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Evaluated Nuclear Data Library

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FOREWORD

The UCRL-50400 series, *An Integrated System for Production of Neutronics and Photonics Calculational Constants,* describes an integrated, computer-oriented system for the production and application of neutronics and photonics calculational constants.

The system supplies reliable, up-to-date data, selects specific types of data on request, provides output in a variety of forms (ultimately in the form of input to other computer codes), and functions rapidly and efficiently.

The UCRL-50400 series comprises the following volumes:

- Vol. 1, Part A, Rev. 3, *ECSIL: A System for Storage, Retrieval, and Display of Experimental Neutron Data,* September 1976.
- Vol. 1, Part B, *Program ECSX4 (Version 78-1): Conversion of Experimentally Measured Cross-Section Data from the Four-Center-Exchange (X-4) Format to the Livermore ESCIL Format,* December 1978.
- Vol. 2, Rev. 2, *A Bibliography of the Experimental Data of Neutron-Induced Interactions,* July 1976.
- Vol. 3, Rev. 2, *An Index of the Experimental Data of Neutron-Induced Interactions,* July 1976.
- Vol. 4, Rev. 1, *Evaluated Nuclear Data Library,* September 1981.
- Vol. 5, Part A, Rev. 1, *CLYDE: A Code for the Production of Calculational Constants from Nuclear Data,* September 1975.
- Vol. 5. Part B, Rev. 1, *Relativistic Transformations between Center-of-Mass and Laboratory Systems for Two-Body Nuclear Reactions,* April 1978.
- Vol. 6, Rev. 2, *Tables and Graphs of Photon-Interaction Cross Sections from 1 keV to 100 MeV,* December 1978.
- Vol. 7, Part A, Rev. 1, *Major Neutron-Induced Interactions ($Z \leqslant 55$): Graphical, Experimental Data,* July 1976.
- Vol. 7, Part B, Rev. 1, *Major Neutron-Induced Interactions ($Z > 55$): Graphical, Experimental Data,* July 1976.
- Vol. 8, Part A, Rev. 1, *Supplemental Neutron-Induced Interactions ($Z \leqslant 35$): Graphical, Experimental Data,* July 1976.
- Vol. 8, Part B, Rev. 1, *Supplemental Neutron-Induced Interactions ($Z > 35$): Graphical, Experimental Data,* July 1976.
- Vol. 9, *Thresholds of Nuclear Reactions Induced by Neutrons, Photons, Deuterons, Tritons, and Alpha Particles,* September 1970.
- Vol. 10, Rev. 1, *Tabulated Experimental Data for Neutron-Induced Interactions,* July 1976.
- Vol. 11, *Experimental Data, Indexes, and Techniques of Obtaining a Selected Set of Neutron Resonance Parameters,* May 1972.
- Vol. 12, *An Atlas of Resolved Neutron Resonance Parameters,* July 1972.
- Vol. 13, *An Atlas of Unresolved Neutron Resonance Parameters,* September 1972.
- Vol. 14, *TARTNP: A Coupled Neutron-Photon Monte Carlotransport Code,* February 1976.
- Vol. 15, Part A, *The LLL Evaluated-Nuclear-Data Library (ENDL): Evaluation Techniques, Reaction Index, and Descriptions of Individual Evaluations,* September 1975.
- Vol. 15, Part B, Rev. 1, *The LLL Evaluated-Nuclear-Data Library (ENDL): Graphs of Cross Sections from the Library,* October 1978.
- Vol. 15, Part C, *The LLL Evaluated-Nuclear-Data Library (ENDL): Translation of ENDL Neutron-Induced Interaction Data into the ENDF/B Format,* April 1976.
- Vol. 15, Part D, Rev. 1, *The LLL Evaluated-Nuclear-Data Library (ENDL): Descriptions of Individual Evaluations for Z= 0–98,* May 1978.
- Vol. 15, Part E, *Data Testing Results for the LLL Nuclear Data Library (ENDL-78),* August 1979.

- Vol. 15, Part F, *Experimental and Evaluated Elastic Nuclear Plus Interference Cross Sections for Light Charged Particles*, July 1980.
- Vol. 16, Rev. 2, *Tabular and Graphical Presentation of 175 Neutron-Group Constants Derived from the LLL Evaluated-Nuclear-Data Library (ENDL)*, October 1978.
- Vol. 17, Part A, Rev. 2, *Program LINEAR (Version 79-1): Linearize Data in the Evaluated Nuclear Data File/Version B (ENDF/B) Format*, October 1979.
- Vol. 17, Part B, Rev. 2, *Program SIGMA1 (Version 79-1): Doppler Broaden Evaluated Cross Sections in the Evaluated Nuclear Data File/Version B (ENDF/B) Format*, October 1979.
- Vol. 17, Part C, *Program RECENT: Reconstruction of Energy-Dependent Cross Sections from Resonance Parameters in the ENDF/B Format*, October 1979.
- Vol. 17, Part D, *Program GROUPIE: Calculation of Self-Shielded Cross Sections and Multiband Parameters from Evaluated Data in the ENDF/B Format*, 1980.
- Vol. 17, Part E, *Program EVALPLOT: Plot Data in the Evaluated-Nuclear-Data File/Version B (ENDF/B) Format*, February 1979.
- Vol. 17, Part F, *DOWNER (Version 79-1): Group Collapse Cross Section and Transfer Matrices*, January 1979.
- Vol. 18, *ACTL: Evaluated Neutron Activation Cross-Section Library*, October 1978.
- Vol. 19, *Neutron-Induced Angular and Energy Distributions: Graphical Experimental Data*, April 1977.
- Vol. 20, *Bonderenko Self-Shielded Cross Sections and Multiband Parameters Derived from the LLL Evaluated-Nuclear-Data Library (ENDL)*, July 1978.
- Vol. 21, Part A, *Maxwell-Averaged Reaction Rates* $\langle\sigma v\rangle$ *for Selected Reactions between Ions with Atomic Mass* $\leqslant 11$, February 1979.
- Vol. 21, Part C, *Program SIGMAL (Version 79-1): Doppler-Broaden Evaluated Cross Sections in the Livermore-Evaluated Nuclear Data Library (ENDL) Format*, March 1979.
- Vol. 22, *GAMIDENT: A Program to Aid in the Identification of Unknown Materials by Gamma-Ray Spectroscopy*, January 1980.
- Vol. 23, *ENSL and CDRL: Evaluated Nuclear Structure Libraries*, February 1981.
- Vol. 24, *Thresholds and* $\underline{Q}$ *Values of Nuclear Reactions Induced by Neutrons, Protons, Deuterons, Tritons,* ^3He *Ions, Alpha Particles, and Photons*, March 1981.

ORIGINAL

CONTENTS

EVALUATED NUCLEAR DATA LIBRARY

ABSTRACT

The Lawrence Livermore National Laboratory (LLNL) collection of evaluated data for neutron-, photon-, and charged-particle-induced reactions is maintained in a computer-oriented system. In this report we recount the history of Evaluated Nuclear Data Library, describe the methods of evaluation, and give examples of input and output representation of the data.

