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INTERNATIONAL ATOMIC ENERGY AGENCY

NUCLEAR DATA SERVICES

DOCUMENTATION SERIES OF THE IAEA NUCLEAR DATA SECTION

# ENDL-78

## LLL Evaluated Nuclear Data Library

## 1978

### Contents and Documentation

Abstract

This document summarizes contents and documentation of the 1978 version of the Evaluated Nuclear Data Library of the Lawrence Livermore Laboratory, USA. The Library contains numerical neutron reaction data for 88 isotopes or elements. The entire Library or selective retrievals from it can be obtained on magnetic tape from the IAEA Nuclear Data Section.

O. Schwerer

July 1979

# ENDL-78

## LLL Evaluated Nuclear Data Library

## 1978

This is the latest version of the Lawrence Livermore Library which contains evaluated neutron reaction data for 88 materials (isotopes or elements) and includes a total of 194 088 records in ENDF/B-IV format.

For each nuclide cross sections and differential data for all significant neutron reactions as well as photon production data for neutron-induced processes are given in the energy range from $10^{-4}$ eV to 20 MeV. In addition, for Ta-181 only, electron production data are also given.

## CONTENTS AND DOCUMENTATION

A documentation of the library contents and summary of evaluation is given in

R. J. Howerton, M. G. MacGregor, Lawrence Livermore Laboratory Report UCRL-50400 Vol. 15 Part D, Rev. 1 (May 1978): "The LLL Evaluated Nuclear Data Library (ENDL): Description of Individual Evaluations for Z=0-98".

For the evaluation of fission neutron yields see also:

R. J. Howerton, Nucl. Sci. and Eng. 62, 438 (1977).

For the list of nuclides covered and additional documentation see the following table.

| Nuclide | Acc. No. | Additional documentation, comments, Authors |
|---|---|---|
| 0-n-1 | 7800 | |
| 1-H-1 | 7801 | Based on Stewart et al., LA-4574 (1970) |
| 1-H-2 | 7802 | 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-internal system. No equivalent representation exists in the ENDF/B format. Consequently, the representation in the "translated form" (in ENDF/B-IV format) is deficient.<br>Based on Stewart, Howerton (1964, 1972) |
| 1-H-3 | 7803 | Based on Horsley, Stewart, LA-3270 (1966), Addendum-1 |
| 2-He-3 | 7804 | " " Stewart, Howerton (1964, 1972) |
| 2-He-4 | 7805 | " " Howerton (1964) |
| 3-Li-6 | 7806 | Howerton (rev. 1977) |
| 3-Li-7 | 7807 | " (rev. 1975) |
| 4-Be-7 | 7808 | Howerton (1974) |
| 4-Be-9 | 7809 | Howerton, Haight (1970, 1972)<br>Format: Additional REACTION-TYPE-members, not included in normal ENDF/B-IV, are used. See page 6. |
| 5-B-10 | 7810 | Howerton, Haight (1970, 1972) |
| 5-B-11 | 7811 | " " (1972) |
| 6-C-12 | 7812 | Howerton |
| 7-N-14 | 7813 | " ; photon production part from Young, Foster, LA-4725 (1972, rev. 73) |
| 8-O-16 | 7814 | Howerton |
| 9-F-19 | 7815 | Partly based on Fu et al., ORNL (1974) |
| 11-Na-23 | 7816 | Howerton |
| 12-Mg-nat | 7817 | " |
| 13-Al-27 | 7819 | Based on Foster, Young, LA-4726 (1972) |
| 14-Si-nat | 7820 | Howerton |
| 15-P-31 | 7821 | " |
| 16-S-32 | 7822 | |
| 17-Cl-nat | 7823 | Howerton |
| 18-Ar-nat | 7824 | " |
| 19-K-nat | 7825 | " |
| 20-Ca-nat | 7826 | " |
| 22-Ti-nat | 7828 | ANL/NDM-28; CEA-R-4883 (1977) |
| 23-V-51 | 7829 | Guenther et al., ANL/NDM-24 (1977) |

| Nuclide | Acc. No. | Additional documentation, comments, Authors |
|---|---|---|
| 24-Cr-nat | 7830 | Howerton |
| 25-Mn-55 | 7831 | " |
| 26-Fe-nat | 7832 | " |
| 27-Co-59 | 7835 | Based on ANL/NDM-1 (1973) |
| 28-Ni-nat | 7836 | Based on ANL/NDM-11 (1975) |
| 28-Ni-58 | 7837 | |
| 29-Cu-nat | 7838 | Howerton |
| 31-Ga-nat | 7840 | " |
| 40-Zr-nat | 7841 | " |
| 41-Nb-93 | 7843 | Based on ANL/NDM-6 |
| 42-Mo-nat | 7844 | Howerton |
| 47-Ag-107 | 7845 | Based on ENDF/B4 MAT-1138 |
| 47-Ag-109 | 7846 | " " 1139 |
| 48-Cd-nat | 7847 | Howerton |
| 50-Sn-nat | 7850 | " |
| 56-Ba-138 | 7851 | " |
| 63-Eu-nat | 7852 | " |
| 64-Gd-nat | 7853 | " |
| 67-Ho-165 | 7854 | " |
| 73-Ta-181 | 7855 | UCRL-51306, Rev. 1 (1975) Also electron production data are given. For those additional FILE-members, not included in normal ENDF/B-IV, are used. See page 5. |
| 74-W-nat | 7856 | Howerton |
| 75-Re-185 | 7858 | Based partly on Henderson, Zwick, GEMP-587 (1968) |
| 75-Re-187 | 7859 | " " " " |
| 78-Pt-nat | 7860 | Howerton |
| 79-Au-197 | 7861 | " |
| 82-Pb-nat | 7862 | " |
| 90-Th-231 | 7863 | " (1976) |
| 90-Th-232 | 7864 | Based on ENDF/B4 (MAT-1296) |
| 90-Th-233 | 7865 | Howerton |
| 92-U-233 | 7866 | Based on ENDF/B4 (MAT-1260) |
| 92-U-234 | 7867 | Howerton |
| 92-U-235 | 7868 | Based on ENDF/B4 (MAT-1261) |
| 92-U-236 | 7869 | Howerton |

