OAK RIDGE NATIONAL LABORATORY

operated by
UNION CARBIDE CORPORATION

for the
U.S. ATOMIC ENERGY COMMISSION

ORNL-RSIC-34 (Vol. 1)
(Rev.)

DEFENSE NUCLEAR AGENCY WORKING CROSS SECTION LIBRARY

DESCRIPTION and CONTENTS

MASTER

RADIATION SHIELDING INFORMATION CENTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

ORNL-RSIC-34

Vol. I
(Rev.)

Contract No. W-7405-eng. 26

Neutron Physics Division

DEFENSE NUCLEAR AGENCY

WORKING CROSS SECTION LIBRARY:

DESCRIPTION AND CONTENTS

Robert W. Roussin
Juanita B. Wright

NOTE:

This Work Supported by
DEFENSE NUCLEAR AGENCY
Under Subtask PB05203

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

JUNE 1974

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37830
operated by
UNION CARBIDE CORPORATION
for the
U.S. ATOMIC ENERGY COMMISSION

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

TABLE OF CONTENTS

	<u>Page</u>
1. INTRODUCTION TO THE DEFENSE NUCLEAR AGENCY (DNA) WORKING CROSS SECTION LIBRARY	1.1
2. FORMAT FOR DESIGNATION OF THE MOD NUMBER FOR DNA EVALUATIONS	2.1
3. HISTORY OF THE MODIFICATIONS TO THE DNA LIBRARY	3.1
4. ACKNOWLEDGEMENTS	4.1
5. LISTINGS OF FILE 1 OF THE DNA LIBRARY TAPES	5.1
6. REPORTS DESCRIBING DNA EVALUATIONS	6.1

DEFENSE NUCLEAR AGENCY WORKING CROSS SECTION LIBRARY:
DESCRIPTION AND CONTENTS

1. INTRODUCTION

The Radiation Shielding Information Center (RSIC) serves as a repository for the Defense Nuclear Agency (DNA) cross-section library. This is a working library in ENDF¹ format whose content can be modified and revised whenever the evaluator deems such changes to be necessary. The key to this approach is a selected evaluator, the person responsible for making the original evaluation for a particular element or elements. He is then responsible for authorizing changes in evaluations for those elements. The evaluated data are for those materials of interest to DNA, whose cross-section values are in a state of rapid flux, and emphasis is placed on neutron energies up to 20 MeV and on secondary gamma-ray production. Evaluations of interest to DNA which are not in a state of rapid change are found in the ENDF/B library, which is available from the National Neutron Cross Section Center at Brookhaven National Laboratory.

The clearinghouse for the program is RSIC. Initial versions of evaluations are received, processed through checking codes to eliminate obvious format errors, and modified as necessary in collaboration with the evaluator. Next, DNA Phase I data testing is performed whereby selected reviewers will be provided with listings, output from checking codes, graphics, etc., and asked to review the data and feed back their comments. These will be relayed to the evaluator and, upon his instruction, appropriate changes will be made.

The data, along with available documentation, are distributed upon request. The users are asked to feed back any comments they have through using the data.

The official DNA library will be maintained at RSIC. Changes to it will be initiated only by the evaluator and each change will be documented so that users can, at any time refer to an identifiable data set when reporting results of their calculations.

Because the data are apt to be revised with some frequency, each evaluation is designated by a DNA MAT number and a MOD number. The DNA MAT number is a unique identification number for an evaluation and is equal to ENDF MAT number plus three thousand for those evaluations which are submitted for inclusion in the ENDF/B library. The MOD number designates the number of times the DNA evaluation has been modified since its initial availability through RSIC.

The current contents of the library are given in Table 1. The format used for designating the MOD number for DNA evaluations is described in Section 2. A history of the modifications to the evaluations is summarized in Section 3. Section 5 contains the listings of file 1 information on the tapes. This is the Evaluator's brief description of his effort and much useful information can be found therein. In Section 6 some published reports describing most of the evaluations are listed.

1. M. K. Drake, Editor, "Data Formats and Procedures for the ENDF Neutron Cross Section Library," BNL-50274 (ENDF-102, Vol. I), October 1970, and D. J. Dudziak, Compiler, "ENDF Formats and Procedures for Photon Production and Interaction Data," LA-4549 (ENDF-102, Vol. II), July 1971.

Table 1. Contents of the DNA Working Cross Section Library

April 1974

Material	Evaluators	DNA MAT	MOD	Date of MOD
N-14	Young, Foster - LASL	4133	4	7-73
O-16	Young, Foster - LASL	4134	2	8-73
Al-27	Foster, Young - LASL	4135	3	11-73
Pb	Fu, Perey - ORNL	4136	5	10-73
H-1	Stewart, LaBauve, Young - LASL	4148	2	10-73
Si	Larson, Perey, Drake, Young - ORNL, SAI, LASL	4151	3	3-74
Ca	Fu, Perey - ORNL	4152	3	2-73
Be-9	Howerton, Perkins - LLL	4154	2	11-73
Na-23	Paik, Pitterle, Perey - WARD, ORNL	4156	0	2-72
H-3	Stewart - LASL	4169	1	10-73
Ta-181	Howerton, Perkins, MacGregor - LLL	4179	3	10-73
Fe	Perey, Fu, Penny, Kinney, Wright - ORNL	4180	2	2-74
U-238	Howerton, MacGregor - LLL	4187	1	3-73
U-235	Howerton, MacGregor - LLL	4188	1	3-73
C-12	F. Perey, C. Perey, Fu - ORNL	4274	0	2-74
He-4	Nisley, Hale, Young - LASL	4504	0	11-73
Mg	Drake, Fricke - SAI	4512	1	4-74
Cu	Drake, Fricke - SAI	4529	1	3-74
Pu-239	Stewart, Hunter - LASL	4539	0	3-73
Pu-240	Stewart, Hunter - LASL	4540	0	3-73
W-182	Young - LASL	4582	2	3-74
W-183	Young - LASL	4583	2	3-74
W-184	Young - LASL	4584	2	3-74
W-186	Young - LASL	4586	2	3-74

Gamma Production Only

F	Fu, Perey - ORNL	4509	0	3-74
Zn	Fu, Perey - ORNL	4530	0	1-74
Ag	Young - LASL	4547	0	1-74
Sn	Young - LASL	4550	0	1-74

2. FORMAT FOR DESIGNATION OF MOD NUMBER FOR DEFENSE NUCLEAR AGENCY EVALUATION

The data formats and procedures to be used for the DNA Working Cross Section Library are essentially the same as those used for the ENDF/B. All processing codes, such as CHECKER², SUPERTOG³, AMPX⁴, will be able to read the data tape regardless of whether the tape is a DNA or ENDF/B data type. The only difference between the two tapes is a flag in the HEAD record of the first section, MT = 451, in File 1. Also the first part of the Hollerith information (first two BCD card image records) will have an artificial structure.

This structure allows the specification of the DNA MOD number in a particular format. Thus, a computer code operating on a DNA evaluation can read the MOD number and use that information to identify more precisely the cross section data being processed.

The modified structure is an adaptation of a format allowed for ENDF/A data which is described in Appendix H of "Data Formats and Procedures for the ENDF Neutron Cross Section Library," BNL 50274, ENDF-102, Vol. 1, Edited by M. K. Drake.

The structure is as follows:

```
[MAT, 1, 451/ZA, AWR, LRP, LFI, NTY, NXC] HEAD
[MAT, 1, 451/0.0, 0.0, LDD, LFP, NWD, 0/
      AID, ALAB, DATE1, AUTH
      REF, DATE2, MOD, DATE3, /H(N)] LIST
[MAT, 1, 451/0.0, 0.0, MF1, MT1, NC1, 0] CØNT
-----
-----
-----
[MAT, 1, 451/0.0, 0.0, MFNXC, MTNXC, NCNXC, 0] CØNT
[MAT, 1, 0/0.0, 0.0, 0, 0, 0, 0] SEND
```

where

NTY is flag to indicate the type of data tape.

If NTY = 0 or blank - ENDF/B tape.

= 6 - DNA tape,

The first part of the Hollerith information (first two BCD card image records) has the structure:

<u>Field</u>	<u>Cols.</u>	<u>Name</u>	<u>Description</u>
(First Card)			
1	2-11	AID	Material name (left adjusted)
2	12-22	ALAB	Originating Laboratory (left adjusted)
3	23-33	DATE1	Date of evaluation (left adjusted)
4	34-66	AUTH	Author of evaluation (left adjusted)
(Second card)			
1	2-22	REF	Reference (left adjusted)
2	23-33	DATE2	Original distribution date (left adjusted)
3	34-39	MOD	Latest modification number (format is 3X,I2)
4	40-44	DATE3	Date of latest modification (left adjusted)

NWD has the same meaning as an ENDF/B tape, i.e., NWD is the count of the number of elements in the Hollerith section (for the BCD card image tapes.) NWD is the number of card images used to describe the data set of this material. NWD includes the count of the first two BCD card images.

-
2. Odelli Ozer, Editor, "Description of the ENDF/B Processing Codes and Retrieval Subroutines," BNL 50300 (ENDF-110). Revised June 1971.
 3. R. Q. Wright, N. M. Greene, Jr., J. L. Lucius, and C. W. Craven, Jr., "SUPERTOG: A Program to Generate Fine Group Constants and P_n Scattering Matrices for ENDF/B," ORNL-TM-2679, September, 1969.
 4. N. M. Greene et al., "AMPX: Multigroup Coupled Neutron-Gamma Cross-Section Generator," Neutron Physics Division Annual Progress Report for Period Ending May 31, 1972, ORNL-4800.

3. HISTORY OF THE MODIFICATIONS TO THE DNA LIBRARY

A brief history of the modifications made to DNA evaluations is given below:

1. Nitrogen - MAT 4133

a. MOD 0* - February 1971

b. MOD 1 - April 1971

Minor clerical errors were corrected, elastic scattering Legendre coefficients were adjusted to agree with Wick's limit, normalization errors were corrected for the (n,2n) reaction, and some capture gamma ray energies were corrected.

c. MOD 2 - July 1971

Minor clerical errors were corrected and information to designate the decay mode of inelastic levels was added to file 3.

d. MOD 3 - February 1972

Modification consisted of using the ENDF/B-III version of nitrogen (MAT 1133), as the current DNA version. In addition RSIC added ENDF/B file 23 photon interaction data to the evaluation, using the RSIC data library DLC-7D.

e. MOD 4** - July 1973

Some file 1 comments were changed. The nonelastic cross sections in the energy range 2 to 20 MeV for exciting discrete levels by (n,n'), (n,p), (n,d), (n,T), and (n, α) were revised to be more consistent with the measurements of Dickens, Love, and Morgan (ORNL-4864, 1973) and some earlier experiments. The (n,n'), (n,p), (n,T), and (n, α) cross sections were reconstructed using the revised discrete level data mentioned above. The elastic scattering cross section as adjusted reflects these changes. Many cross sections were thinned such that the interpolated values between 2 points lie within 2.5% of the fine grid value. Elastic and inelastic scattering angular distributions were thinned such that the interpolated distributions have an rms average deviation from the fine grid set of less than 2.5% and that the maximum excursion at any angle be less than 5%. Primary capture gamma rays are now identified using the LP flag. Gamma-ray production cross sections were recalculated using the relevant decay schemes and revised level excitation cross sections mentioned above. The data were also thinned. Capture gamma-ray angular distributions were made consistent with the revision made to use LP flags.

*MOD 0 denotes the original version received and distributed at RSIC.

**Submitted to NNCSC for ENDF/B-IV.

2. Oxygen - MAT 4134

a. MOD 0* - September 1971

b. MOD 1 - February 1972

Modified to be the same as ENDF/B III oxygen (MAT 1134).
Also, file 23 data added from DLC-7D.

c. MOD 2** - August 1973

The results of an R-Matrix analysis of the 0-16 (n,n), 0-16 (n, α) C-13, and C-13 (α , α) reactions below 6 MeV were incorporated in MF=3, MT=1,2,107, and 780.

Adjustments were made in MF=3, MT=4, 51-55, 103, 107, 780-782 so that MT=2 better agrees with elastic measurements from 7 to 11 MeV. Adjustments were made particularly to MT=51 to improve agreement with (n,n') measurements, and MT=51-89 were modified to improve (somewhat) agreement with sphere transmission integral measurements. The nonelastic cross section was removed from file 3.

Legendre coefficients in MF=4, MT=2 were modified to include R-Matrix analysis results below 6 MeV and new experimental data above 6 MeV. The data were also thinned. Anisotropic inelastic neutron angular distributions were added for MT=51-55.

Anisotropic secondary gamma-ray angular distributions were added for the 6.131 and 6.917 MeV gamma rays. Gamma-ray production cross sections in MF=13 were adjusted to reflect this change and the revisions in file 3 inelastic data mentioned above.

Cross sections for MT=4, 51-89, 103, 104, 107, 780-783 in MF=3 and 13 were thinned.

3. Aluminum - MAT 4135

a. MOD 0* - July 1971

b. MOD 1 - July 1971

Information was added to designate the decay mode of inelastic levels and the threshold energy for the (n,n'p) reaction was corrected.

c. MOD 2 - February 1972

Modified to conform to ENDF/B III aluminum (MAT 1135). Also, file 23 data added from DLC-7D.

d. MOD 3** - November 1973

The file 1 BCD description was revised to reflect the changes that are given below.

*MOD 0 denotes the original version received and distributed at RSIC.

**Submitted to NNCSC for ENDF/B-IV.

The thermal neutron radiative capture gamma-ray spectrum was revised to better agree with recent data. File 13 and 15 ($n,n'\gamma$) and ($n,n'p\gamma$) were revised to include the measurements by Dickens et al. (ORNL-TM-4232, 1973).

Improved (n,p) and (n,α) cross sections were incorporated. These are the same as were provided to the CSEWG Standards Subcommittee. The total cross section was extensively revised, especially below 1 MeV, to include the measurement of Perey et al. (ORNL-4823, 1972).

The (n,n') cross sections to high-lying pseudo levels were revised for neutron energies near 14 MeV to give better agreement to measurements by Kammerdiener (U. Cal. Davis Thesis, 1972). In addition (n,n') data to lower levels were revised to be consistent with the changes made to file 13 and 15 mentioned above. Anisotropic (n,n') angular distributions based on experimental data were incorporated.

4. Lead - MAT 4136

a. MOD 0* - September 1971

b. MOD 1 - February 1972

Modified to conform to ENDF/B III lead (MAT 1136).

c. MOD 2 - April 1972

The capture cross section from 1 keV to 1 MeV was reevaluated based on recent measurements by B. J. Allen et al., of ORNL. Corresponding changes have been made in the elastic and non-elastic scattering cross sections.

d. MOD 3 - August 1972

The energy range covered by File 4 inelastic scatter from discrete levels was made to conform to the energy range covered in File 3. This was done by changing the highest energy in File 4 to correspond to the highest energy in File 3 for a given level.

e. MOD 4 - November 1972.

Card punch errors were found at a few energies in the capture and total cross section. Due to summation and subtraction of various cross sections, errors were also introduced in other cross sections. These errors are present in both MOD 2 and MOD 3. We recommend replacing with MOD 4.

f. MOD 5** - October 1973

MT=16, 17, and 91 in files 3 and 5 were modified according to recent data (1,2) near 14 MeV and statistical-empirical model

*MOD 0 denotes the original version received and distributed at RSIC.
**Submitted to NNCSC for ENDF/B-IV.

calculations. This modification was motivated by integral tests such as the pulsed sphere measurements (3) and analysis (4) and others (5).

1. J. L. Kammerdiener, UCRL-51232 (1972).
2. G. Clayeux et al., CEA-R-4279 (1972).
3. C. Wong et al., UCRL-51144 (1972).
4. E. D. Cashwell, private communication to CSEWG (1973).
5. D. Bogart et al., Preprint of NSE article (1973).

5. Hydrogen - MAT 4148

a. MOD 0* - February 1971

b. MOD 1 - February 1972

Modified to conform to ENDF/B III hydrogen (MAT 1148) and file 23 data added from DLC-7D.

c. MOD 2** - October 1973

The LP flag was implemented in MF=12, MT=102.

6. Silicon - MAT 4151

a. MOD 0* - September 1971

b. MOD 1 - February 1972

Modified to conform to ENDF/B III silicon (MAT 1151) and file 23 data added from DLC-7D.

c. MOD 2 - October 1972

Total cross section reevaluated by spline fitting to NBS data from 0.5 to 20 MeV. This caused corresponding changes to elastic, nonelastic, and inelastic; the inelastic discrete level and continuum cross sections based on ABACUS-2 calculations. The (n,α) was reevaluated from 8.4 to 20 MeV based on new data. Elastic scattering angular distributions were supplemented by new data. Legendre coefficients for the 1.779 level inelastic scattering were calculated from new data. Gamma-ray production data were recalculated to conform to the new cross sections. Continuum energy distribution was calculated by a statistical model.

d. Mod 3** - April 1974

The inelastic scattering files have been revised, based on recent data, and Hauser-Feshbach and direct interaction models. The tertiary reactions (n,np) , (n,pn) , $(n,n\alpha)$ and $(n,\alpha n)$ have been included and the energy distribution for the outgoing charged

*MOD 0 denotes the original version received and distributed at RSIC.

**Submitted to NNCSC for ENDF/B-IV.

particles and neutrons are given. Cross sections, angular distributions and energy distributions have been given for the charged particles resulting from (n,p) and (n, α) reactions. The gamma production files have been revised using calculations based on the newly available data of Dickens et al. of ORNL.

7. Calcium - MAT 4152

a. MOD 0* - September 1971

b. MOD 1 - February 1972

Modified to conform to ENDF/B-III calcium (MAT 1152).

c. MOD 2 - May 1972

The lower limit of the energy range was extended from 0.001 to 0.00001 eV. File 3 cross sections for (n,n'), (n,p), (n, α), (n,n'p) and (n,n' α) were reevaluated above 9 MeV. The file 5 energy distributions of secondary neutrons were reevaluated. In file 12, gamma-ray production multiplicities for (n, γ), (n,n'), (n,p) and (n, α), which were previously combined, are now given separately. Also, multiplicities are now given for (n,n'p) and (n,n' α).

d. MOD 3** - February 1973

This is essentially a complete reevaluation of MOD 2 (May 1972). Details of MOD 3 will be published in ORNL-4866, "A Reevaluation of Neutron and Secondary Gamma-Ray Production for Calcium," by C. Y. Fu and F. G. Perey.

8. Beryllium-9 - MAT 4154

a. MOD 0* - February 1972

This is the same as ENDF/B III beryllium-9 (MAT 1154).

b. MOD 1 - March 1973

The energy range was extended down to 10^{-5} eV. Gamma-ray production (n, γ) data and (n,T) data are now represented as MT=102 and MT=105, respectively, in files 12 and 15. The photon spectrum was assumed independent of incident neutron energy with the multiplicity varied (with incident neutron energy) to conserve energy.

c. MOD 2** - November 1973

The (n,2n) reaction was described using ENDF format modification 73-4 which allows the representation of individual neutrons from sequential (n,2n) reactions. This was done utilizing MT numbers 6-9 and 46-49 in files 3 and 4, and MT=46-49 in file 5. The (n,T) reaction now includes (n,T₀) in addition to (n,T₁) data and these are described using MT=740 and 741 respectively.

*Mod 0 denotes the original version received and distributed at RSIC.

**Submitted to NNCSC for ENDF/B-IV.

9. Sodium - MAT 4156

a. MOD 0* - February 1972

This is the same as ENDF/B-III sodium (MAT 1156).

10. Tritium - MAT 4169

a. MOD 0* - September 1972

b. MOD 1** - October 1973

The capture cross section is less than 6.7 microbarns at thermal energy and therefore was removed from file 3.

11. Tantalum-181 - MAT 4179

a. MOD 0* - February 1972

Note that this is not in ENDF/B-III. It became available after Version III was released.

b. MOD 1 - January 1973

The (n,2n) cross section near threshold was revised to conform to the observed dip in gamma-ray production (ORNL-TM-3702). The (n,3n) and (n,n') cross-sections were modified to correspond to the (n,2n) changes. The (n,Xγ) component is represented as one discrete gamma ray (0.15 MeV) from the two lowest discrete levels with gamma rays from higher levels lumped into a continuum.

c. MOD 2 - August 1973

Electron production cross sections, multiplicities, and spectra have been included for special DNA applications. These are in files 72-75 and are analogous to files 12-15 photon production formats.

The total cross section above 10 MeV was increased by a few per cent to agree with best available data. Elastic scattering cross section was adjusted.

For energies above 750 keV, forward angle elastic scattering was adjusted to agree with Wick's limit. Also, the number of energies at which distributions are given was increased.

The excitation of the 6 keV level is now described because of emphasis on electron production (it deexcites primarily by internal conversion).

Discrete photons of 0.165, 0.153, and 0.136 MeV are now included rather than being lumped in a single 0.15 MeV line.

A modification in the formalism to calculate photon spectra resulted in an increased amount of high energy photons.

*Mod 0 denotes the original version received and distributed at RSIC.

**Submitted to NNCSC for ENDF/B-IV.

d. MOD 3** - October 1973

The gamma-ray production files were revised to incorporate recent measurements by J. K. Dickens at ORNL.

The tabulated elastic scattering angular distribution at 14 MeV was thinned to reduce the number of points below the 100 allowed by ENDF format.

12. Iron - MAT - 4180

a. MOD 0 - March 1972

Note that this is the same as ENDF/B-III iron (MAT 1180). Note also that this supersedes DNA MAT 4124 iron, which has the following history.

MOD 0*- September 1970

MOD 1 - September 1971

Multilevel Breit-Wigner resonance parameters used for the energy range 1 to 60 keV, direct interaction reactions for inelastic scatter were corrected, and the number of energy points and angular distributions were reduced.

MOD 2 - December 1971

Note that this is essentially the same as DNA MAT 4180 MOD 0. The minimum in the total cross section at 24 keV was reduced to 425 mb and the gamma-ray production data were made consistent with the data of Hoot and Orphan, GRT.

b. MOD 1 - August 1972

Point values are given in File 3 rather than resonance parameters. File 1 references are changed. Results from preliminary ORELA measurements have been included for many minima in the total cross sections.

All cross sections have been extended to 20 MeV. New reactions have been introduced - $(n,n'\alpha)$ and $(n,n'p)$. The $(n,2n)$, (n,p) , MT=51 and MT=91 reactions have been revised.

The elastic angular distributions have been revised to include Barnard's data.

The File 5 $(n,2n)$ distributions have been revised and are tabulated in 200 keV secondary energy bins. The MT=91 File 5 distributions are revised and are tabulated in 50 keV secondary energy bins from threshold to 7.1 MeV, in 100 keV bins from 7.1 to 9 MeV, and in 200 keV bins from 9 to 20 MeV.

The capture gamma rays have been revised based on John White's most recent computation. All gamma-ray energy distributions have been thinned so that there are no non-zero values "less than 0.001" of the maximum.

*MOD 0 denotes the original version received and distributed at RSIC.
**Submitted to NNCSC for ENDF/B-IV.

c. MOD 2** - February 1974

This modification supersedes the previous evaluation, DNA 4180 MOD 1, evaluated by S. K. Penny, W. E. Kinney, R. Q. Wright, F. G. Perey, and C. Y. Fu, of ORNL. It was primarily intended for a revision of the secondary neutron distributions as new data have become available and as the pulsed sphere measurements and related calculations indicated that the previous neutron distributions were inadequate, and for a re-evaluation of the gamma-ray production cross sections since the recently available data disagree substantially with the data set upon which the previous evaluation was largely based. These purposes were consistently achieved by an extensive calculation for Fe-56 which also led to the refinement of all reaction cross sections except capture. Significant changes are summarized below. Total cross section between 60 keV and 2 MeV -- peaks and valleys were refined based on 3 sets of ORELA measurements using 1-, 4-, and 12-inch samples. Non-elastic -- obtained by compromising 3 pieces of information, namely, the measured nonelastic cross section, the difference between the evaluated total cross section and the available elastic scattering cross section, and the theoretical interpretation of the total gamma-ray-production cross section. The calculated nonelastic cross section was normalized to this result for constraining the subsequent calculations. Inelastic scattering -- 6 more discrete levels were added based on the Hauser-Feshbach and DWBA calculations in order to include the 4.505-MeV collective state as a discrete level. The direct-interaction components were included in 15 of the 26 discrete levels. The direct-interaction component was included in the continuum using an empirical treatment. MT=51 (0.846-MeV level) was changed between 2 and 5 MeV according to an evaluation by Smith which was based on all available data and his recent measurement. MT=52 (the 1.408-MeV level in Fe-54) was revised based on recently available data.

The Hauser-Feshbach method was used to calculate the $((n,n')$ and (n,nx)), $((n,p)$ and (n,px)) and $((n,\alpha)$ and $(n,x))$ cross sections. The $((n,n')$ and (n,nx)) cross section above 4.531 MeV was split into the (n,n') continuum, $(n,2n)$, (n,np) and $(n,n\alpha)$ cross sections using a statistical-empirical model. The empirical aspects include giant-dipole gamma-ray competition, angular-momentum correction for the second outgoing particle and direct or pre-equilibrium emission of the first particle.

The (n,p) cross section was well-defined by measurements and that of Fe-56 was well-fitted by calculation up to 13 MeV. The (n,pn) cross section was taken to be the difference between the calculated Fe-56 $((n,p)$ and (n,px)) cross section and the measured Fe-56 (n,p) cross section. Neutron distribution for the (n,pn) reaction was calculated and was averaged with that of the reaction for MT=28.

**Submitted to NNCSC for ENDF/B-IV.

There is no measured Fe-56 (n, α) cross section. The calculated Fe-56 (n, α) cross section was restrained by the 14-MeV empirical value and the measured fission-spectrum averages. The Fe-54 (n, α) cross section was taken from a calculation by Kirouac and Slavik. The (n, α n) cross section and neutron distribution were calculated and were combined with those of the (n, $n\alpha$) reaction for MT=22.

The (n,d), (n,t) and (n,He-3) cross sections were based on calculations using the Pearlstein empirical model and parameters.

The two major sets of the gamma-ray production cross sections agree within experimental errors for incident neutron energies below 6 MeV and then start to diverge, the GRT set being 1.6 barns larger than the ORNL set in the 11 to 15 MeV region. Other available data were too limited to resolve this discrepancy. The calculated results are intermediate between the two, being closer to the GRT measurement below 12 MeV and closer to the ORNL data above 12 MeV. For a tentative evaluation, the ORNL data were used for the energy distributions (File 15) as these were given in adequate neutron bins and were the only data available from 15 to 20 MeV. The gamma rays below 0.69 MeV were not measured and were filled in using the calculated values. Up to 10 MeV incident neutron energy, the energy conservation law relating the calculated outgoing particle energy and the evaluated gamma-ray energy was applied to determine the gamma-ray multiplicities. From 10 to 16 MeV the calculated multiplicities were used and were extrapolated to 20 MeV according to the shape given by the ORNL measurement.

13. Uranium-238 - MAT 4187

a. MOD 0* - July 1972

b. MOD 1 - March 1973

The energy range was extended down to 10^{-5} eV. The elastic and capture data below 1 keV were obtained by generating point values from ENDF/B-III MAT 1158 resonance parameters, Doppler broadening to 300°K, and thinning with a 0.2 criterion. For consistency, all data in files 3, 4, and 5 are given at 300°K. At neutron energies below 1.09 MeV, data are given for gamma-ray production spectra from fission and capture, and discrete gamma rays from some low-lying levels (0.05, 0.15 MeV). Above 1.09 MeV the gamma-ray production spectrum from all reactions is given in one reaction (MT=3).

14. Uranium-235 - MAT 4188

a. MOD 0* - July 1972

*MOD 0 denotes the original version received and distributed by RSIC.

b. MOD 1 - March 1974

The energy range was extended down to 10^{-5} eV. The elastic, fission, and capture data below 80 eV were obtained by generating point data from ENDF/B-III MAT 1157 resonance parameters, Doppler broadening to 300°K, and thinning with a 0.1 criterion. For consistency, all data in files 3, 4, and 5 are given at 300°K. The shape of the energy distribution of capture gamma rays was assumed independent of incident neutron energy, with an adjustment made in the multiplicity to conserve energy.

15. Carbon-12 - MAT 4274

a. MOD 0** - February 1974

16. Helium-4 - MAT 4504

a. MOD 0** - November 1973

17. Fluorine - MAT 4509

a. MOD 0* - March 1974

Gamma production files only.

18. Magnesium - MAT 4512

a. MOD 0* - April 1973

b. MOD 1**-April 1974

The excitation function for inelastic scattering to the continuum (MT=91, MF=3) was increased by 150 mb at 14-MeV incident energy and, in a systematic way, everywhere between 8.0- and 20.0-MeV incident energy. The additional cross section for MT=91 was subtracted from that for the (n,α) reaction (MT=107, MF=3). This change and the following revisions were primarily motivated by comparisons to LLL pulsed-sphere measurements (R. J. Howerton, Private Communication, 1973).

Secondary neutron energy distributions for inelastic scattering to the continuum (MT=91, MF=5) were changed at and above 10-MeV incident energy to those typical of a simple evaporation spectrum found more successful in accounting for LLL pulsed-sphere measurements.

19. Copper - MAT 4529

a. MOD 0* - April 1973

b. MOD 1** - March 1974

Excitation functions for inelastic scattering to 0.962 MeV level in Cu-63 (MT=53, MF=3) and to 1.115 MeV level in Cu-65 (MT=54, MF=3) were increased between 3.5- and 10-MeV incident energy to better agree with new ORNL data between 5.5 and 8.0 MeV (W. E.

*MOD 0 denotes the original version received and distributed at RSIC.

**Submitted to NNCSC for ENDF/B-IV.

Kinney, Private Communication, 1973). Additional inelastic scattering cross section was subtracted from elastic scattering cross section (MT=2, MF=3).

Legendre coefficients for elastic scattering (MT=2, MF=4) determined in above reference were added at incident energies 5.5 and 8.5 MeV.

Photon production measurements from 1.25 to 20 MeV incident neutron energy were incorporated from J. K. Dickens et al., ORNL-4846 (1973). In MF=13, all photon production is given under MT=3. In MF=12 and 15, photon production from radiative capture is retained separately under MT=102 at neutron energies below 1.25 MeV. At higher neutron energies all photon production is given in MF=15 under MT=3.

20. Zinc - MAT 4530

- a. MOD 0* - January 1974

Gamma production files only.

21. Plutonium-239 - MAT 4539

- a. MOD 0* - March 1973.

22. Plutonium-240 - MAT 4540

- a. MOD 0* - March 1973.

23. Silver - MAT 4547

- a. MOD 0* - January 1974

Gamma production files only.

24. Tin - MAT 4550

- a. MOD 0* - January 1974.

Gamma production files only.

25. Tungsten-182 - MAT 4582

- a. MOD 0* - July 1973

- b. MOD 1** - November 1973

File 4 (n,2n) and (n,3n) are now given as Legendre coefficients. Data for (n,n')p were added to file 4 (assumed isotropic in lab) and to file 5. The temperatures were based on the same level density parameters that were employed for the (n,2n) and (n,3n) reactions.

- c. MOD 2 - March 1974

Capture gamma-ray multiplicities and spectra below 0.5 eV were changed to agree with Journey's thermal measurement.

*MOD 0 denotes the original version received and distributed at RSIC.

**Submitted to NNCSC for ENDF/B-IV.

26. Tungsten-183 - MAT 4583

a. MOD 0* - July 1973

b. MOD 1** - November 1973

File 4 (n,2n) and (n,3n) are now given as Legendre coefficients. Data for (n,n')p were added to file 4 (assumed isotropic in lab) and to file 5. The temperatures were based on the same level density parameters that were employed for the (n,2n) and (n,3n) reactions.

c. MOD 2 - March 1973

Capture gamma-ray multiplicities and spectra below 0.5 eV were changed to agree with Journey's thermal measurement.

27. Tungsten-184 - MAT 4584

a. MOD 0* - July 1973

b. MOD 1** - November 1973

File 4 (n,2n) and (n,3n) are now given as Legendre coefficients. Data for (n,n')p were added to file 4 (assumed isotropic in lab) and to file 5. The temperatures were based on the same level density parameters that were employed for the (n,2n) and (n,3n) reactions.

c. MOD 2 - March 1974

Capture gamma-ray multiplicities and spectra below 0.5 eV were changed to agree with Journey's thermal measurement.

28. Tungsten-186 - MAT 4586

a. MOD 0* - July 1973

b. MOD 1** - November 1973

The MOD 1 changes are as described above. In addition, errors in the file 5 (n,2n) and (n,3n) U-cutoff and fractional probability energy ranges were corrected.

c. MOD 2 - March 1974

Capture gamma-ray multiplicities and spectra below 0.5 eV were changed to agree with Journey's thermal measurement.

*MOD 0 denotes the original version received and distributed at RSIC.

**Submitted to NNCSC for ENDF/B-IV.

4. ACKNOWLEDGEMENTS

The Defense Nuclear Agency Working Cross Section Library resulted from concepts developed by Captain Dean C. Kaul of the Defense Nuclear Agency. We are grateful for his support of the RSIC work associated with the DNA library. We acknowledge the help and cooperation of the cross section evaluators at various installations in reviewing the contents of the data.

Our sincere appreciation is extended to Henrietta R. Hendrickson of the RSIC staff for her help in checking, updating, maintaining, and distributing the library.

5. LISTINGS OF FILE 1 OF THE DNA LIBRARY TAPES

There follows the listings of file 1 from each tape in the DNA Working Cross Section Library. The evaluation effort is summarized therein. Much useful information is given.

INDEX TO FILE 1 LISTINGS

<u>Element</u>	<u>(MAT, MOD) Numbers</u>	<u>Page</u>
Hydrogen-1	(4148,2)	5.40
Tritium	(4169,1)	5.75
Helium-4	(4504,0)	5.117
Beryllium-9	(4154,2)	5.61
Carbon-12	(4274,0)	5.113
Nitrogen	(4133,4)	5.3
Oxygen-16	(4134,2)	5.14
Fluorine	(4509,0)	5.120
Sodium-23	(4156,0)	5.68
Magnesium	(4512,1)	5.123
Aluminum-27	(4135,3)	5.24
Silicon	(4151,3)	5.44
Calcium	(4152,3)	5.55
Iron	(4180,2)	5.90
Copper	(4529,1)	5.133
Zinc	(4530,0)	5.142
Silver	(4547,0)	5.152
Tin	(4550,0)	5.155
Tantalum-181	(4179,3)	5.80
Tungsten-182	(4582,2)	5.158
Tungsten-183	(4583,2)	5.167
Tungsten-184	(4584,2)	5.176
Tungsten-186	(4586,2)	5.185
Lead	(4136,5)	5.34
Uranium-235	(4188,1)	5.106
Uranium-238	(4187,1)	5.98
Plutonium-239	(4539,0)	5.145
Plutonium-240	(4540,0)	5.149

N-14 LASL EVAL-JAN71 P.G.YOUNG AND D.G.FOSTER, JR
MATERIAL= 4133 ZA= 7014. AWR = 13.8830 FILE= 1 SECTION= 451

MF#14, MT#102 ANGULAR DISTRIBUTIONS WERE MADE CONSISTENT
WITH THE REVISION OF MF#12, MT#102 FOR THE
INCLUSION OF IP FLAGS.

***** DNA 4133 MOD 3 *****

THIS MODIFICATION WAS MADE TO ENABLE THE CURRENT
DNA LIBRARY TO CONFORM TO THE ENDF/B-III LIBRARY
AND TO ADD PHOTON INTERACTION DATA

THE DATA CORRESPONDS TO THE ENDF/B-III EVALUATION
WITH THE MAT NUMBER HAVING THE SAME LAST 3 DIGITS.

FILE 23 DATA - PHOTON INTERACTION - TAKEN FROM RSIC
DATA LIBRARY %DLC-7 D< IS BASED ON DATA FROM
UCRL-50174 SEC. II, REV. 1969 BY MCMASTER ET AL.
AND UCRL-50400, VOL. VI BY PLECHATY AND TERRALL.

***** MAT#4133 NITROGEN MOD.2 7-30-71 *****

MF#1 ONE ERROR IN THE BIBLIOGRAPHY WAS CORRECTED.

MF#2 EH CHANGED FROM 1.0E630 TO 1.0E603.

MF#3, MT#60-82 MODIFIED TO INCLUDE INFORMATION DESIGNATING
DECAY OF THE INELASTIC LEVELS BY PROTON OR
ALPHA EMISSION, AS PROVIDED FOR AT THE LAST
CSEWG MEETING.

MF#4, MT#2, 51-62 HAVE BEEN THINNED SOMEWHAT.

***** MAT#4133 NITROGEN MOD.1 4-6-71 *****

MF # 1 SEVERAL CORRECTIONS AND ADDITIONS WERE MADE.

MT # 3 TWO MINOR CLERICAL ERRORS IN MT#700 WHICH
PROPOGATED INTO MT#103, 3, AND 2 WERE CORRECTED.

MT # 4 THE ELASTIC LEGENDRE COEFFICIENTS %MT#2<
ABOVE ABOUT 13 MEV WERE ADJUSTED SOMEWHAT
TO PRODUCE AGREEMENT WITH WICKS LIMIT. IN ADDITION,
AN ERROR IN THE NORMALIZATION OF THE FIRST
%N,2N< ANGULAR DISTRIBUTION %MT#16< WAS
CORRECTED.

N-14 LASL EVAL-JAN71 P.G.YOUNG AND D.G.FOSTER, JR
MATERIAL= 4133 ZA= 7014. AWR = 13.8830 FILE= 1 SECTION= 451

MT # 5 THE ORIGINAL %N,2N< ENERGY DISTRIBUTION
%MT#16< WERE ERRONEOUSLY GIVEN IN UNITS OF
MEV-1, THESE WERE REDUCED BY A FACTOR OF
10E6 TO GIVE THE RESULTS IN EV-1.

MT # 12 SOME OF THE CAPTURE %MT#102< GAMMA-RAY ENERGIES
WERE ORIGINALLY IN ERROR BY AS MUCH 7 PER CENT,
THESE WERE CORRECTED.

* * * * * *
N-14 FREE ATOM EVAL. JAN. 1971 P.G.YOUNG, D.G.FOSTER, JR. %LASL<
MF#2 ---- RESONANCE PARAMETERS ----
MT#151 EFFECTIVE SCATTERING RADIUS # 0.89014E-12 CM
MF#3 ---- SMOOTH CROSS SECTIONS ----

THE 2200 M/S CROSS SECTIONS ARE AS FOLLOWS,

MT#1 SIGMA# 11.851 BARNS
MT#2 SIGMA# 9.957 BARNS
MT#3 SIGMA# 1.894 BARNS
MT#102 SIGMA# 0.075 BARNS
MT#103 SIGMA# 1.819 BARNS

MT#1 TOTAL CROSS SECTION

ZERO TO 1 EV, SIGT # 9.957E0.3013/SQRT%E< BARNS, FROM ABSORP-
TION OF 1.894 B AT 2200 M/S AND ME49 DATA ABOVE 1 EV.

1 EV TO 10 KEV, FROM DATA OF ME49.

10 KEV TO .5 MEV, FROM HI52, BI59, HU61, AND BI62 WITH ENERGY
SCALFS ADJUSTED TO MATCH, NORMALIZED SEPARATELY TO JOIN
TIME-OF-FLIGHT DATA SMOOTHLY AT 0.5 MEV.

.5 MEV TO 20 MEV, FROM CA70, HE70, AND FO71 USING CA70 ALONE
AT SHARP RESONANCES.

SMOOTHED BY APPROPRIATE FITS. LOG-LOG INTERPOLATION IS GOOD TO
1.3 PCT TO 0.4 MEV, LINEAR INTERPOLATION IS GOOD TO 0.5
PCT FROM 0.4 TO 20 MEV. ABSOLUTE ERROR LESS THAN 1 PCT
ABOVE 0.75 MEV, MAY RISE TO 5 PCT IN EV REGION.

MT#2 ELASTIC SCATTERING CROSS SECTION

ZERO TO 10 MEV, SUBTRACTED EVALUATED NON-ELASTIC FROM THE
EVALUATED TOTAL, ALTHOUGH DIRECT ELASTIC MEASUREMENTS OF
FO55, FO66, BO57, CH61, BA67, PH61, NE70 WERE CONSIDERED.

10 TO 12 MEV, TRANSITION REGION.

12 TO 20 MEV, BASED UPON DATA OF CH61, BA67, NE70, BA63, BO68.

MT# 4 SUM OF MT#51-82 CROSS SECTIONS.

MT#16 %N,2N< CROSS SECTION

BASED UPON DATA OF FE60, BR61, BO65, PR60, ESTIMATE 8-30 PCT ERR.

MT#51-62 INELASTIC CROSS SECTION TO DISCRETE STATES

MT#51 Q#-2.313 MEV	MT#55 Q#-5.691 MEV	MT#59 Q#-7.028 MEV
52 -3.945	56 -5.834	60 -7.966
53 -4.913	57 -6.198	61 -8.061
54 -5.106	58 -6.444	62 -8.489

N-14 LASL EVAL-JAN71 P.G.YOUNG AND D.G.FOSTER, JR
 MATERIAL= 4133 ZA= 7014. AWR = 13.8830 FILE= 1 SECTION= 451

THRESHOLD TO 15 MEV, FROM %N,NG< DATA OF DI69,OR69,CL69,BU69,
 NY69,CO68.

ABOVE 15 MEV, SMOOTH EXTRAPOLATIONS.

MT#63-82 INELASTIC CROSS SECTION TO GROUPS OF DISCRETE STATES IN
 BANDS CENTERED ABOUT THE Q-VALUES THAT ARE GIVEN.

MT#63 Q#- 9.25 MEV	MT#70 Q#-12.75 MEV	MT#77 Q#-16.25 MEV
64 - 9.75	71 -13.25	78 -16.75
65 -10.25	72 -13.75	79 -17.25
66 -10.75	73 -14.25	80 -17.75
67 -11.25	74 -14.75	81 -18.25
68 -11.75	75 -15.25	82 -18.75
69 -12.25	76 -15.75	

THE INTEGRATED CROSS SECTION OVER THESE BANDS WAS ADJUSTED
 SUCH THAT THE DIFFERENCE BETWEEN THE TOTAL AND NON-ELASTIC
 CROSS SECTIONS AGREED WITH ELASTIC DATA %SEE MT#2<. THE
 DIVISION OF THE CROSS SECTION AMONG THE BANDS IS BASED ON
 HAUSER-FESHBACH AND NUCLEAR TEMPERATURE CALCULATIONS.

****PLEASE NOTE THAT MOST OF THE CROSS SECTION TO THESE BANDS
 ****SUBSEQUENTLY RESULTS IN PROTON EMISSION. SINCE THESE DATA
 ****ARE NOT INCLUDED EXPLICITLY AS %N,NP< REACTIONS, IT IS
 ****IMPORTANT THAT THE USER INVOLVED IN CERTAIN CALCULATIONS
 ****%E.G., LOCAL HEATING< BE AWARE OF THIS INFORMATION.

MT#102 %N,GAMMA< CROSS SECTION

ZERO TO 0.25 MEV, 1/V FROM 75 MB %E-10ECT< AT THERMAL %JU63<.
 .25 TO 1 MEV, TRANSITION REGION.

1 TO 20 MEV, DEDUCED FROM N14%P,G<O15 DATA OF KU70, ASSUMING
 CHARGE INDEPENDENCE. ENERGY SCALE ADJUSTED TO MATCH FOOT-
 HILLS OF %P,G< GIANT RESONANCE TO RESONANCE CLUSTERS OB-
 SERVED IN N15 COMPOUND NUCLEUS.

MT#103 SUM OF MT#700-704 CROSS SECTIONS.

MT#104 SUM OF MT#720-723 CROSS SECTIONS.

MT#105 SUM OF MT#740-741 CROSS SECTIONS.

MT#107 SUM OF MT#780-790 CROSS SECTIONS.

MT#108 %N,2ALPHA< CROSS SECTION.

BASED ON LI52,MO67 AND HAUSER-FESHBACH CALCULATION.

MT#700 %N,P< CROSS SECTION TO C14 GROUND STATE.

ZERO TO 4 MEV, FROM DATA OF JO50 AND GA59.

4 TO 13 MEV, FROM INVERSE REACTION DATA OF WO67.

13 TO 20 MEV, SMOOTH EXTRAPOLATION.

MT#701-704 %N,P< CROSS SECTIONS TO C14 EXCITED STATES.

MT#701 Q#-5.468 MEV EX#6.095 MEV %6.58,6.89 MEV LEVEL
 EXCITATION CROSS SECTIONS ARE
 ALSO INCLUDED<

MT#702 Q#-6.102 MEV	EX#6.728 MEV
703 -6.385	7.012
704 -6.711	7.337

THRES.TO 15 MEV, FROM %N,PG< DATA OF OR69,DI69,CL69,BU69,NY69.
 15 TO 20 MEV, SMOOTH EXTRAPOLATIONS.

MT#720 %N,D< CROSS SECTION TO C13 GROUND STATE.

THRES.TO 15 MEV, FROM INVERSE CROSS SECTION DATA OF CH61,BE63

N-14 IASL EVAL-JAN71 P.G.YOUNG AND D.G.FOSTER, JR
 MATERIAL= 4133 ZA= 7014. AWR = 13.8830 FILE= 1 SECTION= 451

NEAR THRES.AND DIRECT DATA OF MI68,FE67,CA57,ZA63 AT 14MEV
 15 TO 20 MEV, SMOOTH EXTRAPOLATIONS.

MT#721-723 %N,D< CROSS SECTION TO EXCITED C13 LEVELS

MT#721 Q#-8.411 MEV EX#3.086 MEV

722 -9.009 3.684

723 -9.179 3.854

THRES.TO 15 MEV, DIRECT DATA OF FE67,ZA63,CA57 AND %N,DG< DATA
 OF OR69 AND DI69 BELOW 13 MEV.

15 TO 20 MEV, SMOOTH EXTRAPOLATIONS.

MT#740-741 %N,T< CROSS SECTIONS TO C12 GROUND AND 4.439 MEV EX-
 CITED STATE.

THRES.TO 15 MEV, DIRECT DATA OF GA59,SC66,RE67,FE67.

15 TO 20 MEV, SMOOTH EXTRAPOLATIONS.

MT#780-790 %N,ALPHA< CROSS SECTION TO DISCRETE B11 STATES.

MT#780 Q#-0.157 MEV EX#0.000 MEV

781 -2.282 2.124

782 -4.602 4.444

783 -5.176 5.019

784 -6.900 6.743

785 -6.950 6.793

786 -7.453 7.296

787 -8.153 7.996

788 -8.723 8.566

789 -9.082 8.925

790 -9.342 9.185

THRES.TO 6 MEV, FROM DIRECT DATA OF JO50,GA59,SC66.

6 TO 15 MEV, USED ABOVE DIRECT DATA, TOGETHER WITH %N,AG< DATA
 OF HA59,DI69,OR69,NY69,BU69. NEAR 14 MEV, DIRECT %N,A<
 DATA OF LI52,BA68,LE68,MA68 WERE ALSO USED.

15 TO 20 MEV, SMOOTH EXTRAPOLATIONS.

MF#4 ----- SECONDARY NEUTRON ANGULAR DISTRIBUTIONS -----

MT#2 ELASTIC ANGULAR DISTRIBUTIONS

ZERO TO 8 MEV, BASED UPON RESONANCE THEORY ANALYSIS OF DATA OF
 FO55,FO66,BO57,CH61,BA67, USING PARAMETERS FROM TOTAL AND
 PARTIAL CROSS SECTION ANALYSES AND AJ70.

8 TO 15 MEV, BASED UPON DATA OF CH61,BA67,NE70,BA63

15 TO 20 MEV,BASED UPON OPTICAL MODEL CALCULATION.

MT#16 ANGULAR DISTRIBUTION FOR %N,2N< REACTION

IN THE ABSENCE OF DATA, ISOTROPY IN THE CM SYSTEM IS ASSUMED,
 AND THE CORRESPONDING 3-BODY PHASE-SPACE TRANSFORMED TO
 THE LAB SYSTEM IS GIVEN. FOR ANY REASONABLE CM DISTRIBUTION
 THE STRONG FORWARD PEAKING OF THE TRANSFORMATION
 WILL DOMINATE. NORMALIZED FOR TRAPEZOIDAL INTEGRATION.

MT#51 TO 62 ANGULAR DISTRIBUTIONS FOR INELASTIC SCATTERING
 ABOVE 7 MEV TAKEN FROM PROTON DATA OF DO64, HA70, AND OD60

ASSUMING CHARGE SYMMETRY, AND NEUTRON DATA OF BA63.

THRESHOLD SHAPES MODELED AFTER HAUSER-FESHBACH CALCS.

MT#63-82 ANGULAR DISTRIBUTIONS FOR INELASTIC SCATTERING.

ASSUMED ISOTROPIC IN CM AT ALL ENERGIES.

MF#5 ----- ENERGY DISTRIBUTION OF SECONDARY NEUTRONS -----

N-14 LASL EVAL-JAN71 P.G.YOUNG AND D.G.FOSTER, JR
MATERIAL= 4133 ZA= 7014. AWR = 13.8830 FILE= 1 SECTION= 451

MT#16 SPECTRUM OF %N,2N< SECONDARY NEUTRONS
IN THE ABSENCE OF DATA, ONLY THE 3-BCDY PHASE-SPACE DISTRIBUTION IS GIVEN. NORMALIZED FOR TRAPEZOIDAL INTEGRATION.

MF#12 ----- PHOTON MULTIPLICITIES -----
MT#102 %N,GAMMA< MULTIPLICITIES
ZERO TO 0.25 MEV, THERMAL SPECTRUM BASED PRIMARILY UPON MEASUREMENTS OF TH67,JO69,GR68, AND MC62.
.25 TO 1 MEV, TRANSITION REGION WHERE THERMAL SPECTRUM IS PHASED INTO SINGLE GROUND-STATE TRANSITION.
1 TO 20 MEV, DEDUCED FROM N14%P,G<0.15 DATA OF KU70,WHO OBSERVED NO SIGNIFICANT TRANSITIONS EXCEPT TO GROUND STATE.

MF#13 ----- PHOTON-PRODUCTION CROSS SECTIONS -----
ALL %N,XG< CROSS SECTIONS AGREE WITH THE EXCITATION CROSS SECTIONS IN MF#3 VIA THE RELEVANT DECAY SCHEME %AJ68,AJ70< HOWEVER, MT#104,105 INCLUDE CONTRIBUTIONS FROM %N,NPG< AND %N,NDG<.

MT#4 %N,NG< CROSS SECTION
FROM DATA OF HA59,DI69,OR69,CL69,BU69,NY69,CO68.

MT#103 %N,PG< CROSS SECTION
FROM DATA OF DI69,OR69,BU69,NY69,CL69.

MT#104 %N,DG<%N,NPG< CROSS SECTION
FROM DATA OF DI69,OR69,BU69,NY69,CL69.

MT#105 %N,TG<%N,NDG< CROSS SECTION
%N,TG< ESTIMATED FROM %N,T< AS DISCUSSED UNDER MF#3,MT#741.
%N,NDG< ESTIMATED FROM MT#63-82.

MT#107 %N,AG< CROSS SECTION
FROM %N,A< DATA OF GA59,SC66 AND %N,AG< DATA OF HA59,DI69,NY69,OR69,BU69.

MF#14 ----- PHOTON ANGULAR DISTRIBUTIONS -----
DATA ON 9 STRONGEST LINES FROM INELASTIC SCATT. AND PARTICLE REACTIONS TAKEN FROM MO64.

MT# 4 INEL. SCATT. TO N14, 1.63 AND 4.91 MEV ANISOTROPIC

MT#102 %N,GAMMA< ANGULAR DISTRIBUTIONS
ZERO TO 0.4 MEV, ALL PHOTONS ARE ISOTROPIC.
.4 TO 20 MEV, ANISOTROPIC DISTRIBUTION FOR THE SINGLE GROUND STATE TRANSITION IS BASED UPON N14%P,G<0.15 DATA BY KU70.

MT#103 %N,P< TO C14, ALL ISOTROPIC

MT#104 %N,NP<%N,D< TO C13, 3.85 MEV ANISOTROPIC

MT#105 %N,ND<%N,T< TO C12, ALL ISOTROPIC

MT#107 %N,ALPHA< TO B11, ALL ISOTROPIC

----- REFERENCES -----

AJ68 F.AJZENBERG-SELOVE&T.LAURITSEN %HAV<, NUCL.PHYS.A114,1%1968<
AJ70 F.AJZENBERG-SELOVE %PEN<, NUCL.PHYS.A152,1 %1970<
BA63 R.W.BAUER ET AL.%LRL<, NUCL. PHYS. 47, 241 %1963<
BA67 R.W.BAUER ET AL.%LRL<, NUCL.PHYS.A93, 673 %1967<.
BA68 R.BACHINGER&M.UHL %IRK<, NUCL.PHYS.A116, 673 %1968<.
BE63 R.E.BENENSON&R.YARAMIS %COL<, PHYS.REV.129, 720 %1963<.
BI59 E.G.BILPUCH ET AL.%DKE<, PRIV. COMM. TO BNL %1959<
BI62 E.G.BILPUCH ET AL.%DKE<, PRIV. COMM. TO R.J.HOWERTON %1962<
BO57 N.A.BOSTROM ET AL.%TNC<, WADC-TR-57-446, %1957<.