INTRODUCTION

The LLNL Evaluated Nuclear Data Library has existed since 1958, in a succession of forms and formats. In its earliest form it was a series of internal memos containing tabulations of cross sections and angular distributions for a few isotopes to be used in neutronics calculations. It was soon found that some type of mechanization should be undertaken both for efficiency and for convenience. Thus, in rapid succession, the library went through stages of punched card and punched paper-tape, and then to the first magnetic-tape BCD card image form. Of course, once the library was in one computer-readable form, it could be translated with relative ease to another computer-readable form. It is currently maintained as a CRAY-1 binary-mode file and contains data for neutron-induced reactions, photon interactions with matter, and charged-particle-induced nuclear reactions. Ten different particles are presently defined. More can be added as needed. The data are made available on magnetic tape in a transmission format described in Appendix A. Those who wish to use the binary file will find its layout described in the fourth section of this report.

Plots and listings of the library are produced routinely. The angular distributions are normalized to unity in the binary form of the library so that renormalization is not necessary if the cross section is changed. The plot of the angular distribution for a given energy is normalized so that 2π times the integral over the cosine of the scattering angle is the cross section for the reaction at that energy. This method of plotting has been found to be the most convenient one for checking purposes. Neither the total cross section nor the nonelastic cross section is carried in the binary form. They are constructed, however, in the computer code that produces the listing, and are presented in a convenient tabular form. The energy mesh with which they are presented is the logical sum of the meshes used for the various interaction cross sections.

All quantities in the library are entered in such a way that linear interpolation is appropriate; hence, the resulting total and nonelastic cross sections are likewise linearly interpolable. Plots are presented for each reaction, with one decade of energy per graph. This permits use of a scale for the ordinate that is appropriate for the energy decade and the reaction being presented. The scale, which is chosen automatically, depends upon the maximum and minimum values of the dependent variable in the energy decade. If the variation between the maximum and minimum values is extreme, a logarithmic scale is used, but the line that is drawn by the computer is derived by linear interpolation between successive library entries.

A table of contents for the Evaluated Nuclear Data Library is produced by computer (see Appendix B). It lists the various aspects of each reaction contained in the library, together with the date of the most recent change in the data for each aspect of the reaction: i.e., the cross sections, angular distributions, energy distributions, average energy of a secondary particle, etc. The labeling of the table of contents is in accordance with the definitions of the conventions used in the input format described in the third section of this report. The first page of the table of contents identifies the specific version, edition, and year of the library, as well as the installation originating the library and the date of the most recent change. Both the UK and ENDF/B libraries have been translated into the LLNL system, so it is a convenience to have the identification of the originating installation explicitly stated. Sample pages of the table of contents are presented in Appendix B.

Libraries are identified by a version number, and successive editions of a version have consecutive edition numbers.

CONVENTIONS AND METHODS OF EVALUATION

The basic principle adhered to in evaluations done at LLNL is to present the maximum information content in as simple a form as possible. All interpolable quantities for neutron-induced reactions are presented so that linear interpolation between successive entries yields values that are consistent with stated experimental errors, where experiments exist, or that adhere to an assumed law, such as 1/v energy dependence, within a small fraction (typically 1%). In the case of an assumed energy-dependence law for cross sections, this is accomplished by creating a large number of (energy, cross section) pairs by computer and subsequently thinning the points to a specified accuracy, using the subroutine THINER.[1]

Although a linear interpolation requires more entries to describe some data than would a log-log or semilog interpolation, there are two advantages to using a linear interpolation: (1) It eliminates a source of clerical error in defining the data in the library. (2) More importantly, the code[2] that uses the evaluated library for input must perform integrals of the products of functions. If the functions are represented linearly, many of the necessary integrations can be done analytically by using the theorem in Ref. 3 rather than an approximating method.

All angular distributions are differential probabilities normalized to an integral of unity over the cosine of the scattering angle. All energy distributions of secondary particles are presented as normalized Legendre polynomial representations $\pi^{\ell}(E \rightarrow E')$. For most multibody reactions, only the $\pi^{0}(E \rightarrow E')$ term is given.

Angular distributions are entered into the library in an energy mesh fine enough for a linear interpolation in energy at each cosine value. The linear interpolation will construct an acceptable angular distribution at an intermediate energy. Since two successive energy entries may require different cosine meshes, each distribution can be expanded to a common cosine mesh, the logical sum of the meshes used for the two distributions. The interpolation is carried out on energy at each resultant cosine mesh point to obtain the angular distribution at the intermediate energy. The resultant distribution is then thinned, using the subroutine THINER.[1] The integrals of the input angular distributions are normalized to unity, so the resulting interpolated angular distribution will be properly normalized before thinning. After thinning, its integral is renormalized to unity.

Energy distributions are normalized so that the integral over the secondary energy of the zero-order, energy-angle Legendre coefficients, $\pi^{0}(E \rightarrow E')$, is unity. Interpolation in incident energy is accomplished by first making a transformation to unit bases in each energy distribution array[4] and then renormalizing the probability to its original area. Linear interpolation in incident energy in the transformed distributions will preserve linearity in the area of the interpolated distribution. The area is then transformed back into the real coordinate system, using the base appropriate to the incident energy for which the interpolation was done.

The testing of evaluated data sets is carried out routinely by calculating the appropriate parameters of integral neutron experiments and comparing the calculations with experimental results. The calculations are carried out by the TARTNP Monte Carlo code.[5] The parameters most often calculated are the neutron multiplication constant (k_{eff}), the secondary neutron energy leakage spectra from critical assemblies, and the neutron or photon spectra from pulsed spheres.[6] Because of the possibility or even likelihood of compensating errors, such calculations cannot ensure the validity of the nuclear data even if the calculations agree with the experiments. They can, however, indicate the invalidity of the data if they do not agree with the experiments. On the other hand, if calculations for many disparate integral experiments all show reasonable agreement with the measurements, one can feel that the evaluations are adequate for neutron transport calculations. This procedure does not provide a means for assessing the validity of the same data sets for activation analysis or other nontransport purposes.

The methods used to produce an evaluated data set for neutron data are described in Vol. 15A of this series. Evaluations for specific materials are described in Vol. 15D, Rev. 1.

ENCODING SYSTEM AND INPUT FORMAT FOR THE LLNL EVALUATED NUCLEAR DATA LIBRARY

The current encoding system for the LLNL Evaluated Nuclear Data Library is based, in large part, on experience with the LLNL experimental neutron cross-section library.[7] Table 1 shows the information that is general to the entire library. Units are b (barns), MeV, sr (steradians), and sh (shake; 1 shake = 10^{-8} s) except if noted otherwise.

The layout of the binary file is explained in the fourth section of this report, but the following brief description of the organization of the file is presented here. The data for each nucleus are treated separately with appropriate header information. The properties of a given nuclear reaction--e.g., integrated cross sections, angular or energy-angular distributions, etc.--are filed together. Thus, the system is oriented to the complete definition of a nuclear reaction, with the reactions appropriate to a particular target nucleus filed together. This is in contrast to other systems in which all integrated cross sections for a nucleus are filed together.

