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The Lawrence Livermore Laboratory Evaluated Nuclear Data Library
(ENDL) Translated into the ENDF/B Format

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The Lawrence Livermore Laboratory Evaluated Nuclear Data Library
(ENDL) Translated into the ENDF/B Format

ABSTRACT

The LLL Evaluated Nuclear Data Library (ENDL) of February 15, 1975 has been translated into the ENDF/B Format. This translation is for the convenience of those persons who wish to use the ENDL data but whose main familiarity is with the ENDF/B formats and procedures. Only the portion of ENDL which deals with neutron-induced interactions (including photon production from neutron-induced reactions) has been translated.

Introduction

The Lawrence Livermore Laboratory Evaluated Nuclear Data Library (ENDL) has existed in one form or another since 1958. During these seventeen years it has undergone numerous changes in form, format, and, of course, content. The changes in form and format have come about because of changing laboratory needs and because newer and more powerful computational facilities allow for a more detailed representation of the physics. Descriptions of the current ENDL system for representing the data, the associated formats,¹ and the concomitant processing code² are available as part of the UCRL 50400 series of reports. The reason that it is possible to make relatively frequent changes in the system, formats, and processing code follows from the magnitude and convenience of the LLL computational facility, and, even more important, from the fact that the activities of the Physical Data Group are directed primarily toward the task of supplying the data needs for only one laboratory, LLL.

During the course of the past seventeen years, requests for the ENDL data have come from many places outside of LLL. These include other ERDA laboratories, DoD laboratories, other U.S. Government agencies and contractors, and universities. To comply with both the letter and the spirit of the law, the ENDL data have been made readily available, but often in a form that is unfamiliar to the requestor (and therefore inconvenient to use). While the ENDF/B system^{3,4} does not contain

provisions for some of the data representations used in ENDL, it is a relatively stable system, has been well publicized, is generally well-known, and will accomodate almost all of the data forms for neutron-induced reactions, including photon production, used in ENDL. It should be noted that the ENDF/B system allows for some data representations which are not currently used in the ENDL system.

In order to accommodate persons outside of LLL who request the ENDL data, the ENDL library has been translated into the ENDF/B format. The first version of the translated library was made available in late 1973.⁵ The version of February 15, 1974 is now available from the Radiation Shielding Information Center (RSIC), Holifield National Laboratory, P.O. Box X, Oak Ridge, Tennessee 37830.

Philosophy and Contents of ENDL

The primary responsibility of the LLL Physical Data Group is to supply the best available calculational constants for the laboratory's needs. To this end, several activities are carried out by the group: a library of experimental neutron-induced reaction data⁶⁻¹⁴ (ECSIL) is maintained; a library of evaluated data (ENDL)¹ for reactions induced by neutrons and charged particles is maintained; a processing code² is maintained which manipulates the ENDL data into the forms required for the laboratory's various neutronics, photonics, and linked neutronics-photonics codes; advanced Monte-Carlo neutronics, photonics, and linked neutronics-photonics computer programs¹⁵ are developed and maintained;

finally, a file of evaluated integral neutron experiments is maintained for data-testing purposes.

The emphasis in this section is on the philosophy and contents of the ENDL data collection, and in particular on the portion of ENDL that pertains to neutron-induced reactions, including photon production. Historically, the original ENDL data were all produced at LLL and were in that sense a private collection. However, during the past five or so years excellent evaluations that were done elsewhere have become available, especially for the light isotopes and for neutron energies less than about 1 keV. Many of these data have been incorporated into ENDL, usually with some modifications, especially for neutron energies greater than about five MeV. The bulk of the ENDL data have been produced at LLL, but whenever a new evaluation from another source has become available, it has been inspected, tested (if possible), and, if judged superior to existing ENDL data, adopted in part or *in toto*. Current plans are to continue to adopt as much useful information as possible from extra-laboratory evaluations.

Many of the evaluations contained in ENDL have not been documented in any formal way. This has been a recognized deficiency in the library but this lack of documentation is currently being remedied.¹⁶

Table I is a table of contents for the seven magnetic tapes which contain the ENDL data in the ENDF/B format. In Table I, 68 materials are listed for which complete evaluations are provided. In addition, 12 isotopes are listed for which only one or two reactions in each case

have been evaluated. Finally, a pseudo-material labeled "Crude Fission Product" is included. This pseudo-material is complete in form, but it represents only a zero-order approximation to an average fission-product. The Crude Fission-Product material is not to be taken too seriously, but for some applications it has proved to be a convenient construct.

Translation Procedures from ENDL to ENDF/B

A computer code (LTOE) was written for the CDC 7600 to translate from the ENDL to the ENDF/B form. As mentioned above, there are some quantities and some representations in ENDL for which there are no equivalent representations in the ENDF/B system. As a result of this circumstance, local and total energy deposits were not translated, and the Legendre representations of energy-angle distributions, $\pi_{\ell}(E \rightarrow E')$, were truncated at the $\ell = 0$ term. The Legendre truncation affects only the secondary-neutron distribution from the (n,2n) reaction of the deuteron.

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Table I. A listing of the magnetic tapes that contain the LLL ENDL data translated into the ENDF/B format.