N-14 IASL EVAL-JAN71 P.G.YOUNG AND D.G.FOSTER, JR
 MATERIAL= 4133 ZA= 7014. AWR = 13.8830 FILE= 1 SECTION= 451

BO65 M.BORMANN ET AL.%HAM<, NUCL.PHYS.63, 438 %1965<.
 BO68 F.BORELI ET AL.%TEX<, PHYS.REV.174, 1221 %1968<.
 BR61 O.D.BRILL ET AL.%RUS<, SOV.PHYS.-DOKL.6, 24 %1961<.
 BU69 P.S.BUCHANAN %TNC<, PRIV.CCMM., %1969<.
 CA57 R.R.CARLSON %LAS<, PHYS.REV.107, 1094 %1957<.
 CA70 A.D.CARLSON, R.J.CERBONE %GGA<, NUCL. SCI. ENG. 42,28,%1970<
 CH61 L.F.CHASE ET AL.%LCK<, AFSWC-TR-61-15, %1961<.
 CL69 G.CLAYEUX&G.GRENIER %FR<, CEA-R-3807, %1969<.
 CO68 H.CONDE ET AL.%SWD<, NEUT.CROSS SECT.AND TECH.CONF., WASH.,
 D.C., P763 %1968<.
 DI69 J.K.DICKENSE&F.G.PEREY %ORL<, NUCL.SCI.ENG.36, 280 %1969<.
 DO64 D.F.DONOVAN ET AL.%BNL<, PHYS. REV. 133, 8113 %1964<
 FE60 J.M.FEEGUSON&W.E.THOMPSON %NRD<, PHYS.REV.118, 228 %1960<.
 FE67 P.FESSENDEN&D.R.MAXSON %BRN<, PHYS.REV.158, 948 %1967<.
 FO55 J.L.FOWLER&C.H.JOHNSON %ORL<, PHYS.REV.98, 728 %1955<.
 FO66 J.L.FOWLER ET AL.%ORL<, NEUT.CROSS SECT.AND TECH.CONF.,
 WASH.,D.C., P653 %1968<.
 FO71 D.G.FOSTER, JR.&D.W.GLASGOW %ENL<, PHYS.REV.%TO BE PUB.,1971<
 GA59 F.GABBARD ET AL.%RIC<, NUCL.PHYS.14,277%1959<.
 GR68 R.C.GREENWOOD %MTR<, PHYS. LETT. 27B, 274 %1968<
 HA59 H.E.HAIL&T.W.BONNER %RIC<, NUCL.PHYS.14, 295 %1959<.
 HA70 L.HANSEN %LRL<, PRIVATE COMMUNICATION %1970<
 HE70 H.T.HEATON ET AL.%NBS<, BULL. AM. PHYS. SOC. 15, 568 %1970<
 AND PRIVATE COMMUNICATION FROM F.B.SCHWARTZ %1970<
 HI52 J.J.HINCHEY ET AL.%MIT<, PHYS. REV. 86, 483 %1952<
 HU61 C.M.HUDDIESTON, F.P.MOORING %ANL<, ANL-6376, P.13 %1961<
 JO50 C.H.JOHNSON&H.H.BARSCHALL %WIS<, PHYS.REV.80, 818 %1950<.
 JO69 L.JONSSON, R.HARDELL %SWD<, SYMPOSIUM ON NEUTRON CAPTURE
 GAMMA RAYS, STODSVIK %1969<
 JU63 E.T.JURNEY, H.T.MOTZ %LAS<, ANL-9797, P. 241 %1963<
 KU70 H.M.KUAN ET AL.%STF<, NUCL. PHYS. A151, 129 %1970<
 LE68 B.LEROUX ET AL.%FR<, NUCL.PHYS.A116, 196 %1968<.
 LI52 A.B.LILLIE %RIC<, PHYS.REV.87, 716 %1952<.
 MA68 D.R.MAXSON ET AL.%BRN<, NUCL.PHYS.A110, 609 %1968<.
 ME49 E.MELKONIAN %COL<, PHYS. REV. 76, 1750 %1949<
 MI68 D.MILJANIC ET AL.%YUG<, NUCL.PHYS.A106, 401 %1968<.
 MO62 H.T.MOTZ ET AL.%LAS<, PILE NEUTRON RESEARCH IN PHYSICS
 %IAEA, VIENNA, 1962<, P. 225
 MO64 I.L.MORGAN ET AL.%TNC<, TNC NUCL.PHYS.DIV.ANN.RPT.%AUG.1964<
 MO67 J.MOSNER ET AL.%GER<, NUCL.PHYS.A103, 238 %1967<.
 NE70 D.O.NELLIS %TNC<, PRIV.CCMM., %1970<.
 NY69 K.NYBERG %SWD<, PRIV.COMM.TO L.STEWART, %1969<.
 OD60 Y.ODA ET AL.%TOK<, J. PHYS. SOC. JAPAN 15, 760 %1960<
 OR69 V.J.OREHAN ET AL. %GGA<, GA-8006, %1969<.
 PH61 D.D.PHILLIPS %LAS<, PRIV.COMM.TO R.J.HOWERTON, %1961<.
 PR60 J.T.PRUDHOMME ET AL.%TNC<, AFSWC-TR-60-30, %1960<.
 RE67 D.RENDIC %YUG<, NUCL.PHYS.A91, 604 %1967<.
 SC66 W.SCOBEL ET AL.%HAM<, Z.PHYSIK 197, 124%1966<.
 TH67 G.E.THOMAS ET AL.%ANL<, NUCL. INST. METH. 56, 325 %1967<
 WO67 C.WONG ET AL.%LRL<, PHYS.REV.160, 769 %1967<.

N-14 IASL EVAL-JAN71 P.G.YOUNG AND D.G.FOSTER, JR
MATERIAL= 4133 ZA= 7014. AWR = 13.8830 FILE= 1 SECTION= 451

ZA63 M.R.ZATZICK&D.R.MAXSON %BRN<, PHYS.REV.129, 1728 %1963<.

N-14 LASL EVAL-JAN71 P.G.YOUNG AND D.G.FOSTER, JR
MATERIAL= 4133 ZA= 7014. AWR = 13.8830 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	GENERAL COMMENTS	472
2	151	RESONANCE DATA	4
3	1	TOTAL	348
3	2	ELASTIC	346
3	4	TOTAL INELASTIC	52
3	16	(N,2N)	8
3	51	(N,N*) 1-ST EXCITED	52
3	52	(N,N*) 2-ND EXCITED	50
3	53	(N,N*) 3-ED EXCITED	48
3	54	(N,N*) 4-TH EXCITED	47
3	55	(N,N*) 5-TH EXCITED	45
3	56	(N,N*) 6-TH EXCITED	43
3	57	(N,N*) 7-TH EXCITED	42
3	58	(N,N*) 8-TH EXCITED	40
3	59	(N,N*) 9-TH EXCITED	38
3	60	(N,N*) 10-TH EXCITED	36
3	61	(N,N*) 11-TH EXCITED	35
3	62	(N,N*) 12-TH EXCITED	33
3	63	(N,N*) 13-TH EXCITED	31
3	64	(N,N*) 14-TH EXCITED	29
3	65	(N,N*) 15-TH EXCITED	27
3	66	(N,N*) 16-TH EXCITED	26
3	67	(N,N*) 17-TH EXCITED	25
3	68	(N,N*) 18-TH EXCITED	23
3	69	(N,N*) 19-TH EXCITED	22
3	70	(N,N*) 20-TH EXCITED	21
3	71	(N,N*) 21-TH EXCITED	20
3	72	(N,N*) 22-TH EXCITED	19
3	73	(N,N*) 23-TH EXCITED	17
3	74	(N,N*) 24-TH EXCITED	16
3	75	(N,N*) 25-TH EXCITED	15
3	76	(N,N*) 26-TH EXCITED	13
3	77	(N,N*) 27-TH EXCITED	12
3	78	(N,N*) 28-TH EXCITED	10
3	79	(N,N*) 29-TH EXCITED	9
3	80	(N,N*) 30-TH EXCITED	8
3	81	(N,N*) 31-TH EXCITED	6
3	82	(N,N*) 32-TH EXCITED	5
3	102	(N,GAMMA)	18
3	103	(N,P)	92
3	104	(N,L)	18
3	105	(N,T)	19
3	107	(N,ALPHA)	93
3	108	(N,2ALPHA)	8
3	700	(N,P) LEVEL	92
3	701	(N,P) LEVEL	17
3	702	(N,P) LEVEL	16
3	703	(N,P) LEVEL	14
3	704	(N,P) LEVEL	14
3	720	(N,D) LEVEL	18

N-14 LASL EVAL-JAN71 P.G.YOUNG AND D.G.FOSTER,JR
MATERIAL= 4133 ZA= 7014. AWR = 13.8830 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
3	721	(N,D) LEVEL	12
3	722	(N,D) LEVEL	10
3	723	(N,D) LEVEL	9
3	740	(N,T) LEVEL	19
3	741	(N,T) LEVEL	9
3	780	(N,A) LEVEL	93
3	781	(N,A) LEVEL	73
3	782	(N,A) LEVEL	46
3	783	(N,A) LEVEL	41
3	784	(N,A) LEVEL	24
3	785	(N,A) LEVEL	23
3	786	(N,A) LEVEL	18
3	787	(N,A) LEVEL	14
3	788	(N,A) LEVEL	13
3	789	(N,A) LEVEL	12
3	790	(N,A) LEVEL	10
4	2	ELASTIC	475
4	16	(N,2N)	46
4	51	(N,N*) 1-ST EXCITED	58
4	52	(N,N*) 2-ND EXCITED	51
4	53	(N,N*) 3-RD EXCITED	34
4	54	(N,N*) 4-TH EXCITED	30
4	55	(N,N*) 5-TH EXCITED	36
4	56	(N,N*) 6-TH EXCITED	40
4	57	(N,N*) 7-TH EXCITED	34
4	58	(N,N*) 8-TH EXCITED	26
4	59	(N,N*) 9-TH EXCITED	20
4	60	(N,N*) 10-TH EXCITED	14
4	61	(N,N*) 11-TH EXCITED	16
4	62	(N,N*) 12-TH EXCITED	10
4	63	(N,N*) 13-TH EXCITED	8
4	64	(N,N*) 14-TH EXCITED	8
4	65	(N,N*) 15-TH EXCITED	8
4	66	(N,N*) 16-TH EXCITED	8
4	67	(N,N*) 17-TH EXCITED	8
4	68	(N,N*) 18-TH EXCITED	8
4	69	(N,N*) 19-TH EXCITED	8
4	70	(N,N*) 20-TH EXCITED	8
4	71	(N,N*) 21-TH EXCITED	8
4	72	(N,N*) 22-TH EXCITED	8
4	73	(N,N*) 23-TH EXCITED	8
4	74	(N,N*) 24-TH EXCITED	8
4	75	(N,N*) 25-TH EXCITED	8
4	76	(N,N*) 26-TH EXCITED	8
4	77	(N,N*) 27-TH EXCITED	8
4	78	(N,N*) 28-TH EXCITED	8
4	79	(N,N*) 29-TH EXCITED	8
4	80	(N,N*) 30-TH EXCITED	8
4	81	(N,N*) 31-TH EXCITED	8
4	82	(N,N*) 32-TH EXCITED	8

N-14 IASL EVAL-JAN71 P.G.YOUNG AND D.G.FOSTER,JR
 MATERIAL= 4133 ZA= 7014. AWR = 13.8830 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
5	16	(N,2N)	65
7	4	TOTAL INELASTIC	4
12	102	(N,GAMMA)	106
13	4	TOTAL INELASTIC	412
13	103	(N,F)	115
13	104	(N,D)	57
13	105	(N,T)	9
13	107	(N,ALPHA)	411
14	4	TOTAL INELASTIC	32
14	102	(N,GAMMA)	52
14	103	(N,F)	1
14	104	(N,D)	13
14	105	(N,T)	1
14	107	(N,ALPHA)	1
23	501	TOTAL PHOTON	17
23	502	RAYLEIGH SCATTERING	17
23	504	COMPTON SCATTERING	17
23	516	PAIR PRODUCTION	9
23	602	PHOTOELECTRIC EFFECT	17

O-16 LASL-AUG,1973 P.G.YOUNG, D.G.FOSTER,JR., G.M.HALE
MATERIAL= 4134 ZA= 8016. AWR = 15.8580 FILE= 1 SECTION= 451

LASL LA-4780 DIST-SEP71 MOD 2-OCT73

***** DNA 4134 MOD 2 8/31/73 *****

THE DATA SET WAS EXTENSIVELY CHANGED TO INCLUDE NEW EXPERIMENTAL AND THEORETICAL RESULTS. FILE 1 WAS REVISED TO INCLUDE THE NEW RESULTS, AND A SUMMARY OF THE CHANGES IS AS FOLLOWS,

1. THE RESULTS OF AN R-MATRIX ANALYSIS OF THE ^{16}N , N^{α} , ^{16}N , ALPHA^{α} , AND ^{13}C , ALPHA^{α} REACTIONS BELOW 6 MEV WAS INCORPORATED IN MF#3, MT#1,2,107,780.
2. ADJUSTMENTS WERE MADE IN MF#3, MT#4,51-55,103,107,780-782 SO THAT MT#2 BETTER AGREES WITH ELASTIC MEASUREMENTS FROM 7 TO 11 MEV. ADJUSTMENTS WERE MADE PARTICULARLY TO MT#51 TO IMPROVE AGREEMENT WITH N , NPRIME^{α} MEASUREMENTS, AND MT#51-89 WERE MODIFIED TO IMPROVE SOMEWHA^{α} AGREEMENT WITH SPHERE TRANSMISSION INTEGRAL MEASUREMENTS.
3. LEGENDRE COEFFICIENTS IN MF#4, MT#2 WERE MODIFIED TO INCLUDE RESULTS FROM THE R-MATRIX ANALYSIS BELOW 6 MEV AND NEW EXPERIMENTAL DATA ABOVE 6 MEV.
4. ANISOTROPIC INELASTIC NEUTRON ANGULAR DISTRIBUTIONS WERE ADDED FOR MT#51-55.
5. ANISOTROPIC SECONDARY GAMMA RAY ANGULAR DISTRIBUTIONS WERE ADDED FOR THE 6.131- AND 6.917-MEV GAMMAS.
6. GAMMA-RAY PRODUCTION CROSS SECTIONS IN MF#13 WERE ADJUSTED TO INCLUDE THE REVISIONS IN ITEM 2 AND 5 USING GAMMA-RAY DECAY SCHEMES FOR THE APPROPRIATE RESIDUAL NUCLEI.
7. CROSS SECTIONS FOR MT# 4,51-89,103,104,107,780-783 IN MF#3 AND 13 WERE THINNED ABOVE EN#6 MEV USING THE REQUIREMENT THAT INTERPOLATED VALUES BETWEEN ANY TWO POINTS LIE WITHIN 2 PER CENT OF THE FINE-GRID VALUE, PROVIDING THAT A CERTAIN BASIC GRID 200 KEV INTERVALS BELOW EN#10 MEV AND 500 KEV ABOVE EN#10 MEV BE MAINTAINED. BELOW EN#6 MEV, A MORE STRINGENT REQUIREMENT OF 1.00 PER CENT WAS IMPOSED ON MT#780 AND 107.
8. THE MT#2 LEGENDRE COEFFICIENTS IN MF#4 WERE THINNED WITH THE REQUIREMENT THAT THE INTERPOLATED ANGULAR DISTRIBUTION HAVE AN RMS DEVIATION FROM THE FINE-GRID SET OF LESS THAN 2.5 PER CENT AND THAT THE MAXIMUM EXCURSION AT ANY ANGLE BE LESS THAN 5.0 PER CENT.
9. THE NONELASTIC CROSS SECTION MT#3^{α} WAS REMOVED FROM FILE 3.

***** DNA 4134 MOD 1 *****

THIS MODIFICATION WAS MADE TO ENABLE THE CURRENT
DNA LIBRARY TO CONFORM TO THE ENDF/B-III LIBRARY
AND TO ADD PHOTON INTERACTION DATA

O-16 LASL-AUG,1973 P.G.YOUNG, D.G.FOSTER,JR., G.M.HALE
MATERIAL= 4134 ZA= 8016. AWF = 15.8580 FILE= 1 SECTION= 451

THE DATA CORRESPONDS TO THE ENDF/B-III EVALUATION
WITH THE MAT NUMBER HAVING THE SAME LAST 3 DIGITS.

FILE 23 DATA - PHOTON INTERACTION - TAKEN FROM RSIC
DATA LIBRARY %DLC-7 D< IS BASED ON DATA FROM
UCRL-50174 SEC. II, REV. 1969 BY MCMASTER ET AL.
AND UCRL-50400, VOL. VI BY PLECHATY AND TERRALL.

* * * * *

O-16 FREE ATOM EVAL. - AUG.1971 - P.G.YOUNG,D.G.FOSTER,JR. %LASL<
REFERENCE -- LA-4780 %ENDF-174<, 1972

MF#2 ----- RESONANCE PARAMETERS -----

MT#151 EFFECTIVE SCATTERING RADIUS #0.54614E-12 CM.

MF#3 ----- SMOOTH CROSS SECTIONS -----

THE 2200 M/S CROSS SECTIONS ARE AS FOLLOWS,

MT#1 SIGMA # 3.7483 BAFNS

MT#2 SIGMA # 3.7481 BAFNS

MT#102 SIGMA # 0.1780 MILLIBARNS

MT#1 TOTAL CROSS SECTION

0.0 TO 5.7 MEV, ESSENTIALLY CALCULATED FROM R-MATRIX
PARAMETERS OBTAINED BY FITTING SIMULTANEOUSLY ALMOST
ALL AVAILABLE DATA FOR REACTIONS $^{160}\text{N}, \text{N}<160$,
 $^{160}\text{C}, \text{ALPHA0}<^{13}\text{C}$, $^{13}\text{C}, \text{ALPHA0}<^{13}\text{C}$ AT ENERGIES
BELOW EN # 5.7 MEV. DATA FOR TOTAL ARE SMOOTHED COMPOS-
ITE OF SC71 AND NORMALIZED CI68, WITH INSERTS OF CI68,
NORMALIZED COMPOSITE FO73, AND NORMALIZED FO61 FOR NAR-
ROW STRUCTURE. FO73 AND FO61 ENERGY SCALES ADJUSTED TO
MATCH CI68. RESOLUTION CORRECTIONS APPLIED SIMULTANEOUS-
LY TO TOTAL AND $^{160}\text{N}, \text{ALPHA0}<$ TO GIVE SAME WIDTH AND CON-
SISTENT HEIGHTS TO PEAKS. LEVEL SCHEME IS BASED ON JO73.
0.44-MEV RESONANCE FROM NORMALIZED DATA OF OK55.
INSERTS FROM THE SMOOTHED COMPOSITE ARE USED OVER SOME
NARROW RESONANCES, AND OVER REGIONS WHERE IT APPEARS TO
BETTER REPRESENT THE EXPERIMENTAL CROSS SECTION.
 $^{160}\text{N}, \text{GAMMA}<$ CAPTURE CROSS SECTION HAS BEEN ADDED AT
LOW ENERGIES, AND THE N-180 TOTAL CROSS SECTION ADDED
IN THE VICINITY OF THE N-160 MINIMUM AT EN # 2.35 MEV.
5.7 TO 20.0 MEV, BASED ON A SMOOTHED, EMPIRICAL FIT TO THE
COMPOSITE OF EXPERIMENTAL DATA DESCRIBED ABOVE.

MT#2 ELASTIC SCATTERING CROSS SECTION

O-16 LASL-AUG,1973 P.G.YOUNG, D.G.FOSTER,JR., G.M.HALE
 MATERIAL= 4134 ZA= 8016. AWR = 15.8580 FILE= 1 SECTION= 451

0.0 TO 5.7 MEV, THE DIFFERENCE OF MT#1 AND MT#780
 6 TO 11 MEV, OBTAINED BY SUBTRACTING THE SUM OF MT#4,102,
 103,104,107 FROM MT#1. HOWEVER, ADJUSTMENTS WERE MADE TO
 CERTAIN REACTION CHANNELS, PARTICULARLY MT#51, TO ENHANCE
 AGREEMENT WITH THE ELASTIC MEASUREMENTS OF PH61,CH61,
 AND ESPECIALLY NE72,KI72, AND BU73.
 11 TO 14 MEV, SMOOTH CURVE DRAWN SO AS TO AGREE WITH 14-MEV
 MEASUREMENTS OF BA63,MC66, AND BE67.
 14 TO 20 MEV, OPTICAL MODEL EXTRAPOLATION USING PARAMETERS
 FROM FIT OF 14-MEV DATA OF BA63, ADJUSTED TO GIVE CORRECT
 TOTAL X/S UP TO 20 MEV.

MT#4 INELASTIC CROSS SECTION
 THRES. TO 20 MEV, SUM OF MT#51-89.

MT#51-70 INELASTIC CROSS SECTION TO DISCRETE STATES

MT#51 Q#-6.052 MEV	MT#58 Q#-10.354 MEV	MT#65 Q#-11.63 MEV
52 -6.131	59 -10.952	66 -12.053
53 -6.917	60 -11.080	67 -12.442
54 -7.119	61 -11.096	68 -12.528
55 -8.872	62 -11.26	69 -12.795
56 -9.597	63 -11.44	70 -12.967
57 -9.847	64 -11.521	

THRES. TO 20 MEV, MT#52-55,59,60 ARE BASED MAINLY ON %N,NG<
 DATA OF DI70,OR70,ER70,BU71,NY69,CI69,EN64 BELOW 15 MEV
 AND WERE EXTRAPOLATED TO 20 MEV WITH COMPOUND NUCLEUS
 REACTION THEORY CALCULATIONS. THE REMAINING MT NUMBERS
 ARE BASED ON COMPD. NUC. CALCULATIONS NORMALIZED TO GIVE
 AN MT#3 IN AGREEMENT WITH ELASTIC DATA OF BA63,BE67,MC66
 AT 14 MEV. AT LOWER ENERGIES, ADJUSTMENTS MADE, ESP. TO
 MT#51, TO ENHANCE AGREEMENT WITH %N,NPRIME< MEASUREMENTS
 OF NE72,KI72 AND WITH ELASTIC MEASUREMENTS OF NE72,KI72,
 AND BU73.

MT#71-89 INELASTIC CROSS SECTION TO 0.3-MEV BANDS CENTERED
 ABOUT Q-VALUES GIVEN BELOW %USED IN LIEU OF MT#91 AND MF#5<.

MT#71 Q#-13.15 MEV	MT#78 Q#-15.25 MEV	MT#85 Q#-17.35 MEV
72 -13.45	79 -15.55	86 -17.65
73 -13.75	80 -15.85	87 -17.95
74 -14.05	81 -16.15	88 -18.25
75 -14.35	82 -16.45	89 -18.55
76 -14.65	83 -16.75	
77 -14.95	84 -17.05	

THRES. TO 20 MEV, INTEGRATED CROSS SECTION ADJUSTED TO GIVE
 A NONELASTIC X/S IN AGREEMENT WITH THE EVALUATED TOTAL
 AND ELASTIC. THE X/S WAS DIVIDED AMONG BANDS ACCORDING
 TO A NUCLEAR TEMPERATURE CALCULATION USING T#2 MEV.

****PLEASE NOTE THAT MUCH OF THE CROSS SECTION TO LEVELS ABOVE
 ****9 MEV SUBSEQUENTLY RESULTS IN CHARGED PARTICLE EMISSION.
 ****MT#56-58,61-66,68-70,72-73,75,77-78,80,82-83,85,87,89, ARE

O-16 LAST-AUG, 1973 P.G. YOUNG, D.G. FOSTER, JR., G.M. HALE
MATERIAL= 4134 ZA= 8016. AWR = 15.8580 FILE= 1 SECTION= 451

****FLAGGED AS DECAYING BY ALPHA EMISSION. THIS CHOICE LEADS TO
****A TOTAL ALPHA EMISSION X/S SIMILAR TO DATA OF LI52, DA68, BO66
****BELOW 17 MEV. THE REMAINING MT NUMBERS ABOVE MT#66 ARE
****FLAGGED AS BEING PROTON EMITTERS.

MT#102 %N, GAMMA< CROSS SECTION
1/V VARIATION FROM 178 MICROBARNs AT 2200 M/S, FROM JU64.

MT#103 %N, P< CROSS SECTION
THRES. TO 15 MEV, USED EVALUATION OF SI65, RAISED 5 P.C.
ABOVE 12 MEV.
15 TO 20 MEV, BASED ON EXPERIMENTAL DATA OF BO66, SE62, DE62,
AND MA54.

MT#104 %N, D< CROSS SECTION
THRES. TO 20 MEV, COMPD. NUC. REACT. THEORY CALC. NORM. TO
SINGLE DATUM POINT OF LI52 AT 14 MEV.

MT#107 %N, ALPHA< CROSS SECTION
THRES. TO 20 MEV, SUM OF MT#780-783.

MT#780 %N, ALPHA< INTEGRATED CROSS SECTION TO 13C GROUND STATE
0.0 TO 5.7 MEV, ESSENTIALLY CALCULATED FROM R-MATRIX FIT DES-
CRIBED UNDER MT#1. ENERGY SCALE OF BA72 ADJUSTED TO
MATCH CI68 TOTAL XSECT AND RESOLUTION CORRECTIONS APPLIED
TO GIVE WIDTH AND HEIGHT OF PEAKS CONSISTENT WITH
TOTAL. NORMALIZATION OF C.85 FOR BA72 DETERMINED FROM
R-MATRIX FIT AND APPLIED. LEVEL SCHEME BASED ON JO73.
5.7 TO 20 MEV, BASED ON DATA OF DA63, DA68, SI68, BA73, AND
COMPOSITE OF MC66A, MA68, AND LE68 AT 14 MEV.

MT#781-783 %N, A< CROSS SECTION TO EXCITED LEVELS OF C13.
THRES. TO 15 MEV, USED %N, A< DATA OF DA63 AND %N, AG< DATA OF
DI70, OR70, CL69, NY69, EN64, AND BU71.
15 TO 20 MEV, BASED ON DATA OF SI68.

MF#4 --- NEUTRON ANGULAR DISTRIBUTIONS ---

MT#2 ELASTIC ANGULAR DISTRIBUTIONS
0.0 TO 5.7 MEV, CALCULATED FROM R-MATRIX FIT (SEE MF#3, MT#1<.
MEASURED ANGULAR DISTRIBUTIONS INPUT TO THE FIT WERE
THOSE OF CH61, FO58, FO70, HI58, HU62, JO67, KI72,
LA60, LI66, MA62, AND PH61.
5.7 TO 14 MEV, SMOOTH CURVE THROUGH COEFFICIENTS DERIVED
FROM FITS TO ELASTIC DATA OF PH61, NE72, CH61, BA63,
BE67, MC66, KI72, AND BU73.
14.0 TO 20 MEV, FROM OPTICAL MODEL CALC. USING PARAMETERS
FROM FIT OF 14 MEV DATA OF BA63, ADJUSTED TO GIVE CORRECT
TOTAL X/S UP TO 20 MEV.

O-16 LASL-AUG, 1973 P.G. YOUNG, D.G. FOSTER, JR., G.M. HALE
MATERIAL= 4134 ZA= 8016. AWR = 15.8580 FILE= 1 SECTION= 451

MT#51-89 INELASTIC ANGULAR DISTRIBUTIONS

THRES. TO 20 MEV, ASSUMED ISOTROPIC IN CENTER OF MASS EXCEPT
FOR MT#51-55 ABOVE 10 MEV WHICH ARE BASED ON FITS OF THE
14-MEV MEASUREMENTS OF BA63 AND MC66. NOTE THAT THE SUM
MT#51&52 IS CONSISTENT WITH ISOTROPY AT 8.56 MEV %KI72<.

MF#12 ----- PHOTON MULTIPLICITIES -----

MT#102 RADIATIVE CAPTURE, PRIVATE COMMUNICATION FROM JU64.

MF#13 --- GAMMA RAY SMOOTH CROSS SECTIONS ---

MT#4 %N,NG< CROSS SECTIONS

THRES. TO 15 MEV, BASED MAINLY ON DATA OF DI70, OR70, DR70,
LU70, BU69, NY69, CI69, AND EN64. DATA GENERATED FROM
MF#3, MT#51-60 USING AN O-16 DECAY SCHEME FROM AJ70.

15 TO 20 MEV, BASED ON EXTRAPOLATION OF MT#51-60 USING
COMPOUND NUCLEUS REACTION THEORY.

*****NOTE THAT THE FIRST EXCITED LEVEL OF C16 AT 6.052 MEV IS
*****ASSUMED TO DECAY WITH EMISSION OF TWO 0.51 MEV GAMMA RAYS

MT#22 %N,NAG< CROSS SECTIONS

THRES. TO 20 MEV, SMOOTH CURVE BASED CRUDELY ON %N,NA< CROSS
SECTION AND KNOWN LEVELS IN C12, ADJUSTED TO AGREE WITH
COMPOSITE OF 14 MEV DATA OF CL69, CR70.

MT#103 %N,PG< CROSS SECTIONS

THRES. TO 20 MEV, BASED ON CRUDE DIVISION OF MF#3, MT#103 X/S
AMONG AVAILABLE LEVELS ACCORDING TO %2*J&1<.

MT#107 %N,AG< CROSS SECTIONS

THRES. TO 15 MEV, BASED MAINLY ON %N,AG< DATA OF DI70, OR70,
CL69, NY69, EN64, BU71, AND %N,A< DATA OF DA63.
15 TO 20 MEV, BASED ON DATA OF SI68.

MF#14 --- GAMMA RAY ANGULAR DISTRIBUTIONS ---

MT#4 %N,NG< ANGULAR DISTRIBUTIONS

ASSUMED ISOTROPIC EXCEPT FOR THE 6.131-MEV GAMMA, WHICH IS
BASED ON THE ANGULAR DIST. MEASUREMENT OF DR70, LU70,
BU71, AND DI70, AND THE 6.917-MEV GAMMA, WHICH IS BASED
ON THE TWO-ANGLE MEASUREMENTS OF DI70.

MT#22 %N,NAG< ANGULAR DISTRIBUTIONS
ASSUMED ISOTROPIC.

MT#103 %N,PG< ANGULAR DISTRIBUTIONS
ASSUMED ISOTROPIC.

MT#107 %N,AG< ANGULAR DISTRIBUTIONS

ASSUMED ISOTROPIC.

----- REFERENCES -----

- AD49 R.K.ADAIR ET AL., PHYS. REV. 75, 1124 %1949<
AJ70 F.AJZENBERG-SELOVE, NUCL. PHYS. A152,1 %1970<
BA63 R.W.BAUER ET AL., NUCL. PHYS. 47, 241 %1963<
BA73 J.K.BAIR AND F.X.HAAS, PHYS.REV.C7,1356 %1973<
%N,A0< XSECT. OBTAINED BY DETAILED BALANCE FROM THIS REF.
BE67 P.L.BEACH ET AL., PHYS. REV. 156, 1201 %1967<
BO66 M.BORMANN ET AL., PROC. IAEA CONF. NUCL. DATA,
PARIS %1966<, P.225
BU71 P.S.BUCHANAN ET AL., ORO-2791-32 %1971<
BU73 W.P.BUCHER ET AL., BRL-R-1652 %1973<
CH61 L.P.CHASE ET AL., AFSWC-TR-61-15 %1961<
CI68 S.CIERJACKS ET AL., KFK-1000 %1968<
CL69 G.CLAYEUX&G.GRENIER, CEA-R-3807 %1969<
DA63 E.A.DAVIS ET AL., NUCL. PHYS. 48, 169 %1963<
DA68 D.DANDY ET AL., AWRE O60/68 %1968<
DE62 J.A.DEJUREN ET AL., PHYS. REV. 127, 1229 %1962<
DI70 J.K.DICKENS&F.G.PEREY, NUCL. SCI. ENG. 40, 283 %1970<
DR70 D.M.DRAKE ET AL., NUCL. SCI. ENG. 40, 294 %1970<
EN64 F.C.ENGESESSER&W.E.THOMPSON, J. NUCL. ENG. 21, 487 %1967<
FO58 J.L.FOWLER AND H.O.COHN, PHYS.REV. 109,89 %1958<
FO70 J.L.FOWLER AND C.H.JOHNSON, PHYS.REV.C2,124 %1970<
FO73 J.L.FOWLER ET.AL., PHYS.REV. C8,545 %1973<
HI58 R.W.HILL, PHYS.REV. 109,2105 %1958<
HU62 W.HUNZINGER AND P.HUBER, HELV.PHYS.ACTA 35,351 %1962<
JO48 W.B.JONES, JR., PHYS. REV. 74, 364 %1948<
JO67 C.H.JOHNSON AND J.L.FOWLER, PHYS.REV. 162,890 %1967<
JO73 C.H.JOHNSON, PHYS.REV. C7,561 %1973<
JU64 F.T.JURNEY AND H.T.MOTZ, BULL.AM.PHYS.SOC. 9, 176 %1964<
KI72 W.E.KINNEY AND F.G.PEREY, CRNI-4780 %1972<
LA60 R.O.LANE ET.AL., ANL-6172 %1960<
LE68 B.LEROUX ET AL., NUCL. PHYS. A116, 196 %1968<
LI52 A.B.LILLIF, PHYS. REV. 87, 716 %1952<
LI66 D.LISTER AND A.SAYRES, PHYS.REV. 143,745 %1966<
LU70 B.LUNDBERG ET AL., PHYSICA SCRIPTA 2, 273 %1970<
MA54 H.C.MARTIN, PHYS. REV. 93, 498 %1954<
MA62 J.P.MARTIN AND M.S.ZUCKER, BULL.AM.PHYS.SOC. 7,72 %1962<
MA68 D.R.MAXSON & R.D.MURPHY, NUCL. PHYS. A110, 555 %1968<
MC66 W.J.MCDONALD ET AL., NUCL. PHYS. 75, 353 %1966<
MC66A W.N.MCDICKEN & W.JACK, NUCL. PHYS. 88, 457 %1966<
ME49 E.MELKONIAN, PHYS. REV. 76, 1750 %1949<
NE71 D.O.NELLIS&P.S.BUCHANAN, PRIVATE COMMUNICATION %1971<
NE72 D.O.NELLIS AND P.S. BUCHANAN, DNA-2716 %1972<
NY69 K.NYBERG, PRIV. COMM. TO LEONA STEWART %1969<
OK55 A.OKAZAKI, PHYS. REV. 99, 55 %1955<
OR70 V.J.ORPHAN ET AL., NUCL. SCI. ENG. 42, 352 %1970<
PH61 D.D.PHILLIPS, PRIVATE COMMUNICATION TO BNL %1961<

O-16 LASI-AUG, 1973 P.G.YOUNG, D.G.FOSTER, JR., G.M.HALE
MATERIAL= 4134 ZA= 8016. AWR = 15.8580 FILE= 1 SECTION= 451

SC71 R.B.SCHWARTZ, PRIVATE COMMUNICATION #1971<
SE62 K.W.SEEMANN&W.E.MOORE, KAPL-2214 #1962<
SI68 VON I. SICK ET AL., HELV. PHYS. ACTA 41, 573 #1968<
SL65 E.L.SLAGGIE&J.T.REYNOLDS, KAPL-M-6452 #1965<

O-16 LASL-AUG, 1973 P.G.YOUNG, D.G.FOSTER, JR., G.M.HALE
MATERIAL= 4134 ZA= 8016. AWR = 15.8580 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	GENERAL COMMENTS	414
2	151	RESONANCE DATA	4
3	1	TOTAL	419
3	2	ELASTIC	417
3	4	TOTAL INELASTIC	84
3	51	(N,N*) 1-ST EXCITED	84
3	52	(N,N*) 2-ND EXCITED	84
3	53	(N,N*) 3-RD EXCITED	71
3	54	(N,N*) 4-TH EXCITED	68
3	55	(N,N*) 5-TH EXCITED	46
3	56	(N,N*) 6-TH EXCITED	42
3	57	(N,N*) 7-TH EXCITED	41
3	58	(N,N*) 8-TH EXCITED	38
3	59	(N,N*) 9-TH EXCITED	36
3	60	(N,N*) 10-TH EXCITED	35
3	61	(N,N*) 11-TH EXCITED	35
3	62	(N,N*) 12-TH EXCITED	34
3	63	(N,N*) 13-TH EXCITED	33
3	64	(N,N*) 14-TH EXCITED	33
3	65	(N,N*) 15-TH EXCITED	32
3	66	(N,N*) 16-TH EXCITED	30
3	67	(N,N*) 17-TH EXCITED	29
3	68	(N,N*) 18-TH EXCITED	28
3	69	(N,N*) 19-TH EXCITED	27
3	70	(N,N*) 20-TH EXCITED	26
3	71	(N,N*) 21-TH EXCITED	26
3	72	(N,N*) 22-TH EXCITED	24
3	73	(N,N*) 23-TH EXCITED	23
3	74	(N,N*) 24-TH EXCITED	22
3	75	(N,N*) 25-TH EXCITED	20
3	76	(N,N*) 26-TH EXCITED	20
3	77	(N,N*) 27-TH EXCITED	19
3	78	(N,N*) 28-TH EXCITED	18
3	79	(N,N*) 29-TH EXCITED	17
3	80	(N,N*) 30-TH EXCITED	16
3	81	(N,N*) 31-TH EXCITED	15
3	82	(N,N*) 32-TH EXCITED	14
3	83	(N,N*) 33-TH EXCITED	12
3	84	(N,N*) 34-TH EXCITED	11
3	85	(N,N*) 35-TH EXCITED	10
3	86	(N,N*) 36-TH EXCITED	8
3	87	(N,N*) 37-TH EXCITED	7
3	88	(N,N*) 38-TH EXCITED	6
3	89	(N,N*) 39-TH EXCITED	4
3	102	(N,GAMMA)	4
3	103	(N,E)	19
3	104	(N,C)	11
3	107	(N,ALPHA)	208
3	780	(N,A) LEVEL	208
3	781	(N,A) LEVEL	80

O-16 LASL-AUG, 1973 P.G.YOUNG, D.G.FOSTER, JR., G.M.HALE
MATERIAL= 4134 ZA= 8016. AWR = 15.8580 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARLS
3	782	(N,A) LEVEL	51
3	783	(N,A) LEVEL	48
4	2	ELASTIC	824
4	51	(N,N*) 1-ST EXCITED	12
4	52	(N,N*) 2-ND EXCITED	12
4	53	(N,N*) 3-ED EXCITED	12
4	54	(N,N*) 4-TH EXCITED	12
4	55	(N,N*) 5-TH EXCITED	12
4	56	(N,N*) 6-TH EXCITED	8
4	57	(N,N*) 7-TH EXCITED	8
4	58	(N,N*) 8-TH EXCITED	8
4	59	(N,N*) 9-TH EXCITED	8
4	60	(N,N*) 10-TH EXCITED	8
4	61	(N,N*) 11-TH EXCITED	8
4	62	(N,N*) 12-TH EXCITED	8
4	63	(N,N*) 13-TH EXCITED	8
4	64	(N,N*) 14-TH EXCITED	8
4	65	(N,N*) 15-TH EXCITED	8
4	66	(N,N*) 16-TH EXCITED	8
4	67	(N,N*) 17-TH EXCITED	8
4	68	(N,N*) 18-TH EXCITED	8
4	69	(N,N*) 19-TH EXCITED	8
4	70	(N,N*) 20-TH EXCITED	8
4	71	(N,N*) 21-TH EXCITED	8
4	72	(N,N*) 22-TH EXCITED	8
4	73	(N,N*) 23-TH EXCITED	8
4	74	(N,N*) 24-TH EXCITED	8
4	75	(N,N*) 25-TH EXCITED	8
4	76	(N,N*) 26-TH EXCITED	8
4	77	(N,N*) 27-TH EXCITED	8
4	78	(N,N*) 28-TH EXCITED	8
4	79	(N,N*) 29-TH EXCITED	8
4	80	(N,N*) 30-TH EXCITED	8
4	81	(N,N*) 31-TH EXCITED	8
4	82	(N,N*) 32-TH EXCITED	8
4	83	(N,N*) 33-TH EXCITED	8
4	84	(N,N*) 34-TH EXCITED	8
4	85	(N,N*) 35-TH EXCITED	8
4	86	(N,N*) 36-TH EXCITED	8
4	87	(N,N*) 37-TH EXCITED	8
4	88	(N,N*) 38-TH EXCITED	8
4	89	(N,N*) 39-TH EXCITED	8
12	102	(N,GAMMA)	16
13	4	TOTAL INELASTIC	463
13	22	(N,N*) ALPHA	10
13	103	(N,E)	64
13	107	(N,ALPHA)	258
14	4	TOTAL INELASTIC	56
14	22	(N,N*) ALPHA	1
14	102	(N,GAMMA)	1

O-16 LASL-AUG, 1973 P.G. YOUNG, D.G. FOSTER, JR., G.M. HALE
 MATERIAL= 4134 ZA= 8016. AWF = 15.8580 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
14	103	(N, P)	1
14	107	(N, ALEHA)	1
23	501	TOTAL PHOTON	17
23	502	RAYLEIGH SCATTERING	17
23	504	COMPTON SCATTERING	17
23	516	PAIR PRODUCTION	9
23	602	PHOTOELECTRIC EFFECT	17

AL-27 IASL EVAL-APR71 E.G.FOSTER, JR AND P.G.YOUNG
MATERIAL= 4135 ZA= 13027. AWR = 26.7500 FILE= 1 SECTION= 451

DIST-JUL71 MCD 3-JAN74

***** DNA 4135 MCD 3 11/73 *****

THE NEW EXPERIMENTAL DATA USED FOR THE MOD 3 REVISIONS ARE INCLUDED IN THE DETAILED DESCRIPTIONS GIVEN BELOW. BRIEFLY, THE FOLLOWING IMPROVEMENTS WERE MADE FOR MCD 3,

1. THE RADIATIVE CAPTURE GAMMA-RAY SPECTRUM FOR THERMAL NEUTRONS WAS REVISED TO BETTER AGREE WITH RECENT DATA.
2. IMPROVED $\Sigma N, P <$ AND $\Sigma N, \alpha <$ CROSS SECTIONS WERE INCORPORATED. THESE DATA ARE THE SAME AS WERE PROVIDED EARLIER TO THE STANDARDS SUBCOMMITTEE OF CSEWG.
3. FILE 13 AND FILE 15 $\Sigma N, \gamma <$ AND $\Sigma N, n\gamma <$ DATA WERE REVISED TO INCLUDE THE MEASUREMENTS OF DI73.
4. THE $\Sigma N, n$ PRIME $<$ CROSS SECTIONS TO HIGH-LYING PSEUDO LEVELS WERE REVISED FOR NEUTRON ENERGIES NEAR 14 MEV TO GIVE BETTER AGREEMENT WITH MEASUREMENTS OF KA72. IN ADDITION, $\Sigma N, n$ PRIME $<$ DATA TO LOWER LEVELS WERE REVISED TO BE CONSISTENT WITH CHANGES MADE UNDER ITEM 3.
5. ANISOTROPIC $\Sigma N, n$ PRIME $<$ ANGULAR DISTRIBUTIONS BASED ON EXPERIMENTAL DATA WERE INCORPORATED.
6. TOTAL NEUTRON CROSS SECTION WAS EXTENSIVELY REVISED, ESPECIALLY BELOW EN#1 MEV, TO INCLUDE THE MEASUREMENT OF PE72.

***** DNA 4135 MOD 2 *****

THIS MODIFICATION WAS MADE TO ENABLE THE CURRENT DNA LIBRARY TO CONFORM TO THE ENDF/B-III LIBRARY AND TO ADD PHOTON INTERACTION DATA

THE DATA CORRESPONDS TO THE ENDF/B-III EVALUATION WITH THE MAT NUMBER HAVING THE SAME LAST 3 DIGITS.

FILE 23 DATA - PHOTON INTERACTION - TAKEN FROM RSIC DATA LIBRARY Σ DLC-7 D< IS BASED ON DATA FROM UCRL-50174 SEC. II, REV. 1969 BY MCMASTER ET AL. AND UCRL-50400, VOL. VI BY PLECHATY AND TERRALL.

AL-27 IASL EVAL-APR71 D.G.FOSTER, JR AND P.G.YOUNG
MATERIAL= 4135 ZA= 13027. AWR = 26.7500 FILE= 1 SECTION= 451

***** MAT#4135 ALUMINUM MCD. 1 7-30-71 *****

MF#3, MT#75-90 MODIFIED TO INCLUDE INFORMATION DESIGNATING
DECAY OF THE INELASTIC LEVELS BY PROTON OR
ALPHA EMISSION

MF#13, MT#28 THE THRESHOLD ENERGY WAS CHANGED FROM
14.0E86 TO 13.093E86 EV

* * * * *

AL-27 FREE ATOM EVAL., NOV. 1973, D.G.FOSTER, JR., P.G.YOUNG & IASL
REFERENCE -- LOS ALAMOS SCIENTIFIC LAB. REPORT LA-4726, 1972

MF#2 --- RESONANCE PARAMETERS ---

MT#151 EFFECTIVE SCATTERING RADIUS # 0.32752E-12 CM

MF#3 --- NEUTRON SMOOTH CROSS SECTIONS ---

THE 2200 M/S CROSS SECTIONS ARE AS FOLLOWS,

MT#1 SIGMA # 1.580 BARNs

MT#2 SIGMA # 1.348 BARNs

MT#3 SIGMA # 0.232 BARNs

MT#102 SIGMA # 0.232 BARNs

MT#1 TOTAL CROSS SECTION

BELOW 4.6 KEV, 1/V FIT TO ME52 AND HI59 & NORMALIZED TO ME52,
USING THERMAL CAPTURE XS OF 232 ME & GO71 & RESULTING
& N,N< XS OF 1.580 B.

4.6 - 189 KEV, FROM GA65 NORMALIZED TO ME52 VIA HI59 AT LOW
ENERGIES AND TO PE72 AT HIGH ENERGIES.

209 - 475 KEV, FROM PE72 WITH ENERGY SCALE CORRECTED TO MATCH
CI68 AT HIGHER ENERGIES.

.475 - 11.5 MEV, COMPOSITE OF PE72 AND SC69, NORMALIZED TO
THEIR WEIGHTED AVERAGE, WITH INSERTS OF NORMALIZED CI68
WHERE NEEDED TO PRESERVE RESOLUTION.

11.5 - 20 MEV, COMPOSITE OF PE72, PO71, AL66, AND PE60 NORM-
ALIZED TO THEIR WEIGHTED AVERAGE. SINCE AT 20 MEV INCLUDES
GUIDANCE FROM TA52.

SMOOTHING BETWEEN 4.6 KEV AND 2 MEV BY APPROXIMATE BREIT-
WIGNER FITS WHERE POSSIBLE, CONNECTED BY POLYNOMIAL FITS.

2 - 12 MEV SMOOTHED BY RUNNING CUBIC POLYNOMIAL FITS.

ABOVE 12 MEV FITTED SECONDARY POLYNOMIAL TO MIDDLES OF
RUNNING POLYNOMIAL FITS.

MT#2 ELASTIC SCATTERING CROSS SECTION

BELOW 5 MEV, SUBTRACTED NONELASTIC FROM TOTAL.

5 TO 16 MEV, MAINLY BASED ON ELASTIC DATA OF HO69, ST59, KI70
, ST65, CO58, CO59, BE58, MI68, BE56, AND KA72 TOGETHER WITH THE

AL-27 IASL EVAL-APR71 D.G.FOSTER, JR AND P.G.YOUNG
MATERIAL= 4135 ZA= 13027. AWR = 26.7500 FILE= 1 SECTION= 451

EVAL. TOTAL AND THE NONELASTIC MEASUREMENTS LISTED BELOW.
16 TO 20 MEV, SMOOTH EXTRAPOLATION TO 1/2 THE TOTAL AT
20 MEV.

MT#3 NONELASTIC CROSS SECTION %IMPLICIT - NOT IN FILE
BELOW 9 MEV, BASED ON THE NONELASTIC MEASUREMENTS OF BA58,
BF56, TA55, DE65, ON THE SUM OF MT#4, 102, 103, 107, AND ON
THE DIFFERENCE BETWEEN THE EVALUATED TOTAL AND THE ELASTIC
MEASUREMENTS OF HO69, KI70, BE56, MI68.

9 TO 16 MEV, BASED ON NONELASTIC MEASUREMENTS OF BA58, TA55,
GR55, PH52, MA57, DE61, FL56, CH67, AND ON THE DIFFERENCE
BETWEEN MT#1 AND ELASTIC MEASUREMENTS OF ST59, ST65, CO58,
CO59, BE58.

16 TO 20 MEV, DIFFERENCE BETWEEN MT#1 AND MT#2

MT#4 INELASTIC CROSS SECTION

THRES. TO 5 MEV, SUM OF MT#51-63.

5 TO 9 MEV, BASED ON %N,NPRIME< DATA OF TH63, TO67, THE EVAL.
%N,NPRIME< DATA OF DI71 WHICH INCLUDES CONSIDERATION OF
SEVERAL OTHER MEASUREMENTS, AND THE %N,NG< DATA OF DI71,
OR71, AND DI73.

9 TO 20 MEV, THE DIFFERENCE BETWEEN MT#1 AND THE SUM OF
MT#2, 16, 102, 103, 104, 105, 107.

MT#16 %N,2N< CROSS SECTION

THRES. TO 20 MEV, ESTIMATED USING A NUCLEAR TEMP. CALCULATION
ASSUMING THAT HIGHLY EXCITED STATES IN AL-27 DECAY 50 PER
CENT BY NEUTRON EMISSION.

MT#51-63 INELASTIC CROSS SECTION TO DISCRETE STATES

MT#51 Q#-0.843 MEV	MT#56 Q#-3.001 MEV	MT#60 Q#-4.409 MEV
52 -1.013	57 -3.678	61 -4.508
53 -2.210	58 -3.956	62 -4.580
54 -2.732	59 -4.055	63 -4.811
55 -2.980		

THRES. TO 5 MEV, BASED ON THE %N,NPRIME< DATA OF TO62, WI63,
TS61, AND THE %N,NG< DATA OF CH68, MA65, DI71, OR71, DI73.

5 TO 9 MEV, BASED ON AN EVALUATION OF SEVERAL MEASUREMENTS
GIVEN IN DI71 %TABLE B1<.

9 TO 20 MEV, SMOOTH EXTRAPOLATION PASSING THROUGH 14 MEV DATA
OF ST65, BO65A.

MT#64-90 INELASTIC CROSS SECTION TO GROUPS OF DISCRETE STATES
IN BANDS CENTERED ABOUT THE Q-VALUES GIVEN BELOW,

MT#64 Q#- 5.25 MEV	MT#73 Q#- 9.75 MEV	MT#82 Q#-14.25 MEV
65 - 5.75	74 -10.25	83 -14.75
66 - 6.25	75 -10.75	84 -15.25
67 - 6.75	76 -11.25	85 -15.75
68 - 7.25	77 -11.75	86 -16.25
69 - 7.75	78 -12.25	87 -16.75
70 - 8.25	79 -12.75	88 -17.375
71 - 8.75	80 -13.25	89 -18.125
72 - 9.25	81 -13.75	90 -18.875

THRES. TO 20 MEV, INTEGRATED CROSS SECTION OVER BANDS
OBTAINED BY SUBTRACTING MT#51-63 FROM MT#4. CROSS SECTION

AL-27 LASL EVAL-APR71 D.G.FOSTER,JR AND P.G.YOUNG
MATERIAL= 4135 ZA= 13027. AWE = 26.7500 FILE= 1 SECTION= 451

DIVIDED AMONG BANDS ACCORDING TO A NUCLEAR TEMPERATURE
CALCULATION USING TEMP. BASED ON $\Sigma N, N_{PRIME}$ DATA OF TH63,
GR53. THE CROSS SECTION TO THE BANDS WITH MT#64-71 WAS
ADJUSTED EXTENSIVELY TO PRODUCE AGREEMENT WITH THE 14-MEV
MEASUREMENTS OF SECONDARY NEUTRON SPECTRA BY KA72.

****PLEASE NOTE THAT MUCH OF THE CROSS SECTION TO BANDS ABOVE EX#
****9 MEV SUBSEQUENTLY RESULTS IN CHARGED PARTICLE EMISSION.
****SINCE THESE DATA ARE NOT INCLUDED EXPLICITLY AS $\Sigma N, N_X$ REAC-
****TIONS, IT IS IMPORTANT THAT USERS INVOLVED IN CERTAIN CALCU-
****LATIONS (E.G., LOCAL HEATING) BE AWARE OF THIS INFORMATION.

MT#102 $\Sigma N, \gamma$ CROSS SECTION

BELOW 1 KEV, $1/V$ FROM THERMAL VALUE OF 232 MB $\Sigma G071$.

1 TO 140 KEV, FROM BL68. 6-KEV RESONANCE HAS WIDTH DEDUCED
FROM TOTAL X-SECT. SMALL RESONANCES NEARBY ALSO FROM TOTAL.
ABOVE 140 KEV, MAINLY FROM HE50, HE53, AND CA62.

MT#103 $\Sigma N, p$ CROSS SECTION (SEE Y072 FOR MORE DETAILS)

THRES. TO 4 MEV, BASED ON THE MEASUREMENTS OF HE54 AND GR67,
EXTRAPOLATED FROM 3 MEV TO THRESHOLD WITH AN $L=0$ PENETRA-
BILITY FUNCTION FOR THE OUTGOING P8MG27 CHANNEL.

4 TO 20 MEV, SMOOTH CURVE THROUGH THE MEASUREMENTS OF HE54,
GR67, CA62, BA66, MA60.

MT#104 $\Sigma N, d$ CROSS SECTION

THRES. TO 20 MEV, SMOOTH CURVE THROUGH SINGLE DATUM OF GL61.

MT#105 $\Sigma N, t$ CROSS SECTION

THRES. TO 20 MEV, SMOOTH CURVE WITH SAME SHAPE AS MT#104,
REACHING MAXIMUM OF 15 MB AT 20 MEV.

MT#107 $\Sigma N, \alpha$ CROSS SECTION (SEE Y072 FOR MORE DETAILS).

THRES. TO 20 MEV, BASED ON A SMOOTH CURVE THROUGH EXPERI-
MENTAL DATA, MAINLY THOSE OF BU63, PA65, AND LI66, WITH
RESULTS FROM GR67, SC61, GR58, BA61, MA60, GA62, IM64,
KE59 AND SEVERAL 14-MEV POINTS ALSO BEING CONSIDERED.
THE CURVE WAS EXTRAPOLATED FROM 6 MEV TO THRESHOLD WITH AN
 $L=0$ PENETRABILITY FUNCTION FOR THE OUTGOING ALPHA8NA24
CHANNEL.