Both the incident particle, y_i, and the outgoing particle of interest, y_o, are designated according to the dictionary in Table 2. The appropriate property of the nuclear reaction is defined by the I number (Table 3). The nuclear reaction is identified by the C number (Table 4). Any limitation or restriction placed upon the nuclear reaction is designated by an S number (Table 5). Field definitions are given in Table 6.

TABLE 1. Input information for the LLNL Evaluated Nuclear Data Library.

Incident and emitted particles	Energy range (MeV)	Interpolation method
Neutrons	10^{-10} to 20	Linear-linear basis
Photons	10^{-3} to 100	Linear, on a log-log basis (except for some transfer data)
Charged particles	10^{-10} to 20	Linear-linear basis

TABLE 2. Particle designator, y.[a]

y	Particle
0	Not applicable[b] or none
1	n
2	p
3	d
4	t
5	^{3}He
6	α
7	γ
8	β^{+}
9	β^{-}
10	EC
11	n as residual nucleus
12	p as residual nucleus
13	d as residual nucleus
14	t as residual nucleus
15	^{3}He as residual nucleus
16	α as residual nucleus

[a]Used to identify both the incident particle, y_i, and the outgoing particle, y_o, to which any distribution data (e.g., energy, angle) pertain: y_i = 0 - 7 only; y_o = 0 - 16.

[b]If no property (e.g., energy distribution) is given, the y_o is zero or left blank in input. If y_i is zero or blank, the data that follow are nuclear structure data.

TABLE 3. Reaction property designator, I.[a]

I	Reaction property	Definition
0	Integrated cross sections (b)	$\sigma(E)$
1	Angular distributions, normalized probabilities (per unit cosine)[b]	$P(E,\mu)$
4	Energy-angle distributions, normalized Legendre coefficients. $\pi^0(E \rightarrow E') = p(E \rightarrow E')$, the usual normalized energy probability (per MeV)	$\pi^\ell(E \rightarrow E')$
7	Average number of neutrons per fission (prompt or delayed)	$\nu(E)$
8	Histogram form of energy distribution (MeV)	$\int P(E,E')dE'$
9	Photon or particle multiplicity	$M(E)$
10	Average energy of a secondary particle (MeV)	$\bar{E}'(y_o,E)$
11	Average energy of a residual nucleus (MeV)	$\bar{E}'(R,E)$
80	Maxwell average reaction rates (b-cm/sh)	$\overline{\sigma v}(kT)$
81	In-flight (Doppler-broadened) cross sections (b)	$\sigma(kT,E)$
84	Maxwell-averaged energy distributions (per MeV)	$P(kT,E')$
90	Maxwell-averaged total average energy of particle (MeV)	$\bar{E}'(y_o,kT)$
91	Maxwell-averaged average energy of residual	$\bar{E}'(R,kT)$
92	Maxwell-averaged total average energy of reacting particles (MeV)	$\bar{E}(y_i,kT)$

[a]We illustrate the use of these designations by constructing a reaction code for the energy distribution of protons from the $^{58}Ni(n,n'p)^{57}Co$ reaction:

Incident particle:	y_i =	01 (neutron)
Reaction property:	I =	04 (energy dist.)
Reaction type:	C =	20 (n,n'p)
Outgoing particle whose property is recorded:	y_o =	02 (proton)
Reaction modifier:	S =	00 (no x-field data)
Q0 of reaction:	Q0 =	-8.02

This gives for the reaction code

y_i	I	C	y_o	S	Q0	X_1
01	04	20	02	00	-8.02	0.0.

[b]Angular data are expressed in the center-of-mass (cm) system for all two-body breakups. Multibody breakups are, of course, in the Laboratory system.

TABLE 4. Reaction identifier C, for I-values of 0 through 98.

Kind of data	C	Reaction type
Miscellaneous	1	Total[a]
	2-7	Unassigned
	8	Large-angle coulomb scattering
	9	Nuclear elastic plus interference
	10	Elastic
Neutrons + gammas only	11	$(y_i, n'\gamma)$
	12	$(y_i, 2n\gamma)$
	13	$(y_i, 3n\gamma)$
	14	$(y_i, 4n\gamma)$
	15	(y_i, Xf) total fission
	16-19	Unassigned
Neutrons + charged particles + gammas	20	$(y_i, n'p\gamma)$
	21	$(y_i, pn'\gamma)$
	22	$(y_i, n'd\gamma)$
	23	$[y_i, n'd\alpha(\alpha)]$
	24	$(y_i, n't\gamma)$
	25	$(y_i, n'\,{}^3He\gamma)$
	26	$(y_i, n'\alpha\gamma)$
	27	$[y_i, n'2\alpha(\alpha)]$
	28	$[y_i, n't\alpha(\alpha)]$
	29	$(y_i, 2np)$
	30	$(y_i, \gamma n\alpha)$
	31	$[y_i, 2n\alpha(\alpha)]$
	32-36	Unassigned
Charged particle and/or gamma formation	37	$[y_i, 2\alpha(\alpha)]$
	38	$[y_i, {}^3He\alpha(\alpha)]$
	39	$[y_i, pt(\alpha)]$
	40	$(y_i, p\gamma)$
	41	$(y_i, d\gamma)$
	42	$(y_i, t\gamma)$
	43	$[y_i, t\alpha(\alpha)]$

TABLE 4. (Continued.)

Kind of data	C	Reaction type
	44	$(y_i, {}^3He\gamma)$
	45	$(y_i, \alpha\gamma)$
	46	(y_i, γ)
	47-49	Unassigned
Particle or gamma production	50	(y_i, Xp)
	51	(y_i, Xd)
	53	(y_i, X^3He)
	54	$(y_i, X\alpha)$
	55	$(y_i, X\gamma)$
	56	(y_i, Xn)
	57	$(y_i, X\beta^-)$
	58-64	Unassigned
	65	Activation (undefined reaction)
	66-69	Unassigned
Photon interaction with cold material	70	Total[a]
	71	Coherent scattering
	72	Incoherent scattering
	73	Photoelectric
	74	Pair production
	75-79	Unassigned
	80-98	Unassigned

[a]Not stored in the system but obtained for output display and transmission format by combining other data.

TABLE 5. Reaction modifier, S.

S	Reaction parameter	X field definition
00 or blank	No X-field data	--
01[a]	Level excitation	W_i (MeV)
02	2nd particle from time sequential reaction	W_i (MeV)
03	Gamma-ray production	E_γ(MeV)
05[b]	Activation	$(ZA)_2$,W_2(MeV), half-life (s)
07	Delayed group half-lives	$\tau_{1/2}$(s)
08	Completely correlated n,2n	W_1(MeV)
10	Wide level exci- tion	W_1(MeV), Γ_1(MeV)
11	Second particle from wide level time-sequential reaction	W_2(MeV), Γ_2(MeV)
13[c]	Photon production from known level excitations	W_1(MeV), E_γ(MeV)

[a]X_1 corresponds to the initial nucleus, X_2 to the second nucleus in a sequence of de-excitations, etc.

