1,2,4,16,102,103
Au-197	1,102(Std)
Bi-209	1
Th-232	1,2,5,16,17,18,22,24,28,41,51-89(All),91,102,600,649,800,849-855(All)
U-235	18(Std)
U-238	18(Std)



# Inventory of ENDF/B-VII.0 Covariance Files (4)

**MF = 35**

**Secondary Particle Energy Spectra**

Isotope	ENDF/B-VII.0 Covariance Files by MT Number
Cf-252	18

**MF = 40**

**Production of Radioactive Nuclei**

Isotope	ENDF/B-VII.0 Covariance Files by MT Number
Nb-93	4

# Completeness of the MF = 33 Covariance Files

Isotope	Completeness
Li-6	Yellow
Li-7	Green
B-10	Yellow
C-nat	Yellow
F-19	Yellow
Ti-48	Green
V-nat	Yellow
Co-59	Yellow
Ni-58	Yellow
Y-89	Green
Nb-93	Yellow
Tc-99	Green
Gd-152	Green
Gd-153	Green

Isotope	Completeness
Gd-154	Green
Gd-155	Green
Gd-156	Green
Gd-157	Green
Gd-158	Green
Gd-160	Green
Ir-191	Green
Ir-193	Green
Au-197	Yellow
Bi-209	Green
Th-232	Green
U-235	Yellow
U-238	Yellow

 Reasonably comprehensive  
 Rather limited

# Future Work (After Release of ENDF/B-VII.0)

- More covariances are sorely needed, especially for the major actinides.
- Discontinuities in evaluation uncertainties at the RR, URR, and Fast Neutron energy boundaries need to be understood and dealt with.
- A better understanding of nuclear model parameter uncertainties and their correlations should be gained from detailed modeling studies.
- Methods used for merging subjective (e.g., model-calculated) and experimental information need more study and steady improvement.
- The experimental database (EXFOR) should be thoroughly examined to eliminate dead wood, correct errors, adjust data values for new standards, obtain improved estimates of experimental errors, etc.
- The approaches for reporting uncertainties of resonance parameters should be revisited in order to arrive at reasonable compromises between what is mathematically possible and what is practical.
- There is a need for broad ranging examination and potential overhaul of the formats that are used to represent covariance data in ENDF.
- Software to test the integrity of covariances and to enable them to be conveniently visualized should be developed for on-line use.