MP#4 --- NEUTRON ANGULAR DISTRIBUTIONS ---

MT#2 ELASTIC ANGULAR DISTRIBUTIONS

FROM SMOOTH CURVES THROUGH PLOTS OF COEFFICIENTS FROM FITS
TO ALL AVAILABLE DATA ABOVE .25 MEV, WITHOUT EVALUATION
OF MEASUREMENTS. MAINLY FROM LA57, CH66, TO62, TS61, KI70,
BE58, WITH OPTICAL-MODEL BRIDGE TO SI62. SOME OF DATA
AUGMENTED BEFORE FITTING BY ZERO-DEGREE POINT SLIGHTLY
ABOVE WICK LIMIT, AND COEFFICIENTS ADJUSTED EMPIRICALLY
AFTERWARDS TO OBEY WICK LIMIT, BUT ONLY BARELY AT HIGHER
ENERGIES.

MT#16 $\Sigma N, 2N$ ANGULAR DISTRIBUTIONS

ASSUMED ISOTROPIC IN CM, USING 2-BODY KINEMATICS TO ESTIMATE
TRANSFORMATION TO LAB SYSTEM.

MT#51-63 INELASTIC NEUTRON ANGULAR DISTRIBUTIONS

AL-27 LASL EVAL-APR71 D.G.FOSTER, JR AND P.G.YOUNG
MATERIAL= 4135 ZA= 13027. AWE = 26.7500 FILE= 1 SECTION= 451

ANISOTROPIC DISTRIBUTIONS BASED ON MEASUREMENTS BY TS61, TO62,
WI63, MI68, TA70, GL72, SI65, BO65A, KA72 WERE IN-
CORPORATED OVER VARYING ENERGY RANGES FROM THRES. TO 20 MEV.
IN SEVERAL REGIONS WHERE DATA WERE LACKING, ISOTROPY WAS
ASSUMED.

MT#64-90 INELASTIC NEUTRON ANGULAR DISTRIBUTIONS
ASSUMED ISOTROPIC IN THE CENTER-OF-MASS SYSTEM.

MF#5 --- NEUTRON ENERGY DISTRIBUTIONS ---

MT#16 %N, 2N< ENERGY DISTRIBUTIONS
BASED ON STATISTICAL THEORY CALCULATION.

MF#12 --- GAMMA RAY MULTIPLICITIES ---

MT#102 %N, G< CAPTURE MULTIPLICITIES
THE AL-28 DECAY SCHEME FOR EXCITATION BY RADIATIVE CAPTURE
WITH THERMAL NEUTRONS FROM HA69 WAS ADOPTED AFTER SOME
MODIFICATION TO ENHANCE AGREEMENT WITH EXPERIMENT. THE
RESULTS HAVE BEEN COMPARED WITH THE LESS DETAILED DATA OF
BA67, JU71, AND MA69, AND ARE REASONABLY CONSISTENT. SOME
OF THE LINES IN RA70 BELOW 1 MEV APPEAR TO BE SPURIOUS
AND HAVE BEEN DROPPED. SPECTRUM FOR THERMAL NEUTRONS IS
ASSUMED TO APPLY AT ALL ENERGIES.

MF#13 --- GAMMA RAY SMOOTH CROSS SECTIONS ---

MT#4 %N, NG< CROSS SECTIONS
THRES. TO 5 MEV, BASED ON THE %N, NPRIME< DATA OF TO62, WI63,
TS61, AND THE %N, NG< DATA OF CH68, MA65, DI71, OR71, AND DI73.
5 TO 20 MEV, MAINLY FROM %N, NG< DATA OF DI73, OR71, DI71,
DR73, PE64, BE66, CL69, EN67, BO65, MA68, CA60, PR60,
SUPPLEMENTED BY STATISTICAL THEORY CALCULATIONS.

MT#28 %N, NPG< CROSS SECTIONS
THRES. TO 20 MEV, BASED ON THE MEASUREMENTS OF DI73, OR71,
EN67, PR60, CL69, BE66, BO65, AND ON STATISTICAL THEORY
CALCULATIONS.

MT#103 %N, PG< CROSS SECTIONS
THRES. TO 9 MEV, USED DATA OF DI71.
9 TO 20 MEV, SMOOTH EXTRAPOLATION.

MF#14 --- GAMMA RAY ANGULAR DISTRIBUTIONS ---

MT#4 %N, NG< ANGULAR DISTRIBUTIONS
ASSUMED ISOTROPIC.

MT#28 %N, NPG< ANGULAR DISTRIBUTIONS
ASSUMED ISOTROPIC.

MT#103 %N, PG< ANGULAR DISTRIBUTIONS
ASSUMED ISOTROPIC.

AL-27 IASL EVAL-APR71 D.G.FOSTER, JR AND P.G.YOUNG
 MATERIAL= 4135 ZA= 13027. AWR = 26.7500 FILE= 1 SECTION= 451

MF#15 --- GAMMA RAY ENERGY DISTRIBUTIONS ---

MT#4 %N,NG< ENERGY DISTRIBUTIONS
 BASED ON STATISTICAL THEORY CALCULATIONS, ADJUSTED TO AGREE
 WITH THE MEASUREMENTS OF DI73.

MT#28 %N,NPG< ENERGY DISTRIBUTIONS
 BASED ON STATISTICAL THEORY CALCULATIONS, ADJUSTED TO AGREE
 WITH THE MEASUREMENTS OF DI73.

----- REFERENCES -----

BA58 W.P.BALL ET AL.%LRL<, PHYS.REV.110,1392 %1958<.
 BA61 B.P.BAYHURST&R.J.PRESTWOOD %LAS<,PHYS.REV.121,1438 %1961<.
 BA66 R.BASS, EANDC%E<-66U,P64, AND PRIVATE COMMUNICATION %1966<.
 BA67 G.A.BARTHOLOMEW ET AL., NUCL. DATA A3, 367 %1967<
 BE55 J.R.BEYSTER ET AL.%LAS<, PHYS.REV.98,1216 %1955<.
 BE56 J.R.BEYSTER ET AL.%LAS<, PHYS.REV.104,1319 %1956<.
 BE58 S.BERKO ET AL., NUCL. PHYS. 6, 210 %1958<
 BE66 V.M.BEZOTOSNYI ET AL.%RUS<,SOV.J.NUCL.PHYS.3,632 %1966<.
 BL68 R.C.BLOCK, PRIVATE COMMUNICATION TO R.J.HOWERTON %1968<
 BO59 N.A.BOSTROM ET AL.%TNCC<, WATC-TN-59-107 %1959<.
 BO65 V.N.BOCHKAREV&V.V.NEFEDOV %IEB<,SOV.J.NUCL.PHYS.1,574%1965<
 BO65A G.C.BONAZZOLA ET AL.%TUR<, PHYS.REV.140,835 %1965<.
 BU63 J.P.BUTLER AND D.C.SANTRY, CAN.J.PHYS.41, 372 %1963.<
 CA60 R.L.CALDWELL ET AL.%SOC<,NUCL.SCI.ENG.8,173 %1960<.
 CA62 G.CALVI ET AL., NUCL. PHYS. 39, 621 %1962<
 CA67 A.D.CARLSON AND H.H.BARSCHAIL, PHYS. REV. 158, 1142 %1967<
 CH66 J.P.CHIEN AND A.B.SMITH, NUCL. SCI. ENG. 26, 500 %1966<
 CH67 A.CHATTERJEE&A.M.GHOSF%BOS<, PHYS.REV.161,1181 %1967<.
 CH68 K.C.CHUNG ET AL.%KTY<,NUCL.PHYS.68,476 %1968<.
 CI68 S.CIERJACKS ET AL., KFK-1000 %1968<
 CL69 G.CLAYEUX&G.GRENIER %FR<,CEA-R-3807,%1969<.
 CO58 J.H.COON ET AL.%LAS<, PHYS.REV. 111,250 %1958<.
 CO59 J.H.COON %LAS<,PRIVATE COMMUNICATION TO R.J.HOWERTON %1959<
 DE61 YU.G.DEGTYAREV&V.G.NADTOCHII %RUS<, SOV.J.AT.ENERGY 11,1043
 %1961<.
 DE65 YU.G.DEGTYAREV %RUS<, J.NUCL.ENERGY 20,818 %1965<.
 DI71 J.K.DICKENS %ORL<, ORNL-TM-3284, 1971.
 DI73 J.K.DICKENS ET AL., ORNL-TM-4232 %1973<.
 DR70 D.M.DRAKE ET AL. %LAS<, NUCL.SCI.ENG.40,294 %1970<.
 EN67 F.C.ENGESESSER&W.E.THOMPSON %NRD<,J.NUCL.ENERGY 21,487 %1967<
 FE67 J.M.FERGUSON&J.C.ALBERGOTTI %NRD<,NUCL.PHYS.98,65 %1967<.
 FL56 N.N.FIEROV&V.M.TALYZIN %RUS<,ATOMNAYA ENERGIYA 1,155 %1956<
 FO71 D.G.FOSTER JR. AND D.W.GLASGOW, PHYS. REV. C 3, 576 %1971<
 GA62 F.GABBARD&B.D.KERN%KTY<, PHYS.REV.128,1276 %1962<.
 GA65 J.B.GARG ET AL., PRIV. COMM. TO R.J.HOWERTON %1965<
 GL61 R.N.GLOVER&E.WIEGOLD %CBR<,NUCL.PHYS.24,630 %1961<.
 GL72 D.W.GLASGOW, PRIVATE COMMUNICATION %1972<.
 GO71 D.T.GOLDMAN, UNPUBLISHED EVALUATION %1971<
 GR53 E.R.GRAVES&L.ROSEN%LAS<,PHYS.REV.89,343 %1953<.

AL-27 IASL EVAL-APR71 D.C.FOSTER, JR AND P.G.YOUNG
 MATERIAL= 4135 ZA= 13027. AWR = 26.7500 FILE= 1 SECTION= 451

GR55 E.R.GRAVES&R.W.DAVIS%LAS<, PHYS.REV.97, 1205%1955<.
 GR58 J.A.GRUNDL ET AL.%LAS<, PHYS.REV.109,425 %1958<.
 GR67 J.A.GRUNDL %LAS<, NUCL.SCI.ENG.30,69 %1967<.
 HA69 R.HARDELL ET AL., NUCL.PHYS.A126,392 %1969<.
 HE50 R.L.HENKEL AND H.H.BARSCHALI, PHYS. REV. 80, 145 %1950<
 HE53 R.L.HENKEL, PRIV. COMM. TO SIGMA CENTER %1953<
 HI59 C.T.HIBDON, PHYS. REV. 114, 179 %1959<
 HO69 B.HOLMQVIST&T.WIEDLING %AE<, AE-366 %1969<.
 IM64 W.L.IMHOF %LOK<, PRIVATE COMMUNICATION TO BNL SIGMA CENTER
 %1964<.
 JO64 G.D.JOANOU&C.A.STEVENS %GA<, GA-5884 %1964<.
 JU71 E.T.JURNEY, PRIVATE COMMUNICATION %1971<
 KA72 J.L.KAMMERDIENER, THESIS, UNIV.OF CAL.AT DAVIS %1972<.
 KE59 B.D.KERN ET AL.%NRD<, NUCL.PHYS.10,226 %1959<.
 KI70 W.E.KINNEY&F.G.PEREY %ORL<, ORNL-4516,%1970<.
 LA57 A.LANGSDORF ET AL., PHYS. REV. 107, 1077 %1957<
 LI66 H.LISKIEN AND A.PAULSEN, NUCLEONICS 8,315 %1966<.
 MA57 M.H.MACGREGOR ET AL.%IRL<, PHYS.REV.108,726%1957<.
 MA60 G.S.MANI ET AL.%HAR<,NUCL.PHYS.19,535 %1960<.
 MA65 S.C.MATHUR ET AL.%TNC<,NUCL.PHYS.73,561 %1965<.
 MA68 G.N.MASLOV ET AL.%RUS<,SOV.J.AT.ENERGY 24,704 %1968<.
 MA69 R.E.MAERKER AND F.J.MUCKENTHALER, ORNL-4382 %1969<.
 ME52 A.W.MERRISON AND E.R.WIBLIN, PROC.RCY.SOC.%L< 215,278%1952<
 MI68 A.MITTLER ET AL.%KTY<, BULL.AM.PHYS.SOC.13,1420 %1968<.
 OR71 V.J.OREPHAN AND C.G.HOOT, GUF-RT-A10743, %1971<.
 PA65 A.PAULSEN&H.LISKIEN %GEL<,J.NUCL.ENERGY 19,907 %1965<.
 PE64 J.L.PERKIN %ALD<,NUCL.PHYS.60,561 %1964<.
 PE72 F.G.PEREY ET AL., ORNL-4823 %1972<.
 PH52 D.D.PHILLIPS ET AL.%IAS<, PHYS.REV.88,600 %1952<.
 PR60 J.T.PRUDHOMME ET AL.%TNC<,AFSWC-TR-60-30 %1960<.
 RA70 N.C.RASMUSSEN ET AL., GA-10248 %1970<
 SC61 H.W.SCHMITTE&J.HALPERIN%ORL<,PHYS.REV.121,827 %1961<.
 SC70 R.B.SCHWARTZ, PRIVATE COMMUNICATION %1970<
 ST59 C.ST.PIERRE ET AL.%MON<, PHYS.REV.115,999 %1959<.
 ST62 T.P.STUART ET AL., PHYS. REV. 125, 276 %1962<
 ST65 P.H.STELSON&R.L.ROBINSON %ORL<, NUCL.PHYS.68,97 %1965<.
 TA55 H.L.TAYLOR ET AL.%RIC<, PHYS.REV.100,174 %1955<.
 TA70 S.TANAKA ET AL., NUCL.DATA FOR REACTORS %IAEA,1970<,P317.
 TH63 D.B.THOMPSON %LAS<,PHYS.REV.129,1649 %1963<.
 TO62 J.H.TOWLE AND W.B.GILEOY, NUCL. PHYS. 39, 300 %1962<
 TO67 J.H.TOWLE&R.O.OWENS%ALD<,NUCL.PHYS.A100,257 %1967<.
 TS61 K.TSUKADA ET AL., PHYSICS OF FAST AND INTERMEDIATE
 REACTORS, VIENNA %1961<.
 WI63 D.WINTERHALTER %ZAG<, NUCL.PHYS.43,339%1963<.
 YO72 P.G.YOUNG, LASL MEMO T-2-99 TO THE NCEM. AND STANDARDS
 SUBCOMMITTEE OF CSEWG, %1972<.

AL-27 LASL EVAL-APR71 D.G.FOSTER, JR AND P.G.YOUNG
MATERIAL= 4135 ZA= 13027. AWR = 26.7500 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	GENERAL COMMENTS	458
2	151	RESONANCE DATA	4
3	1	TOTAL	628
3	2	ELASTIC	628
3	4	TOTAL INELASTIC	67
3	16	(N,2N)	9
3	51	(N,N*) 1-ST EXCITED	67
3	52	(N,N*) 2-ND EXCITED	66
3	53	(N,N*) 3-RD EXCITED	60
3	54	(N,N*) 4-TH EXCITED	57
3	55	(N,N*) 5-TH EXCITED	56
3	56	(N,N*) 6-TH EXCITED	55
3	57	(N,N*) 7-TH EXCITED	52
3	58	(N,N*) 8-TH EXCITED	50
3	59	(N,N*) 9-TH EXCITED	50
3	60	(N,N*) 10-TH EXCITED	47
3	61	(N,N*) 11-TH EXCITED	46
3	62	(N,N*) 12-TH EXCITED	45
3	63	(N,N*) 13-TH EXCITED	44
3	64	(N,N*) 14-TH EXCITED	42
3	65	(N,N*) 15-TH EXCITED	40
3	66	(N,N*) 16-TH EXCITED	38
3	67	(N,N*) 17-TH EXCITED	35
3	68	(N,N*) 18-TH EXCITED	33
3	69	(N,N*) 19-TH EXCITED	32
3	70	(N,N*) 20-TH EXCITED	30
3	71	(N,N*) 21-TH EXCITED	28
3	72	(N,N*) 22-TH EXCITED	27
3	73	(N,N*) 23-TH EXCITED	25
3	74	(N,N*) 24-TH EXCITED	24
3	75	(N,N*) 25-TH EXCITED	23
3	76	(N,N*) 26-TH EXCITED	22
3	77	(N,N*) 27-TH EXCITED	21
3	78	(N,N*) 28-TH EXCITED	19
3	79	(N,N*) 29-TH EXCITED	18
3	80	(N,N*) 30-TH EXCITED	17
3	81	(N,N*) 31-TH EXCITED	16
3	82	(N,N*) 32-TH EXCITED	15
3	83	(N,N*) 33-TH EXCITED	13
3	84	(N,N*) 34-TH EXCITED	12
3	85	(N,N*) 35-TH EXCITED	11
3	86	(N,N*) 36-TH EXCITED	10
3	87	(N,N*) 37-TH EXCITED	9
3	88	(N,N*) 38-TH EXCITED	7
3	89	(N,N*) 39-TH EXCITED	6
3	90	(N,N*) 40-TH EXCITED	4
3	102	(N,GAMMA)	40
3	103	(N,E)	41
3	104	(N,D)	14
3	105	(N,T)	9

AL-27 IASL EVAL-APR71 D.G.FOSTER, JR AND P.G.YOUNG
MATERIAL= 4135 ZA= 13027. AWR = 26.7500 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
3	107	(N,ALPHA)	31
4	2	ELASTIC	126
4	16	(N,2N)	28
4	51	(N,N*) 1-ST EXCITED	40
4	52	(N,N*) 2-ND EXCITED	40
4	53	(N,N*) 3-ED EXCITED	40
4	54	(N,N*) 4-TH EXCITED	20
4	55	(N,N*) 5-TH EXCITED	26
4	56	(N,N*) 6-TH EXCITED	26
4	57	(N,N*) 7-TH EXCITED	8
4	58	(N,N*) 8-TH EXCITED	22
4	59	(N,N*) 9-TH EXCITED	22
4	60	(N,N*) 10-TH EXCITED	20
4	61	(N,N*) 11-TH EXCITED	20
4	62	(N,N*) 12-TH EXCITED	20
4	63	(N,N*) 13-TH EXCITED	16
4	64	(N,N*) 14-TH EXCITED	8
4	65	(N,N*) 15-TH EXCITED	8
4	66	(N,N*) 16-TH EXCITED	8
4	67	(N,N*) 17-TH EXCITED	8
4	68	(N,N*) 18-TH EXCITED	8
4	69	(N,N*) 19-TH EXCITED	8
4	70	(N,N*) 20-TH EXCITED	8
4	71	(N,N*) 21-TH EXCITED	8
4	72	(N,N*) 22-TH EXCITED	8
4	73	(N,N*) 23-TH EXCITED	8
4	74	(N,N*) 24-TH EXCITED	8
4	75	(N,N*) 25-TH EXCITED	8
4	76	(N,N*) 26-TH EXCITED	8
4	77	(N,N*) 27-TH EXCITED	8
4	78	(N,N*) 28-TH EXCITED	8
4	79	(N,N*) 29-TH EXCITED	8
4	80	(N,N*) 30-TH EXCITED	8
4	81	(N,N*) 31-TH EXCITED	8
4	82	(N,N*) 32-TH EXCITED	8
4	83	(N,N*) 33-TH EXCITED	8
4	84	(N,N*) 34-TH EXCITED	8
4	85	(N,N*) 35-TH EXCITED	8
4	86	(N,N*) 36-TH EXCITED	8
4	87	(N,N*) 37-TH EXCITED	8
4	88	(N,N*) 38-TH EXCITED	8
4	89	(N,N*) 39-TH EXCITED	8
4	90	(N,N*) 40-TH EXCITED	8
5	16	(N,2N)	104
12	102	(N,GAMMA)	271
13	4	TOTAL INELASTIC	917
13	28	(N,N*) P	115
13	103	(N,F)	120
14	4	TOTAL INELASTIC	1
14	28	(N,N*) F	1

AL-27 LASL EVAL-APR71 D.G.FOSTER, JR AND P.G.YOUNG
 MATERIAL= 4135 ZA= 13027. AWR = 26.7500 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
14	102	(N,GAMMA)	1
14	103	(N,E)	1
15	4	TOTAL INFLASTIC	342
15	23	(N,N*)E	104
23	501	TOTAL PHCTCN	18
23	502	RAYLEIGH SCATTERING	18
23	504	COMPTON SCATTERING	18
23	516	PAIR PRODUCTION	9
23	602	PHOTOELECTRIC EFFECT	18

LEAD CRNL EVAL-JUL71 C.Y.FU AND F.G. PEREY
MATERIAL= 4136 ZA= 82000. AWR = 205.4300 FILE= 1 SECTION= 451

DIST-SEP71 MOD 5-OCT73

***** DNA 4136 MOD 5 *****

SECTIONS 16, 17 AND 91 IN FILES 3 AND 5 WERE MODIFIED
ACCORDING TO RECENTLY AVAILABLE DATA^{1,2} NEAR 14 MEV AND
STATISTICAL-EMPIRICAL MODEL CALCULATIONS. THIS MODIFICATION
WAS MOTIVATED BY INTEGRAL TESTS SUCH AS THE PULSED SPHERE
MEASUREMENT³ AND ANALYSIS⁴, AND OTHER⁵.

1. J. L. KAMMERDTNER, UCRL-51232¹⁹⁷².
2. G. CLAYEUX ET. AL., CEA-R-4279¹⁹⁷².
3. C. WONG ET. AL., UCRL-51144¹⁹⁷².
4. E. D. CASHWELL, PRIVATE COMMUNICATION TO CSEWG¹⁹⁷³.
5. D. BOGART ET. AL. PREPRINT OF NSF ARTICLE, 1973.

***** DNA 4136 MOD 4 *****

CARD-PUNCH ERRORS IN ENERGY POINTS
CAPTURE CROSS SECTIONS

E#1.5100E05

E#1.9850E05

TOTAL CROSS SECTIONS

E#1.6162E04

E#1.2500E05

E#1.5100E05

DUE TO SUMMATIONS AND SUBTRACTION OF VARIOUS
CROSS SECTIONS, THESE ERRORS WERE ALSO INTRO-
DUCED IN THE ELASTIC-SCATTERING AND NONELASTIC
CROSS SECTIONS.

***** DNA 4136 MOD 3 *****

THE ENERGY RANGE COVERED BY FILE 4 INELASTIC
SCATTER FROM DISCRETE LEVELS WAS MADE TO CONFORM
TO THE ENERGY RANGE COVERED IN FILE 3. THIS WAS
DONE BY CHANGING THE HIGHEST ENERGY IN FILE 4
TO CORRESPOND TO THE HIGHEST ENERGY IN FILE 3
FOR A GIVEN LEVEL.

***** DNA 4136 MOD 2 *****

THE CAPTURE CROSS SECTIONS FROM 1 KEV TO 1 MEV
HAVE BEEN COMPLETELY REEVALUATED BASED PRIMARILY
ON A RECENT HIGH-RESOLUTION MEASUREMENT OF CAPTURE
CROSS SECTIONS FOR THE LEAD ISOTOPES 204, 206,
207 AND 208 BY B. J. ALLEN ET AL. OF ORNL.
APPROXIMATELY 75 PER CENT OF THE CAPTURE CROSS

LEAD ORNL EVAL-JUL71 C.Y.FU AND F.G.PEREY
MATERIAL= 4136 ZA= 82000. AWR = 205.4300 FILE= 1 SECTION= 451

SECTIONS IN THE RANGE FROM 1 KEV TO 200 KEV WERE
GIVEN EXPLICITLY AS RESONANCES. CORRELATION OF
THESE RESONANCES WITH THE TOTAL CROSS SECTIONS
ENABLES US TO REFINE THE RESONANCE WIDTHS AND
AREAS OF THE TOTAL CROSS SECTIONS AS WELL.
CORRESPONDING CHANGES HAVE BEEN MADE IN THE
ELASTIC-SCATTERING AND NON-ELASTIC CROSS SECTIONS.

DETAILS OF THE ABOVE MODIFICATIONS HAVE BEEN
DESCRIBED IN AN ADDENDUM OF THE REPORT, EVALUATION
OF NEUTRON AND GAMMA-RAY-PRODUCTION CROSS SECTIONS
FOR LEAD, ORNL-4746, C. Y. FU AND F. G. PEREY.

***** DNA 4136 MOD 1 *****

THIS DATA IS FROM ENDF/E-III, MAT#1136 %BNL<

* * * * * *

DATA MODIFIED JAN.1972
LOW ENERGY RADIATIVE CAPTURE CROSS SECTION CHANGED TO CONFORM TO
THE CSEWG NORMALIZATION AND STANDARDS SUBCOMMITTEE RECOMMENDED
2200 M/SEC VALUE OF 0.178 EARNS
ALSO LOW ENERGY SCATTERING CROSS SECTION CHANGED TO REPRESENT
FREE ATOM SCATTERING

* * * * * *

NATURAL LEAD, JULY 1971, C. Y. FU AND F. G. PEREY OF ORNL
FILE 1 GENERAL INFORMATION

SECTION 451 DESCRIPTIVE DATA AND DICTIONARY

FILE 2 RESONANCE PARAMETERS

SECTION 151 GENERAL DESIGNATION FOR RESONANCE INFORMATION

ONLY EFFECTIVE SCATTERING LENGTH GIVEN. TAKEN FROM BNL-325.

FILE 3 NEUTRON CROSS SECTIONS

SECTION 1 TOTAL INTERACTION

0.00001 EV TO 1 KEV FROM BNL-325

1 KEV TO 0.47 MEV MOSTLY FROM W. M. GOODE OF ORNL.

0.47 MEV TO 20.0 MEV FROM R. B. SCHWARTZ OF NBS.

SECTION 2 ELASTIC SCATTERING

DERIVED BY SUBTRACTING THE NON-ELASTIC CROSS SECTION FROM THE

TOTAL CROSS SECTION

SECTION 3 NON-ELASTIC INTERACTION

CALCULATED, VERY GOOD AGREEMENT WITH EXPERIMENT

SECTION 4 TOTAL INELASTIC SCATTERING

CALCULATED, VERY GOOD AGREEMENT WITH EXPERIMENT

SECTION 16 n_{2N} REACTION

CALCULATED, EXPERIMENTAL DATA AVAILABLE ONLY NEAR 14 MEV

LEAD CRNL EVAL-JUL71 C.Y.FU AND F.G.PEREY
MATERIAL= 4136 ZA= 82000. AWR = 205.4300 FILE= 1 SECTION= 451

SECTION 17 N,3N< REACTION
CALCULATED, NO DATA AVAILABLE
SECTION 51 THROUGH 85 INELASTIC SCATTERING E.CITING LEVELS
CALCULATED, COMPARED FAVORABLY WITH EXPERIMENT.
48 LEVELS IN 206, 49 LEVELS IN 207 AND 22 LEVELS IN 208 ARE
MERGED TO FORM 35 LEVELS IN NATURAL LEAD
SECTION 91 INELASTIC SCATTERING E.CITING CONTINUUM
DERIVED BY SUBTRACTING THE LEVEL CONTRIBUTION FROM THE TOTAL
INELASTIC CROSS SECTION.
SECTION 102 RADIATIVE CAPTURE
0.00001 EV TO 10 EV--1/V DEPENDENCE ASSUMED WITH 0.198 BARNS
AT 0.0253 EV. CURVE DRAWN THROUGH LIMITED DATA FOR HIGHER E
SECTION 251 MU BAR
DERIVED FROM ELASTIC ANGULAR DISTRIBUTIONS AND KINEMATICS
USING THE COMPUTER PROGRAM SAD.
SECTION 252 .I
SEE SECTION 251.
SECTION 253 GAMMA
SEE SECTION 251.
FILE 4 ANGULAR DISTRIBUTION OF SECONDARY NEUTRONS
ALL DISTRIBUTIONS ARE GIVEN IN THE LEGENDRE POLYNOMIAL
REPRESENTATIONS.
SECTION 2 ELASTIC SCATTERING
0.00001 EV TO 5 MEV--COEFFICIENTS OBTAINED BY FITTING DATA
5 MEV TO 20 MEV--OPTICAL MODEL CALCULATION. OPTICAL MODEL
PARAMETERS BEST FIT DATA AT 7 AND 14 MEV.
REPRESENTATION IS IN CENTER OF MASS SYSTEM.
TRANSFORMATION MATRIX IS GIVEN
SECTION 51 THROUGH 85 INELASTIC SCATTERING E.CITING LEVELS
CALCULATED AND COMPARED FAVORABLY WITH DATA.
REPRESENTATION IS IN CENTER OF MASS SYSTEM.
SECTION 91 INELASTIC SCATTERING E.CITING CONTINUUM
ASSUMED ISOTROPIC.
FILE 5 ENERGY DISTRIBUTION OF SECONDARY NEUTRONS
SECTION 16 N,2N< REACTION
MAXWELLIAN DISTRIBUTIONS WITH TEMPERATURES DERIVED FROM
LEVEL DENSITIES AND LECCUTEUR THEORY.
SECTION 17 N,3N< REACTION
MAXWELLIAN DISTRIBUTIONS WITH TEMPERATURES DERIVED FROM
LEVEL DENSITIES AND LECCUTEUR THEORY.
SECTION 91 INELASTIC SCATTERING E.CITING THE CONTINUUM
EVAPORATION SPECTRA WITH TEMPERATURES DERIVED FROM LEVEL
DENSITIES, COMPARED FAVORABLY WITH RATHER SCARCE DATA.
FILE 12 MULTIPLICITIES OF GAMMA RAYS PRODUCED BY NEUTRON REACTION
SECTION 3 NON-ELASTIC SCATTERING
COMBINED FROM CONTRIBUTIONS FROM RADIATIVE CAPTURE, INELASTIC
SCATTERING, N,2N<, AND N,3N< REACTIONS.
FILE 14 ANGULAR DISTRIBUTIONS OF SECONDARY GAMMA RAYS
SECTION 3 NON-ELASTIC SCATTERING
ASSUMED ISOTROPIC.

LEAD ORNL EVAL-JUL71 C.Y.FU AND F.G.PEREY
MATERIAL= 4136 ZA= 82000. AWR = 205.4300 FILE= 1 SECTION= 451

FILE 15 ENERGY DISTRIBUTION OF SECONDARY GAMMA RAYS

SECTION 3 NON-ELASTIC SCATTERING

0.00001 EV TO 10 EV--ONE SINGLE SPECTRUM RESULTING FROM
THERMAL NEUTRON CAPTURE IS ASSUMED VALID.

1 KEV TO 573 KEV--ONE SINGLE SPECTRUM IS ASSUMED VALID WHICH
WAS DERIVED FROM RATHER LIMITED RESONANCE CAPTURE DATA.

10 EV TO 1 KEV--LINEAR INTERPOLATION BETWEEN ABOVE TWO SPECTRA

573 KEV TO 20 MEV--CALCULATED SPECTRA RESULTING FROM
INELASTIC, $n,2n$ AND $n,3n$ REACTIONS, GIVEN FOR INTERVALS
VARYING FROM 0.25 TO 1.0 MEV, COMPARED FAVORABLY WITH DATA.

FILE 23 PHOTON INTERACTION CROSS SECTION

FROM W. H. MCMASTER ET AL., UCRI-50400 1968<

SECTION 501 TOTAL INTERACTION

SECTION 502 COHERENT SCATTERING

SECTION 504 INCOHERENT SCATTERING

SECTION 516 PAIR PRODUCTION PLUS TRIPLET PRODUCTION

SECTION 602 PHOTOELECTRIC INTERACTION

LEAD CRNL EVAL-JUL71 C.Y.FU AND P.G.PEREY
MATERIAL= 4136 ZA= 82000. AWR = 205.4300 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	GENERAL COMMENTS	267
2	151	RESONANCE DATA	4
3	1	TOTAL	209
3	2	ELASTIC	209
3	3	NON-ELASTIC	94
3	4	TOTAL INELASTIC	27
3	16	(N,2N)	12
3	17	(N,3N)	8
3	51	(N,N*) 1-ST EXCITED	11
3	52	(N,N*) 2-ND EXCITED	12
3	53	(N,N*) 3-ED EXCITED	11
3	54	(N,N*) 4-TH EXCITED	10
3	55	(N,N*) 5-TH EXCITED	10
3	56	(N,N*) 6-TH EXCITED	10
3	57	(N,N*) 7-TH EXCITED	10
3	58	(N,N*) 8-TH EXCITED	11
3	59	(N,N*) 9-TH EXCITED	9
3	60	(N,N*) 10-TH EXCITED	9
3	61	(N,N*) 11-TH EXCITED	10
3	62	(N,N*) 12-TH EXCITED	9
3	63	(N,N*) 13-TH EXCITED	9
3	64	(N,N*) 14-TH EXCITED	10
3	65	(N,N*) 15-TH EXCITED	10
3	66	(N,N*) 16-TH EXCITED	10
3	67	(N,N*) 17-TH EXCITED	9
3	68	(N,N*) 18-TH EXCITED	8
3	69	(N,N*) 19-TH EXCITED	8
3	70	(N,N*) 20-TH EXCITED	9
3	71	(N,N*) 21-TH EXCITED	8
3	72	(N,N*) 22-TH EXCITED	7
3	73	(N,N*) 23-TH EXCITED	8
3	74	(N,N*) 24-TH EXCITED	8
3	75	(N,N*) 25-TH EXCITED	8
3	76	(N,N*) 26-TH EXCITED	8
3	77	(N,N*) 27-TH EXCITED	8
3	78	(N,N*) 28-TH EXCITED	7
3	79	(N,N*) 29-TH EXCITED	8
3	80	(N,N*) 30-TH EXCITED	7
3	81	(N,N*) 31-TH EXCITED	8
3	82	(N,N*) 32-TH EXCITED	7
3	83	(N,N*) 33-TH EXCITED	7
3	84	(N,N*) 34-TH EXCITED	8
3	85	(N,N*) 35-TH EXCITED	8
3	91	(N,N*) CONTINUUM	10
3	102	(N,GAMMA)	66
3	251	MU BAR	11
3	252	XI	11
3	253	GAMMA	11
4	2	ELASTIC	143
4	16	(N,2N)	8

LEAD ORNL EVAL-JUL71 C.Y.FU AND F.G.PEREY
 MATERIAL= 4136 ZA= 82000. AWR = 205.4300 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
4	17	(N,3N)	8
4	51	(N,N*) 1-ST EXCITED	51
4	52	(N,N*) 2-ND EXCITED	75
4	53	(N,N*) 3-ED EXCITED	51
4	54	(N,N*) 4-TH EXCITED	54
4	55	(N,N*) 5-TH EXCITED	45
4	56	(N,N*) 6-TH EXCITED	47
4	57	(N,N*) 7-TH EXCITED	40
4	58	(N,N*) 8-TH EXCITED	66
4	59	(N,N*) 9-TH EXCITED	42
4	60	(N,N*) 10-TH EXCITED	35
4	61	(N,N*) 11-TH EXCITED	40
4	62	(N,N*) 12-TH EXCITED	35
4	63	(N,N*) 13-TH EXCITED	39
4	64	(N,N*) 14-TH EXCITED	54
4	65	(N,N*) 15-TH EXCITED	54
4	66	(N,N*) 16-TH EXCITED	54
4	67	(N,N*) 17-TH EXCITED	32
4	68	(N,N*) 18-TH EXCITED	30
4	69	(N,N*) 19-TH EXCITED	30
4	70	(N,N*) 20-TH EXCITED	48
4	71	(N,N*) 21-TH EXCITED	27
4	72	(N,N*) 22-TH EXCITED	26
4	73	(N,N*) 23-TH EXCITED	24
4	74	(N,N*) 24-TH EXCITED	24
4	75	(N,N*) 25-TH EXCITED	24
4	76	(N,N*) 26-TH EXCITED	39
4	77	(N,N*) 27-TH EXCITED	39
4	78	(N,N*) 28-TH EXCITED	22
4	79	(N,N*) 29-TH EXCITED	22
4	80	(N,N*) 30-TH EXCITED	20
4	81	(N,N*) 31-TH EXCITED	36
4	82	(N,N*) 32-TH EXCITED	20
4	83	(N,N*) 33-TH EXCITED	18
4	84	(N,N*) 34-TH EXCITED	33
4	85	(N,N*) 35-TH EXCITED	33
4	91	(N,N*) CONTINUUM	8
5	16	(N,2N)	149
5	17	(N,3N)	39
5	91	(N,N*) CONTINUUM	212
12	3	NON-ELASTIC	18
14	3	NON-ELASTIC	1
15	3	NON-ELASTIC	869
23	501	TOTAL PHOTON	23
23	502	RAYLEIGH SCATTERING	23
23	504	COMPTON SCATTERING	23
23	516	PAIR PRODUCTION	9
23	602	PHOTOELECTRIC EFFECT	23

H-1 IASL EVAL-AUG70 L.STEWART,F.J.LABAUVE,P.G.YOUNG
MATERIAL= 4148 ZA= 1001. AWR = C.9992 FILE= 1 SECTION= 451

LA-4574 %1971< DIST-FEB71 MCD 2-OCT73

***** DNA 4148 MOD 2 *****

AUGUST 1973 COMMENTS AND CHANGES

1. RECENT TOTAL MEASUREMENTS BY CLEMENT AND STOLER %RPI< AND BY HEATON ET AL. %NBS< DO NOT INDICATE THE NEED FOR CHANGES AT THIS TIME.
2. THE LP#2 FLAG HAS BEEN IMELEMNTED IN MF#12, MT#102 IN VERSION IV.
3. A NEW LISTING HAS BEEN GENERATED FOR THE TOTAL CROSS SECTION TO INSURE THAT THE SUMMATION OF THE PARTIALS IS CONSERVED TO HIGHER PRECISION.
4. THE NORMALIZATION AND STANDARDS SUBCOMMITTEE OF CSEWG REVIEWED THIS FILE IN MARCH, 1973 AND RECOMMENDED NO CHANGES TO THE SCATTERING CROSS SECTION FOR VERSION IV.

***** DNA 4148 MOD 1 *****

THIS MODIFICATION WAS MADE TO ENABLE THE CURRENT DNA LIBRARY TO CONFORM TO THE ENDF/B-III LIBRARY AND TO ADD PHOTON INTERACTION DATA

THE DATA CORRESPONDS TO THE ENDF/B-III EVALUATION WITH THE MAT NUMBER HAVING THE SAME LAST 3 DIGITS.

FILE 23 DATA - PHOTON INTERACTION - TAKEN FROM RSIC DATA LIBRARY %DLC-7 D< IS BASED ON DATA FROM UCRL-50174 SEC. II, REV. 1969 BY MCMASTER ET AL. AND UCRL-50400, VOL. VI BY PLECHATY AND TERRALL.

```
* * * * *
* * * * *
* CROSS SECTION STANDARD    HYDROGEN SCATTERING CROSS SECTION *
* * * * *
* THE SCATTERING CROSS SECTION HAS BEEN RECOMMENDED AS A
* STANDARD BY THE CSEWG NORMALIZATION AND STANDARDS SUBCOMMITTEE*
```

H-1 LASL EVAL-AUG70 L.STEWART,B.J.LABAUVE,P.G.YOUNG
MATERIAL= 4148 ZA= 1001. AWR = C.9992 FILE= 1 SECTION= 451

* FOR THE ENERGY RANGE FROM 1 KEV TO 20 MEV *
* *

HYDROGEN FREE ATOM CROSS SECTIONS AS GIVEN IN LA-4574
ENTRY BY L. STEWART, R.J. LABAUVE, AND P.G. YOUNG
LOS ALAMOS SCIENTIFIC LABORATORY
LOS ALAMOS, NEW MEXICO 87544
OCTOBER 20, 1970

MF#1

MT#451, ATOMIC MASS#1.007825

MF#2

MT#151, SCATTERING LENGTH#1.27565E-12 CM.

MF#3

MT# 1, TOTAL CROSS SECTIONS --- THE TOTAL CROSS SECTIONS ARE
OBTAINED BY ADDING THE ELASTIC SCATTERING AND
RADIATIVE CAPTURE CROSS SECTIONS AT ALL ENERGIES.
1.0E-05 EV TO 20 MEV.

MT# 2, ELASTIC SCATTERING --- FROM AN EXTENSIVE THEORETICAL
TREATMENT OF FAST NEUTRON MEASUREMENTS
BY J. C. HOPKINS%LASL< AND G. ERBIT%STATE
UNIVERSITY OF NEW YORK<. SEE N.D. A9, 145%1971<.
1.0E-05 EV TO 20 MEV.

MT#102, RADIATIVE CAPTURE --- THESE CROSS SECTIONS ARE TAKEN
FROM THE PUBLICATION OF A. HURLEY WHERE A VALUE
OF 332 MB WAS ADOPTED FOR THE THERMAL VALUE. SEE
N.D. A2, 243%1966< ALSO P.C.
1.0E-05 EV TO 20 MEV.

MT#251, AVERAGE VALUE OF COSINE OF SCATTERING ANGLE
IN LAB SYSTEM %PROVIDED BY BNL<.
1.0E-05 EV TO 20 MEV.

MT#252, AVERAGE LOGARITHMIC ENERGY CHANGE PER COLLISION, TAKEN
AS 1, FROM 1.0E-05 EV TO 20 MEV. %PROVIDED BY BNL<.

MT#253, GAMMA, TAKEN AS 1, FROM 1.0E-05 EV TO 20 MEV.
%PROVIDED BY BNL<.

MF#4

MT# 2, NEUTRON ELASTIC SCATTERING ANGULAR DISTRIBUTIONS IN

H-1 LASL EVAL-AUG70 L.STEWART,R.J.LABAUVE,P.G.YOUNG
MATERIAL= 4148 ZA= 1001. AWR = C.9992 FILE= 1 SECTION= 451

THE CENTER OF MASS SYSTEM--GIVEN AS NORMALIZED
POINTWISE PROBABILITIES.

MF#7

MT# 4, .00001 TO 5 EV FREE GAS SIGMA#20.449 BARNS.

MF#12

MT#102, GAMMA RAY MULTIPLICITIES --- MULTIPLICITY, %REFERRED
TO MT#102, MF#3<, IS UNITY AT ALL NEUTRON ENERGIES.
LP#2 NOW IMPLEMENTED, THEREFORE ALL GAMMA ENERGIES
MUST BE CALCULATED.

MF#14

MT#102, GAMMA RAY ANGULAR DISTRIBUTION --- ASSUMED ISOTROPIC
AT ALL NEUTRON ENERGIES.

H-1 IASL EVAL-AUG70 L.STEWART,R.J.LABAUVE,P.G.YOUNG
MATERIAL= 4148 ZA= 1001. AWR = C.9992 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	GENERAL COMMENTS	140
2	151	RESONANCE DATA	4
3	1	TOTAL	48
3	2	ELASTIC	48
3	102	(N,GAMMA)	48
3	251	MU BAR	8
3	252	XI	4
3	253	GAMMA	4
4	2	ELASTIC	37
7	4	TOTAL INELASTIC	4
12	102	(N,GAMMA)	4
14	102	(N,GAMMA)	1
23	501	TOTAL PHOTON	17
23	502	RAYLEIGH SCATTERING	17
23	504	COMPTON SCATTERING	17
23	516	PAIR PRODUCTION	9
23	602	PHOTOELECTRIC EFFECT	17

SI-NAT ORNL FVAL-FEB74 LARSON, FERRY, DRAKE, YOUNG
MATERIAL= 4151 ZA= 14000. AWR = 27.8440 FILE= 1 SECTION= 451

DIST-SEP71 MOD 3-FEB74

***** DNA 4151 MOD 3 *****

1. THE INELASTIC SCATTERING FILES HAVE BEEN REVISED, BASED ON RECENT DATA, AND HAUSER-FESHBACH AND DIRECT INTERACTION MODELS.
2. THE TERTIARY REACTIONS (N,NP), (N,PN), (N,NA), (N,AN) HAVE BEEN INCLUDED AND THE ENERGY DISTRIBUTION FOR THE OUTGOING CHARGED PARTICLES AND NEUTRONS ARE GIVEN.
3. CROSS SECTIONS, ANGULAR DISTRIBUTIONS AND ENERGY DISTRIBUTIONS HAVE BEEN GIVEN FOR THE CHARGED PARTICLES RESULTING FROM (N,P) AND (N,A) REACTIONS.
4. THE GAMMA PRODUCTION FILES HAVE BEEN REVISED USING CALCULATIONS BASED ON THE NEWLY AVAILABLE DATA OF DICKENS ET AL. OF CRNL.

***** DNA 4151 MOD 2 *****

THE FOLLOWING CHANGES WERE MADE BY NNCSC SEPT. 8, 1972.
MF#3 MT#1 SELINE FIT FOR NES TOTAL CROSS-SECTION DATA%REF 58<
FROM 0.5 MEV TO 20.0 MEV
MF#3 MT#2,3,4 CHANGED TO CONFORM TO THE NEW TOTAL AND INELASTIC
CROSS-SECTIONS.
MF#3 MT#51,52,.....71,91. NEW EVALUATION BASED ON ABACUS-2
NUCLEAR MODEL CALCULATIONS WITH GREENLEES PARAMETERS
%REF 59< AND THE NEW TOTAL CROSS-SECTION
MF#3 MT#107 CHANGED FROM 8.4 TO 20.0 MEV BASED ON THE NEW DATA OF
%REF 60,61 <
MF#3 MT#251,252,253 CHANGED TO CONFORM TO THE NEW ELASTIC ANGULAR
DISTRIBUTION DATA IN FILE 4.
MF#4 MT#2 LEGENDRE COEFFICIENTS WERE CALCULATED FOR SOME OF THE
ANGULAR DISTRIBUTION DATA IN THE DRAKE EVALUATION
SUPPLEMENTED BY NEW DATA FROM REF 62.
MF#4 MT#52 LEGENDRE COEFFICIENTS CALCULATED FOR THE INELASTIC
SCATTERING DATA FOR THE 1.779 MEV LEVEL FROM REFS62-67
MF#13 MT#3 RECALCULATED TO CONFORM TO THE NEW EVALUATION
MF#13 MT#4 GAMMA PRODUCTION CROSS-SECTIONS DUE TO INELASTIC SCAT-
TERING CALCULATED FROM THE NEW INELASTIC CROSS-SECTIONS
IN FILE 3.
MF#15 MT#3 CALCULATED FROM A STATISTICAL MODEL

***** DNA 4151 MOD 1 *****

THIS MODIFICATION WAS MADE TO ENABLE THE CURRENT

SI-NAT OENL EVAL-FEB74 LARSON,PEREY,DRAKE,YOUNG
MATERIAL= 4151 ZA= 14000. AWR = 27.8440 FILE= 1 SECTION= 451

DNA LIBRARY TO CONFORM TO THE ENDF/B-III LIBRARY
AND TO ADD PHOTON INTERACTION DATA

THE DATA CORRESPONDS TO THE ENDF/B-III EVALUATION
WITH THE MAT NUMBER HAVING THE SAME LAST 3 DIGITS.

FILE 23 DATA - PHOTON INTERACTION - TAKEN FROM RSIC
DATA LIBRARY γ DIC-7 D< IS BASED ON DATA FROM
UCRL-50174 SEC. II, REV. 1969 BY MCMASTER ET AL.
AND UCRL-50400, VOL. VI BY PLECHATY AND TERRALL.

***** INTRODUCTION *****

EXTENSIVE THEORETICAL CALCULATIONS BASED ON THE HAUSER-FESHBACH METHOD, STATISTICAL MODEL, DIRECT INTERACTION MODEL AND SHELL MODEL CALCULATIONS WERE USED TO REPRODUCE THE ENERGY AVERAGED DATA IN AS CONSISTENT A MANNER AS POSSIBLE. WHERE THE DATA APPEARED TO BE CONSISTENT AND RELIABLE, IT WAS USED IN THE EVALUATION. WHERE A NUMBER OF SETS OF MEASURED DATA WERE IN CONFLICT IN A GIVEN ENERGY RANGE, THE AVERAGE CALCULATION WAS USED. THE STRONGLY RESONANT BEHAVIOR OF THE CROSS SECTIONS IN SILICON APPEAR TO BE THE CAUSE OF SOME OF THE DISCREPANCIES IN THE DATA.

A. THE TOTAL CROSS SECTION BELOW 500 KEV IS UNCHANGED FROM DRAKE ORIGINAL EVALUATION. FROM 500 KEV TO 20 MEV THE DATA OF SCHWARTZ(SC71) AND PEREY(PE72) WERE FOUND TO BE IN GOOD AGREEMENT. THE EVALUATION IS BASED ON A SPLINE FIT TO SC71 BY BHAT DONE FOR DNA 4151 MOD 2(BH72), THINNED IN THE PRESENT EVALUATION TO .5% VIA LINEAR INTERPOLATION TO REDUCE THE NUMBER OF POINTS.

B. THE HAUSER-FESHBACH METHOD WAS USED TO CALCULATE THE COMPETITION AMONG THE $(N,N'+N,NX)$, $(N,P'+N,PX)$ AND $(N,A'+N,AX)$ CROSS SECTIONS. A STATISTICAL-EMPERICAL MODEL (FU73) WAS THEN USED ABOVE 13 MEV TO SPLIT THE CROSS SECTIONS AS FOLLOWS:

$(N,N'+N,NX)$ INTO $N,N'G + N,NP + N,NA + N,2N$
 $(N,P'+N,PX)$ INTO $N,P'G + N,PN$
 $(N,A'+N,AX)$ INTO $N,A'G + N,AN$

THE $N,NP+N,PN$ CROSS SECTIONS WERE ADDED TO FORM FILE 3/28. FOR FILE 5 THE ENERGY DISTRIBUTIONS FOR N,NP AND N,PN WERE WEIGHTED BY THEIR CROSS SECTIONS AND COMBINED TO FORM 5/28 AND 5/719. THE $N,NA+N,AN$ WERE TREATED SIMILARLY TO FORM FILES 3/22, 5/22, 5/799

C. THE N,P CROSS SECTION IS WELL DEFINED BY EXPERIMENT FROM THRESHOLD UP TO 9 MEV, AND AT 14 MEV BY ACTIVATION MEASUREMENTS. THE CALCULATED N,P CROSS SECTION WAS FOUND TO BE IN GOOD AGREEMENT WITH THE MEASUREMENTS AND WAS USED FROM 9 TO 20 MEV. ABOVE 13 MEV THE N,PN COMPONENT WAS REMOVED, LEAVING ONLY THE $(N,PGAMMA)$ IN 3/103.

D. THE N,A CROSS SECTION IS WELL DEFINED UP TO 8.4 MEV BY EXPERIMENT. ABOVE THIS THERE ARE NO RELIABLE MEASUREMENTS OF THE

SI-NAT ORNL EVAL-FFB74 LARSON,FERREY,DRAKE,YOUNG
MATERIAL= 4151 ZA= 14000. AWR = 27.8440 FILE= 1 SECTION= 451

TOTAL N,A CROSS SECTION. THE EVALUATION ABOVE 8.4 MEV IS BASED ON HAUSER-FESHBACH CALCULATIONS WHICH REPRODUCE THE AVERAGE MEASURED N,A UP TO 8.4 MEV AS WELL AS THE SI-30 N,A CROSS SECTION MEASURED AT 14 MEV(SI70). ABOVE 13 MEV THE N,AN COMPONENT IS REMOVED, LEAVING ONLY THE (N,AGAMMA) IN 3/107.

E. THE GAMMA PRODUCTION FILES 13/4,22,28,103,107 ARE TAKEN FROM HAUSER-FESHBACH CALCULATIONS AND WHEN COMBINED REPRODUCE THE SI(N,XGAMMA) DATA OF DI73. THE INDIVIDUAL FILES REPRODUCE ON THE AVERAGE THE DATA LISTED IN THE BELOW DESCRIPTION.

F. ALL ANGULAR DISTRIBUTIONS ARE GIVEN AS NORMALIZED LEGENDRE COEFFICIENTS IN THE C-M FRAME, AND A TRANSFORMATION MATRIX IS INCLUDED FOR TRANSFORMATION OF ELASTIC SCATTERING TO THE LAB FRAME OF REFERENCE.