[b]$(ZA)_2$ = 1000*Z_2 + A_2 of product nucleus.

[c]W_1 corresponds to the level excitation energy, and E_γ is the energy of the photon.

TABLE 6. Field definitions for input data (4E11.4 format with one set of data per record).[a]

Reaction property	I	Data stored in field 1	2	3	4
Integrated cross sections	0	E	$\sigma(E)$	--	--
Angular distributions	1	E	μ	$P(E,\mu)$	--
Energy-angle Legendre coefficients	4	E	E'	ℓ	$\pi^{\ell}(E \rightarrow E')$
Nu-bar	7	E	$\nu(E)$	--	--
Histogram energy distribution	8	E	E'_1	$\int_{E'_1}^{E'_2} P(E,E')dE'$	--
Gamma-ray multiplicity	9	E	$M(E)$	--	--
Total average energy of particle	10	E	$E'(y_o,E)$	--	--
Average energy of residual	11	E	$E'(R,E)$	--	--
Maxwell-averaged reaction rates	80	kT	$\sigma v(kT)$	--	--
In-flight cross sections	81	kT	E	$\sigma(kT,E)$	--
Maxwell-averaged energy distributions	84	kT	E'	$P(kT,E')$	--
Maxwell-averaged total average energy of particle	90	kT	$\overline{E}'(y_o,kT)$	--	--

TABLE 6. (Continued.)

Reaction property	I	Data stored in field 1	2	3	4
Maxwell-averaged average energy of residual	91	kT	$\bar{E}'(R,kT)$	--	--
Maxwell-averaged total average energy of reacting particles	92	kT	$\bar{E}(y_i,kT)$	--	--

[a]For certain applications, it is desirable to combine all reactions leading to a specific residual nucleus. Provision for such "activation" cross sections is made. For example, the (n,n'd) and (n,t) reactions both lead to the same residual nucleus, and the sum of the cross sections for these reactions may be entered, as with the following example:

^{70}Zn(n,n'd + n,t)^{68}Cu to the ground state with a half-life of 32 s.
Incident particle: y_i = 01 (neutron).
Reaction property: I = 00 (integrated cross section).
Reaction type: C = 65 (activation).

Outgoing particle whose property is recorded:
y_o = 00 (not applicable since no property of a secondary particle is given).

Reaction modifier:
S = 05 (activation).

Z_2A_2:
Z_2A_2 = 29068. (X_1 field).

W_2:
w_2 = 0. (X_2 field).

τ_2:
τ_2 = 32. (X_3 field).

For the reaction code this gives

y_i	I	C	y_o	S	Q0	X_1	X_2	X_3
01	00	65	00	05		29068.	0.	32.

THE BINARY-MODE EVALUATED LIBRARY

This section presents the layout of the binary library file and instructions for using the UPDATE code, which modifies the binary file as required or retrieves parts of the library as specified. Retrievals are output in the BCD record input format described in the section on encoding and input format. UPDATE is written in LRLTRAN and, as described here, can be run on the CRAY-1 computer at LLNL.

The code reads either the delete and insert records or the retrieval request records. A retrieval cannot be made during a run that deletes or inserts data. The format of the input records is the same for deletion and retrieval except for a flag designating the type of operation.

For either deletion or retrieval two sets of three records each are required to define the range of data to be deleted or retrieved. Data may be deleted or retrieved for any number of ranges, but each range must be defined by the two sets of three records. The first record of each set (target record) specifies the limits of the range of isotopes or elements (using the 1000*Z + A convention described in the third section of this report), the incident and secondary particles of interest, and the type of operation to be performed (i.e., retrieval or deletion). The second record of each set (reaction record) specifies the limits of the range of reaction descriptors, and the third record of each set (data record) gives the limits of the energy range of the independent variables for which the deletion or retrieval is to be performed. The specification of the fields of these cards can be found in Table 7, for the first two cards of each set. For the third card, the formats and specifications are described in Table 6.

There are several special types of deletions:

1. To delete an entire isotope or element (ZA), set $C_{min} = 1$, $C_{max} = 99$. All other fields of the reaction record and data record may be left blank.

2. To delete a particular reaction (C) or a range of reactions, set:

C_{min} = minimum C to be deleted,

C_{max} = maximum C to be deleted,

$I_{min} = 0$,

$I_{max} = 99$.

All other fields must be set to the minimum-maximum range desired.

TABLE 7. Record layout for retrieving, deleting, or inserting.

	Columns	Format	Name	Description
Record 1	1-6	I6	ZA	1000*Z + A
	8-9	I2	y_i[a]	Incident particle descriptor
	11-12	I2	y_o[a]	Outgoing particle descriptor
	14-24	E11.4	A[b]	Atomic mass for this ZA (amu)
	26-31	I6	Date[b]	Current date (YYMMDD)
	33-34	I2	Flag	Designates the type of operation: 1 = delete, 2 = insert, 3 = retrieve.
	36-46	E11.4		Level energy of the target (MeV)
	48-58	E11.4		Half-life of the target[b] (s)
Record 2	1-2	I2	C[a]	Reaction number
	3-5	I3	I[a]	Reaction property designator
	6-8	I3	S[a]	Reaction modifier flag
	10-20	E11.4	Q0[a]	Mass difference Q for the reaction
	22-32	E11.4	X_1[a]	Value depends upon the value of S.
	34-44	E11.4	X_2[a]	Value depends upon the value of S.
	46-56	E11.4	X_3[a]	Value depends upon the value of S.

[a]A more complete definition of these fields can be found in Tables 2-5.
[b]Does not need to be specified for retrieving or deleting. Half-life of the target must be specified only when the material is entered for the first time.

3. To delete all of a particular reaction property designator (I), leave both data records blank. All other fields must be set to the minimum-maximum range desired.

If the limits specified by the delete request cannot be satisfied, a comment is printed and the code continues. The data sets representing deletions and insertions may be in any order in the input file. The code sorts the sets, performs the deleting operations, and then inserts new data, one target at a time.

If data are to be inserted into the library, the first two records (the target and reaction records) must be as described in Table 7. These records determine the point in the library at which insertions are to be made. The third and following records are data records containing the data to be inserted; they are specified with respect to the format and content described in Table 6. Following the last record of each data set to be inserted is a record with the number 1 in column 72. There is no limit to the number of data records, but angular distributions may have no more than 201 entries for each incident energy. Whenever appropriate, data are merged with existing data, but if equal points are encountered in the merge, they are printed out with the original data left in the library. The code then proceeds. If a match cannot be made between the specifications stated on the first two records of a set to be inserted and those found on the evaluated library, a new isotope (ZA), a new reaction (C), a new reaction modifier (S), any of the X_i fields, or a new reaction property designator (I) is created to fulfill the required specifications. Insert requests are read by the code until it senses an end of file, which signals the code to begin processing the requests.

There is no limit to the number of delete and insert requests that can be present.