| Nuclide | Acc. No. | Additional documentation, comments, Authors |
|---|---|---|
| 92-U-237 | 7870 | Howerton |
| 92-U-238 | 7871 | Based on ENDF/B4 (MAT-1262) |
| 92-U-239 | 7872 | Howerton |
| 92-U-240 | 7873 | " |
| 93-Np-237 | 7874 | Based on ENDF/B4 (MAT-1263) |
| 94-Pu-238 | 7875 | Howerton |
| 94-Pu-239 | 7876 | Based on ENDF/B4 (MAT-1264) |
| 94-Pu-240 | 7877 | " " (MAT-1265) |
| 94-Pu-241 | 7878 | Howerton |
| 94-Pu-242 | 7880 | Based on ENDF/B4 (MAT-1161) |
| 94-Pu-243 | 7881 | Howerton, McCrosson |
| 95-Am-241 | 7882 | Partly based on ENDF/B4 (MAT-1056) |
| 95-Am-242m | 7883 | Howerton |
| 95-Am-243 | 7884 | Howerton, McCrosson |
| 96-Cm-242 | 7885 | " " |
| 96-Cm-243 | 7886 | " " |
| 96-Cm-244 | 7887 | " " |
| 96-Cm-245 | 7888 | " " |
| 96-Cm-246 | 7889 | " " |
| 96-Cm-247 | 7890 | " " |
| 96-Cm-248 | 7891 | " " |
| 97-Bk-249 | 7892 | " " |
| 98-Cf-249 | 7893 | " " |
| 98-Cf-250 | 7894 | " " |
| 98-Cf-251 | 7895 | " " |
| 98-Cf-252 | 7896 | " " |
| FP-120 | 7897 | This is a crude representation of a "typical" fission product. Use with care. |

## FORMAT

### ENDF/B-IV format:

A complete description of the ENDF/B-IV format, including all physical definitions required for the processing of more complicated data types (e.g. differential data) is given in the report BNL-NCS-50496 (ENDF-102), October 1975.

For quick reference of the ENDF/B format (File Numbers and Reaction Type Numbers of the most important data types) see the document IAEA-NDS-10.

Note: Listings of all ENDF/B format data can also be requested in "edited format". Such listings provide all necessary quantity headings, units, etc. and are self-explanatory.

### ENDF/B-format of ENDL-78:

The library has been translated from the LLL-internal system into ENDF/B-IV format. Please note the following peculiarities deviating from "proper" ENDF/B-IV:

1) Cross-sections in the resonance region are given as point data and not in the form of resonance parameters.

2) For $^{9}Be$ partial (n,2n) data and $^{181}Ta$ electron production data, Reaction Type Numbers resp. File Numbers not provided for in "proper" ENDF/B-IV are used (see Table below).

| File Numbers not defined in ENDF/B-IV. (Used for Ta-181 only) | |
|---|---|
| 73 | electron production cross sections |
| 74 | electron angular distributions |

| Reaction Type Numbers not defined in ENDF/B-IV. (Used for Be-9 only) | | |
|---|---|---|
| 10 | (n,2n) cross section for fifth excited state (describes first neutron) | 1) |
| 41 | cross section for describing the second neutron from (n,2n) reaction for first excited state | 2) |
| 42 | cross section for describing the second neutron from (n,2n) reaction for second excited state | 2) |
| 43 | cross section for describing the second neutron from (n,2n) reaction for third excited state | 2) |
| 44 | cross section for describing the second neutron from (n,2n) reaction for fourth excited state | 2) |
| 45 | cross section for describing the second neutron from (n,2n) reaction for fifth excited state | |

1) For the 'first-neutron' data for the first through fourth excited states, the Reaction Type Numbers 6 through 9 are used in agreement with the ENDF/B-IV definition.
For details on the 5 reaction channels of $^{9}$Be (n,2n) see UCRL-50400 Vol. 15, Part D Rev. 1 (May 1978), p. 34.

2) In the ENDF/B-IV library, Reaction Type Numbers 46 through 49 are used for the first through fourth excited states.