***** FILE 3 ***** NEUTRON CROSS SECTIONS

3/1--TOTAL CROSS SECTION

.00001 EV TO 5 KEV--SUM OF CONSTANT SCATTERING AND 1/V CAPTURE
5 KEV TO 100 KEV FI51
100 KEV TO 500 KEV WH68
500 KEV TO 20 MEV SC71 PE72

3/2--ELASTIC SCATTERING

.00001 EV TO 6 KEV 2.15B WE51
6 KEV TO 20 MEV--DERIVED BY SUBTRACTING NONELASTIC FROM TOTAL

3/3--NONELASTIC CROSS SECTION

SUM OF 3/4,16,22,28,102,103,104,107

3/4--TOTAL INELASTIC CROSS SECTION

1.273 MEV TO 20 MEV--SUM OF 3/51 THRU 3/72 AND 3/91

3/16--N,2N CROSS SECTION

ESTIMATED VIA STATISTICAL MODEL FOR EACH ISOTOPE AND COMBINED

3/22--N,NA REACTION

SEE INTRODUCTION

3/28--N,NP REACTION

SEE INTRODUCTION

3/51 THRU 3/72--INELASTIC SCATTERING TO DISCRETE LEVELS

SEE INTRODUCTION AND CL64 DR69 KI70 KN67 MA68 NE72 OB73 PE66
FOR SECTION 52 AND 61 (FIRST AND SECOND EXCITED STATES IN
SI-28). FOR OTHER SECTIONS BA66,GI65,PE73

3/91--NN' TO CONTINUUM

SEE INTRODUCTION AND CL72,MA67,MA69,GI65,PE73,PU73

3/102--RADIATIVE CAPTURE

.00001 EV TO 20 KEV 0.16B ASSUMED AT .0253 EV AND A 1/V
ENERGY DEPENDENCE
20 KEV TO 200 KEV--MA65
200 KEV TO 20 MEV--ASSUMED CONSTANT

3/103--N,P REACTION

THRESHOLD TO 6 MEV--MA56

6 TO 9 MEV--BA66

9 TO 20 MEV--BASED ON HAUSER-FESHBACH (HF) CALCULATION
WITH N,PN COMPONENT REMOVED ABOVE 13 MEV.

SI-NAT ORNL EVAL-FEB74 LARSON, PEREY, DRAKE, YOUNG
MATERIAL= 4151 ZA= 14000. AWE = 27.8440 FILE= 1 SECTION= 451

3/104--N,D REACTION
TAKEN FROM DRAKE EVALUATION AND IS SPECULATIVE DR68
3/107--N,A REACTION
THRESHOLD TO 6.2 MEV--BE65 BI63
6.2 TO 8.4 MEV--MA63 REDUCED BY 30% AND GR69
8.4 TO 20 MEV--BASED ON HF CALCULATION WITH N,AN COMPONENT
REMOVED ABOVE 13 MEV.
3/251 THRU 3/253 -- MU BAR,XI,GAMMA
DERIVED FROM ELASTIC SCATTERING ANGULAR DISTRIBUTION AND
KINEMATICS USING COMPUTER CCEP SAD
3/700 THRU 3/714--N,P REACTION TO DISCRETE LEVELS
BASED ON HF CALCULATIONS FOR SI-28 AND COMPARISON TO
AVERAGED DATA OF GR69 MA56 BA66
3/718--N,P CONTINUUM PROTONS
THRESHOLD TO 9 MEV--DIFFERENCE BETWEEN SUM OF 700 THRU 714
AND THE EVALUATED CROSS SECTION IN 3/103
9 MEV TO 20 MEV--CALCULATED VIA HF ASSUMING CONTINUUM ONLY
ABOVE EX=3 MEV.
3/719--(N,NP+N,PN) REACTION
SAME AS 3/28
3/780 THRU 3/791--N,A REACTION TO DISCRETE LEVELS
BASED ON HF CALCULATION FOR SI-28 AND COMPARISON TO
AVERAGED DATA OF GR69 EI63 MA63
3/798--N,A CONTINUUM ALPHAS
THRESHOLD TO 8.4 MEV--DIFFERENCE BETWEEN SUM OF 780 THRU 791
AND THE EVALUATED CROSS SECTION IN 3/107.
8.4 TO 20 MEV--CALCULATED VIA HF ASSUMING CONTINUUM ONLY ABOVE
EX=4 MEV.
3/799--(N,NA+N,AN) REACTION
SAME AS 3/22

***** FILE 4 ***** PARTICLE ANGULAR DISTRIBUTIONS

4/2--ELASTIC SCATTERING ANGULAR DISTRIBUTIONS
.00001 EV TO 158 KEV--ISOTROPIC AS OBSERVED BY LA61 LA62
150 KEV TO 700 KEV--LA62
700 KEV TO 1.17 MEV--CO66
1.2 MEV TO 3 MEV--LA61 BR64 KN67 OK65
3 MEV TO 11 MEV--KN67 DR69 TA64 KI70 MA68 BR72 VE72 NE72 OB73
TA69
11 MEV TO 20 MEV--OPTICAL MODEL CALCULATION--PE70
4/16--(N,2N) REACTION
ANGULAR DISTRIBUTION FOR BOTH NEUTRONS ASSUMED ISOTROPIC
4/22--(N,NP+N,PN) REACTION
NEUTRON OUT ASSUMED ISOTROPIC
4/28--(N,NA+N,AN) REACTION
NEUTRON OUT ASSUMED ISOTROPIC
4/51 THRU 4/72--(N,N') TO DISCRETE LEVELS
FOR SECTION 52 AND 61 (FIRST AND SECOND EXCITED STATES IN
SI-28) THE ANGULAR DISTRIBUTIONS ARE A WEIGHTED SUM OF HF AND

SI-NAT ORNL EVAL-FEB74 LARSON, FERREY, DRAKE, YOUNG
MATERIAL= 4151 ZA= 14000. AWR = 27.8440 FILE= 1 SECTION= 451

DIRECT INTERACTION CALCULATIONS. SEE ALSO REFERENCES UNDER
3/4. ANGULAR DISTRIBUTIONS FOR REMAINING STATES TAKEN
FROM HF CALCULATIONS.

4/91--(N,N') TO THE CONTINUUM

ASSUMED ISOTROPIC

4/700 THRU 4/714--(N,P) PROTON ANGULAR DISTRIBUTIONS TO DISCRETE
STATES IN SI-28 ONLY

TAKEN FROM HF CALCULATION. COMPARED WITH DE67.

4/718--(N,P) CONTINUUM PROTONS

ASSUMED ISOTROPIC

4/719--(N,NP+N,PN) PROTON ANGULAR DISTRIBUTIONS

ASSUMED ISOTROPIC

4/780 THRU 4/791--(N,A) ALPHA ANGULAR DISTRIBUTIONS TO DISCRETE
STATES. TAKEN FROM HF CALCULATIONS.

4/798--(N,A) CONTINUUM ALPHAS

ASSUMED ISOTROPIC

4/799--(N,NA+N,AN) ALPHA ANGULAR DISTRIBUTIONS

ASSUMED ISOTROPIC

***** FILE 5 ***** ENERGY DISTRIBUTIONS OF PARTICLES

5/16--(N,2N) REACTION

SECONDARY NEUTRONS ASSUMED TO HAVE A MAXWELLIAN SHAPE

5/22--(N,NA+N,AN) SECONDARY NEUTRONS

GIVEN AS PROBABILITY DISTRIBUTIONS

5/28--(N,NP+N,PN) SECONDARY NEUTRONS

GIVEN AS PROBABILITY DISTRIBUTIONS

5/91--(N,N') CONTINUUM NEUTRONS

GIVEN AS PROBABILITY DISTRIBUTIONS

5/718--(N,P) CONTINUUM PROTONS

GIVEN AS PROBABILITY DISTRIBUTIONS

5/719--(N,NP+N,PN) CONTINUUM PROTONS

GIVEN AS PROBABILITY DISTRIBUTIONS

5/798--(N,A) CONTINUUM ALPHAS

GIVEN AS PROBABILITY DISTRIBUTIONS

5/799--(N,NA+N,AN) CONTINUUM ALPHAS

GIVEN AS PROBABILITY DISTRIBUTIONS

***** FILE 12 ***** MULTIPLICITIES OF GAMMA RAYS

12/102--(N,G) RADIATIVE CAPTURE

.00001 EV TO 50 KEV SP70,LY67 BL69

50 KEV TO 1 MEV LU7C

1 MEV TO 20 MEV AVERAGE MULTIPLICITIES FROM ABOVE TWO
ENERGY RANGES.

***** FILE 13 ***** GAMMA PRODUCTION CROSS SECTIONS

13/4--(N,N'G) GAMMA PRODUCTION FROM INELASTIC SCATTERING

UP TO 3 MEV, DISCRETE GAMMAS ARE GIVEN, FROM 3 TO 20 MEV

SI-NAT ORNL EVAL-FEB74 LARSON,FERFY, DRAKE, YOUNG
 MATERIAL= 4151 ZA= 14000. AWR = 27.8440 FILE= 1 SECTION= 451

PROBABILITY DISTRIBUTIONS ARE USED. DISTRIBUTIONS
 CALCULATED VIA HF PLUS DIRECT INTERACTION FOR FIRST AND
 SECOND EXCITED STATES IN SI-28. BRANCHING RATIOS FROM
 DE72 ME70 ME69 EN73. SEE ALSO DI73, DI70 DI74 DR70 NE72.
 13/22--(N,NA+N,AN) GAMMA PRODUCTION IN MG-24
 CALCULATED FROM STATISTICAL MODEL FU73. BRANCHING RATIOS
 FROM EN73.
 13/28--(N,NP+N,PN) GAMMA PRODUCTION IN AL-27
 CALCULATED FROM STATISTICAL MODEL FU73. BRANCHING RATIOS
 FROM EN73.
 13/103--(N,PG) GAMMA PRODUCTION IN AL-28
 CALCULATED FROM HF. BRANCHING RATIOS FROM HA69 MA72 BO71
 EN73
 13/107--(N,AG) GAMMA PRODUCTION IN MG-25
 CALCULATED FROM HF. BRANCHING RATIOS FROM SO69 KE72 SO68
 EN73

 ***** FILE 14 ***** GAMMA RAY ANGULAR DISTRIBUTIONS

14/4,22,28,102,103,107 ALL GAMMA ANGULAR DISTRIBUTIONS
 ASSUMED ISOTROPIC

 ***** FILE 15 ***** ENERGY DISTRIBUTIONS OF
 SECONDARY GAMMA RAYS

15/4,22,28,103,107 ARE ALL GIVEN AS PROBABILITY DISTRIBUTIONS
 UP TO A MAXIMUM GAMMA ENERGY OF 15 MEV. SEE INTRO-
 Duction AND FILE 13 FOR DESCRIPTION OF CALCULATION.

 ***** REFERENCES *****

***** FOR A MORE COMPLETE LIST OF REFERENCES SEE BH72,DR68
 BA66 BASS EANDC (E) 66,64 SEE ALSO CSISRS ACCESSION NO. 60228
 BE65 BETZ AND ROSSLE EANDC (E) 57 'U' FEB 1965
 BH72 BHAT ET.AL BNL REPORT 50379 (ENDF186) 4151 MOD 2 WRITEUP
 BI63 BIRK GOLDBRING AND HILLMAN NIM 21, 197 (1963)
 BL69 BLICHERT-TOFT AND TRIPATHI 69 STUDSVIK, STI/PUB/235 (1969)
 BO71 BOERMA AND SMITH PHYS. REV. C4, 1200 (1971)
 BR64 BREDIN PHYS. REV. 135, B412 (1964)
 BR72 BRANDENBERGER ET.AL NUCL. PHYS. A196, 65 (1972)
 CL64 CLARKE AND CROSS NUCL. PHYS. 53, 177 (1964)
 CL72 CLAYEUX AND VOLGNIER CEA-R-4279 MARCH 72
 CO66 COX CSISRS ACCESSION NO. 52198
 DE67 DEBERTIN NUCL. PHYS A101, 473 (1967)
 DE72 DEVOIGT ET.AL NUCL. PHYS. A186, 365 (1972)
 DI70 DICKENS PHYS. REV. C2, 990 (1970)
 DI73 DICKENS, LOVE AND MORGAN ORNL REPORT TM-4389
 DI74 DICKENS AND MORGAN SUBMITTED TO PHYS REV
 DR68 DRAKE GULF ATOMIC REPORT GA-8628 ORIGINAL EVAL OF SI
 DR69 DRAKE ET.AL NUCL. PHYS A128, 209 (1969)

SI-NAT ORNL EVAL-FEB74 LARSON, PEREY, DRAKE, YOUNG
MATERIAL= 4151 ZA= 14000. AWR = 27.8440 FILE= 1 SECTION= 451

DR70 DRAKE ET.AL NUCL.SCI.ENG. 40,294(1970)
EN73 ENDT AND VAN DER LEUN NUCL PHYS A214,1973
FI51 FIELDS AND WALT PHYS.REV.83,479(1951)
FU73 FU COMPUTER CODE NNNGAM ORNL 1973
GI65 GILBERT AND CAMERON CAN.J.PHYS.43,1446(1965)
GR69 GRIMES NUCL.PHYS. A124,369(1969)
HA69 HARDELL ET.AL NUCL.PHYS.A126,392(1969)
KE72 KEAN AND OLLERHEAD CAN.J.PHYS.50,1539(1972)
KI70 KINNEY AND PEREY ORNL REPORT 4517 JULY 1970
KN67 KNITTER AND COPPOLA ZEITS.PHYS.207,56(1967)
KU72 KUNZ DIRECT INTERACTION CODE DWUCK72
LA61 LANE ET.AL ANN.PHYS. (NY) 12,135(1961)
LA62 LANE ET.AL PHYS. REV.126 1105(1962)
LU70 LUNDBERG AND BERGOVIST PHYS. SCRIPTA 2,265(1970)
LY67 LYCKLAMA ET.AL CAN.J.PHYS. 45,1871(1967)
MA56 MARION ET.AL PHYS.REV.101,247(1956)
MA63 MAINSBRIDGE ET.AL NUCL PHYS.48,83(1963)
MA65 MACKLIN AND GIBBONS REV.MOD.PHYS.37,166(1965)
MA67 MATHUR ET.AL TEXAS NUCLEAR REPORT NDL-TR-86 1967
MA68 MARTIN ET.AL NUCL.PHYS.A113,564(1968)
MA69 MATHUR ET.AL PHYS.REV. 186,1038(1969)
MA72 MAHER ET.AL PHYS REV C5,1322(1972)
ME69 MEYER AND WOLMARANS NUCL PHYS A136,663(1969)
ME70 MEYER ET.AL NUCL PHYS A144,261(1970)
NE72 NELLIS ET.AL DNA REPORT 2716 FEB 1972 TEXAS NUCLEAR
OB73 OBST AND WEIL PHYS REV C7,1076(1973)
OK65 OKLHOVSKII ET.AL IZV.AKAD.NAUK SSSR,SER.FIZ. 29,319(1965)
PE66 PETTIT ET.AL NUCL PHYS 79,231(1966)
PE70 PEREY ORNL COMPUTER CODE GENCA
PE72 PEREY, LOVF AND KINNEY ORNL REPORT 4823
PE73 PENNY HAUSER FESHBACH COMPUTER CODE HELGA(1973)
SC71 SCHWARTZ ET.AL BAPS 16,495(AH3) 1971
SI70 SINGH BAPS 15(BG5) 1970
SO68 SOWERBY AND MCCALLUM NUCL PHYS A112,453(1968)
SO69 SOWERBY ET.AL NUCL PHYS A135,177(1969)
SP70 SPITS ET.AL NUCL PHYS A145,449(1970)
TA64 TANAKA J.PHYS SOC JAPAN 19,2249(1964)
TA69 TANAKA ET.AL JAERI MAY 1969
VE72 VELKLEY BAPS 17,555(1972) AND PRIVATE COMMUNICATIONS
WH68 WHALEN AND MEADOWS WASH-1068,P9 AND PRIVATE COMMUNICATION
TO M.K.DRAKE FEB.1968

SI-NAT ORNL EVAL-FEB74 LARSON, FERREY, DRAKE, YOUNG
MATERIAL= 4151 ZA= 14000. AWR = 27.8440 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	GENERAL COMMENTS	502
2	151	RESONANCE DATA	4
3	1	TOTAL	421
3	2	ELASTIC	421
3	3	NON-ELASTIC	163
3	4	TOTAL INELASTIC	25
3	16	(N,2N)	7
3	22	(N,N*) ALPHA	6
3	28	(N,N*) P	6
3	51	(N,N*) 1-ST EXCITED	9
3	52	(N,N*) 2-ND EXCITED	17
3	53	(N,N*) 3-RD EXCITED	8
3	54	(N,N*) 4-TH EXCITED	8
3	55	(N,N*) 5-TH EXCITED	8
3	56	(N,N*) 6-TH EXCITED	8
3	57	(N,N*) 7-TH EXCITED	7
3	58	(N,N*) 8-TH EXCITED	8
3	59	(N,N*) 9-TH EXCITED	7
3	60	(N,N*) 10-TH EXCITED	7
3	61	(N,N*) 11-TH EXCITED	13
3	62	(N,N*) 12-TH EXCITED	7
3	63	(N,N*) 13-TH EXCITED	7
3	64	(N,N*) 14-TH EXCITED	13
3	65	(N,N*) 15-TH EXCITED	11
3	66	(N,N*) 16-TH EXCITED	10
3	67	(N,N*) 17-TH EXCITED	10
3	68	(N,N*) 18-TH EXCITED	10
3	69	(N,N*) 19-TH EXCITED	9
3	70	(N,N*) 20-TH EXCITED	9
3	71	(N,N*) 21-TH EXCITED	8
3	72	(N,N*) 22-TH EXCITED	8
3	91	(N,N*) CONTINUUM	10
3	102	(N,GAMMA)	43
3	103	(N,P)	66
3	104	(N,P)	17
3	107	(N,ALPHA)	78
3	251	MU BAR	24
3	252	XI	24
3	253	GAMMA	24
3	700	(N,P) LEVEL	14
3	701	(N,P) LEVEL	14
3	702	(N,P) LEVEL	12
3	703	(N,P) LEVEL	12
3	704	(N,P) LEVEL	11
3	705	(N,P) LEVEL	11
3	706	(N,P) LEVEL	11
3	707	(N,P) LEVEL	10
3	708	(N,P) LEVEL	10
3	709	(N,P) LEVEL	10
3	710	(N,P) LEVEL	10

SI-NAT ORNL EVAL-FEB74 LARSON, PEREY, DRAKE, YOUNG
 MATERIAL= 4151 ZA= 14000. AWR = 27.8440 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
3	711	(N,P) LEVEL	10
3	712	(N,P) LEVEL	9
3	713	(N,P) LEVEL	9
3	714	(N,P) LEVEL	9
3	718	(N,P) LEVEL	66
3	719	(N,P) *) CONTINUUM	6
3	780	(N,A) LEVEL	13
3	781	(N,A) LEVEL	12
3	782	(N,A) LEVEL	11
3	783	(N,A) LEVEL	10
3	784	(N,A) LEVEL	10
3	785	(N,A) LEVEL	9
3	786	(N,A) LEVEL	9
3	787	(N,A) LEVEL	9
3	788	(N,A) LEVEL	8
3	789	(N,A) LEVEL	8
3	790	(N,A) LEVEL	8
3	791	(N,A) LEVEL	8
3	798	(N,A) LEVEL	78
3	799	(N,A) *) CONTINUUM	6
4	2	ELASTIC	167
4	16	(N,2N)	8
4	22	(N,N*) ALPHA	8
4	28	(N,N*) F	8
4	51	(N,N*) 1-ST EXCITED	38
4	52	(N,N*) 2-ND EXCITED	122
4	53	(N,N*) 3-RD EXCITED	34
4	54	(N,N*) 4-TH EXCITED	32
4	55	(N,N*) 5-TH EXCITED	32
4	56	(N,N*) 6-TH EXCITED	30
4	57	(N,N*) 7-TH EXCITED	28
4	58	(N,N*) 8-TH EXCITED	30
4	59	(N,N*) 9-TH EXCITED	28
4	60	(N,N*) 10-TH EXCITED	28
4	61	(N,N*) 11-TH EXCITED	93
4	62	(N,N*) 12-TH EXCITED	24
4	63	(N,N*) 13-TH EXCITED	24
4	64	(N,N*) 14-TH EXCITED	62
4	65	(N,N*) 15-TH EXCITED	48
4	66	(N,N*) 16-TH EXCITED	46
4	67	(N,N*) 17-TH EXCITED	42
4	68	(N,N*) 18-TH EXCITED	42
4	69	(N,N*) 19-TH EXCITED	38
4	70	(N,N*) 20-TH EXCITED	38
4	71	(N,N*) 21-TH EXCITED	34
4	72	(N,N*) 22-TH EXCITED	34
4	91	(N,N*) CONTINUUM	10
4	700	(N,P) LEVEL	66
4	701	(N,P) LEVEL	66
4	702	(N,P) LEVEL	54

SI-NAT ORNL EVAL-FEB74 LARSON, FERREY, DRAKE, YOUNG
MATERIAL= 4151 ZA= 14000. AWR = 27.8440 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
4	703	(N,P) LEVEL	54
4	704	(N,P) LEVEL	50
4	705	(N,P) LEVEL	48
4	706	(N,P) LEVEL	48
4	707	(N,P) LEVEL	46
4	708	(N,P) LEVEL	42
4	709	(N,P) LEVEL	42
4	710	(N,P) LEVEL	42
4	711	(N,P) LEVEL	42
4	712	(N,P) LEVEL	40
4	713	(N,P) LEVEL	38
4	714	(N,P) LEVEL	38
4	718	(N,P) LEVEL	10
4	719	(N,P) *) CONTINUUM	8
4	780	(N,A) LEVEL	62
4	781	(N,A) LEVEL	56
4	782	(N,A) LEVEL	50
4	783	(N,A) LEVEL	46
4	784	(N,A) LEVEL	42
4	785	(N,A) LEVEL	38
4	786	(N,A) LEVEL	38
4	787	(N,A) LEVEL	38
4	788	(N,A) LEVEL	32
4	789	(N,A) LEVEL	32
4	790	(N,A) LEVEL	30
4	791	(N,A) LEVEL	30
4	798	(N,A) LEVEL	10
4	799	(N,A) *) CONTINUUM	8
5	16	(N,2N)	7
5	22	(N,N*) ALPHA	84
5	28	(N,N*) P	83
5	91	(N,N*) CONTINUUM	214
5	718	(N,P) LEVEL	226
5	719	(N,P) *) CONTINUUM	89
5	798	(N,A) LEVEL	225
5	799	(N,A) *) CONTINUUM	110
12	102	(N,GAMMA)	173
13	4	TOTAL INELASTIC	62
13	22	(N,N*) ALPHA	6
13	28	(N,N*) P	6
13	103	(N,P)	14
13	107	(N,ALPHA)	12
14	4	TOTAL INELASTIC	1
14	22	(N,N*) ALPHA	1
14	28	(N,N*) P	1
14	102	(N,GAMMA)	1
14	103	(N,P)	1
14	107	(N,ALPHA)	1
15	4	TOTAL INELASTIC	2120
15	22	(N,N*) ALPHA	144

SI-NAT ORNL EVAL-FEB74 LARSON, FEREY, DRAKE, YOUNG
 MATERIAL= 4151 ZA= 14000. AWE = 27.8440 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
15	28	(N,N*)P	211
15	103	(N,F)	864
15	107	(N,ALPHA)	780
23	501	TOTAL PHCTCN	18
23	502	RAYLEIGH SCATTERING	18
23	504	COMPTON SCATTERING	18
23	516	PAIR PRODUCTION	9
23	602	PHOTOELECTRIC EFFECT	18

CA ORNL EVAL-AUG71 FU, PEREY
MATERIAL= 4152 2A= 20000. AWR = 39.7360 FILE= 1 SECTION= 451

DIST-SEP71 MCD 3-FEB73

THIS IS DNA MAT 4152 MOD 3 CALCIUM.
IT IS ESSENTIALLY A COMPLETE REEVALUATION
OF MOD 2 MAY 1972<, DETAILS OF MOD 3 WILL
BE PUBLISHED IN ORNL 4866, -- A REEVALUATION
OF NEUTRON AND GAMMA-RAY PRODUCTION CROSS
SECTIONS FOR CALCIUM -- BY C. Y. FU AND F. G.
PEREY. A HISTORICAL SKETCH OF THE PREVIOUS
CALCIUM EVALUATIONS IS GIVEN BELOW FOLLOWED
BY A DESCRIPTION OF MAT 4152 MOD 3.

CALCIUM EVALUATION - C. Y. FU AND F. G. PEREY, ORNL, FEB. 1973

-----HISTORICAL SKETCH-----

MATERIAL 540 -- EVALUATED BY M. K. DRAKE, GULF GENERAL
ATOMIC REPORT GA-7829, PART 4, 1967. TRANSLATED INTO ENDF FORMAT
BY D. J. DUDZIAK OF LASL, JULY 1969. REVISED BY P. G. YOUNG OF
LASL, MAY 1970.
ENDF/B III MATERIAL 1152 -- INTERIM RESULTS OF A COMPLETE
RE-EVALUATION AT ORNL WERE MERGED WITH MAT 540 BY F. G. PEREY
C. Y. FU AND W. E. KINNEY, AUG. 1971.
DNA LIBRARY MATERIAL 4152 --
MOD 1. SAME AS ENDF/B III 1152.
MOD 2. COMPLETE RESULTS OF ORNL RE-EVALUATION, MAY 1972.
MOD 3. THIS EVALUATION. IT INCORPORATES INTO MOD 2 THE RESULTS
OF EXTENSIVE NUCLEAR MODEL CALCULATIONS AND SEVERAL
RECENT DATA SETS. QUESTIONS AND COMMENTS CONCERNING
THIS EVALUATION ARE WELCOME AND SHOULD BE ADDRESSED TO
F. G. PEREY, ORNL.

-----DESCRIPTION OF DNA 4152 MOD 3-----

FILE 1 GENERAL INFORMATION

SECTION 451 DESCRIPTIVE DATA AND DICTIONARY

FILE 2 RESONANCE PARAMETERS

SECTION 151 GENERAL DESIGNATION FOR RESONANCE INFORMATION

ONLY EFFECTIVE SCATTERING LENGTH GIVEN. TAKEN FROM BNL-325.

FILE 3 NEUTRON CROSS SECTIONS

SECTION 1 TOTAL INTERACTION

0.00001 EV TO 10 EV -- ASSUMED TO BE THE SUM OF A CONSTANT
SCATTERING CROSS SECTION AND THE CAPTURE CROSS SECTION.

10 EV TO 10 KEV -- MAGLEBY ET. AL. DRAKE EVALUATION<

10 KEV TO 180 KEV -- DUKE MEASUREMENTS. DRAKE EVALUATION<

180 KEV TO 480 KEV -- ORNL MEASUREMENT.

480 KEV TO 500 KEV -- AVERAGE OF ORNL AND NBS MEASUREMENTS.

CA ORNL EVAL-AUG71 FU, PEREY
MATERIAL= 4152 ZA= 20000. AWR = 39.7360 FILE= 1 SECTION= 451

500 KEV TO 20 MEV -- WEIGHTED AVERAGE OF ORNL, NBS AND
KARLSRUHE DATA.
SECTION 2 ELASTIC SCATTERING
DERIVED BY SUBTRACTING THE NON-ELASTIC CROSS SECTION FROM THE
TOTAL CROSS SECTION. RESULTING CROSS SECTION CHECKS WELL
WITH AVAILABLE DATA.
SECTION 3 NON-ELASTIC INTERACTION
CALCULATION FITTING MEASURED DATA.
SECTION 4 TOTAL INELASTIC SCATTERING
DERIVED BY SUMMING THE PARTIAL CROSS SECTIONS.
SECTION 16 $\%N, 2N<$ REACTION
CURVE DRAWN THROUGH EXPERIMENTAL DATA.
SECTION 22 $\%N, NA<$ REACTION
SUM OF CALCULATED $\%N, NA<$ AND $\%N, AN<$ CROSS SECTIONS.
CALCULATION FITS MEASURED $\%N, NA<$ BUT NO DATA AVAILABLE FOR
 $\%N, AN<$.
SECTION 28 $\%N, NP<$ REACTION
SUM OF CALCULATED $\%N, NP<$ AND $\%N, PN<$ CROSS SECTIONS.
CALCULATION FITS MEASURED $\%N, NE<$ BUT NO DATA AVAILABLE FOR
 $\%N, PN<$.
SECTION 51 THROUGH 73 INELASTIC SCATTERING EXCITING LEVELS
SECTION 51 FIRST EXCITED STATE IN CA-44. DATA GIVEN IS
ASSUMED.
SECTION 52 TO 64 FIRST 13 EXCITED STATES IN CALCIUM-40.
CALCULATED. GOOD AGREEMENT WITH AVAILABLE DATA.
SECTION 65 TO 73 FROM MERGING 35 LEVEL IN CA-40. CALCULATED.
SECTION 91 INELASTIC SCATTERING EXCITING THE CONTINUUM
CALCULATED.
SECTION 102 RADIATIVE CAPTURE
1/V UP TO 1.0 KEV. RESONANCE CROSS SECTION IS BASED ON
DRAKE'S CALCULATION ASSUMING A CONSTANT RADIATION WIDTH OF
2.5 EV. RESONANCE CAPTURE DATA HAVE BEEN TAKEN BY R. L.
MACKLIN OF ORNL USING ORELA BUT HAVE NOT BEEN REDUCED.
SECTION 103 $\%N, P<$ REACTION
CALCULATION FITTING EXPERIMENTAL DATA.
SECTION 104 $\%N, D<$ REACTION
CALCULATION FITTING EXPERIMENTAL DATA.
SECTION 105 $\%N, T<$ REACTION
CALCULATED.
SECTION 106 $\%N, HE-3<$ REACTION
CALCULATED.
SECTION 107 $\%N, A<$ REACTION
CALCULATED, COMPARED FAVORABLY WITH EXPERIMENTS.
SECTION 108 $\%N, 2A<$ REACTION
CALCULATED.
SECTION 111 $\%N, 2P<$ REACTION
CALCULATED.
SECTION 112 $\%N, PA<$ REACTION
CALCULATED.
SECTION 251 MU BAR

CA ORNL EVAL-AUG71 FU, PEREY
MATERIAL= 4152 ZA= 20000. AWR = 39.7360 FILE= 1 SECTION= 451

DERIVED FROM ELASTIC ANGULAR DISTRIBUTION USING THE COMPUTER
CODE SAD.

SECTION 252 XI

SEE SECTION 251.

SECTION 253 GAMMA

SEE SECTION 251.

FILE 4 ANGULAR DISTRIBUTION OF SECONDARY NEUTRONS

ALL DISTRIBUTIONS ARE GIVEN IN THE LEGENDRE POLYNOMIAL
REPRESENTATIONS.

SECTION 2 ELASTIC SCATTERING

0.00001 EV TO .01 MEV-- ASSUMED ISOTROPIC.

.01 MEV TO 4.0 MEV -- FROM EXPERIMENT.

4.0 MEV TO 20.0 MEV-- CALCULATION FITTING AVAILABLE DATA.

REPRESENTATION IS IN THE CENTER OF MASS SYSTEM.

TRANSFORMATION MATRIX IS GIVEN.

SECTION 16 γ N, 2N< REACTION

ASSUMED ISOTROPIC IN THE CENTER OF MASS FRAME.

SECTION 22 γ N, NA< REACTION

ASSUMED ISOTROPIC IN THE CENTER OF MASS FRAME.

SECTION 28 γ N, NP< REACTION

ASSUMED ISOTROPIC IN THE CENTER OF MASS FRAME.

SECTION 51 INELASTIC SCATTERING EXCITING FIRST LEVEL

ASSUMED ISOTROPIC IN THE CENTER OF MASS FRAME.

SECTION 52 THROUGH 64

CALCULATED. REPRESENTATION IS IN CENTER OF MASS SYSTEM.

SECTION 65 THROUGH 73

ASSUMED ISOTROPIC%EACH SECTION REPRESENTS A GROUP OF LEVELS<.

SECTION 91 INELASTIC SCATERING EXCITING THE CONTINUUM

ASSUMED ISOTROPIC IN THE CENTER OF MASS FRAME.

FILE 5 ENERGY DISTRIBUTION OF SECONDARY NEUTRONS

SECTION 16 γ N, 2N< REACTION

MAXWELLIAN DISTRIBUTIONS WITH TEMPERATURES DERIVED FROM
LEVEL DENSITIES AND LE COUTEUR THEORY.

SECTION 22 γ N, NA< REACTION

TABULATED FROM CALCULATION.

SECTION 28 γ N, NP< REACTION

TABULATED FROM CALCULATION.

SECTION 91 INELASTIC SCATERING EXCITING THE CONTINUUM

TABULATED FROM CALCULATION.

FILE 12 MULTIPLICITIES OF GAMMA RAYS PRODUCED BY NEUTRON REACTION

SECTION 4 TOTAL INELASTIC SCATTERING

BASED ON CALCULATED GAMMA-RAY SPECTRA. GOOD AGREEMENT
WITH EXPERIMENT. THE 1.158 MEV GAMMA-RAY FROM CA-44 IS
PARTIALLY BASED ON EXPERIMENTAL DATA AND IS TREATED AS A
DISCRETE PHOTON.

SECTION 22 γ N, NA< REACTION

BASED ON CALCULATED GAMMA-RAY SPECTRA.

SECTION 28 γ N, NP< REACTION

BASED ON CALCULATED GAMMA-RAY SPECTRA.

SECTION 102 RADIATIVE CAPTURE

CA ORNL EVAL-AUG71 FU, PEREY
MATERIAL= 4152 ZA= 20000. AWR = 39.7360 FILE= 1 SECTION= 451

ONLY GAMMA-RAYS FROM THERMAL-NEUTRON CAPTURE ARE INCLUDED.
SPECTRUM IS CONSTRUCTED FROM THE DECAY SCHEME PROPOSED BY
H. GRUPPELAAR AND P. SPILLING--NP A10271967<226.

SECTION 103 γ , p < REACTION

CALCULATION FITTING EXPERIMENTAL DATA.

SECTION 107 γ , α < REACTION

CALCULATION FITTING EXPERIMENTAL DATA.

FILE 14 ANGULAR DISTRIBUTIONS OF SECONDARY GAMMA RAYS

ASSUMED ISOTROPIC IN THE CENTER OF MASS FRAME.

FILE 15 ENERGY DISTRIBUTION OF SECONDARY GAMMA RAYS

SEE FILE 12.

FILE 23 PHOTON INTERACTION CROSS SECTION

FROM W. H. MCMASTER ET AL., UCRI-50400%1968<

SECTION 501 TOTAL INTERACTION

SECTION 502 COHERENT SCATTERING

SECTION 504 INCOHERENT SCATTERING

SECTION 516 PAIR PRODUCTION PLUS TRIPLET PRODUCTION

SECTION 602 PHOTOELECTRIC INTERACTION

CA ORNL EVAL-AUG71 FU, PEREY
MATERIAL= 4152 ZA= 20000. AWF = 39.7360 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	GENERAL COMMENTS	270
2	151	RESONANCE DATA	4
3	1	TCTAI	626
3	2	ELASTIC	626
3	3	NON-ELASTIC	181
3	4	TOTAL INFLASTIC	37
3	16	(N,2N)	9
3	22	(N,N*) ALPHA	9
3	28	(N,N*) F	9
3	51	(N,N*) 1-ST EXCITED	7
3	52	(N,N*) 2-ND EXCITED	10
3	53	(N,N*) 3-ED EXCITED	10
3	54	(N,N*) 4-TH EXCITED	9
3	55	(N,N*) 5-TH EXCITED	9
3	56	(N,N*) 6-TH EXCITED	10
3	57	(N,N*) 7-TH EXCITED	11
3	58	(N,N*) 8-TH EXCITED	12
3	59	(N,N*) 9-TH EXCITED	9
3	60	(N,N*) 10-TH EXCITED	10
3	61	(N,N*) 11-TH EXCITED	10
3	62	(N,N*) 12-TH EXCITED	9
3	63	(N,N*) 13-TH EXCITED	10
3	64	(N,N*) 14-TH EXCITED	9
3	65	(N,N*) 15-TH EXCITED	10
3	66	(N,N*) 16-TH EXCITED	9
3	67	(N,N*) 17-TH EXCITED	8
3	68	(N,N*) 18-TH EXCITED	9
3	69	(N,N*) 19-TH EXCITED	9
3	70	(N,N*) 20-TH EXCITED	10
3	71	(N,N*) 21-TH EXCITED	8
3	72	(N,N*) 22-TH EXCITED	8
3	73	(N,N*) 23-TH EXCITED	8
3	91	(N,N*) CONTINUUM	10
3	102	(N,GAMMA)	139
3	103	(N,P)	13
3	104	(N,D)	7
3	105	(N,T)	7
3	106	(N,HE3)	7
3	107	(N,ALPHA)	12
3	108	(N,2ALPHA)	6
3	111	(N,2P)	7
3	112	(N,P ALFAA)	6
3	251	MU BAR	23
3	252	XI	23
3	253	GAMMA	23
4	2	ELASTIC	195
4	16	(N,2N)	8
4	22	(N,N*) ALPHA	8
4	28	(N,N*) F	8
4	51	(N,N*) 1-ST EXCITED	8

CA ORNL EVAL-AUG71 FU, PEREY
 MATERIAL= 4152 ZA= 20000. AWR = 39.7360 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
4	52	(N,N*) 2-ND EXCITED	45
4	53	(N,N*) 3-ED EXCITED	57
4	54	(N,N*) 4-TH EXCITED	36
4	55	(N,N*) 5-TH EXCITED	34
4	56	(N,N*) 6-TH EXCITED	34
4	57	(N,N*) 7-TH EXCITED	29
4	58	(N,N*) 8-TH EXCITED	32
4	59	(N,N*) 9-TH EXCITED	28
4	60	(N,N*) 10-TH EXCITED	29
4	61	(N,N*) 11-TH EXCITED	27
4	62	(N,N*) 12-TH EXCITED	27
4	63	(N,N*) 13-TH EXCITED	27
4	64	(N,N*) 14-TH EXCITED	27
4	65	(N,N*) 15-TH EXCITED	8
4	66	(N,N*) 16-TH EXCITED	8
4	67	(N,N*) 17-TH EXCITED	8
4	68	(N,N*) 18-TH EXCITED	8
4	69	(N,N*) 19-TH EXCITED	8
4	70	(N,N*) 20-TH EXCITED	8
4	71	(N,N*) 21-TH EXCITED	8
4	72	(N,N*) 22-TH EXCITED	8
4	73	(N,N*) 23-TH EXCITED	8
4	91	(N,N*) CONTINUUM	8
5	16	(N,2N)	7
5	22	(N,N*) ALPHA	142
5	28	(N,N*) P	181
5	91	(N,N*) CCNTINUUM	196
12	4	TOTAL INELASTIC	25
12	22	(N,N*) ALPHA	6
12	28	(N,N*) P	7
12	102	(N,GAMMA)	4
12	103	(N,P)	11
12	107	(N,ALPHA)	9
14	4	TOTAL INELASTIC	1
14	22	(N,N*) ALPHA	1
14	28	(N,N*) P	1
14	102	(N,GAMMA)	1
14	103	(N,P)	1
14	107	(N,ALPHA)	1
15	4	TOTAL INELASTIC	762
15	22	(N,N*) ALPHA	97
15	28	(N,N*) P	145
15	102	(N,GAMMA)	32
15	103	(N,P)	636
15	107	(N,ALPHA)	669
23	501	TOTAL PHOTCN	18
23	502	RAYLEIGH SCATTERING	18
23	504	COMPTON SCATTERING	18
23	516	PAIR PRODUCTION	9
23	602	PHOTOELECTRIC EFFECT	18

BE-9 ILL EVAL-DEC71 HCWERTON, PERKINS
MATERIAL= 4154 ZA= 4009. AWR = 8.9348 FILE= 1 SECTION= 451

DIST-JAN72 MCD 2-NCV73

***** DNA 4154 MCD 2 *****

THE $\%N,2N<$ REACTION WAS DESCRIBED USING FORMAT MODIFICATION 73-4 WHICH ALLOWS THE REPRESENTATION OF INDIVIDUAL NEUTRONS FROM SEQUENTIAL $\%N,2N<$ REACTIONS. THIS WAS DONE UTILIZING MT#6-9 AND 46-49 IN FILES 3 AND 4, AND MT#46-49 IN FILE 5. MT # 105 NOW INCLUDES $\%N,T0<$ IN ADDITION TO $\%N,T1<$ DATA. THE $\%N,T<$ REACTION WAS SPLIT INTO $\%N,T0<$ AND $\%N,T1<$ COMPONENTS USING MT # 740 AND 741.

***** DNA 4154 MCD 1 *****

1. THE ENERGY RANGE WAS EXTENDED DOWN TO $1.0E-05$ EV.
2. GAMMA RAY PRODUCTION FOR $\%N,G<$ AND $\%N,T<$ ARE NOW REPRESENTED AS MT#102 AND MT#105, RESPECTIVELY, IN FILES 12 AND 15. THE PHOTON SPECTRUM FROM CAPTURE WAS ASSUMED INDEPENDENT OF INCIDENT NEUTRON ENERGY WITH THE MULTIPLICITY VARIED WITH INCIDENT NEUTRON ENERGY TO CONSERVE ENERGY.

FILE 23 DATA - PHOTON INTERACTION - TAKEN FROM RSIC DATA LIBRARY $\%DLC-7$ DC IS BASED ON DATA FROM UCRL-50174 SEC. II, REV. 1969 BY MCMASTER ET AL. AND UCRL-50400, VOL. VI BY PLECHATY AND TERRALL.

BE-9 EVALUATED NEUTRON CROSS SECTIONS
FOR ENDF/B IV AND CNA LIBRARY
EVALUATED BY R.J.HOWERTON AND S.T.PERKINS
LAWRENCE LIVERMORE LABORATORY, LIVERMORE, CA.
SEPTEMBER, 1973

GENERAL COMMENTS

THE NEUTRON ENERGY RANGE COVERED EXTENDS FROM $.00001$ EV TO 20 MEV. IN ADDITION TO ELASTIC SCATTERING WHICH OF COURSE IS EVERYWHERE ENERGETICALLY POSSIBLE, THE FOLLOWING REACTIONS HAVE THRESHOLDS $\%UCRL 50400$, VOL. 9< AT ENERGIES LESS THAN 20 MEV

REACTION	THRESHOLD $\%MEV<$
$N,2N$	1.85
N,P	14.26
N,NP	18.76

BE-9 LLL EVAL-DEC71 HCHERTON, PERKINS
 MATERIAL= 4154 ZA= 4009. AWR = 8.9348 FILE= 1 SECTION= 451

N,D	16.29
N,ND	18.55
N,T	11.60
N,NT	19.65
N,ALPHA	0.67
N,N ALPHA	2.74
N,GAMMA	EXCERGIC

FOR THE $\%N, NP<$, $\%N, ND<$, AND $\%N, NT<$ REACTIONS, THERE ARE NO MEASUREMENTS AND SINCE THE THRESHOLDS ARE SUFFICIENTLY HIGH, THESE CROSS SECTIONS WILL BE CONSIDERED NEGLIGIBLE. THE $\%N, N \text{ ALPHA}<$ REACTION IS IN REALITY A DECAY MODE FOR THE $\%N, 2N<$ REACTION SINCE HE-5 IS UNSTABLE, DECAYING IMMEDIATELY TO A NEUTRON AND AN ALPHA PARTICLE. ADDITIONALLY, THE INELASTIC SCATTERING REACTION IS ALSO A DECAY MODE FOR THE $\%N, 2N<$ REACTION SINCE THE BE-9* RECOIL NUCLEUS ALWAYS DECAYS TO THE FINAL END PRODUCTS OF A NEUTRON AND TWO ALPHA PARTICLES. THE WAY IN WHICH THE CROSS SECTIONS ARE SELECTED FOR ELASTIC SCATTERING, $\%N, 2N<$, $\%N, P<$, $\%N, D<$, $\%N, T<$, $\%N, \text{ALPHA}<$, $\%N, \text{GAMMA}<$, AS WELL AS THE $\%N, X \text{ GAMMA}<$ REACTION IS DISCUSSED BELOW.

ELASTIC SCATTERING CROSS SECTION

IN KEEPING WITH THE PRINCIPLE ESTABLISHED FOR THE ENTIRE LLL EVALUATED CROSS SECTION LIBRARY, THE FREE ATOM CROSS SECTION IS USED FOR ALL ENERGIES BELOW THE USUAL UPPER LIMIT OF THE MOLECULAR BINDING ENERGY $\% \text{ABOUT } 10 \text{ EV}<$. THIS IS EFFECTIVELY ONLY THE NUCLEAR PART OF THE CROSS SECTION OF A STATIONARY TARGET AT ZERO DEGREES KELVIN. IT IS STRONGLY EMPHASIZED THAT THE NUMBERS ARE MEANINGLESS IN THE ABSENCE OF A PROPER THERMAL TREATMENT BY EITHER THE PROCESSING CODE OR THE NEUTRONICS CODE WHICH USES THESE NUMBERS. THEY ARE LIKEWISE MEANINGLESS IF THE MATERIALS FOR WHICH THEY ARE TO BE USED ARE BOUND IN MOLECULES UNLESS MOLECULAR BINDING IS TAKEN INTO ACCOUNT.

THE SCATTERING CROSS SECTION WAS TAKEN EQUAL TO 6 BARNS FROM 0.00001 EV TO 0.01 MEV. FROM 0.01 MEV TO THE $\%N, \text{ALPHA}<$ THRESHOLD AT 0.67 MEV, THE SCATTERING CROSS SECTION IS EQUAL TO THE TOTAL CROSS SECTION SINCE THE $\%N, \text{GAMMA}<$ CROSS SECTION IS NEGLIGIBLE. THE CROSS SECTION WAS BASED ON DATA OF REFS. 63, 92, 720, 772 AND 1002.

ABOVE THE $\%N, \text{ALPHA}<$ THRESHOLD, THE SCATTERING CROSS SECTION WAS TAKEN AS THE DIFFERENCE BETWEEN THE TOTAL AND THE NONELASTIC, WITH THE NONELASTIC BEING EQUAL TO THE SUM OF ITS PARTS. UP TO 2 MEV, THE TOTAL CROSS SECTION WAS BASED ON THE PREVIOUSLY MENTIONED DATA, AS WELL AS THAT FROM REFS. 72, 336 AND 1642. ABOVE THIS ENERGY, WE RELIED ON THE RESULTS OF REF. 3088 OVER THE 2.7 MEV RESONANCE, AND REF. 750 UP TO 15 MEV. THE EXTENSION TO 20 MEV UTILIZED DATA FROM REFS. 107, 673 AND 682.

ELASTIC SCATTERING ANGULAR DISTRIBUTIONS,
 $\% \text{NORMALIZED PROBABILITIES}<$
 UP TO 7 MEV, THERE ARE EXPERIMENTAL DIFFERENTIAL SCATTERING

BE-9 ILL FVAL-DEC71 HCWERTON, PERKINS
MATERIAL= 4154 ZA= 4009. AWR = 8.9348 FILE= 1 SECTION= 451

DATA IN REFS. 121, 151, 231, 296, 500, 571, 945, 1643, 1645, 1646 AND 1647. THESE RESULTS WERE USED TO DETERMINE THE NORMALIZED PROBABILITIES. IN BE BELOW THE $\%N,2N<$ THRESHOLD, THE TOTAL SCATTERING DATA IS EQUIVALENT TO THAT FOR ELASTIC SCATTERING, SINCE THERE IS NO INELASTIC SCATTERING. THE CHANGE IN SHAPE OF THE ANGULAR DISTRIBUTION GOING THROUGH THE SCATTERING RESONANCES WAS TAKEN INTO ACCOUNT. AT 14 MEV, THE PROBABILITIES WERE BASED ON THE RESULTS OF REF. 402, 2585 AND 3106. A SMOOTH EXTRAPOLATION WAS MADE TO 20 MEV.

$\%N,2N<$ CROSS SECTION

THE TOTAL $\%N,2N<$ CROSS SECTION IS BASED ON THE $\%N,2N<$ CROSS SECTIONS, AND NONELASTIC MINUS ABSORPTION CROSS SECTIONS REFERENCED IN PERKINS $\%AN-1443, 1965<$, AS WELL AS THE NEW $N,2N$ DATA GIVEN IN REF. 763 AND 3320 AND THE NEW NONELASTIC RESULTS OF REF. 2595 AND 3321. THE 20 MEV POINT WAS BASED ON INTERPOLATING NONELASTIC CROSS SECTIONS BETWEEN THE 14 MEV VALUE AND THE VALUE AT 25.5 MEV QUOTED IN REF. 356. THE TOTAL $\%N,2N<$ CROSS SECTION WAS THEN SUBDIVIDED INTO 4 PARTIAL REACTIONS WHICH WERE DESCRIBED BY TIME-SEQUENTIAL DECAYS, $BE-9\%N,1<BE-9\%N2<BE-8*$. LEVELS EXCITED WERE AT 1.68, 2.43, 6.76, AND 11.28 MEV IN $BE-9*$, AND 0., 2.94, AND 11.4 MEV IN $BE-8*$. BRANCHING RATIOS WERE TAKEN FROM PERKINS $\%AN-1443, 1965<$ WITH, HOWEVER, THE $BE-9* \%9.1<$ TRANSITION BEING REPLACED BY $BE-9* \%11.28<$.

$\%N,2N<$ FIRST NEUTRON

FOR EACH OF THE PARTIAL $\%N,2N<$ REACTIONS, THE FIRST NEUTRON IS DESCRIBED AS AN INELASTIC SCATTERING EVENT. THE CENTER OF MASS ANGULAR DISTRIBUTION OF THE $\%N,NPRIME<$ NEUTRON FROM $BE-9*\%2.43<$ WAS DESCRIBED BY A P6 LEGENDRE EXPANSION - DATA TAKEN FROM PERKINS $\%AN-1443, 1965<$ AND SMOOTHLY EXTRAPOLATED TO 20 MEV. ALL OTHER REACTIONS WERE ASSUMED ISOTROPIC IN THEIR CENTER OF MASS SYSTEMS.

$\%N,2N<$ SECOND NEUTRON

THE DESCRIPTION OF THE SECOND NEUTRON FROM EACH PARTIAL REACTION NEGLECTS THE ENERGY-ANGLE CORRECTION. THIS IS A VALID APPROXIMATION FOR THIS REACTION, AS HAS BEEN DISCUSSED PREVIOUSLY $\%NSE 31,156\%1968<<$. THE ENERGY SPECTRA ARE GIVEN BY $PI0\%E TO E2<$ WITH THE LAB SYSTEM ANGULAR DISTRIBUTIONS DESCRIBED BY A P9 EXPANSION OF THE TRANSFERENCE FUNCTION. EXCEPT FOR $BE-9* \%2.43<$ AND $BE-8*\%0.<$, ALL LEVELS WERE DESCRIBED BY SINGLE LEVEL DISPERSION THEORY $\%WIDTHS$ TAKEN FROM LAP-117, 1973 AND LAP-118, 1973<. ALL MOMENTS OF THE TRANSFERENCE FUNCTION WERE THEN INTEGRATED OVER THE LEVEL DISTRIBUTIONS $\%EQUATIONS$ IN $AN-1443, 1965<$. THE INTEGRATION SCHEME USED BINS OF EQUAL PROBABILITY WHICH HAS INTRODUCED SOME DISCONTINUITIES INTO THE OUTPUT SPECTRA, PARTICULARLY AT LOW INCIDENT NEUTRON ENERGIES.

BE-9 LLL EVAL-DEC71 HCWERTON, PERKINS
MATERIAL= 4154 ZA= 4009. AWF = 8.9348 FILE= 1 SECTION= 451

$\Sigma N, P <$ CROSS SECTION

THIS CROSS SECTION WAS ESTIMATED FROM THE KNOWN THRESHOLD VALUE AND THE SINGLE MEASUREMENT AT 15.5 MEV GIVEN IN REF. 913.

$\Sigma N, D <$ CROSS SECTION

THIS CROSS SECTION IS BASED IN ITS ENTIRETY ON THE DATA BETWEEN 16.5 AND 18.8 MEV REPORTED IN REF. 3101.

$\Sigma N, T <$ CROSS SECTION

THE CROSS SECTION FOR THE $\Sigma N, T <$ REACTION IS BASED ON A $\Sigma N, T O <$ AND A $\Sigma N, T I <$ COMPONENT, WHICH PROCEED THROUGH THE 0. AND THE 0.477 MEV LEVELS IN LI-7* RESPECTIVELY. THE TOTAL $\Sigma N, T <$ CROSS SECTION NEAR 14 MEV WAS DETERMINED FROM REF. 496 AND 650. THE RESULTS OF REF. 494 WERE NEGLECTED DUE TO THE LARGE UNCERTAINTIES.

THE $\Sigma N, T I <$ CROSS SECTION WAS BASED ON THE WORK IN REF. 605 FROM 13.6 - 14.7 MEV. ABOVE THIS ENERGY, THERE IS A RESONANCE STRUCTURE SEEN IN THE TOTAL CROSS SECTION REPORTED IN REF. 107 AND 682. THIS WAS ASSUMED TO BE DUE TO THE $\Sigma N, T I <$ REACTION AND IS NOT IN CONFLICT WITH THE RAPID INCREASE IN THE CROSS SECTION ABOVE 14.5 MEV SEEN BY REF. 605.

$\Sigma N, \text{ALPHA} <$ CROSS SECTION

THE CROSS SECTION WAS BASED ON THE MEASUREMENTS REPORTED IN REF. 160, 494 AND 733 UP TO NEUTRON ENERGIES OF 8.6 MEV. IT WAS THEN TIED INTO THE THREE VALUES GIVEN AT 14 MEV, REFS. 86, 650 AND 2367, AND THEN SMOOTHLY EXTRAPOLATED TO 20. MEV. NOTE THAT THE MEASURED CROSS SECTION IS TO HE-6%0. MEV< WHICH BETA DECAYS TO LI-6, HIGHER STATES IN HE-6 DECAY TO ALPHA & 2N.

$\Sigma N, \text{GAMMA} <$ CROSS SECTION

THE CROSS SECTION WAS ASSUMED TO BE $1/V$ BELOW 100 EV WITH A 2200 M/SFC CROSS SECTION OF 9.5 MB. IT WAS THEN EXTRAPOLATED LINEARLY ON A LOG-LOG BASIS TO 0.1 MB AT 1 KEV, AND THEN HELD CONSTANT AT THIS VALUE UP TO 20 MEV.

$\Sigma N, X \text{ GAMMA} <$ CROSS SECTION

GAMMA RAYS IN BE-9 ARE PRODUCED BY THE $\Sigma N, \text{GAMMA} <$ AND THE $\Sigma N, T <$ REACTIONS. AT THERMAL ENERGIES, REF. 2415 QUOTES GAMMA RAY ENERGIES OF 0.8535, 2.59, 3.368, 3.444, 5.958 AND 6.81 MEV AND THE CORRESPONDING $\Sigma N, X \text{ GAMMA} <$ CROSS SECTIONS. THE PHOTON SPECTRUM FROM THIS WORK WAS USED AT ALL NEUTRON ENERGIES. THE MULTIPLICITY VARIED WITH NEUTRON ENERGY AS $M\%0 < M\%0 < E\text{CME}\%Q < /Q$. $M\%0 <$ IS THE MULTIPLICITY AT THERMAL AND Q IS THE $\Sigma N, \text{GAMMA} <$ Q VALUE. THIS COMBINATION OF SPECTRA AND MULTIPLICITY CONSERVES ENERGY. THERE ARE NO DOUBT OTHER LEVELS IN BE-10 WITH ENERGIES GREATER THAN 6.81 MEV EXCITED AS THE INCIDENT NEUTRON ENERGY IS INCREASED. THE ENERGIES OF THE HIGHER STATES HAVE NOT YET BEEN DETERMINED SO WE USE THIS ARTIFACT TO CONSERVE ENERGY. THE COMPONENT RESULTING FROM THE

BE-9 ILL EVAL-DEC71 HOWERTON, PERKINS
MATERIAL= 4154 ZA= 4009. AWR = 8.9348 FILE= 1 SECTION= 451

$\Sigma N, T <$ REACTION IS EQUAL TO THE $\Sigma N, T <$ CROSS SECTION SINCE ITS MULTIPLICITY IS UNITY.