Although the significance of making an entry for the outgoing particle is discussed in the third section of this report, it is well to re-emphasize that an entry is made for that quantity if, and only if, the data being described pertain to the outgoing particle. For example, the cross section for an (n,n'p) reaction would be entered without specifying an outgoing particle, while an energy distribution of the resulting neutrons would require an entry of 1 for the y_o (outgoing particle) and an energy distribution for the resulting protons would require a 2 for the y_o. With this feature it is possible to specify completely all aspects of reactions having more than one type of emergent particle.

There are several different forms of printout from the code that tell the user what has been done. The order of the output is as follows:

1. The evaluated library identification word from the input library is decoded and printed with appropriate labels describing the meaning of each quantity. This is followed by the date for this library.

2. The delete and insert requests or the retrieve requests are printed as they were read from the input cards.

3. A printout is made showing the computer time used to process this update.

LAYOUT OF THE ENDL BINARY FILE

Word 0 LIBID - $LIBTYP*10^8 + INST*10^6 + IYEAR*10^4 + IEDIT*10^2 + IVERS$

where

LIBTYP = 1 for incident neutrons,
2 for incident gammas,
3 for hot photons,
4 for charged particles,
5 for activation;

INST = 1 for LLNL,
2 for AWRE,
3 for ENDF/B;

IYEAR = year;

IEDIT = edition;

IVERS = version number.

Word 1 LIBDATE--an integer of the form yymmdd.

Word 2 ISONUM--the number of materials in library.

Words 3-2002--The library directory.

The first 400 words of the directory are reserved for material numbers (ascending ZA). This block is followed by blocks of 400 words reserved for corresponding excitation levels, abundances (not currently used), temperatures (not currently used), and first-word addresses of the materials in the material data section.

Word 2004--The beginning of the material data.

For each material there is a directory of available data, followed by the data. The format of the directory is:

[LOCZA=1]	NNZA (1000*Z+A).
[LOCATM=2]	ATM - atomic mass (exact).
[LOCLEV=3]	ELEVEL - excitation level.
[LOCLIFE=4]	HAFLYF - half-life in seconds (stable=infinite=10^{50} s).
[LOCHDSZ=5]	RPDATE/NWD - date of latest update and size of directory . Date ends in bit18; size ends in bit0.
[LOCDATSZ=6]	NDATSYZ--the number of data words following the directory.
[LOCNUMC=7]	NUMC--the number of reactions described.
[LOCCI=8]	The C number of the first reaction. Starting at LOCCI there will be NUMC pairs of words. The first is the C number of the reaction, the second the FWA in the directory of further descriptions and addresses..
[LOCINUM=LOCCI+2*NUMC]	NUMI - number of reaction properties described for CI. Starting at LOCINUM there will be, for each C, a block containing the number of reaction properties, followed by NUMI*4 words. The first of each four word set is a reaction property identifier (RPID), the second is the FWA in the C block of further descriptions and addresses, and the third and fourth are the minimum and maximum energies for which there are data. The reaction property descriptor is formatted as $I*10^8 + y_o*10^6$ +integer date (yymmdd).

The first C block within the material directory starts at LOCINUM + NUMC + NUMI *4. The storage hierarchy for each material is y_i, C, S, Q0, X1, X2, X3, y_o, I.

DIAGRAM OF LAYOUT OF ENDL LIBRARY (BINARY FILE)

LIBID
LIBDATE
ISONUM

Materials list

Excitation levels

Abundances

Temperatures

FWA's

Directory for
first material

Data for first
material

Directory for
second material

Data for
second material

Directory for
last material

Data for
last material

Library name

DIAGRAM OF LAYOUT OF MATERIAL DIRECTORY

```
LOCZA      NNZA
LOCATM     ATM
LOCLEV     ELEVEL
LOCLIFE    HAFLYF
LOCHDSZ    RPDATE/NWD
LOCDTSZ    NDATSYZ
LOCNUMC    NUMC

LOCCI      C1
           FWA C1

           C2
           FWA C2

           Clast
           FWA Clast

LOCINUM    NUMI C1

           RPID C1I1
           FWA C1I1
           EMIN
           EMAX

           RPID C1I2
           FWA C1I2
           EMIN
           EMAX

           RPID C1Ilast
           FWA C1Ilast
           EMIN
           EMAX

           NUMI C2

           RPID C2I1
           FWA C2I1
           EMIN
           EMAX

           RPID C2I2
           FWA C2I2
           EMIN
           EMAX

           RPID C1Ilast
           FWA C2Ilast
           EMIN
           EMAX
```

```
NUMI Clast

RPID ClastI1
FWA ClastI1
EMIN
EMAX

RPID ClastI2
FWA ClastI2
EMIN
EMAX

RPID ClastIlast
FWA ClastIlast
EMIN
EMAX

Beginning
   of
C blocks
```

DIAGRAM OF LAYOUT OF C BLOCKS

FWA in
data section
of data for
this C

LWA in
data section
of data for
this C

y_i

Cdate

S

Q0

X1

X2

X3

Unused

Unused

I Block
for I1

I Block
for I2

I Block
for Ilast

LAYOUT OF REACTION PROPERTY (I) BLOCKS

Each reaction property is described differently, requiring from two to many words to point to the proper position in the data section.

I = 0 Reaction Cross Sections

FWA for I = 0
LWA for I = 0

I = 1 Angular Distributions

FWA for I = 1
LWA for I = 1
Maximum number of [μ, p(μ)] pairs
Number of incident energies
  FWA of data for 1st incident energy
  FWA of data for 2nd incident energy
  .
  .
  .
  FWA of data for last incident energy

I = 4 Energy-angle Legendre coefficients

FWA for I = 4 data
LWA for I = 4 data
Maximum order of ℓ
Maximum number of incident energies/ℓ
Maximum number of target energy-probability pairs per incident energy
  FWA for ℓ = 0 data
  FWA of data for first incident energy
  .
  .
  .
  FWA of data for last incident energy
  FWA for ℓ = 1 data
  .
  .
  .
  FWA for maximum order ℓ data
  number of incident energies for this ℓ
  FWA of data for first incident energy
  .
  .
  .
  FWA of data for last incident energy

I = 7 Average neutrons per fission (prompt or delayed)

FWA for I = 7
LWA for I = 7

I = 8 Histogram form of energy distribution

FWA for I = 8 data
LWA for I = 8 data
Maximum number of (E1,E2,P(E,E1) = P(E,E2)) sets
Number of incident energies
  FWA of data for first incident energy
  FWA of data for second incident energy
    .
    .
    .
  FWA of data for last incident energy

I = 9 Multiplicities

FWA for I = 9
LWA for I = 9

I = 10 Average energy in outgoing particle

FWA for I = 10
LWA for I = 10

I = 11 Average energy of residual nucleus

FWA for I = 11
LWA for I = 11

I = 80 Maxwellian average reaction rates

FWA for I = 80
LWA for I = 80

I = 81 In-flight reaction cross sections

FWA for I = 81
LWA for I = 81
Maximum number of [E, sigma(E)] pairs
Number of incident temperatures
  FWA of first incident temperature
  FWA of second incident temperature
    .
    .
    .
  FWA of last incident temperature