LLL ENDL Data in ENDF/B Format

Tape Number 1 (13617 Card Image Records)

<u>ZA</u>	<u>Material</u>	<u>MAT Number</u>	<u>Nxγ Included</u>
0001	Neutron	7100	--
1001	Hydrogen	7101	Yes
1002	Deuteron	7102*	Yes
1003	Triton	7103	--
2003	He ³	7104	Yes
2004	He ⁴	7105	--
3006	Li ⁶	7106	Yes
3007	Li ⁷	7107	Yes
4007	Be ⁷	7108	--
4009	Be ⁹	7109	Yes
5010	B ¹⁰	7110	Yes
5011	B ¹¹	7111	Yes
6012	C ¹²	7112	Yes
7014	N ¹⁴	7113	Yes
8016	O ¹⁶	7114	Yes
9019	F ¹⁹	7115	Yes

Tape Number 2 (15181 Card Image Records)

11023	Na ²³	7116	Yes
12000	Mg ^{Nat}	7117	Yes
12024	Mg ²⁴ (Partial)	7118	No

*The energy-angle distribution of secondary neutrons from the n,2n reaction for D is represented by an energy-angle Legendre expansion in the ENDL system. No equivalent representation exists in the ENDF/B system. Consequently, the representation in the translated form is deficient.

Table I (cont')

LLL ENDL Data in ENDF/B Format

<u>ZA</u>	<u>Material</u>	<u>MAT Number</u>	<u>Nxγ Included</u>
13027	Al ²⁷	7119	Yes
14000	Si ^{Nat}	7120	Yes
15031	p31	7121	Yes
16032	S ³²	7122	Yes
17000	Cl ^{Nat}	7123	Yes
18000	Ar ^{Nat}	7124	Yes
19000	K ^{Nat}	7125	Yes
20000	Ca ^{Nat}	7126	Yes

Tape Number 3 (23403 Card Image Records)

21045	Sc ⁴⁵ (Partial)	7127	No
22000	Ti ^{Nat}	7128	Yes
23051	V ⁵¹	7129	Yes
24000	Cr ^{Nat}	7130	Yes
25055	Mn ⁵⁵	7131	Yes
26000	Fe ^{Nat}	7132	Yes
26054	Fe ⁵⁴ (Partial)	7133	No
26058	Fe ⁵⁸ (Partial)	7134	No
27059	Co ⁵⁹	7135	Yes
28058	Ni ⁵⁸	7136	Yes
29000	Cu ^{Nat}	7137	Yes
29063	Cu ⁶³ (Partial)	7138	No
30064	Zn ⁶⁴ (Partial)	7139	No
31000	Ga ^{Nat}	7140	Yes
40000	Zr ^{Nat}	7141	Yes

Table I (cont')

LLL ENDL Data in ENDF/B Format

<u>ZA</u>	<u>Material</u>	<u>MAT Number</u>	<u>Nxγ Included</u>
Tape Number 4 (15357 Card Image Records)			
40090	Zr ⁹⁰ (Partial)	7142	No
41093	Nb ⁹³	7143	Yes
42000	Mo ^{Nat}	7144	Yes
47107	Ag ¹⁰⁷	7145	Yes
47109	Ag ¹⁰⁹	7146	Yes
48000	Cd ^{Nat}	7147	Yes
48114	Cd ¹¹⁴	7148	No
49115	In ¹¹⁵ (Partial)	7149	Partial
50000	Sn ^{Nat}	7150	Yes
56138	Ba ^{Nat}	7151	Yes
63000	Eu ^{Nat}	7152	Yes
64000	Gd ^{Nat}	7153	Yes
67165	Ho ¹⁶⁵	7154	Yes
Tape Number 5 (19516 Card Image Records)			
73181	Ta ¹⁸¹	7155	Yes + N x e
74000	W ^{Nat}	7156	Yes
74186	W ¹⁸⁶ (Partial)	7157	No
75185	Re ¹⁸⁵	7158	Yes
75187	Re ¹⁸⁷	7159	Yes
77191	Ir ¹⁹¹ (Partial)	7160	No
77193	Ir ¹⁹³ (Partial)	7161	No
78000	Pt ^{Nat}	7162	Yes
79197	Au ¹⁹⁷	7163	Yes
82000	Pb ^{Nat}	7164	Yes

Table I (cont')

LLL ENDL Data in ENDF/B Format

<u>ZA</u>	<u>Material</u>	<u>MAT Number</u>	<u>Nxy Included</u>
Tape Number 6 (18465 Card Image Records)			
90232	Th ²³²	7165	Yes
92233	U ²³³	7166	Yes
92234	U ²³⁴	7167	Yes
92235	U ²³⁵	7168	Yes
92236	U ²³⁶	7169	Yes
92237	U ²³⁷	7170	Yes
92238	U ²³⁸	7171	Yes
Tape Number 7 (18359 Card Image Records)			
92239	U ²³⁹	7172	Yes
92240	U ²⁴⁰	7173	Yes
93237	Np ²³⁷	7174	Yes
94238	Pu ²³⁸	7175	Yes
94239	Pu ²³⁹	7176	Yes
94240	Pu ²⁴⁰	7177	Yes
94241	Pu ²⁴¹	7178	Yes
95242	Am ²⁴²	7179	Yes
99120	Crude Fission Product	7180	Yes

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