REFERENCES

- Σ REFERENCE NUMBERS QUOTED HERE REFER TO DATA IN THE LLL EXPERIMENTAL NEUTRON CROSS SECTION LIBRARY. SEE UCRL-50400, VOL. 2 AND 3 FOR COMMENTS AND INDEXES TO THE DATA.
- 63. PHYS. REV. 80, 1011 Σ 1950< C.K. BOCKELMAN.
 - 72. PHYS. REV. 84, 69 Σ 1951< C.K. BOCKELMAN, D.W. MILLER, R.K. ADAIR, H.H. BARSCHALL. R
 - 86. PHYS. REV. 89, 80 Σ 1953< M.E. BATTAT, P.L. RIBE.
 - 92. PRIVATE COMMUNICATION Σ 1954< P.H. STELSON.
 - 107. PHYS. REV. 94, 651 Σ 1954< C.F. COCK, T.W. BONNER.
 - 121. PHYS. REV. 98, 669 Σ 1955< J.D. SEAGRAVE, R.L. HENKEL.
 - 151. PHYS. REV. 104, 1319 Σ 1956< J.R. BEYSTER, M. WALT, E.W. SALMI.
 - 160. PHYS. REV. 106, 1252 Σ 1957< P.H. STELSON, E.C. CAMPBELL.
 - 231. ANL-5567 Σ 1956< A. LANGSDORF, JR., R.O. LANE, J.E. MONAHAN, SEE ALSO, ANL-5554 P. 22 Σ 1956<, PHYS. REV. 107, 1077 Σ 1957<, ANL-5567 Σ REV.< Σ 1961<.
 - 296. PHYS. REV. 98, 677 Σ 1955< M. WALT, J.R. BEYSTER.
 - 336. PROC. PHYS. SOC. Σ LONDON< 64, 388 Σ 1951< G.H. STAFFORD.
 - 356. PHYS. REV. 111, 1155 Σ 1958< M.H. MACGREGOR, W.P. BALL, R. BOOTH.
 - 402. PHYS. REV. 110, 1439 Σ 1959< M.P. NAKADA, J.E. ANDERSON, C.C. GAEDNER, C. WONG.
 - 494. DOKLADY AKADEM. NAUK S.S.S.R. 119, 914 Σ 1958< S.S. VASILEV, V.V. KOMAROV, A.M. POPOVA, SEE ALSO, J. EXPTL. THEORET. PHYS. Σ USSR< 33, 527 Σ 1957<.
 - 496. PHYS. REV. 112, 1264 Σ 1958< M.E. WYMAN, E.M. FRYER, M.M. THORPE.
 - 500. PHYS. REV. 114, 1584 Σ 1959< J.B. MARION, J.S. LEVIN, L. CRANEERG.
 - 571. ANL-6172 Σ 1960< R.O. LANE, A.S. LANGSDORF, JR., J.E. MONAHAN, A.J. ELWYN, SEE ALSO, ANN. PHYS. Σ N.Y.< 12, 135 Σ 1961<.
 - 605. UCRL-5596< Σ 1959< J. BENVENISTE, A.C. MITCHELL, C.D. SCHRADER, J.H. ZENGER, SEE ALSO, NUCLEAR PHYS. 19, 52 Σ 1960<.
 - 650. J. EXPTL. THEORET. PHYS. Σ USSR< 40, 1244 Σ 1961< S.A. MYACHKOVA, V.P. PERELYGIN.
 - 673. PHYS. REV. 120, 521 Σ 1960< J.M. PETERSON, A. BRATENAH, J.P. STCERING.
 - 682. PHYS. REV. 123, 209 Σ 1961< D.B. FOSSAN, R.L. WALTER, W.E. WILSON, H.H. BARSCHALL.
 - 720. PRIVATE COMMUNICATION Σ 1962< E.G. BILFUCH, J.A. FARRELL, G.C. KYKER, JR., P.E. PARKS, H. NEWSON.
 - 733. NUCLEAR PHYS. 23, 122 Σ 1961< R. BASS, T.W. BONNER, H.P. HAENNI.
 - 750. PRIVATE COMMUNICATION Σ 1967< D.G. FOSTER, JR.,

BE-9 ILL EVAL-DEC71 HCWERTON, PERKINS
 MATERIAL= 4154 ZA= 4009. AWR = 8.9348 FILE= 1 SECTION= 451

- D.W. GLASGOW, SEE ALSO, HW-73116 %1962<, HW-77311 %1963<, PHYS. REV. C, 3, 576 %1971<, PHYS. REV. C, 3, 604 %1971<.
763. NUCLEAR PHYS. 129, 305 %1969< M. HOLMBERG, J. HANSEN, SEE ALSO, IAEA CONFERENCE ON NUCLEAR DATA, PARIS, PAPER CN-23/18 %1966<.
772. COMPT. REND. 255, 277 %1962< A. PERRIN, G. SURGET, C. THIEPALT, F. VERRIERE.
913. PHYS. REV. 132, 328 %1963< D.E. AIBUGER.
945. ORNL-2610 P. 14 %1958< H.O. COHN, J.L. FOWLER, SEE ALSO, BULL. AM. PHYS. SOC. 3, 305 %1958<.
1002. PRIVATE COMMUNICATION %1954< C.T. HIBDON, A. LANGSDORF.
1642. BULL. AM. PHYS. SOC. 4, 385 %1959< J.L. FOWLER, H.O. COHN.
1643. DOKLADY AKAD. NAUK S.S.S.R. 158, 574 %1964< G.V. GORLOV, N.S. LEBEDEVA, V.M. MCROZOV, SEE ALSO, YAD. FIZ. 5, 910 %1967<.
1645. PRIVATE COMMUNICATION %1960< J.S. LEVIN, L. CRANBERG, SEE ALSO, WASH-1028 P. 26 %1960<, WASH-1029 P. 44 %1960<.
1646. PRIVATE COMMUNICATION %1961< D.D. PHILLIPS.
1647. PHYS. REV. 133, 409 %1964< E.C. LANE, A.J. ELWYN, A. LANGSDORF, JR.
2367. NUCLEAR PHYS. 96, 476 %1967< G. PAIC, D. RENDIC, P. TOMAS.
2415. GA-10248 %DASA-2570< %1970< N.C. RASMUSSEN, V.J. ORPHAN, T.L. HARPER, J. CUNNINGHAM, S.A. ALI.
2585. PRIVATE COMMUNICATION %1966< R. BCUCHEZ, SEE ALSO, IAEA CONFERENCE ON NUCLEAR DATA, PARIS, PAPER CN-23/75 %1966<.
2595. CONFERENCE ON NEUTRON CROSS SECTION TECHNOLOGY, WASHINGTON D. C., VOL. 1, P. 169 %1968< J.R.P. EATON, J. WAIKE .
3088. CONFERENCE ON NEUTRON CROSS SECTION TECHNOLOGY, WASHINGTON D. C., P. 851 %1968< C.H. JOHNSON, F.X. HAAS, J.L. FOWLER, F.D. MARTIN, R.L. KERNEIL, H.O. COHN.
3101. Z. NATURFORSCH. 24, 289 %1969< W. SCCBEL.
3106. NP-17794 %1968< J. ROTURIER, SEE ALSO, COMPT. REND. 260, 4491 %1965<, BNI-400, 3RD ED. %1970<.
3320. ATOMKERNENERGIE 20,309 %1972< M. ELCSEK
3321. UNIV. OF BIRMINGHAM DEPT. OF PHYS. REPT. 73-02 %1973< D.R. WEAVER, J. WALKER

BE-9 ILL EVAL-DEC71 HOWERTON, PERKINS
 MATERIAL= 4154 ZA= 4009. AWF = 8.9348 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	GENERAL COMMENTS	332
2	151	RESONANCE DATA	4
3	1	TOTAL	84
3	2	ELASTIC	21
3	6	MT NOT ASSIGNED	8
3	7	MT NOT ASSIGNED	10
3	8	MT NOT ASSIGNED	7
3	9	MT NOT ASSIGNED	5
3	46	2ND N FROM BE-9 INEI	8
3	47	MT NOT ASSIGNED	10
3	48	MT NOT ASSIGNED	7
3	49	MT NOT ASSIGNED	5
3	102	(N,GAMMA)	56
3	103	(N,E)	5
3	104	(N,D)	6
3	105	(N,I)	6
3	107	(N,ALPHA)	8
3	740	(N,T) LEVEL	5
3	741	(N,T) LEVEL	6
4	2	ELASTIC	102
4	6	MT NOT ASSIGNED	10
4	7	MT NOT ASSIGNED	100
4	8	MT NOT ASSIGNED	10
4	9	MT NOT ASSIGNED	10
4	46	2ND N FROM BE-9 INEI	218
4	47	MT NOT ASSIGNED	146
4	48	MT NOT ASSIGNED	57
4	49	MT NOT ASSIGNED	49
5	46	2ND N FROM BE-9 INEI	383
5	47	MT NOT ASSIGNED	396
5	48	MT NOT ASSIGNED	251
5	49	MT NOT ASSIGNED	202
12	102	(N,GAMMA)	4
12	741	(N,T) LEVEL	4
14	102	(N,GAMMA)	1
14	741	(N,T) LEVEL	1
15	102	(N,GAMMA)	22
15	741	(N,T) LEVEL	12
23	501	TOTAL PHOTON	17
23	502	RAYLEIGH SCATTERING	17
23	504	COMPTON SCATTERING	17
23	516	PAIR PRODUCTION	9
23	602	PHOTOELECTRIC EFFECT	17

NA-23 WARD-ORNL EVAL-1971 PAIK, PITTIERLE, PEREY
MATERIAL= 4156 ZA= 11023. AWF = 22.7920 FILE= 1 SECTION= 451

MT#102 THERMAL CAPTURE GROSS SECTION FROM REF. 27 # 0.534 BARN,
1/V BEHAVIOR ABOVE THERMAL ENERGY IS JOINED WITH RESONANCE
CALCULATION NEAR 600 EV. FROM 600 EV TO 150 KEV, FILE 3 1
INCLUDES ONLY A BACKGROUND TO RESONANCE PARAMETER CALCU
LATION ABOVE 150 KEV, EVALUATION IS BASED ON REFS. 21 AND 22.

MT#103 γ N, F< - REF. 23

MT#107 γ N, ALPHA< - REF. 23

MT#251 UBAR CALCULATED FROM LEGENDRE POLYNOMIALS OF FILE 4.

MT#252 .I CALCULATED FROM LEGENDRE POLYNOMIALS OF FILE 4.

MT#253 GAMMA - REF. 24-BASED ON ISOTROPIC SCATTERING IN CM SYS.

MF#4 LEGENDRE POLYNOMIALS

MT#2 0.03 TO 0.3 MEV.-REF. 25, 0.3 TO 1.5 MEV-REF. 14.

1.5 TO 4.0 MEV - E.TRAPCATION BASED ON DATA OF REF. 26.

4.0 TO 8.52 MEV-REFS. 11, 12, 15. ABOVE 10.0 MEV-REFS. 29, 30.

MF#5 SECONDARY ENERGY DISTRIBUTIONS

MT#4 NUCLEAR TEMP. FOR MAXWELLIAN DIS. ESTIMATED TO GIVE SAME
AVERAGE ENERGY LOSS AS RESOLVED LEVELS AT 4 MEV. AND E.TRAPO-
LATED TO HIGHER ENERGIES

MT#16 NUCLEAR TEMP. IS GIVEN FOR MAXWELLIAN DISTRIBUTION

MF#7 THERMAL SCATTERING LAW

MT#4 FREE GAS LAW USING FREE ATOM CROSS SECTION # 3.128.-REF. 2
Q VALUES FOR THRESHOLD REACTIONS ARE FROM REF. 24.

REFERENCES

1. CHART OF NUCLIDES - D. GOLDMAN, KAPL #1964<.
2. HOCKENBURY, P.W., BARTOLOME, Z.M., TATARCZUK, J.R., MOYER, W.R.,
AND BLOCK, R.C., PHYS. REV. 178, 1746-1769 #1969<.
3. MOON, M. C., PATTENDON, N. J., CN-23/27 #1966 PARIS CONF.<
4. LE RIGCLEUR, C., ET AL., J. NUC. ENERGY A/B 20, 67 #1966<.
5. RIBON, P., ET. AL., CN-23/72 #1966 PARIS CONF.<
6. JOKI, MILLER, EVANS, PHY. REV. 109, 610 #1955<
7. WHALEN, J., AND SMITH, A.B., PRIVATE COMMUNICATION, ANL, #1970<
8. CIERJACKS, S., FORTI, P., KOPSCH, E., KROPE, L., NEBE, J., AND UNSELD
H., REVISED KFK DATA- KFK-1000, SUPPLEMENT 2 #1968<
9. STOLER, P., YERGIN, P.F., CLEMENT, J.C., GULDING, C.G., AND
FAIRCHILD, R., THIRD CONFERENCE ON NEUTRON CROSS SECTIONS
AND TECHNOLOGY, KNO.VILLE, MARCH 15-17 #1971<
10. PEREY, F.G., KINNEY, W.F. AND MACKLIN, R.L. THIRD CONFERENCE
ON NEUTRON CROSS SECTIONS AND TECHNOLOGY, KNO.VILLE, MARCH
15-17, #TO BE PUBLISHED< #1971<
11. FASOLI, U., TONIOLO, D., ZAGO, G. AND BENZI, V., NUC. PHY. A125,
227-240 #1969<
12. PEREY, F.G., AND KINNEY, W.E., ORNL-4518, AUGUST #1970<
13. TOWLE, J.H., AND OWENS, NUC. PHY. A100, 257 #1967<
14. CHEN, J.P., SMITH, A.B., NUC. SC. & ENG., 26, 500 #1966<
15. TOWLE, J.H., GILBOY, W.B., NUC. PHY. 32, 610 #1962<
16. FREEMAN, J., MONTAGUE, J., NUC. PHY. 9, 181 #1958<
17. LIND, E. A., ANN. OF PHYSICS 12, 485 #1961<
18. SHIPLEY, ET. AL., PHY. REV. 115, 122 #1959<
19. MENLOVE, H.O., COOP, K.L., GRENCH, H.A., AND SHER, R., PHYS. REV.
163, 1308-1314 #1967<

NA-23 WARD-ORNL EVAL-1971 PAIK, FITTERLE, PEREY
MATERIAL= 4156 ZA= 11023. AWR = 22.7920 FILE= 1 SECTION= 451

20. RAHN, F., CARMARDA, H., HACKEN, G., HAVENS, W. JR., LIU, H.,
RAINWATER, J., SLAGOWITZ, M., WYNCHANK, S., COLUMBIA UNIV.
NEVIS LABORATORY %1968<
21. BAME, S. J., CUBITT, R. L., PHY. REV. 113, 256 %1959<.
22. MENLOVE H. O., CONF-660303, VOL. 2 %1966<.
23. BASS, R., ET AL., FANDC%66U, P. 64 %1966<.
24. GARRISON, J. D. AND DRAKE, M. K. NDL-TR-89, PART 2, GA-7829 %1967<
25. LANE, R., MONAHAN, J., PHY. REV. 118, 533, %1960<.
26. ELWYN, A. J., ET AL., NUC. PHY. 59, 113 %1964<.
27. BNL-325 SECOND EDITION %1960< AND SUPP. *2 %1964<.
28. YAMAMURO, N. ET AL., NUC. SCI. ENG. 41, 3, PP. 445 %1970<.
29. CAMPBELL, R. ET AL. NAA-SR-12533 %1968<
30. AGEE, F. P. AND ROSEN, L., LA-3538-MS, VOL. I AND II %1966<
SODIUM PHOTON PRODUCTION EVALUATION - OGNL AUGUST 1971

THE PREVIOUS PHOTON PRODUCTION EVALUATION FOR SODIUM BY
M. K. DRAKE ET AL, MAT 5001, REF 1, WAS PERFORMED IN 1967. SINCE
THEN, MUCH NEW EXPERIMENTAL INFORMATION HAS BECOME AVAILABLE
TO WARRANT A REVISION OF THIS EVALUATION IN THE LOWER ENERGY
REGION. THIS REEVALUATION, MAT 1156, WAS UNDERTAKEN TO BE
COMPATIBLE IN FORMAT WITH A REEVALUATION OF THE NEUTRON CROSS
SECTIONS CONCURRENTLY PERFORMED AT WARD. BECAUSE MUCH DATA WERE
AVAILABLE AND DUE TO THE FORMATS CHOSEN, THESE PHOTON PRODUCTION
FILES SHOULD BE QUITE RELIABLE UP TO 8 MEV INCIDENT NEUTRON
ENERGY. ABOVE THAT ENERGY, WE HAVE BORROWED FROM MAT 5001 TO
EXTEND THE FILES UP TO 15 MEV.

UP TO 8 MEV NEUTRON CAPTURE AND INELASTIC SCATTERING DOMINATE
PHOTON PRODUCTION IN SODIUM. ALTHOUGH γ , n, ϵ AND n, α
REACTIONS HAVE LOW THRESHOLDS, THE CROSS SECTIONS ARE SMALL
BELOW 8 MEV AND CALCULATIONS INDICATE THAT MOSTLY THE GROUND
STATES ARE POPULATED. THEREFORE WE HAVE NEGLECTED PHOTON
PRODUCTION ARISING FROM n, p AND n, α REACTIONS.

ABOVE 8 MEV THE ENERGY DISTRIBUTION FOR PHOTONS FOR MT#91 WAS
FROM MAT 5001.

FILE 12

MT#51 TO 63

TRANSITION PROBABILITIES ARE RATHER WELL ESTABLISHED FOR
THESE LEVELS AND THE VALUES ADOPTED FOLLOW THE REVIEW OF REF. 2.
MT#58 REPRESENTS A DOUBLET OF LEVELS HAVING THE SAME SPIN BUT
OPPOSITE PARITY. CALCULATIONS INDICATE THAT THE CROSS SECTIONS
TO EACH MEMBER ARE EQUAL TO WITHIN A FEW PER CENT. THE TRANSITION
PROBABILITIES FOR MT#58 ARE THE AVERAGE OF THOSE FOR THE TWO
LEVELS.

MT#64 TO 68

EACH ONE OF THESE MT NUMBERS REPRESENT GROUPS OF LEVELS. NO
EXPERIMENTAL DATA ARE AVAILABLE TO CORRECTLY DESCRIBE THE
TRANSITION PROBABILITIES FOR MT#64 TO 68. FOR MT#64 AND 65
EQUAL PROBABILITY FOR DECAY TO THE GROUND STATE AND FIRST EXCITED
STATE HAVE BEEN ASSIGNED. FOR MT#66 TO 68 WE HAVE GIVEN THE
AVERAGE BRANCHING RATIO FOR 6 LEVELS SEEN FROM 6.9 TO 7.1 MEV
IN REF. 3. THESE ASSIGNMENTS FOR MT#64 TO 68 SHOULD NOT

NA-23 WARD-ORNL EVAL-1971 PAIK, PITTEBLE, PEREY
MATERIAL= 4156 ZA= 11023. AWR = 22.7920 FILE= 1 SECTION= 451

UNDERESTIMATE THE AMOUNT OF PENETRATING PHOTONS FOR THESE LEVELS
MT#91

THIS IS ADAPTED FROM MAT 5001, REF. 1.

MT#102

THE LOW ENERGY NEUTRON CAPTURE IN SODIUM IS DOMINATED BY THE 2.85 KEV RESONANCE. THERE ARE NO DATA WHICH INDICATE THAT THE GAMMA RAY SPECTRUM OBSERVED AT THERMAL SHOULD NOT APPLY TO THE 2.85 KEV RESONANCE. WE HAVE THEREFORE USED A SINGLE GAMMA RAY SPECTRUM TO DESCRIBE CAPTURE OVER THE COMPLETE ENERGY RANGE. THE MULTIPLICITIES WERE ARRIVED AT FROM A DECAY SCHEME BASED ON THE VERY CONSISTENT THERMAL CAPTURE DATA OF REF. 4 AND 5.

FILE 14

ALL GAMMA RAYS HAVE BEEN ASSUMED TO BE ISOTROPIC. THERE IS SUFFICIENT INFORMATION ON MANY TRANSITIONS TO GENERATE FAIRLY ACCURATE ANGULAR DISTRIBUTIONS SHOULD THE NEED ARISE.

FILE 15

THE CONTINUOUS PHOTON ENERGY SPECTRA FOR MT#91 IN THIS FILE WERE TAKEN FROM MAT 5001.

FILE 23

THE SEMI-EMPIRICAL PHOTON CROSS SECTION INFORMATION IN THIS FILE IS FROM UCRL 50400

REFERENCES

- 1- M.K.DRAKE ET AL GA-7829
- 2- A.R.FOLETTI ET AL PHYS. REV. C2-964 %1970<
3. C.P.SWANN NUC. PHYS. A167-201 %1971<
4. R.C.GREENWOOD PHYS. LETTERS 23-482 %1966< AND GIVEN IN BARTHOLOMEW ET AL NUC. DATA B-367 %1967<
5. NICHOL ET AL CAN. JOUR. PHYS. 47-953 %1969<

NA-23
MATERIAL= 4156

WARD-ORNL EVAL-1971 PAIK, PITTLERLE, PEREY
ZA= 11023. AWR = 22.7920

FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	GENERAL COMMENTS	283
1	453	DECAY CHAIN DATA	11
2	151	RESONANCE DATA	13
3	1	TCTAI	608
3	2	ELASTIC	592
3	3	NCN-ELASTIC	152
3	4	TOTAL INELASTIC	94
3	16	(N,2N)	6
3	51	(N,N*) 1-ST EXCITED	95
3	52	(N,N*) 2-ND EXCITED	32
3	53	(N,N*) 3-ED EXCITED	27
3	54	(N,N*) 4-TH EXCITED	24
3	55	(N,N*) 5-TH EXCITED	24
3	56	(N,N*) 6-TH EXCITED	20
3	57	(N,N*) 7-TH EXCITED	16
3	58	(N,N*) 8-TH EXCITED	15
3	59	(N,N*) 9-TH EXCITED	13
3	60	(N,N*) 10-TH EXCITED	12
3	61	(N,N*) 11-TH EXCITED	12
3	62	(N,N*) 12-TH EXCITED	12
3	63	(N,N*) 13-TH EXCITED	11
3	64	(N,N*) 14-TH EXCITED	11
3	65	(N,N*) 15-TH EXCITED	11
3	66	(N,N*) 16-TH EXCITED	10
3	67	(N,N*) 17-TH EXCITED	8
3	68	(N,N*) 18-TH EXCITED	9
3	91	(N,N*) CONTINUUM	7
3	102	(N,GAMMA)	20
3	103	(N,P)	37
3	107	(N,ALPHA)	37
3	251	MU BAF	21
3	252	XI	21
3	253	GAMMA	21
4	2	ELASTIC	225
4	16	(N,2N)	10
4	51	(N,N*) 1-ST EXCITED	10
4	52	(N,N*) 2-ND EXCITED	10
4	53	(N,N*) 3-ED EXCITED	10
4	54	(N,N*) 4-TH EXCITED	10
4	55	(N,N*) 5-TH EXCITED	10
4	56	(N,N*) 6-TH EXCITED	10
4	57	(N,N*) 7-TH EXCITED	10
4	58	(N,N*) 8-TH EXCITED	10
4	59	(N,N*) 9-TH EXCITED	10
4	60	(N,N*) 10-TH EXCITED	10
4	61	(N,N*) 11-TH EXCITED	10
4	62	(N,N*) 12-TH EXCITED	10
4	63	(N,N*) 13-TH EXCITED	10
4	64	(N,N*) 14-TH EXCITED	10
4	65	(N,N*) 15-TH EXCITED	10

NA-23
MATERIAL= 4156

WARD-ORNL EVAL-1971 PAIK, PITTLERLE, PEREY
ZA= 11023. AWR = 22.7920

FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
4	66	(N,N*) 16-TH EXCITED	10
4	67	(N,N*) 17-TH EXCITED	10
4	68	(N,N*) 18-TH EXCITED	10
4	91	(N,N*) CONTINUUM	10
5	16	(N,2N)	7
5	91	(N,N*) CONTINUUM	8
7	4	TOTAL INELASTIC	4
12	51	(N,N*) 1-ST EXCITED	3
12	52	(N,N*) 2-ND EXCITED	3
12	53	(N,N*) 3-ED EXCITED	3
12	54	(N,N*) 4-TH EXCITED	3
12	55	(N,N*) 5-TH EXCITED	3
12	56	(N,N*) 6-TH EXCITED	3
12	57	(N,N*) 7-TH EXCITED	4
12	58	(N,N*) 8-TH EXCITED	4
12	59	(N,N*) 9-TH EXCITED	3
12	60	(N,N*) 10-TH EXCITED	3
12	61	(N,N*) 11-TH EXCITED	3
12	62	(N,N*) 12-TH EXCITED	3
12	63	(N,N*) 13-TH EXCITED	3
12	64	(N,N*) 14-TH EXCITED	3
12	65	(N,N*) 15-TH EXCITED	3
12	66	(N,N*) 16-TH EXCITED	5
12	67	(N,N*) 17-TH EXCITED	5
12	68	(N,N*) 18-TH EXCITED	5
12	91	(N,N*) CONTINUUM	8
12	102	(N,GAMMA)	187
14	51	(N,N*) 1-ST EXCITED	1
14	52	(N,N*) 2-ND EXCITED	1
14	53	(N,N*) 3-ED EXCITED	1
14	54	(N,N*) 4-TH EXCITED	1
14	55	(N,N*) 5-TH EXCITED	1
14	56	(N,N*) 6-TH EXCITED	1
14	57	(N,N*) 7-TH EXCITED	1
14	58	(N,N*) 8-TH EXCITED	1
14	59	(N,N*) 9-TH EXCITED	1
14	60	(N,N*) 10-TH EXCITED	1
14	61	(N,N*) 11-TH EXCITED	1
14	62	(N,N*) 12-TH EXCITED	1
14	63	(N,N*) 13-TH EXCITED	1
14	64	(N,N*) 14-TH EXCITED	1
14	65	(N,N*) 15-TH EXCITED	1
14	66	(N,N*) 16-TH EXCITED	1
14	67	(N,N*) 17-TH EXCITED	1
14	68	(N,N*) 18-TH EXCITED	1
14	91	(N,N*) CONTINUUM	1
14	102	(N,GAMMA)	1
15	91	(N,N*) CONTINUUM	48
23	501	TOTAL PHOTON	18
23	502	RAYLEIGH SCATTERING	18

NA-23 WAED-ORNL EVAL-1971 PAIR, PITTERLE, PEREY
MATERIAL= 4156 ZA= 11023. AWR = 22.7920 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
23	504	COMPTON SCATTERING	18
23	516	PAIR PRODUCTION	9
23	602	PHOTOELECTRIC EFFECT	18

TRITIUM LASL EVAL-FEB65 LEONA STEWART
MATERIAL= 4169 ZA= 1003. AWR = 2.9901 FILE= 1 SECTION= 451

DIST-SEP72 MOD 1-OCT73

***** DNA 4169 MCD 1 *****

THE MT#102 MEASURED CROSS SECTION IS LESS THAN
6.7 MICROBARNs AT THERMAL ENERGY. SINCE THE
Q VALUE IS EITHER ZERO OR POSITIVE, THIS CROSS
SECTION WAS ASSUMED ZERO AT ALL ENERGIES AND
WAS REMOVED FROM FILE 3 FOR THIS MOD.

***** DNA 4169 MCD 0 *****

FILE 23 DATA - PHOTON INTERACTION - TAKEN FROM RSIC
DATA LIBRARY ~~MD~~LC-7 D< IS BASED ON DATA FROM
UCRL-50174 SEC. II, REV. 1969 BY MCMASTER ET AL.
AND UCRL-50400, VOL. VI BY PLECHATY AND TERRALL.

* * * * *
TRITIUM IN ENDF/B-III FORMAT

PRIMARY REFERENCE LA-3270 BY
LEONA STEWART ~~7~~FEBRUARY 1965, UPDATED
AUGUST 1967<
LOS ALAMOS SCIENTIFIC LABORATORY

DATA INPUT FEBRUARY, 1971

MF#1

MT#451 ATOMIC MASS # 3.01605

MF#2

MT#151 SCATTERING LENGTH#0.32164 X 1.0E-12 CM

MF#3

MT#1 TOTAL CROSS SECTIONS. TOTAL CROSS
SECTIONS FROM 290 KEV TO 20 MEV FROM
LASL MEASUREMENTS ~~7~~REF.1<. ESTIMATED
BELOW 290 KEV.

MT#2.

ELASTIC SCATTERING. INPUT AS
PROBABILITY VERSUS COSINE IN THE
CENTER-OF-MASS SYSTEM. DATA TAKEN FROM
MEASUREMENTS ~~7~~REF. 2 TO 10< UP TO 1967

TRITIUM LASL EVAL-FEB65 LFCNA STEWART
MATERIAL= 4169 ZA= 1003. AWE = 2.9901 FILE= 1 SECTION= 451

ON N-T AND P-HE3 SYSTEMS.
ALSO, RECENT MEASUREMENTS ON N-T BY
SEAGRAVE ET AL. %REF.11< AND ON P-HE3
BY MORALES AND CAHILL %REF.12< AND BY
HUTSON ET AL %REF.13< HAVE BEEN USED TO
UPDATE THE ELASTIC ANGULAR DISTRIBUT-
IONS ABOVE 15 MEV. %FEBRUARY 1971<
%THIS IS THE ONLY CHANGE MADE TO THE
EVALUATION FROM THAT DESCRIBED IN
IA-3270<.

MT#16 %N,2N< CROSS SECTIONS. ONLY ONE
MEASUREMENT EXISTS, THAT OF MATHER AND
PAIN %REF.14< AT 14.1 MEV. ESTIMATES
OF THIS CROSS SECTION WERE THEREFORE
MADE FROM SYSTEMATICS AND THE P-HE3
REACTION STUDIES OF ROSEN AND LELAND
%REF.9< AND OF ANDERSON %REF.15<.

MT#17 %N,3N< CROSS SECTION. NO DATA GIVEN
SINCE ESTIMATES FROM ISOSPIN CON-
SIDERATIONS GIVEN ESSENTIALLY ZERO
PROBABILITIES. MATHER AND PAIN
%REF.14< AND COCKSON %REF. 16< CONFIRM
THESE ESTIMATES.

NOT GIVEN MT#102 THE MEASURED CROSS SECTION IS LESS THAN
OR EQUAL TO 6.7 MICROBARNS AT THERMAL
SINCE THE Q VALUE IS UNCERTAIN
BUT EITHER ZERO OR POSITIVE, THIS
CROSS SECTION IS ASSUMED ZERO AT ALL
ENERGIES.

MT#251 AVERAGE VALUE OF THE SCATTERING ANGLE
IN THE LABORATORY SYSTEM FROM 1.0E-05
EV TO 20 MEV.

MT#252 AVERAGE LOGARITHMIC ENERGY CHANGE PER
COLLISION, FROM 1.0E-05 EV TO 20 MEV.

MT#253 GAMMA, FROM 1.0E-05 EV TO 20 MEV.

MF#4

MT#2 NEUTRON ELASTIC ANGULAR DISTRIBUTIONS
IN THE CENTER OF MASS SYSTEM.
THESE ARE GIVEN AS NORMALIZED
PROBABILITIES VERSUS COSINE OF THE
SCATTERING ANGLE.

MT#16 %N,2N< ANGULAR DISTRIBUTIONS ARE GIVEN

TRITIUM LASL EVAL-FEB65 LFONA STEWART
MATERIAL= 4169 ZA= 1003. AWR = 2.9901 FILE= 1 SECTION= 451

IN THE LABORATORY SYSTEM AS NORMALIZED
PROBABILITIES VERSUS COSINE OF THE
SCATTERING ANGLE. SEE LA-3270 FOR
DETAILS ON THESE DISTRIBUTION
FUNCTIONS.

MF#5

MT#16

%N, 2N< ENERGY DISTRIBUTIONS ARE GIVEN
AS NORMALIZED PROBABILITIES VERSUS
ENERGY OF THE OUT GOING NEUTRON IN THE
LABORATORY SYSTEM. SEE LA-3270 FOR
DETAILS ON THESE DISTRIBUTION
FUNCTIONS.

MF#12, 13, 14, 15

ONLY RADIATIVE CAPTURE PRODUCES GAMMA
RAYS. SINCE THE CAPTURE CROSS SECTION
IS ASSUMED ZERO AT ALL ENERGIES,
THESE FILES ARE PURPOSELY LEFT EMPTY.

REFERENCES

1. LOS ALAMOS PHYSICS AND CRYOGENICS GROUPS, NUCL.
PHYS. 12, 291 %1959<.
2. J.D. SPAGHAVE, ET AL, PHYS. REV. 119, 1981 %1960<.
3. J.H. COON, ET AL, PHYS. REV. 81, 33 %1951<.
4. T.B. CLEGG, ET AL, NUCL. PHYS. 50, 621 %1964<.
5. W. HAEBERLI, ET AL, PHYS. REV. 133, B1178 %1964<.
6. J.E. BROLLEY, JR., ET AL, PHYS. REV. 117, 1307
%1960<. DATA AT BACK ANGLES WHERE THE HE3 PARTICLES
WERE OBSERVED WERE IGNORED IN THIS ANALYSIS.
7. R.H. LOVBERG, PHYS. REV. 103, 1393 %1956<.
8. R.A. VANFISTAN AND E.D. FEDCHENKO, SOVIET J. OF
ATOMIC ENERGY, TRANS. 2, 141 %1957<, AND
K.P. ARTEMOV, S.P. KALININ AND L.H. SAMOILOV,
JETP 10, 474 %1960<. THE LATTER DATA WERE NOT
USED, SINCE THEY COVERED THE 5- TO 10-MEV ENERGY
REGION AND WERE NOT AVAILABLE.
9. L. ROSEN AND W.T. LEIAND, WASH-1064 %RANDC%US<-79
U< %OCT. 1966<, P. 99.

TRITIUM LASL EVAL-FEB65 LEONA STEWART
MATERIAL= 4169 ZA= 1003. AWR = 2.9901 FILE= 1 SECTION= 451

10. D. BLANC, P. CAMBOU, M. NIEL, AND G. VEDRENNE,
J. DE PHYSIQUE, SUPPLEMENT FASC. 3-4, C1-98 %1966<.
11. J.D. SEAGRAVE ET AL., LA-DC-12954 %1971<.
12. J.R. MORALES AND T.P. CAHILL, BULL. AM. PHYS. SOC.
14, 554 %1969<, AND PRIVATE COMMUNICATION.
13. R.L. HUTSON ET AL., PHYS. REV. 4, C17 %1971<.
14. D.S. MATHER AND L.F. PAIN, AWRE 047/69 %1969<.
15. JOHN D. ANDERSON, PRIVATE COMMUNICATION, 1965, AND
ANDERSON ET AL, PHYS. REV. LETTERS 15, 66 %1965<.
16. J.A. COOKSON, PHYSICS LETTERS 22, 612 %1966<.

*

*

*

*

*

*

TRITIUM LASL EVAL-FEB65 LECNA STEWART
 MATERIAL= 4169 ZA= 1003. AWR = 2.9901 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	GENERAL COMMENTS	187
1	457	MT NOT ASSIGNED	8
2	151	RESONANCE DATA	4
3	1	TOTAL	28
3	2	ELASTIC	28
3	3	NCN-ELASTIC	13
3	16	(N,2N)	13
3	251	MU BAR	8
3	252	XI	8
3	253	GAMMA	8
4	2	ELASTIC	83
4	16	(N,2N)	140
5	16	(N,2N)	198
23	501	TOTAL PHOTON	17
23	502	RAYLEIGH SCATTERING	17
23	504	COMPTON SCATTERING	17
23	516	PAIR PRODUCTION	9
23	602	PHOTOELECTRIC EFFECT	17

TA-181 LLL EVAL-JAN72 HCWERTON, PERKINS, MACGREGOR
MATERIAL= 4179 ZA= 73181. AWP = 179.4000 FILE= 1 SECTION= 451

DIST-JAN72 MOD 3-JAN74

***** DNA 4179 MOD 3 *****

REFERENCE UCFL 51306-REV.1
NOVEMBER 1973

PHOTON FILES ARE CHANGED.
DATA FROM J. K. DICKENS, PRIVATE COMMUNICATION.

THE TABULATED ELASTIC SCATTERING ANGULAR DISTRIBUTION
AT 14 MEV WAS THINNED TO REDUCE THE NUMBER OF POINTS
TO LESS THAN THE 100 LIMIT ALLOWED BY ENDF FORMAT.

***** DNA 4179 MOD 2 *****

ELECTRON PRODUCTION CROSS SECTIONS, MULTIPLICITIES,
AND SPECTRA HAVE BEEN INCLUDED FOR DNA SPECIAL
APPLICATIONS. THESE ARE IN FILES 72, 73, 74, AND 75
AND ARE ANALOGOUS TO FILES 12, 13, 14, AND 15 PHOTON
PRODUCTION FORMATS.

THE TOTAL CROSS SECTION ABOVE 10 MEV WAS INCREASED
BY A FEW PERCENT TO AGREE WITH BEST AVAILABLE DATA.
THE ELASTIC SCATTERING CROSS WAS ADJUSTED TO
ACCOMMODATE THIS CHANGE.

FOR ENERGIES .GT. 750 KEV, THE FORWARD ANGLE ELASTIC
SCATTERING PROBABILITIES WERE ADJUSTED TO AGREE WITH
WICKS LIMIT. ALSO THE NUMBER OF ENERGIES AT WHICH
DISTRIBUTIONS WERE GIVEN WAS INCREASED.

DATA ARE NOW GIVEN FOR EXCITING THE 6 KEV LEVEL
BECAUSE OF THE EMPHASIS ON ELECTRON PRODUCTION DATA
%IT DE-EXCITES PRIMARILY BY INTERNAL CONVERSION<.
A Q-VALUE HAS BEEN INSERTED FOR MT#91.

THE FORMALISM USED FOR PHOTON SPECTRUM DETERMINATIONS
WAS MODIFIED RESULTING IN AN INCREASED AMOUNT OF HIGH
ENERGY PHOTONS.

PHOTON PRODUCTION NOW INCLUDES DISCRETE LINES AT
0.165, 0.153, AND 0.136 MEV INSTEAD OF BEING LUMPED
IN AT 0.15 MEV.

TA-181 LLL EVAL-JAN72 HCWERTON, PERKINS, MACGREGOR
 MATERIAL= 4179 ZA= 73181. AWF = 179.4000 FILE= 1 SECTION= 451

***** DNA 4179 MCD 1 *****

THE %N,2N< CROSS SECTION NEAR THRESHOLD WAS
 REVISED TO CONFORM TO THE OBSERVED DIP IN
 GAMMA-RAY PRODUCTION %ORNL-TM-37C2<.

THE %N,3N< CROSS SECTION WAS MODIFIED TO
 CORRESPOND TO THE %N,2N< CHANGES.

THE %N,XG< COMPONENT IS REPRESENTED AS ONE
 DISCRETE GAMMA RAY ENERGY %0.15 MEV< FROM
 THE TWO LOWEST DISCRETE LEVELS WITH GAMMA
 RAYS FROM HIGHER LEVELS LUMPED INTO A
 CONTINUUM.

***** DNA 4179 MOD C *****

FILE 23 DATA - PHOTON INTERACTION - TAKEN FROM RSIC
 DATA LIBRARY %DLC-7 D< IS BASED ON DATA FROM
 UCRL-50174 SEC. II, REV. 1969 BY MCMASTER ET AL.
 AND UCRL-50400, VOL. VI BY PLECHATY AND TERRALL.

TA-181 EVALUATED NEUTRON CROSS SECTIONS
 S.J.HOWERTON, S.T.PERKINS, R.C.HAIGHT AND M.H. MACGREGOR
 LAWRENCE LIVERMORE LABORATORY, LIVERMORE, CALIFORNIA

GENERAL COMMENTS

THE NEUTRON ENERGY RANGE EXTENDS FROM .00001 EV TO 20 MEV. IN
 ADDITION TO ELASTIC SCATTERING, WHICH OCCURS AT ALL ENERGIES, THE
 FOLLOWING REACTIONS HAVE THRESHOLD %UCRL-50400, VOL. 9< ENERGIES
 LESS THAN 20 MEV.

REACTION	THRESHOLD %MEV<
N,N*	0.00623
N,2N	7.69
N,3N	14.30
N,P	0.24
N,NP	5.97
N,D	3.73
N,ND	11.16
N,T	4.87
N,NT	11.00
N,HE3	6.20
N,NHE3	13.24
N,ALPHA	EXOTHERMIC %Q # 7.41<
N,N ALPHA	EXOTHERMIC %Q # 1.53<

N,GAMMA EXOERGIC %Q # 6.06<

ALL CHARGED PARTICLE PRODUCING REACTIONS, EXCEPT THE %N,P< PROCESS WILL BE NEGLECTED AS THERE ARE ESSENTIALLY NO MEASUREMENTS. THE CROSS SECTIONS FOR %N,N<, %N,N*,<, %N,2N<, %N,3N<, %N,P<, %N,GAMMA<, AND %N,X GAMMA< REACTIONS ARE DISCUSSED BELOW, AS ARE THE SECONDARY NEUTRON ANGULAR AND ENERGY DISTRIBUTIONS FOR THESE REACTIONS. DISCUSSIONS ARE ALSO INCLUDED FOR PHOTON AND ELECTRON PRODUCTION CROSS SECTIONS, MULTIPLICITIES, ENERGY DISTRIBUTIONS, AND ANGULAR DISTRIBUTIONS. TO PROVIDE A MECHANISM FOR ENTERING ELECTRON PRODUCTION DATA INTO THE ENDF/B FORMAT, FILES 32, 33, 34, AND 35 WERE DEFINED EXACTLY ANALOGOUS TO FILES 12, 13, 14, AND 15. FOR DOCUMENTATION SEE LA-4549 ENDF-102, REV., VOL. II< AND READ ELECTRON FOR PHOTON IN THAT REFERENCE.

THE DATA BASE FOR THE EVALUATION IS GIVEN IN UCRL-50400, VOL. 2 AND 3. REFERENCES NOT SPECIFICALLY CITED HERE ARE GIVEN IN THESE TWO VOLUMES.

NEUTRON CROSS SECTIONS

ELASTIC SCATTERING CROSS SECTION

MF # 3 MT # 2

THE ELASTIC SCATTERING CROSS SECTIONS IS EQUAL TO 6.25 BARNS AT 0.0253 EV, THE DIFFERENCE BETWEEN THE TOTAL AND N,GAMMA CROSS SECTIONS, AND IS ESSENTIALLY CONSTANT OVER THE THERMAL ENERGY REGION. IN THE RESOLVED RESONANCE REGION, UP TO ABOUT 300 EV, THE CROSS SECTION WAS DETERMINED FROM A SINGLE LEVEL ANALYSIS FOR ZERO DEGREES KELVIN MATERIAL TEMPERATURE. THE PARAMETERS USED WERE THE RECOMMENDED SET IN BNL-325, SUPPL. 2, VOL. IIC 1966<.

AT HIGHER ENERGIES, THE ELASTIC SCATTERING CROSS SECTION WAS TAKEN AS THE DIFFERENCE BETWEEN THE TOTAL AND THE NONELASTIC CROSS SECTION. THE NONELASTIC WAS DERIVED FROM THE SUM OF ITS PARTS WHERE DATA WERE AVAILABLE, FROM MEASUREMENTS OF THE NONELASTIC C/S WHERE AVAILABLE AND OTHERWISE FROM SYSTEMATICS.

ELASTIC SCATTERING ANGULAR DISTRIBUTIONS,

MF # 4 MT # 2

NORMALIZED PROBABILITIES

THE ELASTIC SCATTERING WAS ASSUMED TO BE ISOTROPIC IN THE CENTER OF MASS SYSTEM FOR ENERGIES LESS THAN 50 KEV. FROM 50 KEV TO 14.6 MEV THE EVALUATIONS WERE BASED ON EXPERIMENTAL DATA WHERE SUCH DATA EXIST. FOR ENERGIES EQUAL TO OR GREATER THAN ONE MEV OPTICAL MODEL CALCULATIONS WERE DONE TO OBTAIN AN ESTIMATE OF THE INELASTIC SCATTERING TO LOW LYING LEVELS INCLUDED IN THE EXPERIMENTAL RESULTS. TO PROVIDE A REASONABLE NUMBER OF ANGULAR DISTRIBUTIONS, OPTICAL MODEL CALCULATIONS WERE USED AT INTERMEDIATE ENERGIES AND FOR ENERGIES GREATER THAN 14.6 MEV. THE OPTICAL MODEL RESULTS AGREED VERY WELL WITH THE EXPERIMENTS EXCEPT AT THE MINIMA WHERE ONE WOULD EXPECT THE LOW LYING LEVEL EXCITATIONS TO CAUSE A FILLING OF THE MINIMA. THE WICK LIMIT WAS TESTED AGAINST ALL DISTRIBUTIONS AND IT WAS FOUND THAT THE CRITERION WAS

TA-181 III EVAL-JAN72 HCWERTON, PERKINS, MACGREGOR
MATERIAL= 4179 ZA= 73181. AWE = 179.4000 FILE= 1 SECTION= 451

MET.

INELASTIC SCATTERING CROSS SECTION

MF # 3 MT # 51-60 AND 91

THE EXCITATION FUNCTION FOR THE 6 KEV LEVEL WAS BASED ON CALCULATIONS DONE BY DONALD GARDNER USING THE COMNUC CODE. THE EXCITATION FUNCTIONS FOR THE NEXT 9 LEVELS WERE OBTAINED FROM REF. 885 AND FROM RECENT ORNL DATA (DICKENS AND MORGAN 1973). THE RESULTS WERE SMOOTHLY EXTRAPOLATED TO 10 MB AT 2-4 MEV AND KEPT CONSTANT TO 20 MEV.

THE TOTAL INELASTIC CROSS SECTION WAS BASED ON INDIVIDUAL LEVEL DATA AT ENERGIES OF THE ORDER OF ONE MEV. FROM 1 TO 20 MEV THERE ARE FEW MEASUREMENTS AND THE EXCITATION FUNCTION WAS ESTIMATED FROM NUCLEAR SYSTEMATICS. THE DIFFERENCE BETWEEN THE TOTAL INELASTIC AND THE LEVEL DATA WAS ASSIGNED TO THE INELASTIC CONTINUUM CROSS SECTION. THE EXPERIMENT REPORTED IN REF. 885 COULD NOT RESOLVE CERTAIN DOUBLETS SO A MEAN ENERGY WAS ASSIGNED WHICH, OF COURSE, DIFFERS FROM THE ENERGIES PRESENTED IN ALL TABULATIONS OF LEVELS OR LEVEL DIAGRAM FOR TA-181.

INELASTIC SCATTERING ANGULAR DISTRIBUTIONS.

MF # 4 MT # 51-60 AND 91

NORMALIZED PROBABILITIES

THE LEVEL DATA WERE ASSUMED ISOTROPIC IN THE CENTER OF MASS SYSTEM AND THE CONTINUUM COMPONENT WAS ASSUMED ISOTROPIC IN THE LABORATORY SYSTEM FOR ENERGIES LESS THAN 8.0 MEV. FOR HIGHER ENERGIES THE DISTRIBUTIONS WERE PEAKED FORWARD.

INELASTIC SCATTERING ENERGY DISTRIBUTIONS

MF # 5 MT # 91

THE CONTINUUM INELASTIC SCATTERING ENERGY DISTRIBUTION IS COMPOSED OF AN EVAPORATION COMPONENT PLUS A HIGH ENERGY PRE-EQUILIBRIUM COMPONENT. THIS LATTER PORTION DECREASES WITH INCREASING SECONDARY ENERGY AND ITS CONTRIBUTION INCREASES WITH THE INCIDENT NEUTRON ENERGY. THE EVAPORATION TEMPERATURE WAS ASSUMED TO VARY AS THE SQUARE ROOT OF THE INCIDENT NEUTRON ENERGY. IN THE DETAILED EVALUATION, A SEPARATION WAS MADE INTO NEUTRONS WITH INCIDENT ENERGIES ABOVE THE $n,2n$ THRESHOLD, AND THOSE WITH ENERGIES BELOW. THE FORMER WERE ASSUMED TO EMIT PRIMARILY HIGH ENERGY NEUTRONS IN THE n,n' REACTION.

$n,2n$ CROSS SECTION

MF # 3 MT # 16

THE $n,2n$ CROSS SECTION NEAR THRESHOLD WAS DETERMINED FROM THE OBSERVED DIP IN GAMMA RAY PRODUCTION (CAK RIDGE REPORT ORNL-TM-3702, FEB, 1972), USING THE FORMALISM OF HCWERTON AND PLECHATY (NUCL.SCI.ENG.32,178 1968). THE OVERALL SHAPE FOR THE EXCITATION FUNCTION WAS SET EQUAL TO THAT OF U238, WITH SUITABLE ADJUSTMENTS TO MATCH THE SYSTEMATICS OF TANTALUM.

$n,2n$ ENERGY DISTRIBUTIONS

TA-181 ILL EVAL-JAN72 HCWERTON, PERKINS, MACGREGOR
MATERIAL= 4179 ZA= 73181. AWR = 179.4000 FILE= 1 SECTION= 451

MF # 5 MT # 16
THE FORMALISM OF THE TEMPERATURE MODEL WAS USED FOR CONVENIENCE IN THE ABSENCE OF MEASUREMENT.

$\Sigma N, 3N <$ CROSS SECTION

MF # 3 MT # 17
THE $\Sigma N, 3N <$ EXCITATION FUNCTION WAS BASED ON THE DIFFERENCE BETWEEN A CONSTANT NONELASTIC CROSS SECTION OF 2.45 BARNS AND THE SUM OF THE INELASTIC AND $\Sigma N, 2N <$ CROSS SECTIONS.

$\Sigma N, 3N <$ ENERGY DISTRIBUTIONS

MF # 5 MT # 17
THE FORMALISM OF THE TEMPERATURE MODEL WAS USED FOR CONVENIENCE IN THE ABSENCE OF MEASUREMENT.

$\Sigma N, P <$ CROSS SECTION

MF # 3 MT # 103
THE $\Sigma N, P <$ CROSS SECTION WAS BASED ON THE DATA OF REF. 2887, WITH SMOOTH EXTRAPOLATIONS TO THRESHOLD AND TO 20 MEV.

$\Sigma N, \text{GAMMA} <$ CROSS SECTION

MF # 3 MT - 102
THE $\Sigma N, \text{GAMMA} <$ CROSS SECTION IS EQUAL TO 21.9 BARNS AT .0253 EV AND IS $1/V$ OVER THE THERMAL REGION. IN THE RESOLVED RESONANCE REGION, THE CROSS SECTION $\Sigma \text{AT ZERO DEGREES KELVIN} <$ WAS OBTAINED FROM A SINGLE LEVEL ANALYSIS - SEE SECTION UNDER ELASTIC SCATTERING CROSS SECTION.

FROM ABOUT 300 EV TO 10 KEV, THE LEAD SLOWING-DOWN-TIME SPECTROMETER DATA OF REF. 1960 WAS USED. THIS WAS MERGED SMOOTHLY INTO THE RELATIVELY LARGE AMOUNT OF DATA AVAILABLE FOR ENERGIES BELOW 5 MEV, AND SMOOTHLY EXTRAPOLATED TO 20 MEV.

GAMMA RAY PRODUCTION CROSS SECTIONS

$\Sigma N, X \text{ GAMMA} <$ CROSS SECTION FROM THE $\Sigma N, \text{GAMMA} <$ REACTION

MF # 12 MT # 102
THE MULTIPLICITY FOR GAMMA RAYS, $M_{\gamma} <$, FROM THE $\Sigma N, \text{GAMMA} <$ REACTION WAS OBTAINED BELOW 35 KEV NEUTRON ENERGY BY NORMALIZING THE SPECTRAL SHAPES TO THE BINDING ENERGY $\Sigma BE <$ PLUS THE NEUTRON ENERGY E MINUS THE ENERGY DIVERTED BY INTERNAL CONVERSION. ABOVE 35 KEV, THIS CROSS SECTION IS INCLUDED IN THE $\Sigma N, X \text{ GAMMA} <$ CROSS SECTION. NOTE THAT THE ASSUMED ENERGY VARIATION OF THE MULTIPLICITY CONSERVES ENERGY FOR THE REACTION WITH THE ENERGY DISTRIBUTION DESCRIBED BELOW.

$\Sigma N, X \text{ GAMMA} <$ ENERGY DISTRIBUTION FROM THE $\Sigma N, \text{GAMMA} <$ REACTION

MF # 15 MT # 102
THE DISTRIBUTIONS ARE EXPRESSED AS NORMALIZED PROBABILITY

TA-181 ILL EVAL-JAN72 HOWERTON, PERKINS, MACGREGOR
MATERIAL= 4179 ZA= 73181. AWF = 179.4000 FILE= 1 SECTION= 451

BILITY DISTRIBUTIONS.

AT 10^{11} MEV NEUTRON ENERGY, THIS ENERGY DISTRIBUTION WAS TAKEN TO BE THAT OF REF. 2415 FOR PHOTONS BETWEEN 2.5 AND 5. MEV. ABOVE 5. MEV THE THERMAL CAPTURE DATA OF REF. 3211 WERE USED AFTER HAVING BEEN NORMALIZED TO REF. 2415. BELOW 0.5 MEV PHOTON ENERGY, THE DATA OF REF. 3211 WERE USED, NORMALIZED AT 402 KEV TO REF. 2415. THE PRODUCTION OF K AND L X-RAYS FOLLOWING INTERNAL CONVERSION WAS TAKEN FROM THE INTERNAL CONVERSION CROSS SECTIONS DISCUSSED BELOW. A FLUORESCENCE YIELD OF 100 WAS ASSUMED FOR EACH K AND L VACANCY. BETWEEN 0.5 AND 2.5 MEV, THE ENERGY DISTRIBUTION WAS TAKEN FROM A GAMMA CASCADE CALCULATION.