I = 84 Maxwell-averaged energy distribution from thermal equilibrium reactions

FWA for I = 84
LWA for I = 84
Maximum number of (E,P(E)) pairs

Number of incident temperatures
FWA of first incident temperature
FWA of second incident temperature
.
.
.
FWA of last incident temperature

I = 90 Maxwell-averaged total average energy of particle

FWA for I = 90
LWA for I = 90

I = 91 Maxwell-averaged energy of residual

FWA for I = 91
LWA for I = 91

I = 92 Maxwell-averaged total average energy of reacting particles

FWA for I = 92
LWA for I = 92

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HJK/ca

APPENDIX A

TRANSMITTAL FORMAT

The various data files maintained at LLNL are available on magnetic tape, upon request from the National Nuclear Data Center, Brookhaven National Laboratory; the Radiation Shielding Information Center, Oak Ridge National Laboratory; and the Nuclear Data Section, International Atomic Energy Agency, Vienna, Austria. Because no other existing format makes provision for all the properties that are part of the LLNL data files, a transmittal format has been developed that is simple and closely related to the input format for the updating code described in Tables 6 and 7. The record layout for the first two records of each set of data is given in Table A-1. These first two records are called the header records. The records that follow the header records are appropriately called the data records, and the layout used for the data records is a function of the reaction property ("I-value") described in the second of the two header records. Only three types of layouts, or

TABLE A-1. Field definitions for header records.

	Columns	Format	Name	Description
Record 1	1-6	I6	ZA	1000Z + A.
	8-9	I2	y_i[a]	Incident particle descriptor.
	11-12	I2	y_o[a]	Outgoing particle descriptor.
	14-24	E11.4	A	Atomic mass for this ZA (amu).
	26-31	I6	DATE	Date last changed.
	36-46	E11.4		Level energy of the target (MeV).
	48-58	E11.4		Half-life of the target (s).
Record 2	1-2	I2	C[a]	Reaction number.
	3-5	I3	I[a]	Reaction property designator.
	6-8	I3	S[a]	Reaction modifier flag.
	10-20	E11.4	Q0[a]	Mass difference Q for the reaction.
	22-32	E11.4	X_1[a]	Value depends upon the value of S.
	34-44	E11.4	X_2[a]	Value depends upon the value of S.
	46-56	E11.4	X_3[a]	Value depends upon the value of S.

[a] A more complete definition of these fields can be found in Tables 2-5.

organizations, are required to handle the data for the 11 I-values defined in Table 3.

All numbers in the data records are in floating-point format, in particular, E11.4 format. Following the data records is an end-of-data record that is blank except for a 1 in column 72. This facilitates skipping unneeded data, if it is desirable to do so, by reading over a set of data until the end-of-data record is encountered. Each read-command following the two header records may be done with a 6E11.4, 5x, il format.

For I = 0, 7, 9, 10, 11, 80, 90, 91, and 92, the first data record gives the number of pairs of independent/dependent variables to follow. The significance of the independent and dependent variables is given in Table 6 for each I-value.

For I = 1, 8, 81, and 84, the first record gives the number of values of the factorable parameter (incident particle energy for I = 1, 8; kT for I = 81, 84). The following data records are given in sets, with the number of sets equal to the value given in the first-record described above. Each set has a first record that gives the value of the parameter (E or kT), followed by the number of pairs of independent/dependent variables, which are defined in Table 6 for each I-value.

For I = 4 there are two parameters (ℓ and E). The first data record gives the number of ℓ-values (sets of Legendre polynominal coefficients) that follow. For each set of coefficients, the first record gives the order of ℓ, followed by the number of incident-particle energies for which secondary-energy/coefficient pairs are given. For each incident-particle energy there is a record that gives the incident-particle energy and the number of pairs of secondary-energy/coefficient pairs that follow. The remaining data for that subset are the secondary-energy/coefficient values for that order of Legendre polynominals and that incident-particle energy.

Tables A-2, A-3, and A-4 give a schematic for the three I-value-dependent layouts.

TABLE A-2. Field definitions for I = 0, 7, 9, 10, 11, 80, 90, 91, 92.

Record	
1	First header record, see Table A-1.
2	Second header record, see Table A-1.
3	Number of pairs of independent/dependent variables, e.g., energy/cross section (E11.4).
4 et seq.	Three pairs per record (6E11.4) of independent/dependent variables.
Last	End-of-data record (1 in column 72).

TABLE A-3. Field definitions for I = 1, 8, 81, 84.

Record	
1	First header record, see Table A-1.
2	Second header record, see Table A-1.
3	Number of values of the factorable parameter (NF) (E11.4). (E for I = 1, 8, kT = for I = 81, 84).
4[a]	Value of the factorable parameter, number of pairs of independent/dependent variables that follows (2E11.4).
5 et seq.[a]	Three pairs per record (6E11.4) of independent/dependent variables [e.g., for I = 1, ?, P(E,μ)].
Last	End-of-data record (1 in column 72).

[a]Repeated NF times.

TABLE A-4. Field definitions for I = 4.

Record	
1	First header record, see Table A-1.
2	Second header record, see Table A-1.
3	Number of values of ℓ (E11.4), NL.
4[a]	Value of ℓ, number of incident energies for this ℓ (2E11.4), NE.
5[b]	Incident energy; number of secondary energy coefficients to follow (2E11.4).
6 et seq.[b]	Three pairs per record of secondary energies and coefficients (6E11.4).
Last	End-of-data record (1 in column 72).

[a]Repeated NL times.
[b]Repeated NE times.

APPENDIX B

SAMPLE TABLE OF CONTENTS FOR

NEUTRON LIBRARY THROUGH ^{4}He

*** EVALUATED LIBRARY IDENTIFICATION INFORMATION ***

INSTALLATION ORIGINATING THIS LIBRARY	-	LLNL
YEAR ORIGINATED	-	81
LIBRARY EDITION NO.	-	3
LIBRARY VERSION NO.	-	26
DATE OF LAST DATA CHANGE	-	810918
LIBRARY TYPE	-	1
UTILITY VERSION OF	-	092181
LIBRARY NAME - INTERNAL	-	ND810918
LIBRARY NAME - XEQ LINE	-	ND810918

NUCLIDES IN THIS LIBRARY

1	GROUND STATE
1001	GROUND STATE
1002	GROUND STATE
1003	GROUND STATE
2003	GROUND STATE
2004	GROUND STATE
3006	GROUND STATE
3007	GROUND STATE
4007	GROUND STATE
4009	GROUND STATE
5010	GROUND STATE
5011	GROUND STATE
6012	GROUND STATE
7014	GROUND STATE
8016	GROUND STATE
9019	GROUND STATE
11023	GROUND STATE
12000	GROUND STATE
12024	GROUND STATE
13027	GROUND STATE
14000	GROUND STATE
15031	GROUND STATE
16032	GROUND STATE
17000	GROUND STATE
18000	GROUND STATE
19000	GROUND STATE
20000	GROUND STATE
21045	GROUND STATE
22000	GROUND STATE
23051	GROUND STATE
24000	GROUND STATE
25055	GROUND STATE
26000	GROUND STATE
26054	GROUND STATE
26058	GROUND STATE
27059	GROUND STATE
28000	GROUND STATE
28058	GROUND STATE
29000	GROUND STATE
29063	GROUND STATE
30064	GROUND STATE
31000	GROUND STATE
40000	GROUND STATE
40090	GROUND STATE
41093	GROUND STATE
42000	GROUND STATE
47107	GROUND STATE
47109	GROUND STATE
48000	GROUND STATE
48114	GROUND STATE
49115	GROUND STATE
50000	GROUND STATE
56138	GROUND STATE
63000	GROUND STATE
64000	GROUND STATE
67165	GROUND STATE

73181	GROUND STATE
74000	GROUND STATE
74186	GROUND STATE
75185	GROUND STATE
75187	GROUND STATE
77191	GROUND STATE
77193	GROUND STATE
78000	GROUND STATE
79193	GROUND STATE
79194	GROUND STATE
79195	GROUND STATE
79196	GROUND STATE
79197	GROUND STATE
79198	GROUND STATE
79199	GROUND STATE
79200	GROUND STATE
82000	GROUND STATE
83209	GROUND STATE
90230	GROUND STATE
90231	GROUND STATE
90232	GROUND STATE
90233	GROUND STATE
90234	GROUND STATE
92233	GROUND STATE
92234	GROUND STATE
92235	GROUND STATE
92236	GROUND STATE
92237	GROUND STATE
92238	GROUND STATE
92239	GROUND STATE
92240	GROUND STATE
93237	GROUND STATE
94238	GROUND STATE
94239	GROUND STATE
94240	GROUND STATE
94241	GROUND STATE
94242	GROUND STATE
94243	GROUND STATE
95241	GROUND STATE
95242	LEVEL = 4.8200E-02
95243	GROUND STATE
96242	GROUND STATE
96243	GROUND STATE
96244	GROUND STATE
96245	GROUND STATE
96246	GROUND STATE
96247	GROUND STATE
96248	GROUND STATE
97249	GROUND STATE
98249	GROUND STATE
98250	GROUND STATE
98251	GROUND STATE
98252	GROUND STATE
99120	GROUND STATE

YI,YO NO.	PARTICLE DESCRIPTION
00	NOT APPLICABLE OR NONE
01	NEUTRON
02	PROTON
03	DEUTERON
04	TRITON
05	HE-3
06	ALPHA
07	GAMMA RAY
08	BETA
09	BETA-
10	ELECTRON
11	NEUTRON AS RECOIL NUCLEUS
12	PROTON AS RECOIL NUCLEUS
13	DEUTERON AS RECOIL NUCLEUS
14	TRITON AS RECOIL NUCLEUS
15	HE-3 AS RECOIL NUCLEUS
16	ALPHA AS RECOIL NUCLEUS

REACTION DESCRIPTOR DEFINITIONS

C NO.	REACTION TYPE	C NO.	REACTION TYPE
8	LARGE ANGLE COULOMB SCAT	43	Y,TA(A)
9	SCAT+INT	44	Y,HE3
10	ELASTIC	45	Y,A
11	Y,N'	46	Y,GAMMA
12	Y,2N	47	
13	Y,3N	48	
14	Y,4N	49	
15	Y,F	50	Y,XP
16		51	Y,XD
17		52	Y,XT
18		53	Y,XHE3
19		54	Y,XA
20	Y,N'P	55	Y,XGAMMA
21	Y,PN'	56	Y,XN
22	Y,N'D	57	Y,XE
23	Y,N'DA(A)	58	
24	Y,N'T	59	
25	Y,N'HE3	60	
26	Y,N'A	61	
27	Y,N'2A(A)	62	
28	Y,N'TA(A)	63	
29	Y,2NP(A)	64	
30	Y,GNA	65	ACTIVAT.
31	Y,2NPA(A)	66	YIELD TO (Z2,A2)
32		67	
33		68	
34		69	
35		70	TOTAL
36		71	COHERENT SCATTERING
37	Y,2A(A)	72	INCOHERENT SCATTER
38	Y,HE3,A(A)	73	PHOTO ELECTRIC
39	Y,TP(A)	74	PAIR PRODUCT.
40	Y,P	75	PAIR PROD.(ELECTRONIC)
41	Y,D	76	PHOTO NUCLEAR
42	Y,T	77	

S NO.	SWITCH DESCRIPTION
00	NO X-FIELD DATA
01	LEVEL EXCITATION X1 = W(MEV)
02	PRE-EQUILIBRIUM AND UNRESOLVED DIRECT INTERACTION PROCESSES NO X-FIELD DATA
03	GAMMA-RAY PRODUCTION X1 = E-GAM(MEV)
04	MATERIAL TEMPERATURE X1 = KT(MEV)
05	ACTIVATION X1 = Z2A2, X2 = LEVEL, X3 = HLIFE
06	DOPPLER BROADENING X1 = KT, X2 = ND, X3 = TH
07	DELAYED GROUP HALF-LIVES X1 = SQRT(TAU)
08	COMPLETELY CORRELATED REACTION X1 = W(MEV)
09	UNUSED
10	WIDE LEVEL EXCITATION X1 = W(MEV), X2 = GAMMA(MEV)
11	SECOND NEUTRON EMISSION X1 = W(MEV), X2 = GAMMA(MEV)
15	DENSITY AND TEMPERATURE DEPENDENT X1 = DENSITY, X2 = TEMPERATURE(KEV)

I NO.	REACTION PROPERTY
00	INTEGRATED CROSS SECTIONS AND RELATED PARAMETERS
01	ANGULAR DISTRIBUTIONS, NORMALIZED PROBABILITIES
04	ENERGY-ANGLE DISTRIBUTIONS, NORMALIZED LEGENDRE COEFFICIENTS
07	AVERAGE NEUTRONS PER FISSION (PROMPT OR DELAYED)
08	HISTOGRAM FORM OF ENERGY DISTRIBUTION
09	MULTIPLICITIES
10	AVERAGE ENERGY DEPOSITS TO YO
11	AVERAGE ENERGY DEPOSITS TO RESIDUAL
20	ENERGY LOSS CROSS SECTIONS
80	MAXWELLIAN AVERAGE REACTION RATES
81	IN-FLIGHT REACTION CROSS-SECTIONS
84	ENERGY DISTRIB. FROM THERMAL EQUILIB. REACTIONS
90	MAXWELL AVERAGED TOTAL AVERAGE ENERGY OF THE PARTICLE
91	MAXWELL AVERAGED AVERAGE ENERGY OF THE RESIDUAL
92	MAXWELL AVERAGED TOTAL AVERAGE ENERGY OF REACTING PARTICLES
99	SUPPLEMENTAL PARAMETERS

1-H -1 GROUND STATE STABLE N0810918
ATOMIC MASS - 1.007800E+00 NO. OF REACTIONS - 2 HEADER RECORD SIZE - 157 DATA RECORD SIZE - 1032