AT 2 KEV NEUTRON ENERGY THE SAME PROCEDURE WAS FOLLOWED EXCEPT THAT THE 2 KEV DATA OF REF. 3211 WAS USED FOR THE PHOTON ENERGIES ABOVE 5. MEV. AT 35 KEV NEUTRON ENERGY THE ENERGY DISTRIBUTION WAS ASSUMED TO BE THE SAME AS AT 2 KEV.

$\Sigma N, X$ GAMMA CROSS SECTION

MF # 13 MT # 3

THIS COMPONENT INCLUDES ALL GAMMA RAYS EXCEPT THOSE FROM THE CAPTURE PROCESS DISCUSSED ABOVE. FOUR DISCRETE LINES WERE ENTERED EXPLICITLY. THE MEASUREMENTS OF LICKENS AND MORGAN (1973), LARSEN (1973), AND OF ROGERS ET AL (1971) WERE USED AS GUIDES FOR LINES AT 0.108, 0.1361, 0.152, 0.165, 0.179, 0.1937, 0.205, 0.259, 0.288, 0.301, 0.331, 0.345, 0.3589, 0.482, 0.80, 0.99, 1.08, 1.150, 1.206, 1.245, 1.308, 1.382, AND 1.426 MEV. K AND L X-RAYS FOLLOWING INTERNAL CONVERSION WERE ALSO INCLUDED. GAMMA RAYS FROM THE OTHER DISCRETE $\Sigma N, N^*$ LEVELS WERE LUMPED INTO THE CONTINUUM. CONTINUUM CONTRIBUTIONS WERE HANDLED BY USING THE HOWERTON AND PLECHATY RECIPE WITH MEASURED GAMMA RAY TEMPERATURES (ORNL-TM-3702) FOR EACH REACTION. THE AVERAGE PHOTON ENERGY IN THE SPECTRA WERE CHOSEN TO GIVE OVERALL ENERGY CONSERVATION FOR THE COMBINED NEUTRON-PLUS-GAMMA PRODUCTION PROCESSES.

$\Sigma N, X$ GAMMA ENERGY DISTRIBUTIONS

MF # 15 MT # 3

EXPERIMENTAL GAMMA RAY TEMPERATURES (ORNL-TM-3702) WERE USED WITH THE HOWERTON AND PLECHATY RECIPE (LCC. CIT.) IN A CALCULATION THAT WAS MATCHED TO GAMMA RAY PRODUCTION DATA (ORNL-TM-3702) AND TO NEUTRON SYSTEMATICS, WITH ENERGY BEING CONSERVED ON THE AVERAGE FOR ALL NEUTRON AND GAMMA RAY PRODUCTION PROCESSES.

CONVERSION ELECTRON PRODUCTION CROSS SECTIONS

$\Sigma N, X$ ELECTRON CROSS SECTIONS FROM THE
 $\Sigma N, X$ GAMMA REACTION

MF # 72 MT # 102

THE MULTIPLICITY OF CONVERSION ELECTRONS WAS DETERMINED FROM THE MULTIPLICITY OF PHOTONS AND THE CONVERSION ELECTRON/

TA-181 ILL EVAL-JAN72 HCWERTON, PERKINS, MACGREGOR
MATERIAL= 4179 ZA= 73181. AWR = 179.4000 FILE= 1 SECTION= 451

GAMMA RAY RATIO AS INDICATED IN REF. 3212.

%N,X ELECTRON ENERGY DISTRIBUTIONS FROM THE
%N,GAMMA< REACTION

MF # 75 MT # 102

THE ENERGY DISTRIBUTION WAS TAKEN FROM THE THERMAL CAPTURE DATA OF REF. 3212 FOR ELECTRON ENERGIES ABOVE 60 KEV AND FROM REF. 3213 BELOW 60 KEV. THE SPECTRUM BELOW 40 KEV WAS ESTIMATED. THE ENERGY DISTRIBUTION IS EXPRESSED AS A NORMALIZED PROBABILITY DISTRIBUTION AND IS ASSUMED INDEPENDENT OF NEUTRON ENERGY.

%N,X ELECTRON< CROSS SECTIONS AND SPECTRA

MF # 73,74 AND 75 MT # 3

THIS COMPONENT INCLUDES ALL CONVERSION ELECTRONS EXCEPT THOSE FROM THE %N,GAMMA< REACTION. THE 6 KEV LEVEL OF TA-181 DECAYS BY INTERNAL CONVERSION 98 OF THE TIME %REF. MUIR %1965<<. OTHER RADIATIVE TRANSITIONS WERE SEEN IN THE %N,N*GAMMA< REACTION BY DICKENS AND MORGAN %1973<. MULTIPOLARITIES OF AVIGNONE ET AL %1971< AND ALEXANDER ET AL %1966< TOGETHER WITH STANDARD CONVERSION COEFFICIENTS GAVE THE CROSS SECTIONS FOR K AND L CONVERSION ELECTRON LINES. L1, L2 AND L3 LINES WERE LUMPED TOGETHER. M,N,...ETC. LINES WERE NEGLECTED EXCEPT FOR THE 6 KEV TRANSITION. ABOVE 7.7 MEV NEUTRON ENERGY, THE CROSS SECTIONS WERE ASSUMED CONSTANT.

REFERENCES

REFERENCE NUMBERS QUOTED HERE REFER TO DATA IN THE LLL EXPERIMENTAL NEUTRON CROSS SECTION LIBRARY. SEE UCRL-50400, VOL. 2 AND 3 FOR COMMENTS AND INDEXES TO THE DATA, AS WELL AS FOR OTHER EXPERIMENTAL RESULTS THAT WERE USED IN THE EVALUATION.

885. PRIVATE COMMUNICATION %1966< A.B.SMITH %ANL<
1019 PRIVATE COMMUNICATION %1968< W.F.TUCKER %TEXAS NUCLEAR<
1497 NUCLEAR SCI. ENG. 40, 294 %1970< D.M.DRAKE ET AL. %LASL<
1960 J.EXPTL.THEORET.PHYS. %USSR< 46, 80 %1964< V.A.KONKS ET AL.
2402 INR-795/I/PL %1967< J.ERZOSKO ET AL. %POLAND<
2415 GA-10248 %DASA-2570< %1970< N.C.RASMUSSEN ET AL. %GGA<
2887 NUCLEAR PHYS. 123, 603 %1969< J.S.ERZCSKO ET AL. %POLAND<
3211 NUCLEAR PHYS. A168, 449 %1971< R.G. HELMER, R.C. GREENWOOD
AND C.W. REICH %MTR<
3212 P.F.A. GUDSMIT, THESIS, UNIV. AMSTERDAM %1969<
3213 BULL. ACAD. SCI. %PHYS. SER.< 32, 1833 %1968< YA K. ALKENIS,
M.K. BALODIS, AND P.T. FROKCFØEV
NUCLEAR PHYSICS 68, 305 %1965< A.H. MUIR
NUCL. SCI. AND ENG. 45, 297 %1971< V.C. ROGERS, L.E. BEGHIAN,
AND F.M. CLIKEMAN
NUCLEAR PHYSICS 76, 167 %1966< P. ALEXANDER, H RYDE, AND E.
SELTZER
NUCLEAR PHYSICS A167, 169 %1971< F.T. AVIGONE III, J. H.
TRUEBLOOD AND Z.W. GRABOWSKI

TA-181 ILL EVAL-JAN72 HCWERTON, PERKINS, MACGREGOR
MATERIAL= 4179 ZA= 73181. AWR = 179.4000 FILE= 1 SECTION= 451

J.K. DICKENS AND G.L. MORGAN, PRIVATE COMMUNICATION #1973<
J. LARSEN, PRIVATE COMMUNICATION #1973<
OAK RIDGE REPORT ORNL-TM-3702, FEB., 1972, MORGAN, LOVE, DICKENS, PEREY

TA-181 LIL EVAL-JAN72 HCWERTON, PERKINS, MACGREGOR
 MATERIAL= 4179 ZA= 73181. AWR = 179.4000 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	GENERAL COMMENTS	408
2	151	RESONANCE DATA	4
3	1	TOTAL	885
3	2	ELASTIC	351
3	4	TOTAL INELASTIC	18
3	16	(N,2N)	9
3	17	(N,3N)	6
3	51	(N,N*) 1-ST EXCITED	7
3	52	(N,N*) 2-ND EXCITED	6
3	53	(N,N*) 3-ED EXCITED	6
3	54	(N,N*) 4-TH EXCITED	6
3	55	(N,N*) 5-TH EXCITED	5
3	56	(N,N*) 6-TH EXCITED	5
3	57	(N,N*) 7-TH EXCITED	5
3	58	(N,N*) 8-TH EXCITED	7
3	59	(N,N*) 9-TH EXCITED	6
3	60	(N,N*) 10-TH EXCITED	6
3	91	(N,N*) CONTINUUM	8
3	102	(N,GAMMA)	617
3	103	(N,E)	5
4	2	ELASTIC	130
4	16	(N,2N)	10
4	17	(N,3N)	10
4	51	(N,N*) 1-ST EXCITED	10
4	52	(N,N*) 2-ND EXCITED	10
4	53	(N,N*) 3-ED EXCITED	10
4	54	(N,N*) 4-TH EXCITED	10
4	55	(N,N*) 5-TH EXCITED	10
4	56	(N,N*) 6-TH EXCITED	10
4	57	(N,N*) 7-TH EXCITED	10
4	58	(N,N*) 8-TH EXCITED	10
4	59	(N,N*) 9-TH EXCITED	10
4	60	(N,N*) 10-TH EXCITED	10
4	91	(N,N*) CONTINUUM	21
5	16	(N,2N)	266
5	17	(N,3N)	125
5	91	(N,N*) CONTINUUM	118
12	102	(N,GAMMA)	5
13	3	NCN-ELASTIC	320
14	3	NCN-ELASTIC	1
14	102	(N,GAMMA)	1
15	3	NCN-ELASTIC	681
15	102	(N,GAMMA)	45
23	501	TOTAL PHOTON	23
23	502	RAYLEIGH SCATTERING	23
23	504	COMPTON SCATTERING	23
23	516	PAIR PRODUCTION	9
23	602	PHOTOELECTRIC EFFECT	23
72	102	(N,GAMMA)	5
73	3	NCN-ELASTIC	177

TA-181 ILL EVAL-JAN72 HCWERTON, PERKINS, MACGREGOR
MATERIAL= 4179 ZA= 73181. AWR = 179.4000 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
74	3	NCN-ELASTIC	1
74	102	(N,GAMMA)	1
75	102	(N,GAMMA)	20

IRON ORNL EVAL-1974 PEREY, FU, PENNY, KINNEY, WRIGHT
MATERIAL= 4180 ZA= 26000. AWR = 55.3650 FILE= 1 SECTION= 451

ORNL-4617%1970< EVAL-1970 MCD 2-FEB744

***** DNA 4180 MOD 2 *****

THIS MODIFICATION SUPERSEDES THE PREVIOUS EVALUATION, DNA 4180 MOD 1, EVALUATED BY S. K. PENNY, W. E. KINNEY, R. Q. WRIGHT, F. G. PEREY AND C. Y. FU OF ORNL.

IT WAS PRIMARILY INTENDED FOR A REVISION OF THE SECONDARY NEUTRON DISTRIBUTIONS AS NEW DATA %KA72, CI72< HAVE BECOME AVAILABLE AND AS THE PULSED SPHERE MEASUREMENTS %HA73< AND RELATED CALCULATIONS %HA73, CR73< INDICATED THAT THE PREVIOUS NEUTRON DISTRIBUTIONS WERE INADEQUATE, AND FOR A REEVALUATION OF THE GAMMA-RAY-PRODUCTION CROSS SECTIONS SINCE THE RECENTLY AVAILABLE DATA %DI73< DISAGREE SUBSTANTIALLY WITH THE DATA SET %OR71< UPON WHICH THE PREVIOUS EVALUATION WAS LARGELY BASED. THESE PURPOSES WERE CONSISTENTLY ACHIEVED BY AN EXTENSIVE CALCULATION FOR FE-56 WHICH ALSO LED TO THE REFINEMENT OF ALL REACTION CROSS SECTIONS EXCEPT CAPTURE. SIGNIFICANT CHANGES ARE SUMMARIZED BELOW.

1. TOTAL CROSS SECTION BETWEEN 60 KEV AND 2 MEV -- PEAKS AND VALLEYS WERE REFINED BASED ON 3 SETS OF CREIA MEASUREMENTS %HA72< USING 1-, 4-, AND 12-INCH SAMPLES.

2. NONELASTIC -- OBTAINED BY COMPROMISING 3 PIECES OF INFORMATION, NAMELY, THE MEASURED NONELASTIC CROSS SECTION, THE DIFFERENCE BETWEEN THE EVALUATED TOTAL CROSS SECTION AND THE AVAILABLE ELASTIC SCATTERING CROSS SECTION, AND THE THEORETICAL INTERPRETATION OF THE TOTAL GAMMA-RAY-PRODUCTION CROSS SECTION. THE CALCULATED NONELASTIC CROSS SECTION WAS NORMALIZED TO THIS RESULT FOR CONSTRAINING THE SUBSEQUENT CALCULATIONS.

3. INELASTIC SCATTERING -- 6 MORE DISCRETE LEVELS WERE ADDED BASED ON THE HAUSER-FESHBACH %PE73< AND DWBA %BA66< CALCULATIONS IN ORDER TO INCLUDE THE 4.505-MEV COLLECTIVE STATE AS A DISCRETE LEVEL. THE DIRECT-INTERACTION COMPONENTS WERE INCLUDED IN 15 OF THE 26 DISCRETE LEVELS %MA71<. THE DIRECT-INTERACTION COMPONENT WAS INCLUDED IN THE CONTINUUM USING AN EMPIRICAL TREATMENT %PU73<. MT#51%0.846-MEV LEVEL< WAS CHANGED BETWEEN 2 AND 5 MEV ACCORDING TO AN EVALUATION BY SMITH %SM73< WHICH WAS BASED ON ALL AVAILABLE DATA AND HIS RECENT MEASUREMENT. MT#52%THE 1.408-MEV LEVEL IN FE-54< WAS REVISED BASED ON RECENTLY AVAILABLE DATA %KI73<.

4. THE HAUSER-FESHBACH METHOD WAS USED TO CALCULATE THE %N,N'< %N,NX<<, %N,P<%N,PX<< AND %N,A<%N,AX<< CROSS SECTIONS. THE %N,N'<%N,NX<< CROSS SECTION ABOVE 4.531 MEV WAS SPLIT INTO THE %N,N'< CONTINUUM, %N,2N<, %N,NP< AND %N,NA< CROSS SECTIONS USING A STATISTICAL-EMPIRICAL MODEL%PU73<. THE EMPIRICAL ASPECTS INCLUDE GIANT-DIPOLE GAMMA-RAY COMPETITION, ANGULAR-MOMENTUM CORRECTION FOR THE SECOND OUTGOING PARTICLE AND DIRECT OR PREEQUILIBRIUM EMISSION OF THE FIRST PARTICLE.

5. THE %N,P< CROSS SECTION WAS WELL-DEFINED BY MEASUREMENTS %GO66,RO73< AND THAT OF FE-56 WAS WELL-FITTED BY CALCULATION UP TO 13 MEV. THE %N,PN< CROSS SECTION WAS TAKEN TO BE THE DIFFERENCE

IRON ORNL EVAL-1974 FERRY, FU, PENNY, KINNEY, WRIGHT
MATERIAL= 4180 ZA= 26000. AWR = 55.3650 FILE= 1 SECTION= 451

BETWEEN THE CALCULATED FE-56 $\sigma_{N,P<}$ CROSS SECTION AND THE MEASURED FE-56 $\sigma_{N,P<}$ CROSS SECTION. NEUTRON DISTRIBUTION FOR THE $\sigma_{N,PN<}$ REACTION WAS CALCULATED AND WAS AVERAGED WITH THAT OF THE $\sigma_{N,NP<}$ REACTION FOR MT#28.

6. THERE IS NO MEASURED FE-56 $\sigma_{N,A<}$ CROSS SECTION. THE CALCULATED FE-56 $\sigma_{N,A<}$ CROSS SECTION WAS RESTRAINED BY THE 14-MEV EMPIRICAL VALUE AND THE MEASURED FISSION-SPECTRUM AVERAGES. THE FE-54 $\sigma_{N,A<}$ CROSS SECTION WAS TAKEN FROM A CALCULATION BY KIROUAC AND SLAVIK $\sigma_{KI72<}$. THE $\sigma_{N,AN<}$ CROSS SECTION AND NEUTRON DISTRIBUTION WERE CALCULATED AND WERE COMBINED WITH THOSE OF THE $\sigma_{N,NA<}$ REACTION FOR MT#22.

7. THE $\sigma_{N,D<}$, $\sigma_{N,T<}$ AND $\sigma_{N,HE-3<}$ CROSS SECTIONS WERE BASED ON CALCULATIONS USING THE PEARISTFIN EMPIRICAL MODEL AND PARAMETERS $\sigma_{PE71<}$.

8. THE TWO MAJOR SETS $\sigma_{DI73,OR71<}$ OF THE GAMMA-RAY-PRODUCTION CROSS SECTIONS AGREE WITHIN EXPERIMENTAL ERRORS FOR INCIDENT NEUTRON ENERGIES BELOW 6 MEV AND THEN START TO DIVERGE, THE GRT SET $\sigma_{OR71<}$ BEING 1.6 BARNS LARGER THAN THE ORNL SET $\sigma_{DI73<}$ IN THE 11 TO 15 MEV REGION. OTHER AVAILABLE DATA WERE TOO LIMITED TO RESOLVE THIS DISCREPANCY. THE CALCULATED RESULTS ARE INTERMEDIATE BETWEEN THE TWO, BEING CLOSER TO THE GRT MEASUREMENT BELOW 12 MEV AND CLOSER TO THE ORNL DATA ABOVE 12 MEV. FOR A TENTATIVE EVALUATION THE ORNL DATA WERE USED FOR THE ENERGY DISTRIBUTIONS $\sigma_{FILE 15<}$ AS THESE WERE GIVEN IN ADEQUATE NEUTRON BINS AND WERE THE ONLY DATA AVAILABLE FROM 15 TO 20 MEV. THE GAMMA RAYS BELOW 0.69 MEV WERE NOT MEASURED AND WERE FILLED IN USING THE CALCULATED VALUES. UP TO 10 MEV INCIDENT NEUTRON ENERGY THE ENERGY CONSERVATION LAW RELATING THE CALCULATED OUTGOING PARTICLE ENERGY AND THE EVALUATED GAMMA-RAY ENERGY WAS APPLIED TO DETERMINE THE GAMMA-RAY MULTIPLICITIES. FROM 10 TO 16 MEV THE CALCULATED MULTIPLICITIES WERE USED AND WERE EXTRAPOLATED TO 20 MEV ACCORDING TO THE SHAPE GIVEN BY THE ORNL MEASUREMENT.

IN THE FOLLOWING A DESCRIPTION OF EACH FILE AND SECTION IS GIVEN. THE REFERENCES GIVEN ARE BY NO MEANS EXHAUSTIVE. WHERE A COMPUTER CODE IS REFERRED TO, IT MEANS THAT INTERPOLATION AND EXTRAPOLATION OF THE GIVEN EXPERIMENTAL DATA WERE BASED ON CALCULATIONS.

***** DNA 4180 MCD 1 *****

1. POINT VALUES ARE GIVEN IN FILE 3 RATHER THAN RESONANCE PARAMETERS
2. FILE 1 REFERENCES ARE CHANGED
3. RESULTS FROM PRELIMINARY ORELA MEASUREMENTS HAVE BEEN INCLUDED FOR MANY MINIMA IN THE TOTAL CROSS SECTIONS
4. ALL CROSS SECTIONS HAVE BEEN EXTENDED TO 20 MEV
5. NEW REACTIONS HAVE BEEN INTRODUCED - $\sigma_{N,NA<}$, AND $\sigma_{N,NP<}$
6. THE $\sigma_{N,2N<}$, $\sigma_{N,P<}$, MT#51 AND MT#91 REACTIONS HAVE

IRON ORNL EVAL-1974 FEREY, FU, FENNY, KINNEY, WRIGHT
MATERIAL= 4180 ZA= 26000. AWR = 55.3650 FILE= 1 SECTION= 451

BEEN REVISED

7. THE ELASTIC ANGULAR DISTRIBUTIONS HAVE BEEN REVISED TO INCLUDE BARNARDS DATA
8. THE FILE 5 %N,2N< DISTRIBUTIONS HAVE BEEN REVISED AND ARE TABULATED IN 200 KEV SECONDARY ENERGY BINS
9. THE MT#91 FILE 5 DISTRIBUTIONS ARE REVISED AND ARE TABULATED IN 50 KEV SECONDARY ENERGY BINS FROM THRESHOLD TO 7.1 MEV, IN 100 KEV BINS FROM 7.1 TO 9 MEV, AND IN 200 KEV BINS FROM 9 TO 20 MEV
10. THE CAPTURE GAMMA RAYS HAVE BEEN REVISED A LA JOHN WHITES MOST RECENT COMPUTATION
11. ALL GAMMA RAY ENERGY DISTRIBUTIONS HAVE BEEN THINNED SO THAT THERE ARE NO NON-ZERO VALUES LESS THAN .001 OF THE MAXIMUM

***** DNA 4180 MCD 0 *****

THIS DATA IS FROM ENDF/E-III, MAT#1180 %BNL<

FILE 3 NEUTRON CROSS SECTIONS

SECTION 1 TOTAL INTERACTION

.00001 EV TO 330 KEV -- HA72 HC69 SC66 ST70

330 KEV TO 20 MEV -- CA69 CI68 HA72 IR7C

SECTION 2 ELASTIC SCATTERING

DERIVED BY SUBTRACTING THE NON-ELASTIC CROSS SECTION FROM THE TOTAL CROSS SECTION.

SECTION 3 NON-ELASTIC INTERACTION

SEE SUMMARY GIVEN ABOVE.

SECTION 4 TOTAL INELASTIC SCATTERING

DERIVED BY ADDING INELASTIC SCATTERING CROSS SECTIONS FOR EXCITING DISCRETE LEVELS AND THE CONTINUUM.

SECTION 16 N,2N REACTION

SEE SUMMARY GIVEN ABOVE AND SA71.

SECTION 22 N,NA REACTION

SEE SUMMARY GIVEN ABOVE.

SECTION 28 N,NP REACTION

SEE SUMMARY GIVEN ABOVE AND AL61 SC66.

SECTION 51 INELASTIC SCATTERING EXCITING FIRST LEVEL IN FE-56

.8611 MEV TO 1.5 MEV -- VO71

1.5 MEV TO 2.122 MEV -- GI65 VC71

2.122 MEV TO 20 MEV -- BA66 GII65 KI70 MA71 RA70 PE73 PE69 SM73

SECTION 52 INELASTIC SCATTERING EXCITING FIRST LEVEL IN FE-54 KI73

SECTION 53 THROUGH 76 -- INELASTIC SCATTERING EXCITING SECOND THROUGH 25TH LEVELS IN FE-56

IRON ORNL EVAL-1974 FEREY, FU, PENNY, KINNEY, WRIGHT
MATERIAL= 4180 ZA= 26000. AWR = 55.3650 FILE= 1 SECTION= 451

BA66 GIL65 MA71 RA70 PE73

SECTION 91 INELASTIC SCATTERING EXCITING THE CONTINUUM

SEE SUMMARY GIVEN ABOVE AND GO66 KI7C KA73 BO63 SC65 CL72 MA69
FU73.

SECTION 102 RADIATIVE CAPTURE

HO69 SI7C

SECTION 103 N,P REACTION

SEE SUMMARY GIVEN ABOVE AND GO66 RO73.

SECTION 104 N,D REACTION

SEE SUMMARY GIVEN ABOVE.

SECTION 105 N,T REACTION

SEE SUMMARY GIVEN ABOVE.

SECTION 106 N,HE-3 REACTION

SEE SUMMARY GIVEN ABOVE.

SECTION 107 N,A REACTION

SEE SUMMARY GIVEN ABOVE AND GO66 KI72.

SECTION 251 MU BAR

DERIVED FROM ELASTIC SCATTERING ANGULAR DISTRIBUTIONS AND
KINEMATICS USING THE COMPUTER CODE SAD.

SECTION 252 XI

SEE SECTION 251.

SECTION 253 GAMMA

SEE SECTION 251.

FILE 4 ANGULAR DISTRIBUTION OF SECONDARY NEUTRONS

ALL DISTRIBUTIONS ARE GIVEN IN THE CENTER OF MASS SYSTEM IN
THE LEGENDRE POLYNOMIAL REPRESENTATION.

SECTION 2 ELASTIC SCATTERING

.00001 EV TO 1.23 MEV -- BA68 CO63 KC63 PA64

1.23 MEV TO 4 MEV -- BA68 BE56 PE66 EO59 CR69 HO68

4 MEV TO 20 MEV -- BA68 KI70 PE70

TRANSFORMATION MATRIX GIVEN WAS CALCULATED USING THE
COMPUTER CODE SAD.

SECTION 16 N,2N REACTION

BOTH NEUTRONS ARE ASSUMED TO BE ISOTROPIC.

SECTION 22 N,NA REACTION

ASSUMED ISOTROPIC.

SECTION 28 N,NP REACTION

ASSUMED ISOTROPIC.

SECTION 51 INELASTIC SCATTERING EXCITING FIRST LEVEL IN FE-56

BA66 GIL65 KI70 RA70 PE73

SECTION 52 INELASTIC SCATTERING EXCITING FIRST LEVEL IN FE-54

ASSUMED ISOTROPIC.

SECTION 53 THROUGH 76 -- INELASTIC SCATTERING EXCITING SECOND
THROUGH 25TH LEVELS IN FE-56

BA66 GIL65 KI70 RA70 MA71 PE73

SECTION 91 INELASTIC SCATTERING EXCITING THE CONTINUUM

ASSUMED ISOTROPIC.

FILE 5 ENERGY DISTRIBUTIONS OF SECONDARY NEUTRONS

SECTION 16 N,2N REACTION

SEE SUMMARY GIVEN ABOVE AND MA69 SA71.

IRON ORNL EVAL-1974 FEREY, FU, PENNY, KINNEY, WRIGHT
MATERIAL= 4180 ZA= 26000. AWF = 55.3650 FILE= 1 SECTION= 451

SECTION 22 N,NA REACTION
SEE SUMMARY GIVEN ABOVE.
SECTION 28 N,NP REACTION
SEE SUMMARY GIVEN ABOVE.
SECTION 91 INELASTIC SCATTERING EXCITING THE CONTINUUM
KI70 MA69 FE69 BO63 SC65 KA72 FU73 CI72 HA73
FILE 12 MULTIPLICITIES OF GAMMA RAYS PRODUCED BY NEUTRON REACTIONS
SECTION 3 NCN-ELASTIC INTERACTION
BA66 DI73 GIL65 FU73 OR71 PE73
SECTION 51 INELASTIC SCATTERING EXCITING FIRST LEVEL IN FE-56
NEUTRON ENERGY IS 0.8611 TO 2.122 MEV. ONE DISCRETE GAMMA
RAY IS GIVEN.
SECTION 52 INELASTIC SCATTERING EXCITING FIRST LEVEL IN FE-54
ENERGY RANGE IS 1.433 TO 2.122 MEV. ONE DISCRETE GAMMA RAY
IS GIVEN.
SECTION 102 RADIATIVE CAPTURE
THESE GAMMA RAYS ARE REPRESENTATIVE OF NEUTRON ENERGY RANGES.
THE LAST RANGE STRICTLY EXTENDS ONLY TO 1 MEV BUT IS
ASSUMED TO EXTEND TO 20 MEV. WH73
FILE 14 ANGULAR DISTRIBUTIONS OF SECONDARY GAMMA RAYS
ASSUMED ISOTROPIC.
FILE 15 ENERGY DISTRIBUTIONS OF SECONDARY GAMMA RAYS
SEE SUMMARY GIVEN ABOVE AND REFS. OF FILE 12.
FILE 23 PHOTON INTERACTION CROSS SECTIONS
MC69 PL68
SECTION 501 TOTAL INTERACTION
SECTION 502 COHERENT SCATTERING
SECTION 504 INCOHERENT SCATTERING
SECTION 516 PAIR PRODUCTION PLUS TRIPLET PRODUCTION
SECTION 602 PHOTOELECTRIC INTERACTION

REFERENCES

AL61 D. I. ALLAN, NUCL. PHYS. 24, 274%1961<.
BA66 R. H. EASSEL ET. AL., COMPUTER CODE JULIE, ORNL%1966<.
BA68 E. BARNARD ET. AL., PEL-180, PELINCAEA, PRETORIA%1968<.
BE56 J. R. BEYSTER ET. AL., PHYS. REV. 104, 1319%1956<.
BE66 R. L. BECKER ET. AL., NUCL. PHYS. 89, 154%1966<.
BO59 N. A. ECSTROM ET. AL., WADC-TR-59-31%1959<.
BO63 G. C. PONAZZOLA ET. AL., NUCL. PHYS. 51, 353%1963<.
CA69 A. D. CARLSON AND R. J. CERBONE, GA-9149%1969<.
CI68 S. CIERJACKS ET. AL., KFK-1000%1968<.
CL72 G. CLAYEUX ET. AL., CEA-R-4279%1972<.
CO63 S. A. COX, BULL. AM. PHYS. SOC. 8, 478%1963<.
CR69 L. CRANBERG AND J. S. LEVIN, PHYS. REV. 103, 343%1969<.
CR73 S. N. CRAMER ET. AL., CRNL-TM-4072%1973<.
DI73 J. K. DICKENS ET. AL., NSE 50, 311%1973< AND ORNL-4798%1973<.
FU73 C. Y. FU, COMPUTER CODE NNGAM, ORNL%1973<.
GI65 W. B. GILBOY AND J. B. TOWLE, NUCL. PHYS. 64, 130%1965<.
GIL65 A. GILBERT AND A. G. W. CAMERON, CAN. J. PHYS. 43, 1446%1965<.
GO66 M. D. GOLDBERG ET. AL., BNI-325%1966<.

IRON ORNL EVAL-1974 PEREY, FU, PENNY, KINNEY, WRIGHT
MATERIAL= 4180 ZA= 26000. AWR = 55.3650 FILE= 1 SECTION= 451

HA72 J. A. HARVEY, USAEC CONF-720901, P. 1075%1972<.
HA73 L. F. HANSEN ET. AL., NSE 51, 278%1973<.
HO68 B. HOLMQUIST, ARKIV FYSIK 38, 403%1968<.
HO69 R. W. HOCKENBURY ET. AL., PHYS. REV. 178, 1746%1969<.
IR70 D. C. IRVING AND E. A. STRAKER, ORNL-TM-2891%1970<.
KA72 J. L. KAMMERDIENER, UCRL-51232%1972<.
KI70 W. E. KINNEY AND F. G. PEREY, CRNL-4515%1970<.
KI72 G. J. KIROUAC AND C. J. SLAVIK, PRIVATE COMMUNICATION%1972<.
KI73 W. E. KINNEY AND F. G. PEREY, CRNL-4907%1973<.
KO63 I. O. KORZH AND M. T. SKYLAR, UKR. FIZ. ZH. 8, 1389%1963<.
MA69 S. C. MATHUR ET. AL., PHYS. REV. 186, 1038%1969<.
MA71 G. S. MANI, NUCL. PHYS. A165, 225%1971<.
MC69 W. H. MCMASTER ET. AL., UCRL 50174%1969<.
OR71 V. J. CRPHAN ET. AL., GRT-A10743%1971<, REVISION BY V.
ROGERS, IRT, PRIVATE COMMUNICATION%1973<.
PA64 M. V. PASECHNIK ET. AL., AT. EN. USSR 16, 207%1964<.
PE69 R. J. PETERSON, ANNALS OF PHYSICS 53, 40%1969<.
PE70 F. G. PFREY, COMPUTER CODE GENOA, CRNI%1970<.
PE71 S. PEARLSTEIN, BNL-16271%1971<.
PE73 S. K. PENNY, COMPUTER CODE HELGA, CRNI%1973<.
PL68 E. F. PLECHATY AND J. R. TERFALL, UCRL-50400%1968<.
RA70 M. N. RAO, NUCL. DATA SHEETS B3-3, 4-43%1970<.
RO73 J. C. ROBERTSON ET. AL., J. NUC. ENERGY 27, 139%1973<.
SA71 O. A. SALNIKOV ET. AL., SOVIET J. CP NUCL. PHYS. 12, 620
%1971<.
SC65 R. M. SCHECTMAN AND J. D. ANDERSON, PHYS. REV. 77, 241%1965<
SC66 J. J. SCHMIDT, KFK-120%1966<.
SM73 A. B. SMITH, PRIVATE COMMUNICATION%1973<.
ST70 J. S. STORY, UKAEA WINFRITH, PRIVATE COMMUNICATION%1970<.
VO71 F. VOSS ET. AL., USAEC CONF-710301, P. 218%1971<.
WH73 J. E. WHITE ET. AL., NSE 51, 496%1973<.

IRON ORNL EVAL-1974 PEREY, FU, FENNY, KINNEY, WRIGHT
MATERIAL= 4180 ZA= 26000. AWR = 55.3650 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	GENERAL COMMENTS	378
2	151	RESONANCE DATA	4
3	1	TOTAL	1370
3	2	ELASTIC	1370
3	3	NON-ELASTIC	527
3	4	TOTAL INELASTIC	181
3	16	(N,2N)	10
3	22	(N,N*) ALPHA	8
3	28	(N,N*) F	11
3	51	(N,N*) 1-ST EXCITED	158
3	52	(N,N*) 2-ND EXCITED	11
3	53	(N,N*) 3-ED EXCITED	10
3	54	(N,N*) 4-TH EXCITED	10
3	55	(N,N*) 5-TH EXCITED	8
3	56	(N,N*) 6-TH EXCITED	8
3	57	(N,N*) 7-TH EXCITED	8
3	58	(N,N*) 8-TH EXCITED	9
3	59	(N,N*) 9-TH EXCITED	9
3	60	(N,N*) 10-TH EXCITED	11
3	61	(N,N*) 11-TH EXCITED	9
3	62	(N,N*) 12-TH EXCITED	10
3	63	(N,N*) 13-TH EXCITED	9
3	64	(N,N*) 14-TH EXCITED	9
3	65	(N,N*) 15-TH EXCITED	9
3	66	(N,N*) 16-TH EXCITED	9
3	67	(N,N*) 17-TH EXCITED	9
3	68	(N,N*) 18-TH EXCITED	9
3	69	(N,N*) 19-TH EXCITED	9
3	70	(N,N*) 20-TH EXCITED	10
3	71	(N,N*) 21-TH EXCITED	10
3	72	(N,N*) 22-TH EXCITED	9
3	73	(N,N*) 23-TH EXCITED	9
3	74	(N,N*) 24-TH EXCITED	10
3	75	(N,N*) 25-TH EXCITED	10
3	76	(N,N*) 26-TH EXCITED	9
3	91	(N,N*) CONTINUUM	13
3	102	(N,GAMMA)	346
3	103	(N,P)	12
3	104	(N,C)	7
3	105	(N,T)	8
3	106	(N,HE3)	6
3	107	(N,ALPHA)	10
3	251	MU BAR	46
3	252	XI	46
3	253	GAMMA	46
4	2	ELASTIC	313
4	16	(N,2N)	8
4	22	(N,N*) ALPHA	8
4	28	(N,N*) F	8
4	51	(N,N*) 1-ST EXCITED	206

IRON ORNL EVAL-1974 EERFY, FU, PENNY, KINNEY, WRIGHT
MATERIAL= 4180 ZA= 26000. AWR = 55.3650 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
4	52	(N,N*) 2-ND EXCITED	8
4	53	(N,N*) 3-ND EXCITED	51
4	54	(N,N*) 4-TH EXCITED	44
4	55	(N,N*) 5-TH EXCITED	44
4	56	(N,N*) 6-TH EXCITED	40
4	57	(N,N*) 7-TH EXCITED	41
4	58	(N,N*) 8-TH EXCITED	39
4	59	(N,N*) 9-TH EXCITED	36
4	60	(N,N*) 10-TH EXCITED	34
4	61	(N,N*) 11-TH EXCITED	36
4	62	(N,N*) 12-TH EXCITED	37
4	63	(N,N*) 13-TH EXCITED	36
4	64	(N,N*) 14-TH EXCITED	34
4	65	(N,N*) 15-TH EXCITED	30
4	66	(N,N*) 16-TH EXCITED	31
4	67	(N,N*) 17-TH EXCITED	32
4	68	(N,N*) 18-TH EXCITED	28
4	69	(N,N*) 19-TH EXCITED	30
4	70	(N,N*) 20-TH EXCITED	28
4	71	(N,N*) 21-TH EXCITED	16
4	72	(N,N*) 22-TH EXCITED	16
4	73	(N,N*) 23-TH EXCITED	16
4	74	(N,N*) 24-TH EXCITED	16
4	75	(N,N*) 25-TH EXCITED	16
4	76	(N,N*) 26-TH EXCITED	21
4	91	(N,N*) CONTINUUM	8
5	16	(N,2N)	74
5	22	(N,N*) ALPHA	71
5	28	(N,N*) P	75
5	91	(N,N*) CONTINUUM	207
12	3	NCN-ELASTIC	13
12	51	(N,N*) 1-ST EXCITED	4
12	52	(N,N*) 2-ND EXCITED	4
12	102	(N,GAMMA)	10
14	3	NCN-ELASTIC	1
14	51	(N,N*) 1-ST EXCITED	1
14	52	(N,N*) 2-ND EXCITED	1
14	102	(N,GAMMA)	1
15	3	NCN-ELASTIC	883
15	102	(N,GAMMA)	1186
23	501	TOTAL PHOTON	18
23	502	RAYLEIGH SCATTERING	18
23	504	COMPTON SCATTERING	18
23	516	PAIR PRODUCTION	9
23	602	PHOTOELECTRIC EFFECT	18

U-238 LIL EVAL-MAR72 HCWERTON, MACGREGOR
MATERIAL= 4187 ZA= 92238. AWR = 236.0100 FILE= 1 SECTION= 451

DIST-JUL72 MCD 1-MAR73

***** DNA 4187 MCD 1 *****

1. THE ENERGY RANGE WAS EXTENDED DOWN TO $1.0E-05$ EV.
2. THE ELASTIC AND CAPTURE DATA BELOW 1 KEV WERE OBTAINED BY GENERATING POINT DATA FROM ENDF/B-III MAT 1158 RESONANCE PARAMETERS, DOPLER BROADENING TO 300 DEG. K, AND THINNING WITH A 0.2 CRITERION. FOR CONSISTENCY, ALL DATA IN FILES 3, 4, AND 5 ARE GIVEN AT 300 DEG. K.
3. AT NEUTRON ENERGIES BELOW 1.09 MEV, DATA ARE GIVEN FOR GAMMA-RAY PRODUCTION SPECTRA FROM FISSION AND CAPTURE, AND DISCRETE GAMMA RAYS FROM INELASTIC SCATTERING TO SOME LOW LYING LEVELS ≤ 0.05 , ≤ 0.15 MEV. ABOVE 1.09 MEV THE GAMMA-RAY PRODUCTION SPECTRUM FROM ALL REACTIONS IS GIVEN IN ONE REACTION $\%MT\#3$.

FILE 23 DATA - PHOTON INTERACTION - TAKEN FROM RSIC DATA LIBRARY $\%DIC-7$ D< IS BASED ON DATA FROM UCRL-50174 SEC. II, REV. 1969 BY MCMASTER ET AL. AND UCRL-50400, VOL. VI BY PLECHATY AND TERRALL.

U-238 EVALUATED NEUTRON CROSS SECTIONS
EVALUATED BY R.J.HOWEFTON AND M.H.MACGREGOR
LAWRENCE LIVERMORE LABORATORY, LIVERMORE, CALIFORNIA
JANUARY 1973

GENERAL COMMENTS

THE NEUTRON ENERGY RANGE EXTENDS FROM 0.00001 EV TO 20 MEV. IN ADDITION TO ELASTIC SCATTERING, WHICH OCCURS AT ALL ENERGIES, THE FOLLOWING REACTIONS HAVE THRESHOLD $\%UCRL-50400$, VOL. 9< ENERGIES LESS THAN 20 MEV.

REACTION	THRESHOLD $\%MEV$ <
N,2N	6.17
N,3N	11.32
N,4N	17.89
N,P	3.19
N,NP	7.69
N,D	5.46
N,ND	11.41
N,T	5.13
N,NT	9.99

U-238 LIL EVAL-MAR72 HOWERTON, MACGREGOR
MATERIAL= 4187 ZA= 92238. AWR = 236.0100 FILE= 1 SECTION= 451

N,FISSION 0.45
N,NALPHA EXOERGIC
N,GAMMA EXCERGIC

ALL CHARGED-PARTICLE-PRODUCING REACTIONS ARE NEGLECTED, BOTH BECAUSE THERE ARE ESSENTIALLY NO MEASUREMENTS AND BECAUSE THESE REACTIONS ARE SUPPRESSED BY THE COULOMB BARRIER. CROSS SECTIONS FOR ELASTIC AND INELASTIC SCATTERING, $\Sigma N,2N<$, $\Sigma N,3N<$, $\Sigma N,4N<$, $\Sigma N,GAMMA<$, $\Sigma N,FISSION<$, AND $\Sigma N,X,GAMMA<$ REACTIONS ARE DISCUSSED BELOW. THE DATA BASE FOR THE EVALUATION IS GIVEN IN UCRL-50400, VOL. 2 AND 3. REFERENCES NOT SPECIFICALLY CITED HERE ARE GIVEN IN THESE TWO VOLUMES. THE DATA ARE GIVEN AS POINTS. NO RESONANCE-PARAMETER DATA ARE INCLUDED EXPLICITLY IN THIS EVALUATION. FOR ENERGIES BELOW 1 KEV, THE DATA WERE BASED ON THE ENDF/B EVALUATED LIBRARY, AS NOTED BELOW.

NEUTRON CROSS SECTIONS

ELASTIC SCATTERING CROSS SECTION

FOR ENERGIES LESS THAN ONE KEV, THE RESONANCE PARAMETERS OF ENDF/E-III $\Sigma MAT 1158<$ WERE USED TO PRODUCE POINTWISE DATA. THESE DATA WERE THEN TEMPERATURE BROADENED TO 300 DEGREES KELVIN AND THINNED USING A 20 PERCENT THINNING CRITERION. THIS YIELDS A MANAGEABLE LENGTH FILE AND IS FULLY JUSTIFIED IN TERMS OF THE ACCURACY OF THE EXPERIMENTAL DATA ON WHICH THE RESONANCE PARAMETER REPRESENTATIONS WERE BASED.

EXPERIMENTAL MEASUREMENTS OF THE ELASTIC CROSS SECTION EXIST BETWEEN 0.3 AND 4 MEV AND AT 7 AND 14.1 MEV. THESE MEASUREMENTS WERE COMBINED WITH THE SYSTEMATICS OBTAINED FROM THE DIFFERENCE BETWEEN TOTAL AND NONELASTIC CROSS SECTIONS WHERE THESE HAVE BEEN MEASURED.

ELASTIC SCATTERING ANGULAR DISTRIBUTIONS, NORMALIZED PROBABILITIES

EXPERIMENTAL MEASUREMENTS OF ELASTIC SCATTERING ANGULAR DISTRIBUTIONS EXIST FROM 0.075 TO 4 MEV AND AT 7 AND 14.1 MEV. AT HIGHER ENERGIES OPTICAL MODEL CALCULATIONS FORMED THE BASIS FOR THE EVALUATION.

INELASTIC SCATTERING CROSS SECTION

A BROAD-RESOLUTION EXCITATION FUNCTION IS USED TO DESCRIBE THIS CROSS SECTION. FOR NEUTRON ENERGIES UP TO 4 MEV, THE EXCITATION OF INDIVIDUAL LINES IS COMBINED WITH A CONTRIBUTION FROM THE CONTINUUM, WITH THE RESULTS BASED ON EXPERIMENTAL DATA. ABOVE 4 MEV, ONLY THE CONTINUUM EXCITATION IS CONSIDERED, AND THE INELASTIC SCATTERING EVALUATION IS BASED ON NUCLEAR SYSTEMATICS.

INELASTIC SCATTERING ANGULAR DISTRIBUTIONS, NORMALIZED PROBABILITIES

SOME DATA DO EXIST ON THE ANGULAR DISTRIBUTIONS OF INELASTICALLY-SCATTERED NEUTRONS. HOWEVER, THESE DATA INDICATE ALMOST

U-238 LII EVAL-MAR72 HCWERTON, MACGREGOR
MATERIAL= 4187 ZA= 92238. AWR = 236.0100 FILE= 1 SECTION= 451

ISOTROPIC ANGULAR DISTRIBUTIONS. HENCE, ALTHOUGH ANGULAR DISTRIBUTION DATA ARE ENTERED INTO THE EVALUATION, ALL OF THESE EXCEPT FOR THE LOWEST LEVEL $0.05 \text{ MEV} < \text{SHOW ISOTROPIC DISTRIBUTIONS}$.

INELASTIC SCATTERING ENERGY DISTRIBUTIONS

AT NEUTRON ENERGIES BELOW 4 MEV, THE ENERGY SPECTRUM OF THE INELASTICALLY-SCATTERED NEUTRONS IS OBTAINED FROM EXPERIMENT (SEE REFERENCES 397, 1264, 1267, 1272, AND 1274). ABOVE 4 MEV, THE ENERGY SPECTRUM OF THE INELASTICALLY-SCATTERED NEUTRONS IS TAKEN FROM A MODEL THAT INCLUDES BOTH A LOW ENERGY TEMPERATURE COMPONENT AND A HIGH ENERGY TAIL. THE HIGH ENERGY TAIL, WHICH COMPRISES ABOUT 15 PERCENT OF THE INELASTICALLY-SCATTERED NEUTRONS AT 4 MEV AND ESSENTIALLY 100 PERCENT AT 15 MEV AND ABOVE, CONSISTS OF DIRECT-INTERACTION AND PRE-EQUILIBRIUM NEUTRONS, CHOSEN IN APPROPRIATE FRACTIONS.

$\Sigma N, 2N <$ CROSS SECTION

THE $\Sigma N, 2N <$ EXCITATION FUNCTION IS BASED ON EXPERIMENTAL DATA FROM 6.4 TO 16 MEV (SEE REFERENCES 359, 2092, AND 2519) AND ON NUCLEAR SYSTEMATICS.

$\Sigma N, 2N <$ ENERGY DISTRIBUTIONS

THE FORMALISM OF THE TEMPERATURE MODEL IS USED FOR CONVENIENCE IN THE ABSENCE OF MEASUREMENT. THE EVAPORATION TEMPERATURE IS ASSUMED TO BE THE SAME FOR BOTH NEUTRONS AND IS SELECTED SO THAT ENERGY IS CONSERVED ON THE AVERAGE, TAKING INTO ACCOUNT THE ENERGY THAT APPEARS AS GAMMA RADIATION.

$\Sigma N, 3N <$ CROSS SECTION

THE $\Sigma N, 3N <$ EXCITATION FUNCTION IS BASED ON EXPERIMENTAL DATA FROM 12.6 TO 18.8 MEV (SEE REFERENCES 1270, 1347, AND 2519) AND ON NUCLEAR SYSTEMATICS.

$\Sigma N, 3N <$ ENERGY DISTRIBUTIONS

THE FORMALISM FOR $\Sigma N, 2N <$ SPECTRA WAS ALSO USED FOR $\Sigma N, 3N <$ SPECTRA.

$\Sigma N, 4N <$ CROSS SECTION

THE $\Sigma N, 4N <$ EXCITATION FUNCTION IS BASED ON EXPERIMENTAL DATA AT 17.8 AND 18.8 MEV (SEE REFERENCE 1347) AND ON NUCLEAR SYSTEMATICS.

$\Sigma N, 4N <$ ENERGY DISTRIBUTIONS

THE FORMALISM FOR $\Sigma N, 2N <$ SPECTRA WAS ALSO USED FOR $\Sigma N, 4N <$ SPECTRA.

$\Sigma N, \text{GAMMA} <$ CROSS SECTION

FOR ENERGIES LESS THAN ONE KEV, THE RESONANCE PARAMETERS OF ENDF/B-III (MAT 1158) WERE USED TO PRODUCE POINTWISE DATA. THESE DATA WERE THEN TEMPERATURE BROADENED TO 300 DEGREES KELVIN

U-238 LIL EVAL-MAR72 HOWERTON, MACGREGOR
MATERIAL= 4187 ZA= 92238. AWR = 236.0100 FILE= 1 SECTION= 451

AND THINNED USING A 20 PERCENT THINNING CRITERION. THIS YIELDS A MANAGEABLE LENGTH FILE AND IS FULLY JUSTIFIED IN TERMS OF THE ACCURACY OF THE EXPERIMENTAL DATA ON WHICH THE RESONANCE PARAMETER REPRESENTATIONS WERE BASED.

THE Σ N, GAMMA< CROSS SECTION WAS OBTAINED FROM EXPERIMENTAL DATA UP TO 7.6 MEV AND AT 14.5 MEV, AND FROM NUCLEAR SYSTEMATICS.

Σ N, FISSION< CROSS SECTION

THE Σ N, FISSION< CROSS SECTION WAS TAKEN FROM EXPERIMENT.

Σ N, FISSION< ANGULAR DISTRIBUTION,
NORMALIZED PROBABILITIES

THE ANGULAR DISTRIBUTION OF FISSION NEUTRONS IS ASSUMED TO BE ISOTROPIC.

Σ N, FISSION< ENERGY DISTRIBUTIONS

THE ENERGY SPECTRUM OF FISSION NEUTRONS WAS OBTAINED FROM THE PAPERS OF HOWERTON [REF.1] AND OF HOWERTON AND DOYAS [REF.2]. THE FIRST OF THESE PAPERS GIVES A METHOD FOR PREDICTING THE VALUE OF NUBAR IN THE ABSENCE OF MEASUREMENTS, WHERE NUBAR IS THE AVERAGE NUMBER OF NEUTRONS EMITTED PER FISSION. THE SECOND PAPER GIVES THE FISSION TEMPERATURE AS A FUNCTION OF NUBAR. THUS A COMBINATION OF THESE RESULTS GIVES THE FISSION NEUTRON ENERGY SPECTRUM. THE SLOPE OF THE ENERGY DEPENDENCE OF NUBAR CHANGES AS THE THRESHOLDS CORRESPONDING TO Σ N, FISSION<, Σ N, N* FISSION<, Σ N, 2N FISSION<, ETC., ARE REACHED. HENCE IN THE EVALUATION, THE FISSION NEUTRON ENERGY SPECTRUM IS QUOTED AT ENERGIES THAT CORRESPOND TO THRESHOLDS AND MIDPOINTS BETWEEN THRESHOLDS.

Σ N, FISSION< PROMPT NUBAR

THE DATA AND THE SYSTEMATICS FOR CALCULATING PROMPT NUBAR FOR U-238 ARE GIVEN IN DETAIL IN THE PAPER OF HOWERTON [REFERENCE 1]. PREDICTED VALUES FROM THE SYSTEMATICS [1963] ARE IN VERY GOOD AGREEMENT WITH EXPERIMENTS CARRIED OUT SUBSEQUENT TO THE DEVELOPMENT OF THE SYSTEMATICS [SEE ESPECIALLY REFERENCE 211, MEASUREMENTS BY SOLIEIHAC ET AL.].

GAMMA RAY PRODUCTION CROSS SECTIONS

GENERAL COMMENTS

AT NEUTRON ENERGIES OF 1.09 MEV AND ABOVE, EXPERIMENTAL Σ N, X GAMMA< MEASUREMENTS EXIST WHICH ENCOMPASS ALL OF THE GAMMA-PRODUCING REACTIONS. AT ENERGIES BELOW 1.09 MEV, GAMMA RAYS ARE PRODUCED BY NEUTRON CAPTURE PROCESSES, BY FISSION, AND BY INELASTIC SCATTERING TO SOME LOW-LYING LEVELS.

Σ N, X GAMMA< CROSS SECTION FROM THE
 Σ N, GAMMA< REACTION

THE ENERGY SPECTRUM OF GAMMA RAYS FROM NEUTRON CAPTURE IN U-238 HAS BEEN MEASURED ONLY AT THERMAL ENERGIES. TO OBTAIN THE

U-238 LLL EVAL-MAR72 HCWERTON, MACGREGOR
MATERIAL= 4187 ZA= 92238. AWR = 236.0100 FILE= 1 SECTION= 451

PROPER MULTIPLICITY FOR GAMMA RAY PRODUCTION AT HIGHER ENERGIES, THE MULTIPLICITY AT THERMAL WAS INCREASED BY THE RATIO $\frac{\sigma_{EN}}{\sigma_{Q238}}$ /Q238, WHERE EN IS THE NEUTRON KINETIC ENERGY AND Q238 IS THE THERMAL NEUTRON CAPTURE ENERGY RELEASE.

%N,X GAMMA< ENERGY DISTRIBUTION FROM
THE %N,GAMMA< REACTION

IN THE ABSENCE OF RELIABLE DATA AT HIGHER ENERGIES, THE GAMMA RAY ENERGY SPECTRUM FROM THERMAL NEUTRON CAPTURE WAS USED FOR ALL ENERGIES UP TO 1.09 MEV.

%N,X GAMMA< CROSS SECTION FROM THE
%N,N PRIME< REACTION BELOW 1.09 MEV

THE .05 MEV AND .15 MEV INELASTIC LEVELS WERE TREATED AS DISCRETE LINES UP TO 1.09 MEV WITH A BRANCHING RATIO FOR THE .15 MEV DECAY. GAMMA RAYS FROM HIGHER INELASTIC LEVELS WERE BINNED. CALCULATED CONTRIBUTIONS FROM INELASTIC SCATTERING WERE USED TO DETERMINE THE SHAPE OF THE LOW ENERGY SPECTRUM FOR THE %N,X GAMMA< CROSS SECTION AT 1.09 MEV.