MATERIAL	C	YI	YO	S	Q	X(1)	X(2)	X(3)	COUNT	DATE	I	MIN.-ENG.	MAX.-ENG.
1001	10	1		0	0.	0.	0.	0.		810730			
			0						99	720727	0	1.0000E-10	2.0000E+01
			1						13	720727	1	1.0000E-01	2.0000E+01
			1						4	810717	10	1.0000E-10	2.0000E+01
			12						13	800618	1	1.0000E-01	2.0000E+01
			12						4	810717	10	1.0000E-10	2.0000E+01
1001	46	1		0	2.2247E+00	0.	0.	0.		810730			
			0						219	710224	0	1.0000E-10	2.0000E+01
			7						4	721101	1	1.0000E-10	2.0000E+01
			7						2	721101	4	1.0000E-10	2.0000E+01
			7						2	721101	9	1.0000E-10	2.0000F+01
			7						2	810717	10	1.0000E-10	2.0000E+01
			13						2	810310	4	1.0000E-10	2.0000E+01
			13						2	810717	10	1.0000E-10	2.0000E+01

1-H -2 GROUND STATE STABLE NDB10918
ATOMIC MASS - 2.014100E+00 NO. OF REACTIONS - 3 HEADER RECORD SIZE - 303 DATA RECORD SIZE - 2922

MATERIAL	C	YI	YO	S	Q	X(1)	X(2)	X(3)	COUNT	DATE	I	MIN.-ENG.	MAX.-ENG.
1002	10	1		0	0.	0.	0.	0.		810730			
			0						40	720103	0	1.0000E-10	2.0000E+01
			1						14	720103	1	5.0000E-02	2.0000E+01
			1						25	810717	10	1.0000E-10	2.0000E+01
			13						14	800618	1	5.0000E-02	2.0000E+01
			13						25	810717	10	1.0000E-10	2.0000E+01
1002	12	1		8	-2.2300E+00	2.2300E+00	0.	0.		810730			
			0						12	720709	0	3.3500E+00	2.0000E+01
			1						2	720709	1	3.3500E+00	2.0000E+01
			1						10	721025	4	3.3500E+00	2.0000E+01
			1						2	810717	10	3.3500E+00	2.0000E+01
			12						10	800618	4	3.3500E+00	2.0000E+01
			12						2	810717	10	3.3500E+00	2.0000E+01
1002	46	1		0	6.2500E+00	0.	0.	0.		810730			
			0						72	720103	0	1.0000E-10	2.0000E+01
			7						2	721101	4	1.0000E-10	2.0000E+01
			7						2	721101	9	1.0000E-10	2.0000E+01
			7						2	810717	10	1.0000E-10	2.0000E+01
			14						2	810310	4	1.0000E-10	2.0000E+01
			14						2	810717	10	1.0000E-10	2.0000E+01

1-H -3 GROUND STATE HALF-LIFE = 1.23E+01 YRS. NDB10918
ATOMIC MASS - 3.017000E+00 NO. OF REACTIONS - 2 HEADER RECORD SIZE - 160 DATA RECORD SIZE - 1971

MATERIAL	C	YI	YO	S	Q	X(1)	X(2)	X(3)	COUNT	DATE	I	MIN.-ENG.	MAX.-ENG.
1003	10	1		0	0.	0.	0.	0.		810730			
			0						36	720707	0	1.0000E-10	2.0000E+01
			1						12	720103	1	5.0000E-02	2.0000E+01
			1						19	810717	10	1.0000E-10	2.0000E+01
			14						12	800618	1	5.0000E-02	2.0000E+01
			14						26	810717	10	1.0000E-10	2.0000E+01
1003	12	1		0	-6.2600E+00	0.	0.	0.		810730			
			0						11	720707	0	8.3600E+00	2.0000E+01
			1						5	720707	1	8.3600E+00	2.0000E+01
			1						7	720707	4	8.3600E+00	2.0000E+01
			1						3	810717	10	8.3600E+00	2.0000E+01
			13						7	810310	4	8.3600E+00	2.0000E+01
			13						3	810717	10	8.3600E+00	2.0000E+01

2-HE-3 GROUND STATE STABLE ND810918
ATOMIC MASS - 3.016000E+00 NO. OF REACTIONS - 4 HEADER RECORD SIZE - 243 DATA RECORD SIZE - 1390

MATERIAL	C	YI	YO	S	Q	X(1)	X(2)	X(3)	COUNT	DATE	I	MIN.-ENG.	MAX.-ENG.
2003	10	1		0	0.	0.	0.	0.		810730			
			0						55	750103	0	1.0000E-10	2.0000E+01
			1						10	720103	1	5.0000E-01	2.0000E+01
			1						12	810717	10	1.0000E-10	2.0000E+01
			15						10	800618	1	5.0000E-01	2.0000E+01
			15						23	810717	10	1.0000E-10	2.0000E+01
2003	40	1		0	7.6000E-01	0.	0.	0.		810730			
			0						140	720710	0	1.0000E-10	2.0000E+01
			2						2	810227	1	1.0000E-10	2.0000E+01
			2						2	810717	10	1.0000E-10	2.0000E+01
			14						2	810227	1	1.0000E-10	2.0000E+01
			14						2	810717	10	1.0000E-10	2.0000E+01
2003	41	1		0	-3.2700E+00	0.	0.	0.		810730			
			0						23	720710	0	4.3500E+00	2.0000E+01
			3						2	810227	1	4.3500E+00	2.0000E+01
			3						2	810717	10	4.3500E+00	2.0000E+01
			13						2	810227	1	4.3500E+00	2.0000E+01
			13						2	810717	10	4.3500E+00	2.0000E+01
2003	46	1		0	2.0578E+01	0.	0.	0.		810730			
			0						2	721101	0	1.0000E-10	2.0000E+01
			7						2	721101	4	1.0000E-10	2.0000E+01
			7						2	721101	9	1.0000E-10	2.0000E+01
			7						2	810717	10	1.0000E-10	2.0000E+01
			16						2	810310	4	1.0000E-10	2.0000E+01
			16						2	810717	10	1.0000E-10	2.0000E+01

2-HE-4 GROUND STATE STABLE ND810918
ATOMIC MASS - 4.002600E+00 NO. OF REACTIONS - 1 HEADER RECORD SIZE - 115 DATA RECORD SIZE - 2246

MATERIAL	C	YI	YO	S	Q	X(1)	X(2)	X(3)	COUNT	DATE	I	MIN.-ENG.	MAX.-ENG.
2004	10	1		0	0.	0.	0.	0.		810730			
			0						31	720709	0	1.0000E-10	2.0000E+01
			1						30	720103	1	2.0000E-02	2.0000E+01
			1						19	810717	10	1.0000E-10	2.0000E+01
			16						30	800618	1	2.0000E-02	2.0000E+01
			16						29	810717	10	1.0000E-10	2.0000E+01

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R. J. Howerton

MS. date: October 17, 1978

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