%N,X GAMMA< CROSS SECTION FROM THE
FISSION REACTION BELOW 1.09 MEV

THE GAMMA RAY SPECTRUM AND MULTIPLICITY FROM U235 FISSION WERE USED TOGETHER WITH THE U238 FISSION CROSS SECTION TO GIVE THE FISSION CONTRIBUTION TO THE %N,X GAMMA< CROSS SECTION BETWEEN .4 MEV AND 1.09 MEV. THE FISSION GAMMA RAY SPECTRUM WAS ALSO USED AS THE BASIS FOR ATTACHING A SMALL HIGH-ENERGY TAIL TO THE MEASURED %N,X GAMMA< CROSS SECTIONS ABOVE 1.09 MEV.

%N,X GAMMA< CROSS SECTION

THIS CROSS SECTION WAS MEASURED AT NEUTRON ENERGIES EXTENDING FROM 1.09 MEV TO 14.8 MEV BY P. S. BUCHANAN ET AL. [REFERENCE 3]. THESE MEASUREMENTS GIVE BOTH THE ABSOLUTE CROSS SECTIONS AND THE SPECTRAL SHAPES. OVERALL ENERGY BALANCE WAS USED TO ASCERTAIN THAT THE EXPERIMENTAL NORMALIZATIONS WERE CORRECT. DATA AT 0.302 MEV DID NOT CONSERVE ENERGY AND WERE NOT USED IN THE EVALUATION. AS MENTIONED ABOVE, A SMALL HIGH-ENERGY FISSION TAIL WAS ATTACHED TO THE EXPERIMENTAL %N,X GAMMA< SPECTRA.

TESTING OF THE EVALUATED DATA

IN THE MORE EXTENSIVE REPORT FORM OF THIS DISCUSSION, RESULTS OF CRITICAL ASSEMBLY CALCULATIONS WILL BE GIVEN IN SOME DETAIL. FOR THIS ABBREVIATED DESCRIPTION, IT SUFFICES TO POINT OUT THAT A LARGE NUMBER OF U-238-CONTAINING INTEGRAL NEUTRON EXPERIMENTS HAVE BEEN CALCULATED, WITH SATISFACTORY AGREEMENT BETWEEN EXPERIMENT AND CALCULATION. ALSO, CALCULATIONS HAVE BEEN CARRIED OUT TO TEST THE EVALUATION AT ENERGIES OF 14 TO 15 MEV BY COMPARING THESE CALCULATIONS WITH DATA FROM A U238 PULSED SPHERE EXPERIMENT DONE AT LLL AND SCON TO BE PUBLISHED. AGREEMENT BETWEEN CALCULATION AND EXPERIMENT WAS GENERALLY GOOD.

U-238 LLL EVAL-MAR72 HCWERTON, MACGREGOR
MATERIAL= 4187 ZA= 92238. AWR = 236.0100 FILE= 1 SECTION= 451

REFERENCES

1. NUCL. SCI. AND ENG. 46, 42 %1971< R.J.HCWERTON %LLL<
2. NUCL. SCI. AND ENG. 46, 414 %1971< R.J.HCWERTON AND R.J.DOYAS
3. TEXAS NUCLEAR REPORT ORO-2791-32, FEB. 15 %1971< P.S.BUCHANAN

THE REFERENCE NUMBERS QUOTED BELOW REFER TO DATA IN THE LLL EXPERIMENTAL CROSS SECTION LIBRARY. SEE UCRL-50400, VOLS. 2 AND 3, FOR COMMENTS AND INDEXES TO THE DATA, AS WELL AS FOR OTHER EXPERIMENTAL RESULTS THAT WERE USED IN THE EVALUATION.

211. PRIVATE COMMUNICATION %1968< M.SOLEILHAC ET AL. %FRANCE<
359. PHYS.REV.112,259%1958< J.D.KNIGHT ET AL. %LASL<
397. PHYS.REV.109,2063%1958< L.CRANBERG,J.S.LEVIN %LASL<
1264. NUCL.PHYS.65,236%1965< R.BATCHELOR ET AL. %AWRE<
1267. NUCL.PHYS.80,46%1966< E.BARNARD ET AL. %AERE<
1270. J.NUCL.ENERGY, PARTS A/B,14,100%1961< K.W.ALLEN ET AL.%AWRE<
1272. NUCL.PHYS.47,633%1963< A.B.SMITH %ANL<
1274. PROC.PHYS.SOC.%LONDON<73,193%1959< R.BATCHELOR ET AL.%AWRE<
1347. J.NUCL.ENERGY, PARTS A/B,16,261%1962< P.H.WHITE %AWRE<
2092. PRIVATE COMMUNICATION %1969< D.S.MATHER %AWRE<
- 2519.AWRE-O-47/69 D.S.MATHER,L.F.FAIN %AWRE<

U-238 LLL EVAL-MAR72 HOWERTON, MACGREGOR
 MATERIAL= 4187 ZA= 92238. AWR = 236.0100 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	GENERAL COMMENTS	324
1	452	NEUTRONS PER FISSION	6
2	151	RESONANCE DATA	4
3	1	TOTAL	565
3	2	ELASTIC	150
3	4	TOTAL INELASTIC	18
3	16	(N,2N)	8
3	17	(N,3N)	7
3	18	TOTAL FISSION	12
3	37	(N,4N)	5
3	51	(N,N*) 1-ST EXCITED	9
3	52	(N,N*) 2-ND EXCITED	7
3	53	(N,N*) 3-RD EXCITED	6
3	54	(N,N*) 4-TH EXCITED	7
3	55	(N,N*) 5-TH EXCITED	7
3	56	(N,N*) 6-TH EXCITED	7
3	57	(N,N*) 7-TH EXCITED	6
3	91	(N,N*) CONTINUUM	11
3	102	(N,GAMMA)	484
4	2	ELASTIC	192
4	16	(N,2N)	10
4	17	(N,3N)	10
4	18	TOTAL FISSION	10
4	37	(N,4N)	10
4	51	(N,N*) 1-ST EXCITED	10
4	52	(N,N*) 2-ND EXCITED	10
4	53	(N,N*) 3-RD EXCITED	10
4	54	(N,N*) 4-TH EXCITED	10
4	55	(N,N*) 5-TH EXCITED	10
4	56	(N,N*) 6-TH EXCITED	10
4	57	(N,N*) 7-TH EXCITED	10
4	91	(N,N*) CONTINUUM	10
5	16	(N,2N)	82
5	17	(N,3N)	103
5	18	TOTAL FISSION	203
5	37	(N,4N)	40
5	91	(N,N*) CONTINUUM	143
12	18	TOTAL FISSION	4
12	102	(N,GAMMA)	4
13	3	NCN-ELASTIC	32
14	3	NCN-ELASTIC	1
14	18	TOTAL FISSION	1
14	102	(N,GAMMA)	1
15	3	NCN-ELASTIC	68
15	18	TOTAL FISSION	28
15	102	(N,GAMMA)	48
23	501	TOTAL PHOTON	24
23	502	RAYLEIGH SCATTERING	24
23	504	COMPTON SCATTERING	24
23	516	PAIR PRODUCTION	9

U-238 LLL EVAL-MAR72 HCWERTON, MACGREGOR
MATERIAL= 4187 ZA= 92238. AWR = 236.0100 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
23	602	PHOTOELECTRIC EFFECT	24

U-235 LLL EVAL-APR72 HOWERTON, MACGREGOR
MATERIAL= 4188 ZA= 92235. AWR = 233.0200 FILE= 1 SECTION= 451

DIST-JUL72 MCD 1-MAR73

***** DNA 4188 MOD 1 *****

1. THE ENERGY RANGE WAS EXTENDED DOWN TO 1.0E-05 EV.
2. THE ELASTIC, FISSION AND CAPTURE DATA BELOW 80 EV WERE OBTAINED BY GENERATING POINT DATA FROM ENDF/B-III MAT 1157 RESONANCE PARAMETERS, DOPPLER BROADENING TO 300 DEG. K, AND THINNING WITH A 0.1 CRITERION. FOR CONSISTENCY, ALL DATA IN FILES 3, 4, AND 5 ARE GIVEN AT 300 DEG. K.
3. THE SPECTRAL SHAPE OF THE ENERGY DISTRIBUTION OF CAPTURE GAMMA RAYS WAS ASSUMED INDEPENDENT OF INCIDENT NEUTRON ENERGY, WITH AN ADJUSTMENT MADE IN THE MULTIPLICITY TO CONSERVE ENERGY.

FILE 23 DATA - PHOTON INTERACTION - TAKEN FROM RSIC DATA LIBRARY WDL-7 C< IS BASED ON DATA FROM UCRL-50174 SEC. II, REV. 1969 BY MCMASTER ET AL. AND UCRL-50400, VOL. VI BY PLFCHATY AND TERRALL.

U-235 EVALUATED NEUTRON CROSS SECTIONS
EVALUATED BY R.J.HOWERTON AND M.H.MACGREGOR
LAWRENCE LIVERMORE LABORATORY, LIVERMORE, CALIFORNIA
JANUARY 1973

GENERAL COMMENTS

THE NEUTRON ENERGY RANGE IS FROM 0.00001 EV TO 20 MEV. IN ADDITION TO ELASTIC SCATTERING, WHICH OCCURS AT ALL ENERGIES, THE FOLLOWING REACTIONS HAVE THRESHOLD >UCRL-50400, VOL. 9< ENERGIES LESS THAN 20 MEV.

REACTION	THRESHOLD<MEV<
N,2N	5.33
N,3N	12.20
N,4N	17.97
N,P	0.62
N,NP	6.76
N,D	4.53
N,ND	9.75
N,T	3.47
N,NT	10.01
N,HE3	4.70

U-235 LLL EVAL-AER72 HCWERTON, MACGREGOR
 MATERIAL= 4188 ZA= 92235. AWR = 233.0200 FILE= 1 SECTION= 451

N,NHE3	9.50
N,ALPHA	EXCERGIC
N,NALPHA	EXCERGIC
N,GAMMA	EXOERGIC
N,FISSION	EXOERGIC

ALL CHARGED-PARTICLE-PRODUCING REACTIONS ARE NEGLECTED, BOTH BECAUSE THERE ARE ESSENTIALLY NO MEASUREMENTS AND BECAUSE THESE REACTIONS ARE SUPPRESSED BY THE COULOMB BARRIER. CROSS SECTIONS FOR ELASTIC AND INELASTIC SCATTERING, $\sigma_{N,2N}$, $\sigma_{N,3N}$, $\sigma_{N,4N}$, $\sigma_{N,GAMMA}$, $\sigma_{N,FISSION}$, AND $\sigma_{N,X,GAMMA}$ REACTIONS ARE DISCUSSED BELOW. THE DATA BASE FOR THE EVALUATION IS GIVEN IN UCRL-50400, VOL. 2 AND 3. REFERENCES NOT SPECIFICALLY CITED HERE ARE GIVEN IN THESE TWO VOLUMES. BELOW 1 KEV, RESOLUTION CROSS SECTIONS ARE USED, CONSTITUTING AVERAGES OVER RESONANCES. NO RESONANCE-PARAMETER DATA ARE INCLUDED EXPLICITLY IN THIS EVALUATION. FOR ENERGIES BELOW 80 EV, THE DATA WERE BASED ON THE ENDF/B EVALUATED LIBRARY, AS NOTED BELOW.

NEUTRON CROSS SECTIONS

ELASTIC SCATTERING CROSS SECTION

THE ELASTIC SCATTERING CROSS SECTION HAS A THERMAL VALUE OF 14 BARNS σ_{TOTAL} CROSS SECTION MINUS CAPTURE MINUS FISSION. EXPERIMENTAL MEASUREMENTS OF THE ELASTIC CROSS SECTION EXIST BETWEEN 0.3 AND 1.5 MEV. ABOVE AND BELOW THIS ENERGY RANGE, THE ELASTIC SCATTERING CROSS SECTION WAS DETERMINED FROM SYSTEMATICS AND FROM THE DIFFERENCE OF MEASURED TOTAL AND NONELASTIC CROSS SECTIONS WHERE THEY EXIST. AT ENERGIES BELOW 80 EV, THE ELASTIC CROSS SECTION WAS BASED ON THE ENDF/B EVALUATED LIBRARY, WITH THE DATA TEMPERATURE-BROADENED TO 300 DEGREES KELVIN AND THINNED WITH A 10 PERCENT THINNING CRITERION.

ELASTIC SCATTERING ANGULAR DISTRIBUTIONS, NORMALIZED PROBABILITIES

EXPERIMENTAL MEASUREMENTS OF ELASTIC SCATTERING ANGULAR DISTRIBUTIONS EXIST FROM 0.5 MEV TO 4 MEV. ABOVE THIS ENERGY, OPTICAL MODEL CALCULATIONS PROVIDED THE BASIS FOR THE EVALUATION. IN THE ENERGY RANGE BELOW 0.5 MEV, THE EVALUATION IS BASED ON DATA MEASURED FOR U-238.

INELASTIC SCATTERING CROSS SECTION

A BROAD-RESOLUTION EXCITATION FUNCTION IS USED TO DESCRIBE THIS CROSS SECTION. FOR NEUTRON ENERGIES UP TO 4 MEV, THIS EXCITATION FUNCTION IS BASED ON EXPERIMENTAL DATA. ABOVE 4 MEV, IT IS BASED ON NUCLEAR SYSTEMATICS.

INELASTIC SCATTERING ANGULAR DISTRIBUTIONS, NORMALIZED PROBABILITIES

THE INELASTICALLY-SCATTERED NEUTRONS ARE ASSUMED TO BE ISOTROPIC IN THE LABORATORY FRAME OF REFERENCE.

U-235 LIL EVAL-APR72 HOWERTON, MACGREGOR
MATERIAL= 4188 ZA= 92235. AWR = 233.0200 FILE= 1 SECTION= 451

INELASTIC SCATTERING ENERGY DISTRIBUTIONS

AT NEUTRON ENERGIES BELOW 4 MEV, THE ENERGY SPECTRUM OF THE INELASTICALLY-SCATTERED NEUTRONS IS OBTAINED FROM EXPERIMENT (SEE REFERENCES 77, 1377, AND 2598). ABOVE 4 MEV, THE ENERGY SPECTRUM OF THE INELASTICALLY-SCATTERED NEUTRONS IS TAKEN FROM A MODEL THAT INCLUDES BOTH A LOW ENERGY TEMPERATURE COMPONENT AND A HIGH ENERGY TAIL. THE HIGH ENERGY TAIL, WHICH COMPRISES ABOUT 15 PERCENT OF THE INELASTICALLY-SCATTERED NEUTRONS AT 4 MEV AND ESSENTIALLY 100 PERCENT AT 15 MEV AND ABOVE, CONSISTS OF DIRECT-INTERACTION AND PRE-EQUILIBRIUM NEUTRONS, CHOSEN IN APPROPRIATE FRACTIONS.

$\Sigma N, 2N$ CROSS SECTION

THE $\Sigma N, 2N$ EXCITATION FUNCTION IS BASED ON TWO MEASURED POINTS AT 7 AND 8 MEV AND ON NUCLEAR SYSTEMATICS.

$\Sigma N, 2N$ ENERGY DISTRIBUTIONS

THE FORMALISM OF THE TEMPERATURE MODEL IS USED FOR CONVENIENCE IN THE ABSENCE OF MEASUREMENT. THE EVAPORATION TEMPERATURE IS ASSUMED TO BE THE SAME FOR BOTH NEUTRONS AND IS SELECTED SO THAT ENERGY IS CONSERVED ON THE AVERAGE, TAKING INTO ACCOUNT THE ENERGY THAT APPEARS AS GAMMA RADIATION.

$\Sigma N, 3N$ AND $\Sigma N, 4N$ CROSS SECTIONS

THE $\Sigma N, 3N$ AND $\Sigma N, 4N$ EXCITATION FUNCTIONS ARE BASED ON NUCLEAR SYSTEMATICS.

$\Sigma N, 3N$ AND $\Sigma N, 4N$ ENERGY DISTRIBUTIONS

THE FORMALISM FOR $\Sigma N, 2N$ SPECTRA WAS ALSO USED FOR $\Sigma N, 3N$ AND $\Sigma N, 4N$ SPECTRA.

$\Sigma N, \text{GAMMA}$ CROSS SECTION

FOR ENERGIES BELOW 80 EV, THE $\Sigma N, \text{GAMMA}$ CROSS SECTION WAS BASED ON THE ENDF/B EVALUATED LIBRARY, WITH THE DATA TEMPERATURE-BROADENED TO 300 DEGREES KELVIN AND THINNED WITH A 0.1 THINNING CRITERION. BETWEEN 80 EV AND 1 MEV, THE $\Sigma N, \text{GAMMA}$ CROSS SECTION WAS OBTAINED FROM EXPERIMENT. ABOVE 1 MEV, THE CROSS SECTION WAS ASCERTAINED BY THE USE OF NUCLEAR SYSTEMATICS.

$\Sigma N, \text{FISSION}$ CROSS SECTION

THE $\Sigma N, \text{FISSION}$ CROSS SECTION WAS TAKEN FROM EXPERIMENT. FOR ENERGIES BELOW 80 EV, THE ENDF/B EVALUATED LIBRARY WAS USED, WITH THE DATA TEMPERATURE-BROADENED TO 300 DEGREES KELVIN AND THINNED USING A 0.1 THINNING CRITERION. FROM 100 EV THROUGH A FEW KEV, THE EVALUATION WAS BASED ON LASL PHYSICS 8 EXPERIMENTAL DATA. IN THE MODERATE KEV RANGE, THE STRUCTURE OBSERVED IN EXPERIMENTS PERFORMED AT LLL, LASL, AND IN FRANCE WAS USED. IN THE HIGH KEV AND MEV RANGES, THE NECESSARY SELECTION FROM AMONG THE MANY EXPERIMENTS WAS MADE BY READING THE EXPERIMENTAL REPORTS

U-235 LIL EVAL-APR72 HCWFRTCN, MACGREGOR
MATERIAL= 4188 ZA= 92235. AWR = 233.0200 FILE= 1 SECTION= 451

AND DISCUSSING THEM WITH VARIOUS EXPERIMENTALISTS.

%N,FISSION< ANGULAR DISTRIBUTION,
NORMALIZED PROBABILITIES

THE ANGULAR DISTRIBUTION OF FISSION NEUTRONS IS ASSUMED TO
BE ISOTROPIC.

%N,FISSION< ENERGY DISTRIBUTIONS

THE ENERGY SPECTRUM OF FISSION NEUTRONS WAS OBTAINED FROM THE
PAPERS OF HOWERTON %REF.1< AND OF HOWERTON AND DOYAS %REF.2<.
THE FIRST OF THESE PAPERS GIVES A METHOD FOR PREDICTING THE VALUE
OF NUBAR IN THE ABSENCE OF MEASUREMENTS, WHERE NUBAR IS THE
AVERAGE NUMBER OF NEUTRONS EMITTED PER FISSION. THE SECOND PAPER
GIVES THE FISSION TEMPERATURE AS A FUNCTION OF NUBAR. THUS A
COMBINATION OF THESE RESULTS GIVES THE FISSION NEUTRON ENERGY
SPECTRUM. THE SLOPE OF THE ENERGY DEPENDENCE OF NUBAR CHANGES AS
THE THRESHOLDS CORRESPONDING TO %N,FISSION<, %N,N* FISSION<,
%N,2N FISSION<, ETC., ARE REACHED. HENCE IN THE EVALUATION, THE
FISSION NEUTRON ENERGY SPECTRUM IS QUOTED AT ENERGIES THAT CORRES-
POND TO THRESHOLDS AND MIDPOINTS BETWEEN THRESHOLDS.

%N,FISSION< PROMPT NUBAR

A PROMPT NUBAR VALUE OF 2.42 WAS SELECTED FOR A NEUTRON
ENERGY OF 0.025 EV. THE VALUE FOR NUBAR WAS INCREASED SMOOTHLY
AS A FUNCTION OF INCREASING NEUTRON ENERGY SO AS TO MATCH THE
MEASUREMENTS OF SOULHAC ET AL. %REF.211 AND LATER MEASUREMENTS
OF THE SAME GROUP, RECEIVED AS A PRIVATE COMMUNICATION FROM J.
FREHAUT<. THESE MEASUREMENTS WERE USED FOR THE EVALUATION OVER
THE ENTIRE RANGE OF ENERGIES COVERED BY THE EXPERIMENT. FROM
ABOUT 15 MEV TO 20 MEV, THE TREND ESTABLISHED BELOW 15 MEV WAS
CONTINUED. THE VARIOUS CONTRADICTORY MEASUREMENTS BELOW 1 MEV
WERE NOT USED FOR THIS EVALUATION.

GAMMA RAY PRODUCTION CROSS SECTIONS

GENERAL COMMENTS

AT NEUTRON ENERGIES OF 1.09 MEV AND ABOVE, EXPERIMENTAL
%N,X GAMMA< MEASUREMENTS EXIST WHICH ENCOMPASS ALL OF THE GAMMA-
PRODUCING REACTIONS. AT ENERGIES BELOW 1.09 MEV, WHERE
%N,X GAMMA< MEASUREMENTS HAVE NOT YET BEEN CARRIED OUT, GAMMA RAYS
ARE PRODUCED BY CAPTURE AND FISSION PROCESSES, AND ALSO BY
INELASTIC SCATTERING TO MANY LOW-LYING LEVELS.

%N,X GAMMA< CROSS SECTION FROM THE
%N,GAMMA< REACTION

NO MEASUREMENTS EXIST ON THE SPECTRUM OF GAMMA RAYS FROM
NEUTRON CAPTURE IN U-235. ACCORDINGLY, THE SPECTRUM OF GAMMA
RAYS FROM NEUTRON CAPTURE IN U-238 WAS TAKEN OVER AND USED FOR
THE U-235 EVALUATION. DENOTING THE MULTIPLICITY OF GAMMA RAYS
FROM THERMAL NEUTRON CAPTURE IN U-238 AS MC, WE TOOK THE MULTI-

U-235 LIL EVAL-APR72 HOWERTON, MACGREGOR
MATERIAL= 4188 ZA= 92235. AWR = 233.0200 FILE= 1 SECTION= 451

PLICITY FOR THERMAL NEUTRON CAPTURE IN U-235 TO BE $\frac{Q_{235}}{Q_{238}}$, WHERE Q_{235} AND Q_{238} ARE $\Sigma \sigma_{\gamma}$ VALUES FOR U235, U238. ALSO, FOR NEUTRON CAPTURE AT HIGHER NEUTRON ENERGIES, THE THERMAL MULTIPLICITY WAS INCREASED BY THE RATIO $\frac{\Sigma \sigma_{\gamma}}{Q_{235}}$, WHERE $\Sigma \sigma_{\gamma}$ IS THE INCIDENT NEUTRON ENERGY. ALTHOUGH THE CAPTURE CROSS SECTION IS INCLUDED EXPLICITLY OVER THE ENTIRE ENERGY RANGE UP TO 20 MEV, THE MULTIPLICITY IS SET EQUAL TO ZERO AT 1.09 MEV AND ABOVE, SINCE CAPTURE GAMMA RAYS ARE IMPLICITLY INCLUDED IN THE MEASURED $\Sigma \sigma_{\gamma}$ SPECTRA, WHICH START AT 1.09 MEV.

$\Sigma \sigma_{\gamma}$ ENERGY DISTRIBUTION FROM THE $\Sigma \sigma_{\gamma}$ REACTION

AS STATED ABOVE, THE ENERGY DISTRIBUTION OF CAPTURE GAMMA RAYS WAS TAKEN FROM THERMAL CAPTURE MEASUREMENTS IN U-238. THE SPECTRAL SHAPE OF THE ENERGY DISTRIBUTION WAS ASSUMED TO BE INDEPENDENT OF INCIDENT NEUTRON ENERGY, WITH AN ADJUSTMENT MADE IN THE MULTIPLICITY IN ORDER TO CONSERVE ENERGY. THIS ASSUMPTION IS ESSENTIALLY CONSISTENT WITH OUR PRESENT EXPERIMENTAL KNOWLEDGE OF CAPTURE GAMMA RAY SPECTRA IN THE URANIUM ISOTOPES.

$\Sigma \sigma_{\gamma}$ CROSS SECTION FROM THE $\Sigma \sigma_{\gamma}$ REACTION

THE FISSION GAMMA RAY SPECTRUM WAS TAKEN FROM THE MEASUREMENTS OF REF. 3. IN THE ABSENCE OF DATA, THIS SPECTRUM WAS ASSUMED TO APPLY AT ALL ENERGIES UP TO 1.09 MEV. ABOVE 1.09 MEV, THE FISSION GAMMA RAYS ARE INCLUDED IN THE MEASURED $\Sigma \sigma_{\gamma}$ SPECTRA. HENCE NO EXPLICIT FISSION GAMMA RAYS ARE INCLUDED ABOVE 1.09 MEV, EXCEPT THAT THE MEASURED FISSION SPECTRUM WAS USED AS THE BASIS FOR ATTACHING A SMALL HIGH-ENERGY TAIL ONTO THE MEASURED $\Sigma \sigma_{\gamma}$ SPECTRA.

$\Sigma \sigma_{\gamma}$ CROSS SECTION

THIS CROSS SECTION WAS MEASURED AT NEUTRON ENERGIES EXTENDING FROM 1.09 MEV TO 14.8 MEV BY P. S. BUCHANAN ET AL. [REF. 4] AND AT 4, 6, AND 7.5 MEV BY DRAKE [REF. 5]. THESE MEASUREMENTS GIVE BOTH THE ABSOLUTE CROSS SECTIONS AND THE SPECTRAL SHAPES. THE TWO MEASUREMENTS AGREE WELL IN THEIR REGION OF OVERLAP. ALSO, THE MEASUREMENTS WERE COMPARED TO THE RECIPE OF HOWERTON AND PLECHATY [REF. 6], AND THE AGREEMENT WAS GOOD. THE DATA OF REF. 5 ARE USEFUL IN EXTRAPOLATING THE DATA OF REF. 4 DOWN TO ZERO GAMMA RAY ENERGY. AS STATED ABOVE, A SMALL HIGH ENERGY TAIL OF FISSION GAMMA RAYS WAS ADDED TO THE MEASURED $\Sigma \sigma_{\gamma}$ SPECTRA. OVERALL ENERGY BALANCE WAS CHECKED TO ASCERTAIN THAT THE NORMALIZATIONS OF THE GAMMA RAY DATA ARE APPROXIMATELY CORRECT.

TESTING OF THE EVALUATED DATA

IN THE MORE EXTENSIVE REPORT FORM OF THIS DISCUSSION, RESULTS OF CRITICAL ASSEMBLY CALCULATIONS WILL BE GIVEN IN SOME DETAIL. FOR THIS ABBREVIATED DESCRIPTION, IT SUFFICES TO POINT OUT THAT UPWARDS OF FORTY U-235-CONTAINING INTEGRAL NEUTRON EXPERIMENTS

U-235 LLL EVAL-APR72 HCWERTON, MACGREGOR
MATERIAL= 4188 ZA= 92235. AWR = 233.0200 FILE= 1 SECTION= 451

HAVE BEEN CALCULATED, WITH SATISFACTORY AGREEMENT BETWEEN EXPERIMENT AND CALCULATION. ALSO, CALCULATIONS HAVE BEEN CARRIED OUT TO TEST THE EVALUATION AT ENERGIES OF 14 TO 15 MEV BY COMPARING THESE CALCULATIONS WITH A U235 PULSED SPHERE EXPERIMENT DONE AT LLL AND SOON TO BE PUBLISHED. AGREEMENT BETWEEN CALCULATION AND EXPERIMENT WAS GENERALLY GOOD.

REFERENCES

1. NUCL. SCI. AND ENG. 46, 42 %1971< R.J.HCWERTON %LLL<
2. NUCL. SCI. AND ENG. 46, 414 %1971< R.J.HCWERTON AND R.J.DOYAS
3. PHYS. REV. C3, 373 %1971<, R.W. PEELEE, F.C. MAIENSCHIN %ORNLC
4. TEXAS NUCLEAR REPORT ORO-2791-32, FEB. 15 %1971< P.S. BUCHANAN
5. NUCL. PHYS. A133, 108 %1969< D.M. DRAKE %IASLC
6. NUCL. SCI. ENG. 32, 178 %1968< R.J.HCWERTON AND E. PLECHATY

THE REFERENCE NUMBERS QUOTED BELOW REFER TO DATA IN THE LLL EXPERIMENTAL NEUTRON CROSS SECTION LIBRARY WHICH ALSO INCLUDES SOME OF THE REFERENCES LISTED ABOVE<. SEE UCRL-50400, VOL. 2 AND 3, FOR COMMENTS AND INDEXES TO THE DATA, AS WELL AS FOR OTHER EXPERIMENTAL RESULTS THAT WERE USED IN THE EVALUATION.

77. LOS ALAMOS REPORT LA-2177 %1959< L. CRANBERG
211. PRIVATE COMMUNICATION %1968< M. SOLEILHAC ET AL. %FRANCE<
1377. IAEA CONFERENCE ON NUCLEAR DATA, PARIS %1966< PAPER CN-23/22
2598. AWRE-0-55/69 %1969< R. BATCHELOR AND K. WYLD %AWRE<

U-235 LLL EVAL-APR72 HCWERTON, MACGREGOR
 MATERIAL= 4188 ZA= 92235. AWR = 233.0200 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	GENERAL COMMENTS	313
1	452	NEUTRONS PER FISSION	8
2	151	RESONANCE DATA	4
3	1	TOTAL	797
3	2	ELASTIC	91
3	4	TOTAL INELASTIC	12
3	16	(N,2N)	8
3	17	(N,3N)	5
3	18	TOTAL FISSION	535
3	37	(N,4N)	4
3	91	(N,N*) CONTINUUM	12
3	102	(N,GAMMA)	261
4	2	ELASTIC	232
4	16	(N,2N)	10
4	17	(N,3N)	10
4	18	TOTAL FISSION	10
4	37	(N,4N)	10
4	91	(N,N*) CONTINUUM	10
5	16	(N,2N)	84
5	17	(N,3N)	61
5	18	TOTAL FISSION	150
5	37	(N,4N)	37
5	91	(N,N*) CONTINUUM	119
12	18	TOTAL FISSION	4
12	102	(N,GAMMA)	4
13	3	NCN-ELASTIC	9
14	3	NCN-ELASTIC	1
14	18	TOTAL FISSION	1
14	102	(N,GAMMA)	1
15	3	NCN-ELASTIC	108
15	18	TOTAL FISSION	28
15	102	(N,GAMMA)	48
23	501	TOTAL PHOTON	24
23	502	RAYLEIGH SCATTERING	24
23	504	COMPTON SCATTERING	24
23	516	PAIR PRODUCTION	9
23	602	PHOTOELECTRIC EFFECT	24

C-12 ORNL EVAL-DEC73 PEREY, PEREY, FU
MATERIAL= 4274 ZA= 6012. AWE = 11.8969 FILE= 1 SECTION= 451

DIST-FFB74 MCD 0-FEB74

***** DNA 4274 MCD 0 *****

C-12 ENDF/B IV ORNL PEREY, PEREY AND FU DEC-1973

* * *
DATA POINTS AT 15.0 MEV WERE EXTENDED LINEARLY TO 20.0 MEV TO
SATISFY FORMAL REQUIREMENT FOR ENDF/B IV NC PRESENCE AT AN EVAL.
ABOVE 15 MEV .

* * *
EXCEPT AS NOTED HERE THIS IS AN EXTENSIVE REVISION OF MAT-1165
NO CHANGES MADE BELOW 2.0 MEV. TOTAL CROSS SECTION IS THE CSEWG
NORM. AND STAND. SUBCOM. RECOMMENDATION %N.C. FRANCIS ET AL CONF.
ON NEUT. STAND. AND FLUX NORM. ANI OCT 1970, PAGE 166<. CAPTURE IS
1/V WITH THERMAL VALUE OF 3.36 MB. ABOVE 2.0 MEV ONLY REMNANT OF
MAT 1165 IS MT-91 THE COMBINATION OF %N, NFFIME< AND %N, NPRIME3AL-
PHA<.

MF-3

* * *
*** NEUTRON X-SECTIONS ***
* * *

MT-1 TOTAL CROSS SECTION. REVISED ABOVE 2.0 MEV ON BASIS
R.B. SCHWARTZ, B.T. HEATON II AND R.A. SCHRACK. NBS. BULL. AM. PHYS. SOC
15, 567%1967<

S. CIERJACHS ET AL EURFNR-591%1968<, AND PRIV. COMM. %1969<
F.G. PEREY, T.A. LOVE AND W.E. KINNEY ORNL-4823%1972<

MT-2 ELASTIC CROSS SECTION. ENTIRELY DERIVED ON BASIS OF
OTHER EVALUATED CROSS SECTIONS EXCEPT AT 14.5 MEV. EXTENSIVE
DATA SETS WHICH OFTEN HAVE 4.43 MEV INELASTIC SCATTERING WERE
USED ONLY FOR ANGULAR DISTRIBUTION SHAPES. ALL ELASTIC AND INE-
LASTIC DATA SOURCES ARE GIVEN BELOW.

A.B. SMITH ANL PRIVATE COMM. %MARCH 1972<

F.G. PEREY AND W.E. KINNEY PRIV. COMM. %1972<

D.W. GLASGOW ET AL. AEROSPACE RESEARCH LAB. PRIV. COMM. %1972<

J.E. BRALEY AND C.W. COCK, PHYS. REV. 118, 808%1960<

D. LISTER AND SAYRES, PHYS. REV. 143, 745%1966<

F.G. PEREY AND W.E. KINNEY ORNL-4441%1969<

M. WALT AND J.R. BEYSTER, PHYS. REV. 98, 677%1955<

J.R. BEYSTER, M. WALT AND E.W. SALMI, PHYS. REV. 104, 1319%1956<

E. HADAD AND D.D. PHILLIPS, BULL. AM. PHYS. SOC. 4, 358%1959<

J.E. WILLS ET AL, PHYS. REV. 109, 891%1958<

N.A. BOSTROM ET AL. TEXAS NUCL. CCRP %1959<

J.T. LINDOW ET AL, BULL. AM. PHYS. SOC. 15, 86%1970<

W. GALATI ET AL, PHYS. REV. C5, 1508%1972<

R.W. WILENZICK ET AL, NUCL. PHYS. 62, 511%1965<

G.V. GORLOV ET AL DOKLADY AKADE. NAUK. 158, 574%1964<

G. HAOUAT AND COCU CEN B-III KIEV CONF. %1973< AND PRIV. COMM. %1973

**BELOW 4 MEV NUMEROUS PRE 1965 DATA SETS USED IN PUBLISHED RMAT
RIX ANALYSES WERE ALSO USED %SEE ENL-325<

**AROUND 14.5 MEV 12 DATA SOURCES

C-12 ORNL EVAL-DEC73 PEREY, PEREY, FU
 MATERIAL= 4274 ZA= 6012. AWE = 11.8969 FILE= 1 SECTION= 451

MT-3 NON-ELASTIC CROSS SECTION. COMPLETELY DERIVED X-SEC
 MT-4 INELASTIC X-SECTION. COMPLETELY DERIVED X-SECTION
 MT-51 INELASTIC SCATTERING X-SECTION TO 4.43 MEV LEVEL
 SEE ABOVE DATA SOURCES FOR MT-2. FROM 5.2 TO 8.7 MEV BASED MOSTLY
 ON UNPUBLISHED DATA FROM ORNL BY F.G.PEREY AND W.E.KINNEY .FROM
 9 TO 12 MEV BASED MOSTLY ON 3 DATA ECINIS BY G.HAOUAT AND F.COCU
 CEN B-III %1973<. ABOUT 14 MEV BASED ON 7 DATA SETS. THIS EVALUA.
 TION OF MT-51 DIFFERS FROM MAT 1165 OFTEN BY MORE THAN 25 PERCENT
 IN GENERAL IT IS NOW LOWER BELOW 10 MEV AND HIGHER ABOVE. IT IS
 CLOSELY THE SAME AROUND 14.5 MEV.

MT-91 CONTINUUM INELASTIC X-SECTION. SURPRISINGLY UNCHANG-
 ED FROM MAT 1165. THE DECISION TAKEN FOR ENDF/B III TO LUMP TOGE-
 THER π , π PRIME TO HIGHER LEVELS WITH π , π PRIME3ALPHAS HAS BEEN
 RETAINED. PRELIMINARY RESULTS FROM PHASE II DATA TESTING WED OBLOW
 ,ORNL PRIV. COMM. 1973< INDICATE SATISFACTORY RESULTS FROM 10 TO
 15 MEV FOR NEUTRON CONTINUUM.

MT-102 RADIATIVE CAPTURE X-SECTION. 1/V CURVE BASED ON
 3.36MB AT THERMAL SAME AS IN MAT-1165

MT-107 N, ALPHA X-SECTION. VERY CONSIDERABLE CHANGES OVER
 MAT-1165. IT IS NOW A FACTOR OF 2 BIGGER BELOW 10.5 MEV AND A
 FACTOR OF 2 SMALLER ABOVE. POST 1965 DATA ON INVERSE REACTION
 INDICATE A FACTOR OF 2 DISCREPANCY IN DATA OF
 E.A.DAVIS ET AL, NUCL. PHYS. 48, 169%1963<
 ALL DATA SETS ON INVERSE REACTION ARE CONSISTENT AND AGREE WITH
 FORWARD REACTION AT 14.5 MEV . DATA SETS USED TO EVALUATE MT-107
 V.V.VERBINSKY ET AL , PHYS. REV. 170, 916%1968<
 T.RETZ ET AL , BULL. AM. PHYS. SOC 5, 110%1960<
 E.R.GRAVES AND R.W.DAVIS , PHYS. REV. 97, 1205%1955<
 A.W.OBST ET AL, PHYS. REV. C5, 738%1972<
 L.VAN DER ZWAN AND K.W.GEIGER, NUCL. PHYS. A152, 481%1970<

MF-4

*** NEUTRON ANG. DISTRIBUTIONS ***

MT-2 ELASTIC SCATTERING. FROM 2 TO 5 MEV SMALL BUT SIGN-
 IFICANT CHANGES OVER MAT 1165. FROM 3 TO 5 MEV MOST WEIGHT WAS
 GIVEN TO DATA OF W.GALATI ET AL PHYS. REV. C5, 1508%1972< TO MODIFY
 RESULTS OF OUR OWN R-MATRIX ANALYSIS %SIMILAR TO MANY PREVIOUSLY
 DONE ANALYSIS< . ABOVE 5 MEV VERY CONSIDERABLE CHANGES FROM MAT
 1165 EXCEPT AROUND 14.5 MEV. MOST WEIGHT WAS GIVEN TO THE DATA OF
 F.G.PEREY AND W.E.KINNEY ORNL PRIV. COMM. %1972< 40 ANG.DISTRIB.
 AT 18 ANGLES FOR BOTH ELASTIC AND INELASTIC SCATTERING FROM 5.2
 TO 8.7 MEV THIS DATA REVEALS GREAT RESONANCE STRUCTURE CONSISTE-
 NT WITH OTHER DATA IN THIS ENERGY REGION. FROM 9 TO 12 MEV DATA OF
 G.HAOUAT AND F.COCU SHOWS BROAD RESONANCE. DUE TO CONSIDERABLE
 RESONANCE STRUCTURE THE FILE IS LARGE AND WAS CAREFULLY THINNED

MT-51 INELASTIC SCATTERING TO 4.43 MEV LEVEL. VERY CON-
 SIDERABLE CHANGES OVER MAT 1165 EXCEPT AROUND 14.5 MEV. SAME GEN-
 ERAL REMARKS ON DATA SOURCES AND STRUCTURE IN FILE AS FOR MT-2

MF-5

*** NEUTRON ENERGY DISTRIBUTIONS ***

5.115

C-12 OFNL EVAL-DEC73 PERFY, PEEFY, FU
MATERIAL= 4274 ZA= 6012. AWF = 11.8969 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	GENFRAL COMMENTS	172
2	151	RESONANCE DATA	4
3	1	TOTAL	134
3	2	ELASTIC	133
3	3	NON-ELASTIC	47
3	4	TOTAL INELASTIC	36
3	51	(N,N*) 1-ST EXCITED	29
3	91	(N,N*) CONTINUUM	11
3	102	(N,GAMMA)	6
3	107	(N,ALPHA)	14
4	2	ELASTIC	467
4	51	(N,N*) 1-ST EXCITED	150
4	91	(N,N*) CONTINUUM	10
5	91	(N,N*) CONTINUUM	19
12	102	(N,GAMMA)	13
13	51	(N,N*) 1-ST EXCITED	29
14	51	(N,N*) 1-ST EXCITED	185
14	102	(N,GAMMA)	1
23	501	TOTAL PHOTON	17
23	502	RAYLEIGH SCATTERING	17
23	504	COMPTON SCATTERING	17
23	516	PAIR PRODUCTION	9
23	602	PHOTOELECTRIC EFFECT	17
33	1	TOTAL	23

HE-4 LASL EVAL-OCT73 NISLEY, HALE, YOUNG
MATERIAL= 4504 ZA= 2004. AWR = 4.0015 FILE= 1 SECTION= 451

DIST-NCV73 MCD 0-NCV73

***** DNA 4504 MCD 0 *****

HE-4 LASL-CCT, 1973 R.A.NISLEY, G.M.HALE, P.G.YOUNG

MF#3 ----- SMOOTH CROSS SECTIONS -----

THE 2200 M/S CROSS SECTIONS ARE AS FOLLOWS,

MT#1 SIGMA# 0.75916 BARNs

MT#2 SIGMA# 0.75916 BARNs

MT#1 TOTAL CROSS SECTION
SEE DISCUSSION UNDER MT#2 BELOW

MT#2 ELASTIC SCATTERING CROSS SECTION
ALTHOUGH THE ONLY REACTION POSSIBLE FOR NEUTRONS INCIDENT ON HE-4 BELOW 20 MEV IS ELASTIC SCATTERING, THE MAJORITY OF THE N-4HE DATA IS RATHER IMPRECISE. IN ORDER TO OVERCOME THIS PROBLEM, AN R-MATRIX ANALYSIS WAS PERFORMED WITH A DATA SET WHICH INCLUDED NOT ONLY THE N-4HE DATA BUT ALSO VERY PRECISE P-4HE DATA. ALL THE AVAILABLE N-4HE AND P-4HE DATA BELOW 20 MEV WERE CONSIDERED IN THE ANALYSIS. SINCE THE PREVIOUS EVALUATION WAS COMPLETED IN 1968, SEVERAL N-4HE ELASTIC SCATTERING MEASUREMENTS HAVE BEEN DONE. THE MOST SIGNIFICANT OF THESE ARE THE LOW ENERGY NEUTRON CROSS SECTION OF RORER 1969, THE RPI TOTAL CROSS SECTION MEASUREMENT 1973, WHICH COVER THE RANGE EN#0.7-30 MEV, AND THE RELATIVE ANGULAR DISTRIBUTIONS OF MORGAN 1968. A COMPLETE LIST OF REFERENCES FOR THE N-4HE DATA USED IS GIVEN BELOW. THE P-4HE DATA WAS SELECTED TO SATISFY VERY STRINGENT STATISTICAL CRITERIA AND WE BELIEVE THE POSSIBLE ERRORS OF THE PREDICTED VALUES FOR THE P-4HE SCATTERING TO BE LESS THAN 1.0 PER CENT. A SIMPLE MODEL FOR THE CHARGE DIFFERENCES BETWEEN THE N-4HE AND P-4HE SYSTEMS WAS ASSUMED AND THE N-4HE AND P-4HE DATA SETS WERE SIMULTANEOUSLY ANALYZED. THE VALUES OF THE CROSS SECTIONS AND ANGULAR DISTRIBUTIONS CONTAINED IN FILES 3 AND 4 ARE PROBABLY ACCURATE TO WITHIN 2.0 PERCENT.

MF#4 ----- NEUTRON ANGULAR DISTRIBUTIONS -----

MT#2 ELASTIC SCATTERING ANGULAR DISTRIBUTIONS
OBTAINED FROM THE R-MATRIX ANALYSIS DESCRIBED ABOVE
UNDER MF#3, MT#2. LEGENDRE POLYNOMIAL REPRESENTATION USED.

----- REFERENCES -----

AU62 S.M.AUSTIN ET AL., PHYS.REV. 126 1962 1532.

HE-4 LASL EVAL-OCT73 NISLEY, HAIE, YOUNG
MATERIAL= 4504 ZA= 2004. AWR = 4.0015 FILE= 1 SECTION= 451

BR72 W.B.BROSTE ET AL., PHYS.REV. C5%1972< 761.
BU66 F.W.BUSSER ET AL., NUCL.PHYS. 88%1966< 593.
CR72 D.S.CRAMER & L.CRANEERG, NUCL.PHYS. A180%1972< 273.
FA63 U.FASOLI & G.ZAGO, NUOVO CIMENTO 30%1963< 1169.
GO73 C.A.GOULDING ET AL., BULL.AM.PHYS.SCC. 18%1973< 538.
HO66 E.HOCE, JR. & H.H.BARSCHALL, NUCL.PHYS. 83%1966< 65.
JE66 R.W.JEWELL ET AL., PHYS.REV. 142%1966< 687.
MA63 T.H.MAY ET AL., NUCL.PHYS. 45%1963< 17.%REV. MO68 & SA68<
MO68 G.L.MORGAN & R.L.WALTER, PHYS.REV. 168%1968< 1114.
NI71 A.NIILER ET AL., PHYS.REV. C4%1971< 36. %REV. 9/72<
RO69 D.C.FORER ET AL., NUCL.PHYS. 133%1969< 410.
SA68 J.R.SAWERS ET AL., PHYS.REV. 168%1968< 1102.
SE53 J.D.SEAGRAVE, PHYS.REV. 92%1953< 1222.
SH55 D.F.SHAW, PROC.PHYS.SOC.%LCNDON< 68%1955< 43.
SH64 R.E.SHAMU & J.G.JENKIN, PHYS.REV. 135%1964< B99.
SM54 J.R.SMITH, PHYS.REV. 95%1954< 730.
ST70 T.STAMMBACH ET AL., PHYS.REV. C2%1970< 434.
WH57 R.E.WHITE & F.J.M.FARLEY, NUCL.PHYS. 3%1957< 476.
YO63 P.G.YOUNG ET AL., AUST.J.PHYS. 16%1963< 185.

HE-4 LASL EVAL-OCT73 NISLEY, HAIE, YOUNG
 MATERIAL= 4504 ZA= 2004. AWR = 4.0015 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	GENERAL COMMENTS	82
2	151	RESONANCE DATA	4
3	1	TOTAL	89
3	2	ELASTIC	89
4	2	ELASTIC	96
23	501	TOTAL PHOTON	17
23	502	RAYLEIGH SCATTERING	17
23	504	COMPTON SCATTERING	17
23	516	PAIR PRODUCTION	9
23	602	PHOTOELECTRIC EFFECT	17

FLUORINE ORNL EVAL-MAR74 C.Y.FU AND F.G.PEREY
MATERIAL= 4509 ZA= 9019. AWR = 18.8350 FILE= 1 SECTION= 451

DIST-MAR74 MCD 4-MAR74

*****DNA 4509 MCD 0 *****

THIS EVALUATION CONTAINS ONLY GAMMA-RAY PRODUCTION CROSS SECTIONS IN FILES 13, 14 AND 15 FOR SPECIAL APPLICATIONS.

DICKENS%DI74< HAS MEASURED THE γ N,XG< CROSS SECTIONS AT AN ANGLE OF 125 DEGREES FOR NEUTRON ENERGIES FROM 1.26 TO 20 MEV AND GAMMA-RAY ENERGIES FROM 0.7 TO 10 MEV USING THE OAK RIDGE ELECTRON LINEAR ACCELERATOR, A LITHIUM FLUORIDE SAMPLE AND A SODIUM IODIDE DETECTOR. THE RESULT AGREES WITHIN EXPERIMENTAL ERRORS WITH THE EXISTING DATA%ST66< AND WAS ADOPTED. THE HIGH ENERGY PORTION OF THE GAMMA-RAY SPECTRA WHICH, CONSISTING OF GAMMA-RAYS FROM NEUTRON CAPTURE IN LITHIUM, FLUORINE AND POSSIBLY IODINE IN THE DETECTOR, COULD NOT BE SEPARATED INTO THEIR INDIVIDUAL COMPONENTS, WAS REMOVED.

THE PRODUCTION CROSS SECTIONS OF THE 110-KEV AND THE 197-KEV GAMMA RAYS FROM INELASTIC SCATTERING, NOT COVERED BY DICKENS, WERE TAKEN FROM BRODER%BR70< UP TO 3.6 MEV AND ESTIMATED FOR HIGHER ENERGIES. THESE CROSS SECTIONS WERE ALSO MEASURED BY ROGERS%RO74< UP TO 1.7 MEV AND BY FREEMAN%FR57< UP TO 1 MEV. FOR THE 110-KEV GAMMA-RAY, THE THREE SETS OF DATA AGREE REASONABLY, BUT SHOW OVER 50 PERCENT SPREAD FOR THE 197-KEV GAMMA RAY. THE TENTATIVE CHOICE OF BRODER'S DATA WAS DUE MAINLY TO HIS WIDER ENERGY RANGE, BETTER ENERGY RESOLUTION AND THE AGREEMENT WITH THE DATA OF DAY AND WALT%DA60< AT 2.56 MEV.

THE CAPTURE COMPONENT OF THE GAMMA-RAY PRODUCTION CROSS SECTIONS WAS TAKEN TO BE THE PRODUCT OF THE CAPTURE CROSS SECTION AND THE GAMMA-RAY MULTIPLICITIES EVALUATED FOR DIFFERENT NEUTRON ENERGY RANGES. THE CAPTURE CROSS SECTIONS UP TO 1.8 MEV WERE COMPUTED FROM A SET OF EVALUATED PARAMETERS FOR 20 RESONANCES%MA73,MU73,GA59,NY71,BL68,MA65< USING THE SINGLE LEVEL BREIT-WIGNER FORMULA. THE GAMMA WIDTH OF THE 270-KEV S-WAVE RESONANCE WAS ADJUSTED TO YIELD A THERMAL CROSS SECTION OF 9.5 MB%MU73<. ALL OTHER RESONANCES WERE ASSUMED TO BE P-WAVES. ABOVE 1.8 MEV THE CAPTURE CROSS SECTION IS VERY SMALL AND WAS ASSUMED TO DECREASE LINEARLY WITH ENERGY.

THE DECAY SCHEME OF F-20 PROPOSED BY SPILLING%SP68< WAS USED AS A BASIS FOR CONSTRUCTING THE CAPTURE GAMMA-RAY SPECTRA. THE THERMAL-CAPTURE GAMMA-RAY SPECTRUM WAS CONSTRUCTED BY AVERAGING THE PRIMARY INTENSITIES MEASURED BY SPILLING%SP68< AND BY HARDELL%HA69<. THE PRIMARY INTENSITIES FOR THE 27-KEV AND THE 49-KEV RESONANCES MEASURED BY BERGQVIST ET. AL.%BE67< WERE USED IN CONSTRUCTING A GAMMA-RAY SPECTRUM FOR EACH RESONANCE RESPECTIVELY. THE AVERAGE PRIMARY INTENSITIES OF THESE TWO RESONANCES WERE USED FOR ALL OTHER P-WAVE RESONANCES. THESE AVERAGES WERE FURTHER AVERAGED WITH THEIR THERMAL-CAPTURE COUNTERPARTS FOR THE REMAINING NEUTRON ENERGIES. TOTAL ENERGY AVAILABLE WAS CONSERVED BY PROPERLY SHIFTING THE ENERGIES OF THE PRIMARY GAMMA-RAYS.

FLUORINE CRNL EVAL-MAR74 C.Y.FU AND F.G.PEREY
MATERIAL= 4509 2A= 9019. AWR = 18.8350 FILE= 1 SECTION= 451

THE ANGULAR DISTRIBUTIONS OF ALL SECONDARY GAMMA-RAYS ARE
ASSUMED TO BE ISOTROPIC.

REFERENCES

- BE67 I. BERGQVIST ET. AL., PHYS. REV. 158, 1049%1967<.
- BL68 R. C. BLOCK ET. AL., RENSSELAER POLYTECHNIC INSTITUTE, TROY,
NEW YORK, ANNUAL TECHNICAL REPORT%1968<.
- BR70 D. L. BRODER ET. AL., IAEA CONF., HELSINKI, VOL. 2, P. 295%1970<.
- DA60 R. E. DAY AND M. WALT, PHYS. REV. 117, 1330%1960<.
- DI74 J. K. DICKENS, CRNL, PRIVATE COMMUNICATION%1974<.
- FR57 J. M. FREEMAN, PHIL. MAG. 2, 628%1957<.
- GA59 F. GABBARD ET. AL., PHYS. REV. 114, 201%1959<.
- HA69 R. HARDELL AND A. HASSELGREN, NUC. PHYS. A123, 215%1969<.
- MA65 R. L. MACKLIN AND J. H. GIBBONS, FEV. MCD. PHYS. 37, 166%1965<.
- MA73 R. L. MACKLIN AND R. R. WINTERS, PHYS. REV. C7, 1766%1973<.
- MU73 S. F. MUGHABGHAB AND E. I. GARFEE, ENL-325, THIRD EDITION%1973<.
- NY71 G. NYSTROM ET. AL., PHYS. SCR. 4, 95%1971<.
- RO74 V. C. ROGERS, PHYS. REV. C9, 527%1974<.
- SP68 P. SPILLING ET. AL., NUC. PHYS. A113, 395%1968<.
- ST66 J. R. STEHN ET. AL., BNL-325%1966<.

FLUORINE ORNL EVAL-MAR74 C.Y.FU AND F.G.PEREY
 MATERIAL= 4509 ZA= 9019. AWR = 18.8350 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	GENERAL COMMENTS	81
13	3	NCN-ELASTIC	10
13	4	TOTAL INELASTIC	49
13	102	(N,GAMMA)	126
14	3	NCN-ELASTIC	1
14	4	TOTAL INFLASTIC	1
14	102	(N,GAMMA)	1
15	3	NCN-ELASTIC	487
15	102	(N,GAMMA)	793

MAGNESIUM GRT, SAI EVAL-1970 M.R. DRAKE, M.P. FRICKE
MATERIAL= 4512 ZA= 12000. AWR = 24.0963 FILE= 1 SECTION= 451

DIST-APR73 MCD 1-FEB74

* * * * * DNA 4512 MCD 1 * * * * *

THESE DATA ARE THE SAME AS THOSE OF DNA 4512 MOD 0 EXCEPT AS
FOLLOWS:

%1< THE EXCITATION FUNCTION FOR INELASTIC SCATTERING TO THE
CONTINUUM @MT#91, MF#3< WAS INCREASED BY 150 MB AT 14-MEV
INCIDENT ENERGY AND, IN A SYSTEMATIC WAY, EVERYWHERE BETWEEN
8.0- AND 20.0-MEV INCIDENT ENERGY. THE ADDITIONAL CROSS SECTION
FOR MT#91 WAS SUBTRACTED FROM THAT FOR THE %N, ALPHA< REACTION
%MT#107, MF#3<. THIS CHANGE AND THE FOLLOWING REVISIONS WERE
PRIMARILY MOTIVATED BY COMPARISONS TO LIL PULSED-SPHERE
MEASUREMENTS %R.J. HOWERTON, PRIVATE COMMUNICATION, 1973<.

%2< SECONDARY NEUTRON ENERGY DISTRIBUTIONS FOR INELASTIC
SCATTERING TO THE CONTINUUM @MT#91, MF#5< WERE CHANGED AT AND
ABOVE 10-MEV INCIDENT ENERGY TO THOSE TYPICAL OF A SIMPLE
EVAPORATION SPECTRUM FOUND MORE SUCCESSFUL IN ACCOUNTING FOR LLL
PULSED SPHERE MEASUREMENTS.

* * * * *
* * * THE FOLLOWING DESCRIPTION PERTAINS TO THE DATA OF MOD 0 * *

* * * * *
***** DNA 4512 MOD 0 *****

FILE 23 DATA - PHOTON INTERACTION - TAKEN FROM RSIC
DATA LIBRARY %DLC-7 D< IS BASED ON DATA FROM
UCRL-50174 SEC. II, REV. 1969 BY MCMASTER ET AL.
AND UCRL-50400, VOL. VI BY PLECHATY AND TERRALL.

* * * * *
THIS FILE CONTAINS NEUTRON AND GAMMA-RAY PRODUCTION CROSS
SECTIONS FOR NATURAL MAGNESIUM. ENERGY AND ANGULAR DISTRIBUTIONS
ARE GIVEN FOR ALL SECONDARY NEUTRONS AND GAMMA RAYS PRODUCED BY
NEUTRON INTERACTIONS. THE CUTOFF DATE FOR NEW MATERIAL WAS
NOV. 1972.

* * * * * FILE 2 %RESONANCE PARAMETERS< * * * * *
RESONANCE PARAMETERS WERE NOT CONSIDERED NECESSARY. AN EFFECTIVE
SCATTERING RADIUS OF 0.5E-12 CM. IS GIVEN.

* * * * * FILE 3 %NEUTRON CROSS SECTIONS< * * * * *
TOTAL CROSS SECTION %MT#1< * * * * *

IN THE ENERGY RANGE FROM THERMAL UP TO 350 KEV, SEVERAL
SETS OF EXPERIMENTAL DATA WERE AVAILABLE. THESE MEASUREMENTS GAVE
RESULTS WHICH WERE IN AGREEMENT. THE DATA OBTAINED BY NEWSON,
ET.AL.%1< WERE HEAVILY WEIGHTED. FROM 350 TO 600 KEV, THE DATA
MEASURED BY CRANBERG %2< WERE USED AND FROM 600 KEV TO 1.5 MEV
THE DATA MEASURED AT ANL BY ELWYN AND SMITH %3< WERE USED. VERY
POOR AND UNCERTAIN DATA EXISTED FOR THE ENERGY REGION FROM 1.5
TO 2.0 MEV %4<. A SMOOTH CURVE WAS DRAWN THROUGH THE AVAILABLE

MAGNESIUM GRT, SAI EVAL-1970 M.K. DRAKE, M.P. FRICKE
MATERIAL= 4512 ZA= 12000. AWR = 24.0963 FILE= 1 SECTION= 451

DATA BUT THE STRUCTURE IN THIS CURVE IS NOT LIKELY TO BE VERY REALISTIC. BETWEEN 2 AND 3 MEV, DATA OBTAINED BY GALLOWAY %5< AND POSTER, ET.AL. WERE USED, HOWEVER THESE TWO RESULTS WERE IN VERY POOR AGREEMENT. POSTERS %6< DATA WERE USED FROM 3 TO 5 MEV. FROM 5 TO 14 MEV, CARLSONS %7< DATA WERE USED. ABOVE 14 MEV A CURVE WAS DRAWN THROUGH SEVERAL DATA SETS, BUT MAINLY THROUGH RESULTS OBTAINED BY PETERSON %8<.

ELASTIC SCATTERING CROSS SECTION %MT#2< * * * * *

THE ELASTIC SCATTERING CROSS SECTION WAS OBTAINED EVERYWHERE BY SUBTRACTING THE NON-ELASTIC CROSS SECTION FROM THE EVALUATED TOTAL CROSS SECTION. THIS CROSS SECTION WAS COMPARED TO THE RESULTS FROM THE AVAILABLE EXPERIMENTAL DATA %9,10,11,12,13<. THESE MEASUREMENTS WERE TYPICALLY MADE AT LOW ENERGY RESOLUTION AND THEREFORE THE RESULTS REPRESENT AVERAGES OVER THE STRUCTURE IN THE ELASTIC SCATTERING CROSS SECTION. THERE WAS FAIRLY GOOD AGREEMENT BETWEEN THE MEASURED AND EVALUATED DATA, WITH THE EXCEPTION THAT THE EVALUATED DATA WERE SLIGHTLY HIGHER THAN THE RESULTS OBTAINED BY KINNEY AND PEREY %9< FOR NEUTRON ENERGIES BETWEEN 4 AND 8.5 MEV.

NON-ELASTIC CROSS SECTION %MT#3< * * * * *

FOR NEUTRON ENERGIES UP TO THE THRESHOLD FOR INELASTIC SCATTERING %0.605 MEV<, THE NON-ELASTIC CROSS SECTION WAS TAKEN TO BE THE SAME AS THE RADIATIVE CAPTURE CROSS SECTION. BETWEEN 0.605 MEV AND 9 MEV, THE NON-ELASTIC CROSS SECTION FOR THE ELEMENT WAS OBTAINED FROM THE NON-ELASTIC CROSS SECTIONS FOR THE INDIVIDUAL ISOTOPES OF MAGNESIUM. THESE CROSS SECTIONS WERE, IN TURN, OBTAINED FROM THE SUM OF THEIR RESPECTIVE COMPONENTS, INELASTIC SCATTERING, %N,2N<, %N,PROTON<, AND %N,ALPHA<. ABOVE 9 MEV, THE NON-ELASTIC CROSS SECTION WAS BASED ON SEVERAL SETS OF EXPERIMENTAL DATA %14,15,16,17<. ABOVE 15 MEV, WHERE THERE WERE DATA, THE NON-ELASTIC CROSS SECTION WAS ASSUMED TO FALL-OFF GRADUALLY WITH INCREASING NEUTRON ENERGY, SIMILAR IN SHAPE TO THE TOTAL CROSS SECTION.

INELASTIC SCATTERING CROSS SECTION %MT#4,51, ,91< * * * * *

THE INELASTIC SCATTERING CROSS SECTION FOR MAGNESIUM HAS BEEN GIVEN AS THE TOTAL INELASTIC SCATTERING CROSS SECTION, LEVEL EXCITATION CROSS SECTIONS FOR THE FIRST 40 LEVELS, AND A CONTINUUM PORTION. THE CROSS SECTIONS FOR THE ELEMENT WERE OBTAINED BY COMBINING THE EVALUATED CROSS SECTIONS FOR THE INDIVIDUAL ISOTOPES.

THE LEVEL EXCITATION CROSS SECTIONS FOR THE FIRST LEVEL IN MG-24, Q # -1.37 MEV, WAS BASED ON AN EVALUATION BY DRAKE %33< FOR NEUTRON ENERGIES FROM THRESHOLD UP TO 3 MEV. BETWEEN 3 AND 9 MEV, THE EXPERIMENTAL DATA OF KINNEY AND PEREY %9<, THOMSON, ET.AL %10<, BRODER, ET.AL.%38<, AND MATHUR, ET. AL. %39<. NEAR 14 MEV, THE DATA OF CLARKE AND CROSS %12< AND STELSON, ET.AL. %11< WERE USED. INTERPOLATION AND EXTRAPOLATION OF DATA TO HIGHER ENERGIES WAS DONE BY USING CALCULATED RESULTS FROM THE HELENE AND JUPITOR CODES.

THE EXCITATION FUNCTIONS FOR THE 4.12 AND 4.23 LEVELS IN MG-24

MAGNESIUM GRT, SAI EVAL-1970 M.K. DRAKE, M.P. FRICKE
MATERIAL= 4512 ZA= 12000. AWF = 24.0963 FILE= 1 SECTION= 451

WERE BASED ON CALCULATIONS. THE SUM OF THESE TWO LEVELS WAS CONSISTENT WITH THE ORNL DATA %9< BETWEEN 6 TO 8.6 MEV AND THE STELSON DATA %11< AT 14 MEV BUT THE INDIVIDUAL LEVELS WERE HIGHER THAN THE ORNL DATA AT 8.6 MEV.

ALL OTHER LEVEL EXCITATION FUNCTIONS WERE BASED ON CALCULATIONS AND THE RESULTS AGREED WITH THE LIMITED EXPERIMENTAL DATA %39,40,38<.

%N,2N< CROSS SECTION %MT#16< * * * * *

THE %N,2N< CROSS SECTION FOR THE ELEMENT WAS OBTAINED FROM THE %N,2N< CROSS SECTIONS FOR THE INDIVIDUAL ISOTOPES. THE %N,2N< CROSS SECTION FOR MG-24 WAS BASED ON A MEASUREMENT MADE BY ARNOLD %18<. THE %N,2N< CROSS SECTIONS FOR MG-25 AND MG-26 WERE BASED ON STATISTICAL MODEL CALCULATIONS MADE BY PEARLSTEIN %19<.

%N,P< AND %N,N-P< CROSS SECTIONS %MT,103,28< * * * * *

THE %N,P< AND THE %N,N-P< CROSS SECTIONS FOR THE ELEMENT WERE OBTAINED FROM THE CROSS SECTIONS FOR THE INDIVIDUAL ISOTOPES. ALMOST NO EXPERIMENTAL DATA WERE AVAILABLE FOR THE %N,N-P< REACTION, THEREFORE THESE CROSS SECTIONS WERE EVALUATED TO BE CONSISTENT WITH THE %N,P< CROSS SECTIONS FOR THE INDIVIDUAL ISOTOPES.

MG-24

BETWEEN 5.0 AND 12 MEV THE %N,P< CROSS SECTION WAS BASED ON MEASUREMENTS BY BUTLER AND SANTRY %20< AND BY LISKEIN AND PAULSEN %21<. IN THE ENERGY REGION OF OVER-LAP FOR THESE TWO MEASUREMENTS, 6 TO 8 MEV, THEIR RESULTS WERE IN GOOD AGREEMENT. NUMEROUS SETS OF EXPERIMENTAL RESULTS WERE AVAILABLE FOR THE ENERGY REGION FROM 12 TO 14 MEV AND THE DATA WERE NOT IN GOOD AGREEMENT %8/- 30 PERCENT<. IN THIS ENERGY REGION, THE DATA MEASURED BY FERGUSON AND ALBERGCTII WERE USED %22<. CONSIDERABLE STRUCTURE HAD BEEN OBSERVED IN THE %N,P< CROSS SECTION AND THE RECOMMENDED DATA WAS EVALUATED TO HAVE THE SAME STRUCTURE AS SEEN IN THE TOTAL AND %N,P< CROSS SECTION. BETWEEN 14 AND 15 MEV, THE STRUCTURE AS OBSERVED BY PAULSEN AND LISKEIN %23< WAS USED. THE MAGNITUDE WAS BASED ON THIS AND OTHER MEASUREMENTS %24,25,26<. ABOVE 15 MEV, THE %N,P< CROSS SECTION DECREASED FAIRLY RAPIDLY AND THE RECOMMENDED DATA WERE BASED ON MEASUREMENTS BY IMHOF %26< AND PAULSEN AND LISKEIN %23<.

NO EXPERIMENTAL DATA WERE AVAILABLE FOR THE %N,N-P< REACTION. THE RECOMMEND VALUES WERE BASED ON SEMI-THEORETICAL ARGUMENTS. THE SUM OF THE %N,P< AND %N,N-P< WAS ASSUMED TO HAVE THE SAME ENERGY DEPENDENCE AS THE NON-ELASTIC CROSS SECTION. THE THRESHOLD FOR THE %N,N-P< REACTION WAS AT 12.2 MEV. THE RECOMMENDED %N,N-P< CROSS SECTION WAS TAKEN TO BE ZERO AT 12.6 AND REACH A MAXIMUM VALUE OF 90 MB AT 20 MEV. THE RESULTING CROSS SECTION WAS VERY UNCERTAIN.

MG-25

NO EXPERIMENTAL RESULTS WERE AVAILABLE FOR NEUTRON ENERGIES LESS THAN 13 MEV. THE RECOMMENDED DATA WERE BASED ON SEVERAL SETS OF EXPERIMENTAL DATA SETS THAT WERE AVAILABLE FOR THE ENERGY REGION FROM 13 TO 17 MEV. THE SHAPE OF THE RECOMMENDED CROSS

MAGNESIUM GRT, SAI EVAL-1970 M.K. DRAKE, M.P. FRICKE
MATERIAL= 4512 ZA= 12000. AWR = 24.0963 FILE= 1 SECTION= 451

SECTION WAS TAKEN FROM THE MEASUREMENT BY BORMANN %27<. THE CROSS SECTION AT 14.5 MEV WAS AN AVERAGE OF THE RESULTS BY BORMANN %27< PASQUARELLI %24<, PRASD AND SARKAR %28<. FROM THE EFFECTIVE THRESHOLD AT 4.5 MEV TO 13 MEV THE RECOMMEND CROSS SECTION WAS ASSUMED TO HAVE THE SAME SHAPE AS CALCULATED FROM A STATISTICAL MODEL AND WAS NORMALIZED TO THE EXPERIMENTAL DATA AT 13 MEV. THE SAME PROCEDURE WAS USED TO OBTAIN THE %N,N-P< CROSS SECTION AS WAS USED FOR MG-24

MG-26

ALMOST NO EXPERIMENTAL DATA WERE AVAILABLE FOR THE %N,P< AND %N,N-P< REACTIONS. VERY CRUDE ESTIMATES OF THESE CROSS SECTION WERE MADE. THESE ESTIMATES WERE BASED ON STATISTICAL MODEL CALCULATIONS AND THE EXPERIMENTAL DATA MEASURED BY NURMIA AND FINK %29< AND ALLAN %30<.

THE %N,ALPHA< AND %N,N-ALPHA< CROSS SECTIONS %MT#107,22< * *

THESE CROSS SECTIONS WERE EVALUATED IN THE SAME MANNER AS THE %N,P< AND %N,N-P< CROSS SECTIONS. HOWEVER, FAR LESS EXPERIMENTAL DATA WERE AVAILABLE. THE %N,ALPHA< CROSS SECTION FOR THE ELEMENT WAS TIED ALMOST EXCLUSIVELY TO THE EXPERIMENTAL DATA FOR MG-26. EXPERIMENTAL DATA MEASURED BY BORMANN %27<, PRASD AND SARKAR %28<, AND PASQUARELLI %24< WERE USED TO DEFINE THE MG-26 %N,ALPHA< CROSS SECTION FOR THE ENERGY RANGE FROM 13 TO 17 MEV. STATISTICAL MODEL CALCULATIONS WERE USED TO OBTAIN THE CROSS SECTION FOR THIS ISOTOPE FROM ITS EFFECTIVE THRESHOLD AT ABOUT 7.5 MEV UP TO 13 MEV AND ABOVE 17 MEV. FROM 2.1 TO 3.0 MEV THE INVERSE CROSS SECTION, NE-22%ALPHA,N-ZERO<MG-25, AS MEASURED BY ASHERY %31<, WAS USED TO DETERMINE THE MG-25%N,ALPHA< CROSS SECTION. ABOVE 3 MEV, STATISTICAL MODEL CALCULATIONS WERE USED TO PREDICT THE SHAPE OF THE CROSS SECTION. THE MAGNITUDE OF THE MG-25 %N,ALPHA< CROSS SECTION AT 14.5 MEV WAS BASED ON THE EVALUATED MG-26 %N,ALPHA< CROSS SECTION AT THIS ENERGY AND A CALCULATED RATIO FOR MG-25/MG-26 %32<. SINCE THERE WERE NO USEABLE EXPERIMENTAL DATA FOR MG-24, THE EVALUATED CROSS SECTION FOR THIS ISOTOPE WAS BASED ON A STATISTICAL MODEL CALCULATION, NORMALIZED TO A CALCULATED RATIO %32<.

THE %N,N-ALPHA< CROSS SECTIONS FOR THE ISOTOPE WAS OBTAINED IN THE SAME MANNER AS THE %N,N-P< CROSS SECTION. THE %N,ALPHA< AND %N,N-ALPHA< CROSS SECTIONS ARE VERY UNCERTAIN DUE TO THE LACK OF EXPERIMENTAL DATA AND THE RELIANCE ON NUCLEAR MODEL CALCULATIONS.

THE RADIATIVE CAPTURE CROSS SECTION %MT#102< * * * * *

THE RADIATIVE CAPTURE CROSS SECTION WAS TAKEN TO BE THE SAME AS THAT EVALUATED BY DRAKE %33< FOR NEUTRON ENERGIES LESS THAN 500 KEV. THIS WAS BASED ON A THERMAL CROSS SECTION OF 0.063 BARNS AND WAS 1/V UP TO 1.0 KEV. BETWEEN 1.0 KEV AND 500 KEV, THE CAPTURE CROSS SECTION FOR THE ELEMENT WAS CALCULATED FROM THE EVALUATED RESONANCE PARAMETERS FOR THE ISOTOPES %33<. ABOVE 500 KEV, THE CROSS SECTION WAS TAKEN TO BE 1/E UP TO ABOUT 3 MEV WHERE DIRECT CAPTURE MECHANISMS PREDOMINATE. ABOVE 5 MEV, THE CAPTURE CROSS SECTION WAS TAKEN TO BE RELATIVELY CONSTANT AND THE RECOMMENDED CROSS SECTION AT 14 MEV WAS BASED ON EXPERIMENTAL

MAGNESIUM GRT, SAI EVAL-1970 M.K. DRAKE, M.P. FRICKE
MATERIAL= 4512 ZA= 12000. AWF = 24.0963 FILE= 1 SECTION= 451

RESULTS OBTAINED BY CVELBAR %34<.

FILE 4 %ANGULAR DISTRIBUTIONS OF SECONDARY NEUTRONS< * * * *
ELASTIC SCATTERING %MT#2< LEGENDRE COEFFICIENT REPRESENTATION
THE ANGULAR DISTRIBUTION OF ELASTICALLY SCATTERED NEUTRONS
WAS ASSUMED TO BE ISOTROPIC UP TO 25 KEV. JUST ABOVE 25 KEV
SEVERAL P-WAVE RESONANCES HAVE BEEN OBSERVED AND THE ANGULAR
DISTRIBUTIONS ARE PEAKED IN THE BACKWARD DIRECTION. BETWEEN 25
KEV AND 300 KEV, THE RECOMMENDED ANGULAR DISTRIBUTIONS WERE
BASED ON A MEASUREMENT MADE BY LANGSDORF, ET.AL.%35<. BETWEEN
0.3 AND 1.0 MEV, THE DISTRIBUTIONS WERE BASED ON MEASUREMENTS
BY LANGSDORF %35<, COX %36<, AND KORZH %13<. BETWEEN 2.0 AND
4.0 MEV, THE DATA MEASURED BY THOMPSON %10< WAS USED. BETWEEN
5 AND 8.5 MEV, THE ORNL %9< MEASUREMENTS WERE USED. NEAR 14 MEV,
THE EXPERIMENTAL DATA MEASURED BY STELSON, ET.AL.%11<, CLARKE AND
CROSS %12<, AND BERKO, ET.AL.%37< WERE USED. BETWEEN 8.5 AND
14 MEV AND ABOVE 15 MEV, THE RECOMMENDED ANGULAR DISTRIBUTIONS
WERE OBTAINED FROM DEFORMED NUCLEUS MODEL CALCULATIONS.

ANGULAR DISTRIBUTION OF INELASTICALLY SCATTERED NEUTRONS * *
THE ANGULAR DISTRIBUTIONS FOR NEUTRONS THAT LEAD TO THE 1.37
MEV LEVEL IN MG-24 WERE BASED ON THE EXPERIMENTAL DATA OF
THOMPSON, ET.AL.%10< FOR POINTS AT 2.84, 3.79, AND 4.76 MEV, DATA
OF KINNEY AND PEREY %9< AT 5.44 AND 7.55 MEV, DATA OF STELSON,
ET.AL.%11< AND CLARKE AND CROSS %12< AT 14 MEV. THE ANGULAR
DISTRIBUTION FOR ALL OTHER INCIDENT ENERGY POINTS WERE BASED ON
HELENE AND JUPITOR CALCULATIONS. THE DISTRIBUTION DATA FOR THE
4.12 AND 4.23 MEV LEVELS IN MG-24 WERE BASED ON CALCULATIONS. THE
ANGULAR DISTRIBUTIONS FOR ALL OTHER LEVELS AND THE CONTINUUM WERE
ASSUMED TO BE ISOTROPIC IN THE C.M. SYSTEM.

%N,2N<, %N,N-P<, AND %N,N-ALPHA< ANGULAR DISTRIBUTIONS * * * *
NEUTRON FROM THESE REACTIONS WERE ASSUMED TO BE ISOTROPIC IN
THE C.M. SYSTEM.

FILE 5 %ENERGY DISTRIBUTIONS OF SECONDARY NEUTRONS< * *
INELASTIC SCATTERING %MT#91< AND N,2N %MT#16<
THE ENERGY DISTRIBUTIONS OF NEUTRONS FROM THESE REACTIONS
WERE BASED ON A STATISTICAL MODEL CALCULATION. AN EFFECTIVE
NUCLEAR TEMPERATURE OF 1.0 MEV AT 14 MEV %INCIDENT< FOR THE FIRST
NEUTRON WAS BASED ON MEASUREMENTS BY MATHUR, ET.AL.%41< AND
AND SAL-NIKOV, ET.AL.%42<. A SQUARE ROOT OF ENERGY DEPENDENCE
WAS USED. AN EFFECTIVE NUCLEAR TEMPERATURE WAS USED FOR EACH
ISOTOPE FOR THE SECOND NEUTRON. THE FINAL ENERGY DISTRIBUTIONS
WERE GIVEN AS HISTOGRAMS.

FILE 12 %RADIATIVE CAPTURE GAMMA-RAY MULTIPLICITIES< *
THE MULTIPLICITIES FOR GAMMA RAYS FROM RADIATIVE CAPTURE HAVE
BEEN BASED ON THE DATA MEASURED BY ORPHAN, ET.AL.%43< AT THERMAL
NEUTRON ENERGIES. THE DATA MEASURED BY BIED, ET.AL.%14< HAVE BEEN
USED TO DESCRIBE THE GAMMA RAYS FROM CAPTURE IN THE 84 KEV
RESONANCE. THE MULTIPLICITIES FOR ALL OTHER ENERGIES WERE BASED
ON VALUES AT THERMAL AND THEY INCREASE AS A FUNCTION OF INCIDENT
NEUTRON ENERGY TO PRESERVE TOTAL ENERGY RELEASED.

FILE 13 %GAMMA RAY PRODUCTION CROSS SECTIONS< * * * *

THE GAMMA RAY PRODUCTION CROSS SECTIONS FOR INELASTIC SCATTERING AND $n, 2n$ REACTIONS HAVE BEEN CALCULATED WITH A MODIFIED VERSION OF THE SPECT10 CODE. THE INPUT TO THIS CODE WAS NUCLEAR LEVEL DENSITY INFORMATION AND EXCITATION CROSS SECTIONS %FILE 3 DATA. THE GAMMA RAYS FROM INELASTIC SCATTERING WERE TREATED AS A CONTINUUM EXCEPT FOR THE STRONG 1.37 MEV LINE. THE CALCULATED VALUES FOR THIS LINE WERE COMPARED WITH THE AVAILABLE EXPERIMENTAL DATA %MOST OF THESE DATA WERE USED IN THE EVALUATION OF THE EXCITATION CROSS SECTION FOR THIS LEVEL, AND THE CALCULATED CURVE WAS RAISED SLIGHTLY ABOVE 10 MEV TO OBTAIN AGREEMENT WITH THE MEASUREMENT OF EGESSON AND THOMSON %40.

FILE 15 %ENERGY DISTRIBUTION OF SECONDARY GAMMA RAYS*
 THE SPECT10 CODE WAS USED TO PREDICT THE SECONDARY ENERGY DISTRIBUTION FOR THE $n, n-g$ AND $n, 2n-g$ REACTIONS. THE ENERGY DISTRIBUTIONS FOR n, g REACTIONS WERE BASED ON MEASUREMENTS BY ORPHAN ET.AL.%43 AND BIRD, ET.AL.%44. HISTOGRAM REPRESENTATIONS HAVE BEEN USED TO DESCRIBE THE ENERGY DISTRIBUTIONS.

REFERENCES

- %1< H.W.NEWSON, ET.AL., ANN.PHYS. 8, 211 %1959<.
- %2< L.CRANBERG, %UNPUBLISHED, SEE WASH-1006 %1958<<.
- %3< A.J.ELWYN AND A.B.SMITH, %UNPUBLISHED, SEE WASH-1053 %1964<<.
- %4< G.FRIER, ET.AL., PHYS.REV. 78, 508 %1950<.
- %5< I.A.GALLOWAY AND E.F.SHRADER, REPORT COO-1573-6 %1966<.
- %6< D.G.FOSTER, ET.AL., PHYS.REV. 3, C576 %1971<.
- %7< A.D.CARLSON, ET.AL., PHYS.REV. 158, 1142 %1967<.
- %8< J.M.PETERSON, ET.AL., PHYS.REV. 120, 521 %1960<.
- %9< W.E.KINNEY AND F.G.PEREY, CNL-4550 %1970<.
- %10< D.B.THOMSON, ET.AL., PHYS.REV. 125, 2049 %1962<.
- %11< P.H.STELSON, ET.AL., NUCL. PHYS. 68, 97 %1965<.
- %12< R.C.CLARKE AND W.G.CROSS, NUCL.PHYS. 53, 177 %1964<.
- %13< I.A.KORZH, ET.AL., ATOMIC ENERGY 16, 260 %1964<.
- %14< W.P.BALL, ET.AL., PHYS.REV. 110, 1392 %1958<.
- %15< V.I.STRIZHAK, A.E. 2, 68 %1957<.
- %16< N.V.FLEFCV AND V.M.TALYZIN, A.E. 1, 155 %1956<.
- %17< E.ANDERS, PHYS.REV. 110, 427 %1958<.
- %18< D.M.ARNOLD, PH.D. THESIS, UNIV. GEORGIA %1965<.
- %19< S.FEARISTEIN, REPORT ENL-897 %1964<.
- %20< J.P.BUTLER AND D.C.SANTRY, CAN.J.PHYS. 41, 372 %1963<.
- %21< H.LISKIEN AND A.PAULSEN, NUKLEONIK 8, 315 %1966<.
- %22< J.M.FERGUSON AND J.C.ALBERTGOTTI, NUCL.PHYS. 98, 65 %1967<.
- %23< A.PAULSEN AND H.LISKEIN, J.NUCL.ENG A/B 19, 907 %1965<.
- %24< A.PASQUARELLI, NUCL.PHYS. 93, 218 %1967<.
- %25< R.C.BARFALL, ET. AL., REPORT AFWL-TR-68-134 %1969<.
- %26< W.L.IMHOF, %LOOKHEED< PRI.COMM. %1964<.
- %27< M.BORMANN, ET.AL., PROC.CCNP.ON NUCL.DATA FOR REACTORS, PARIS, VOL I, 225 %1966<.
- %28< R.PRASI AND D.C.SARKAR, NUCL.PHYS. 85, 476 %1966<.
- %29< M.J.NURMIA AND R.W.FINK, NUCL.PHYS. 8, 139 %1958<.
- %30< D.I.ALIAN, NUCL.PHYS. 24, 274 %1961<.
- %31< D.ASHERY, NUCL.PHYS. A136, 481 %1969<.

MAGNESIUM GRT, SAI EVAL-1970 M.K. DRAKE, M.P. FRICKE
MATERIAL= 4512 ZA= 12000. AWR = 24.0963 FILE= 1 SECTION= 451

%32< D.G.GAFDNER AND YU-UEN YU, NUCL.PHYS.60, 49%1964<.
%33< M.K.DRAKE, REPORT NDL-TR-89, PART 3 %1967<.
%34< F.C.VELBAR, NUCL.PHYS. A138, 412 %1969<.
%35< A.LANGSDORF, ET.AL., REPORT ANL-5567 %1956<.
%36< S.A.COX %ANL< PRI. COMM. %1966<.
%37< S.BERKO, ET.AL., NUCL.PHYS. 6,210 %1958<.
%38< D.L.ERCDER, ET.AL., A.E. 16, 103 %1964<
%39< S.C.MATHUR, ET.AL., NUCL.PHYS.73, 561 %1965<
%40< F.C.ENGESESSER AND W.E.THOMPSON, REPORT USNRDL-TR-916 %1965<
%41< S.C.MATHUR, ET.AL., PHYS.REV. 186, 1038 %1969<
%42< O.A.SAL-NIKOV, ET.AL., YAD.FIZ. 4, 1154 %1966<
%43< V.J.ORPHAN, ET.AL. REPORT GA-10248 %1970<
%44< J.R.BIRD, ET.AL., REPORT ORNL-TM-3379 %1971<

MAGNESIUM GRT, SAI EVAL-1970 M.K. DRAKE, M.P. FRICKE
 MATERIAL= 4512 ZA= 12000. AWF = 24.C963 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	GENERAL COMMENTS	434
2	151	RESONANCE DATA	4
3	1	TCTAI	299
3	2	ELASTIC	299
3	3	NCN-ELASTIC	299
3	4	TOTAL INELASTIC	221
3	16	(N,2N)	57
3	22	(N,N*) ALPHA	25
3	28	(N,N*) P	20
3	51	(N,N*) 1-ST EXCITED	87
3	52	(N,N*) 2-ND EXCITED	48
3	53	(N,N*) 3-RD EXCITED	45
3	54	(N,N*) 4-TH EXCITED	42
3	55	(N,N*) 5-TH EXCITED	41
3	56	(N,N*) 6-TH EXCITED	40
3	57	(N,N*) 7-TH EXCITED	36
3	58	(N,N*) 8-TH EXCITED	34
3	59	(N,N*) 9-TH EXCITED	34
3	60	(N,N*) 10-TH EXCITED	34
3	61	(N,N*) 11-TH EXCITED	31
3	62	(N,N*) 12-TH EXCITED	31
3	63	(N,N*) 13-TH EXCITED	30
3	64	(N,N*) 14-TH EXCITED	29
3	65	(N,N*) 15-TH EXCITED	29
3	66	(N,N*) 16-TH EXCITED	28
3	67	(N,N*) 17-TH EXCITED	28
3	68	(N,N*) 18-TH EXCITED	27
3	69	(N,N*) 19-TH EXCITED	27
3	70	(N,N*) 20-TH EXCITED	27
3	71	(N,N*) 21-TH EXCITED	26
3	72	(N,N*) 22-TH EXCITED	26
3	73	(N,N*) 23-TH EXCITED	26
3	74	(N,N*) 24-TH EXCITED	26
3	75	(N,N*) 25-TH EXCITED	24
3	76	(N,N*) 26-TH EXCITED	24
3	77	(N,N*) 27-TH EXCITED	23
3	78	(N,N*) 28-TH EXCITED	22
3	79	(N,N*) 29-TH EXCITED	19
3	80	(N,N*) 30-TH EXCITED	16
3	81	(N,N*) 31-TH EXCITED	15
3	82	(N,N*) 32-TH EXCITED	15
3	83	(N,N*) 33-TH EXCITED	14
3	84	(N,N*) 34-TH EXCITED	14
3	85	(N,N*) 35-TH EXCITED	13
3	86	(N,N*) 36-TH EXCITED	13
3	87	(N,N*) 37-TH EXCITED	12
3	88	(N,N*) 38-TH EXCITED	12
3	89	(N,N*) 39-TH EXCITED	11
3	90	(N,N*) 40-TH EXCITED	11
3	91	(N,N*) CONTINUUM	61

MAGNESIUM GRT, SAI EVAL-1970 M.K. DRAKE, M.P. FRICKE
 MATERIAL= 4512 ZA= 12000. AWR = 24.0963 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
3	102	(N,GAMMA)	299
3	103	(N,F)	102
3	107	(N,ALPHA)	138
3	251	MU BAR	23
3	252	XI	23
3	253	GAMMA	23
4	2	ELASTIC	220
4	16	(N,2N)	10
4	22	(N,N*) ALPHA	10
4	28	(N,N*) F	10
4	51	(N,N*) 1-ST EXCITED	10
4	52	(N,N*) 2-ND EXCITED	10
4	53	(N,N*) 3-ED EXCITED	136
4	54	(N,N*) 4-TH EXCITED	10
4	55	(N,N*) 5-TH EXCITED	10
4	56	(N,N*) 6-TH EXCITED	10
4	57	(N,N*) 7-TH EXCITED	10
4	58	(N,N*) 8-TH EXCITED	10
4	59	(N,N*) 9-TH EXCITED	10
4	60	(N,N*) 10-TH EXCITED	10
4	61	(N,N*) 11-TH EXCITED	10
4	62	(N,N*) 12-TH EXCITED	10
4	63	(N,N*) 13-TH EXCITED	10
4	64	(N,N*) 14-TH EXCITED	10
4	65	(N,N*) 15-TH EXCITED	10
4	66	(N,N*) 16-TH EXCITED	10
4	67	(N,N*) 17-TH EXCITED	10
4	68	(N,N*) 18-TH EXCITED	58
4	69	(N,N*) 19-TH EXCITED	58
4	70	(N,N*) 20-TH EXCITED	10
4	71	(N,N*) 21-TH EXCITED	10
4	72	(N,N*) 22-TH EXCITED	10
4	73	(N,N*) 23-TH EXCITED	10
4	74	(N,N*) 24-TH EXCITED	10
4	75	(N,N*) 25-TH EXCITED	10
4	76	(N,N*) 26-TH EXCITED	10
4	77	(N,N*) 27-TH EXCITED	10
4	78	(N,N*) 28-TH EXCITED	10
4	79	(N,N*) 29-TH EXCITED	10
4	80	(N,N*) 30-TH EXCITED	10
4	81	(N,N*) 31-TH EXCITED	10
4	82	(N,N*) 32-TH EXCITED	10
4	83	(N,N*) 33-TH EXCITED	10
4	84	(N,N*) 34-TH EXCITED	10
4	85	(N,N*) 35-TH EXCITED	10
4	86	(N,N*) 36-TH EXCITED	10
4	87	(N,N*) 37-TH EXCITED	10
4	88	(N,N*) 38-TH EXCITED	10
4	89	(N,N*) 39-TH EXCITED	10
4	90	(N,N*) 40-TH EXCITED	10

MAGNESIUM GRT, SAI EVAL-1970 M.K. DRAKE, M.P. FRICKE
 MATERIAL= 4512 ZA= 12000. AWR = 24.0963 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
4	91	(N,N*) CCNTINUUM	10
5	16	(N,2N)	85
5	22	(N,N*) ALPHA	7
5	28	(N,N*) P	7
5	91	(N,N*) CCNTINUUM	95
12	102	(N,GAMMA)	12
13	4	TOTAL INELASTIC	79
13	16	(N,2N)	7
14	4	TOTAL INELASTIC	1
14	16	(N,2N)	1
14	102	(N,GAMMA)	1
15	4	TOTAL INELASTIC	238
15	16	(N,2N)	89
15	102	(N,GAMMA)	48
23	501	TOTAL PHOTON	18
23	502	RAYLEIGH SCATTERING	18
23	504	COMPTON SCATTERING	18
23	516	PAIR PRODUCTION	9
23	602	PHOTOELECTRIC EFFECT	18

COPPER SAI EVAL-1972 M.K. DRAKE, M.P. FRICKE
MATERIAL= 4529 ZA= 29000. AWR = 62.9940 FILE= 1 SECTION= 451

DIST-APR73 MCD 1-FEB74

***** DNA 4529 MCD 1 *****

THESE DATA ARE THE SAME AS THOSE OF DNA 4529 MOD 0 EXCEPT AS FOLLOWS:

%1< EXCITATION FUNCTIONS FOR INELASTIC SCATTERING TO 0.962-MEV LEVEL IN CU-63%MT#53,MF#3< AND TO 1.115-MEV LEVEL IN CU-65%MT#54,MF#3< WERE INCREASED BETWEEN 3.5- AND 10-MEV INCIDENT ENERGY TO BETTER AGREE WITH NEW CRNL DATA BETWEEN 5.5 AND 8.0 MEV %W.E. KINNEY, PRIVATE COMMUNICATION, 1973<. ADDITIONAL INELASTIC SCATTERING CROSS SECTION WAS SUBTRACTED FROM ELASTIC SCATTERING CROSS SECTION %MT#2,MF#3<.

%2< LEGENDRE COEFFICIENTS FOR ELASTIC SCATTERING %MT#2,MF#4< DETERMINED IN ABOVE REFERENCE WERE ADDED AT INCIDENT ENERGIES 5.5 AND 8.5 MEV.

%3< PHOTON PRODUCTION MEASUREMENTS FROM 1.25- TO 20-MEV INCIDENT NEUTRON ENERGY WERE INCORPORATED FROM J.K. DICKENS ET AL., ORNL-4846%1973<. IN MF#13, ALL PHOTON PRODUCTION IS GIVEN UNDER MT#3. IN MF#12 AND 15, PHOTON PRODUCTION FROM RADIATIVE CAPTURE IS RETAINED SEPARATELY UNDER MT#1C2 AT NEUTRON ENERGIES BELOW 1.25 MEV. AT HIGHER NEUTRON ENERGIES, ALL PHOTON PRODUCTION IS GIVEN IN MF#15 UNDER MT#3.

***** DNA 4529 MCD 0 *****

FILE 23 DATA - PHOTON INTERACTION - TAKEN FROM RSIC DATA LIBRARY %DLC-7 D< IS BASED ON DATA FROM UCRL-50174 SEC. II, REV. 1969 BY MCMASTER ET AL. AND UCRL-50400, VOL. VI BY PLECHATY AND TERRALL.

* * * * *
THIS MATERIAL CONTAINS NEUTRON AND GAMMA RAY PRODUCTION CROSS SECTIONS FOR THE ELEMENT COPPER. ENERGY AND ANGULAR DISTRIBUTIONS ARE GIVEN FOR ALL SECONDARY NEUTRONS AND GAMMA RAYS PRODUCED BY NEUTRON INTERACTIONS. THE CUTOFF DATE FOR NEW INFORMATION WAS NOV. 1972.

* * * * * FILE 2 %RESONANCE PARAMETERS< * * * * *

MULTI-LEVEL BRIET-WIGNER RESOLVED RESONANCE PARAMETERS HAVE BEEN PROVIDED TO SATISFY THE NUCLEAR DATA REQUIREMENTS FOR MANY APPLICATIONS. THESE PARAMETERS DESCRIBE THE TOTAL, ELASTIC SCATTERING, AND RADIATIVE CAPTURE CROSS SECTIONS FOR THE ENERGY RANGE FROM 10 EV TO 30 KEV. SMALL BACKGROUND CROSS SECTIONS HAVE BEEN GIVEN IN FILE 3 FOR THE TOTAL, ELASTIC SCATTERING, AND RADIATIVE CAPTURE CROSS SECTIONS TO ACCOUNT FOR MISSING LEVELS IN THE RESOLVED PARAMETERS. THE RESOLVED PARAMETERS WERE TAKEN FROM THE ENDF/B-III LIBRARY, MAT#1087. THIS EVALUATION USED THE RECOMMENDED PARAMETERS GIVEN IN BNL-325 %2< AS THE PRINCIPAL

COPPER SAI EVAL-1972 M.K. DRAKE, M.P. FRICKE
MATERIAL= 4529 ZA= 29000. AWF = 62.9940 FILE= 1 SECTION= 451

SOURCE OF INFORMATION %1<.

NO UNRESOLVED RESONANCE PARAMETERS WERE GIVEN FOR THIS MATERIAL. CONSIDERABLE STRUCTURE HAS BEEN OBSERVED IN THE TOTAL CROSS SECTION FOR NEUTRON ENERGIES ABOVE 30 KEV AND THIS STRUCTURE WAS REPRESENTED IN FILE 3 RATHER THAN GIVING THE AVERAGE CROSS SECTION WITH UNRESOLVED RESONANCE PARAMETERS.

* * * * * FILE 3 %NEUTRON CROSS SECTIONS< * * * * *

LOW ENERGY CROSS SECTIONS * * * * *

THE TOTAL, ELASTIC SCATTERING AND RADIATIVE CAPTURE CROSS SECTIONS FOR NEUTRONS IN THE ENERGY RANGE FROM 0.00001 TO 10 EV HAVE BEEN TAKEN FROM MAT#1087 %1<. THERE WERE NO NEW EXPERIMENTAL DATA FOR THIS ENERGY RANGE AND THE CROSS SECTIONS IN MAT#1087 WERE CONSIDERED TO BE THE BEST AVAILABLE.

TOTAL CROSS SECTION %MT#1< * * * * *

BETWEEN 30 KEV AND 100 KEV, THE DATA MEASURED BY GARG, ET.AL. %3< WERE USED. IN THIS ENERGY RANGE THERE WAS CONSIDERABLE STRUCTURE IN THE EXPERIMENTAL DATA, BUT IT WAS NOT MEASURED WELL ENOUGH TO OBTAIN RESOLVED RESONANCE PARAMETERS. IN THE EN. REGION FROM 100 KEV TO 1.5 MEV, THE ANL RESULTS OBTAINED BY MEADOWS AND WHALEN %4< WERE USED. IN THE UPPER PORTION OF THIS ENERGY RANGE %1.2 TO 1.5 MEV< THE EXPERIMENTAL DATA WERE AVERAGED OVER 200 KEV ENERGY BANDS SINCE THE VARIATIONS IN THE EXPERIMENTAL DATA APPEARED TO BE MORE STATISTICAL THAN STRUCTURE IN THE CROSS SECTION

VERY POOR QUALITY DATA WERE AVAILABLE FOR THE REGION FROM 1.5 TO 2.3 MEV %5,6<. A SMOOTH CURVE WAS DRAWN FOR THE TOTAL CROSS SECTION. THE CURVE DID NOT GO THROUGH THE AVERAGE OF THE DATA, RATHER THE CURVE WAS DRAWN TO FIT THE BETTER DATA BELOW 1.5 MEV AND ABOVE 2.3 MEV. BETWEEN 2.3 AND 12 MEV, A SMOOTH CURVE WAS DRAWN THROUGH THE FOSTER AND GLASGOW %7< DATA. AN AVERAGE OF THE DATA MEASURED BY FOSTER AND GLASGOW %7<, AIBERGOTTI AND FERGUSON %8<, AND ROBINSON, ET.AL.%9< WERE USED FOR NEUTRON ENERGIES BETWEEN 12 AND 15 MEV. ABOVE 15 MEV A SMOOTH AND SLOWLY DECREASING CURVE WAS DRAWN THROUGH THE AVAILABLE DATA %10,11,12,13<.

* * ELASTIC SCATTERING CROSS SECTION %MT#2< * * * * *

IN THE ENERGY REGION FROM 10 EV TO 30 KEV, THE ELASTIC SCATTERING CROSS SECTION WAS REPRESENTED AS RESOLVED RESONANCE PARAMETERS AND THESE WERE GIVEN IN FILE 2. BETWEEN 1.0 AND 30 KEV A SMALL BACKGROUND CROSS SECTION HAS BEEN INCLUDED IN FILE 3 TO ACCOUNT FOR MISSING LEVELS IN THE RESOLVED RESONANCES. AT ALL OTHER ENERGIES, THE ELASTIC SCATTERING CROSS SECTION WAS OBTAINED BY SUBTRACTING THE NON-ELASTIC CROSS SECTION FROM THE EVALUATED TOTAL CROSS SECTION. THE RESULTING CROSS SECTION WAS COMPARED TO THE AVAILABLE EXPERIMENTAL DATA FOR ELASTIC SCATTERING. IN THE ENERGY REGION FROM 0.3 TO 4.0 MEV, THE EVALUATED CROSS SECTION AGREED VERY WELL WITH THE AVAILABLE MEASUREMENTS %14,15,16,17<. BETWEEN 4 AND 8 MEV, THE EVALUATED CURVE WAS SLIGHTLY HIGHER THAN THE MEASURED DATA OF HOLMQUIST %17<.

* * NON-ELASTIC CROSS SECTION %MT#3< * * * * *

THE NON-ELASTIC CROSS SECTION FOR THE ELEMENT WAS OBTAINED

COPPER SAI EVAL-1972 M.K. DEAKF, M.P. FRICKE
 MATERIAL= 4529 ZA= 29000. AWR = 62.9940 FILE= 1 SECTION= 451

BY EVALUATING THE NON-ELASTIC CROSS SECTIONS FOR THE ISOTOPES. BELOW 600 KEV, THE NON-ELASTIC CROSS SECTION WAS THE SAME AS THE RADIATIVE CAPTURE CROSS SECTION. BETWEEN 600 KEV AND 5 MEV, THE NON-ELASTIC CROSS SECTIONS FOR THE ISOTOPES WERE OBTAINED BY SUMMING THE COMPONENTS. ABOVE 5 MEV, THE NON-ELASTIC CROSS SECTIONS FOR THE ISOTOPES WERE TAKEN TO BE THE SAME AS THE ELEMENT WHICH WAS EVALUATED BY DRAWING A SMOOTH CURVE THROUGH THE EXISTING EXPERIMENTAL DATA $\sigma_{18,19,20,21,22,23,24,25,26,27}$. IN THE ENERGY RANGE FROM 6 TO 9 MEV, THERE WAS A DISCREPANCY BETWEEN THE AVAILABLE EXPERIMENTAL DATA FOR ELASTIC SCATTERING σ_{17} AND NON-ELASTIC CROSS SECTION $\sigma_{18,20}$. THE EVALUATED CROSS SECTION FOR BOTH THE ELASTIC AND NON-ELASTIC CROSS SECTIONS WERE SLIGHTLY HIGHER THAN THE EXPERIMENTAL DATA. THIS WAS DONE TO PRESERVE THE TOTAL CROSS SECTION WHICH WAS EXPERIMENTALLY MEASURED MORE ACCURATELY.

* $\sigma_{N,2N}$ CROSS SECTION $\sigma_{MT\#16}$ * * * * *

THE $\sigma_{N,2N}$ CROSS SECTION WAS OBTAINED FROM EVALUATIONS OF THE $\sigma_{N,2N}$ CROSS SECTIONS FOR THE ISOTOPES. BOTH CU-63 $\sigma_{N,2N}$ AND CU-65 $\sigma_{N,2N}$ CROSS SECTIONS HAVE USED AS CROSS SECTION STANDARDS, CU-65 MORE THAN CU-63.

MANY SETS OF EXPERIMENTAL DATA WERE AVAILABLE FOR CU-63. SOME OF THESE MEASUREMENTS WERE ABSOLUTE AND OTHERS WERE RELATIVE MEASUREMENTS. THE RELATIVE MEASUREMENTS $\sigma_{28,29,30,31,32}$ WERE RE-NORMALIZED TO 0.568 BARNS AT 14.7 MEV, A VALUE WHICH WAS CONSISTENT WITH THE CU-65 $\sigma_{N,2N}$ CROSS SECTION AT THIS ENERGY THE ABSOLUTE VALUES $\sigma_{33,34,35,36}$ ALONG WITH THE RESULTS FROM 14 MEV MEASUREMENTS AND THE RE-NORMALIZED CROSS SECTION VALUES WERE USED TO OBTAIN THE RECOMMENDED CROSS SECTION.

THE CU-65 $\sigma_{N,2N}$ CROSS SECTION WAS TAKEN FROM THE ENDF/B DOSIMETRY LIBRARY. THIS EVALUATION WAS BASED ON MEASUREMENTS BY SANTRY AND BUTLER σ_{37} , PRESTWOOD AND BAYHURST σ_{38} , PAULSEN AND LISKIEN σ_{39} , RAYBURN σ_{31} , AND BORMANN AND LAMMERS σ_{36} .

* $\sigma_{N,P}$ AND $\sigma_{N,N-P}$ CROSS SECTIONS $\sigma_{MT\#28,103}$ * * * * *

THESE CROSS SECTIONS WERE OBTAINED FOR THE ELEMENT BY EVALUATING THE RESPECTIVE CROSS SECTIONS FOR THE ISOTOPES. THERE WAS VERY LITTLE EXPERIMENTAL DATA AVAILABLE FOR CU-63 $\sigma_{N,P}$ OR CU-63 $\sigma_{N,N-P}$. THESE CROSS SECTIONS WERE OBTAINED FROM STATISTICAL MODEL CALCULATIONS. THE CALCULATED RESULTS WERE NORMALIZED AT 14.5 MEV TO THE SPARSE EXPERIMENTAL DATA $\sigma_{40,41,42,43}$.

THE $\sigma_{N,P}$ CROSS SECTION FOR CU-65 HAS BEEN MEASURED FROM THRESHOLD $\sigma_{\text{ABOUT 3 MEV}}$ TO 20 MEV. THE DATA MEASURED BY SANTRY AND BUTLER σ_{37} WERE USED FOR THE COMPLETE ENERGY RANGE. THE MAGNITUDE OF THE CROSS SECTION NEAR 14 MEV WAS WELL ESTABLISHED BY SEVERAL OTHER MEASUREMENTS. FEW AND WIDELY DISAGREEING VALUES HAVE BEEN MEASURED FOR THE $\sigma_{N,N-P}$ CROSS SECTION. THE SAME PROCEDURE AS USED FOR CU-63 $\sigma_{N,N-P}$ WAS USED TO OBTAIN THE CU-65 $\sigma_{N,N-P}$ CROSS SECTION.

* $\sigma_{N,\text{ALPHA}}$ AND $\sigma_{N,N-\text{ALPHA}}$ CROSS SECTIONS $\sigma_{MT\#22,107}$ * * * *

THE CROSS SECTIONS FOR THE ELEMENT WERE OBTAINED FROM EVALUATED CROSS SECTIONS FOR THE ISOTOPES. THE $\sigma_{N,\text{ALPHA}}$ CROSS

COPPER SAI EVAL-1972 M.K. DRAKE, M.D. FRICKE
 MATERIAL= 4529 ZA= 29000. AWE = 62.9940 FILE= 1 SECTION= 451

SECTION FOR CU-63 WAS TAKEN FROM THE ENDF/E DOSIMETRY FILE. THIS EVALUATION WAS BASED ON THE DATA OF PAULSEN AND LISKIE ⁴⁴. THE ¹N,N-ALPHA CROSS SECTION FOR CU-63 WAS BASED ON A STATISTICAL MODEL CALCULATION WHICH WAS NORMALIZED TO AN EXPERIMENTAL VALUE AT 14.8 MEV MEASURED BY IRFAN AND JACK ⁴⁵.

THE ¹N,ALPHA CROSS SECTION FOR CU-65 WAS BASED ON A STATISTICAL MODEL CALCULATION AND THE CALCULATED CURVE WAS NORMALIZED TO THE AVAILABLE EXPERIMENTAL DATA ^{46,47,48} AT 14 MEV. THE ¹N,N-ALPHA CROSS SECTION WAS BASED ON THE EXPERIMENTAL DATA OF SANTRY AND BUTLER ³⁷, BRAMLITT AND FINK ⁴⁶, AND KANTELE AND GARDNER ⁴⁹.

* * * * * RADIATIVE CAPTURE CROSS SECTION ¹MT#102 * * * * *

ABOVE 30 KEV, THE RADIATIVE CAPTURE CROSS SECTION WAS OBTAINED BY EVALUATING THIS CROSS SECTION FOR THE ISOTOPIES. BETWEEN 30 KEV AND 3 MEV, THE CU-63 ¹N,G CROSS SECTION WAS BASED ON THE EXPERIMENTAL DATA OF DOVBENKO, ET.AL. ⁵⁰ AND ZAIKIN, ET.AL. ⁵¹. THE RECOMMENDED CURVE WAS DRAWN SLIGHTLY HIGHER THAN THE DOVBENKO DATA AND LOWER THAN THE ZAIKIN DATA. AT 14 MEV, THE RECOMMENDED CURVE WAS DRAWN THROUGH THE DATA OF PERKIN ⁵² AND A RECENT COLUMBIA VALUE ⁵³.

THE CU-65 ¹N,G CROSS SECTION HAD BEEN MEASURED SEVERAL TIMES ABOVE 30 KEV. THE RESULTS FROM THESE MEASUREMENTS WERE NOT IN GOOD AGREEMENT. THE RECOMMENDED CURVE WAS DRAWN THROUGH 46 MB AT 25 KEV, WHICH WAS AN AVERAGE OF SEVERAL MONO-ENERGETIC MEASUREMENTS BETWEEN 20 AND 25 KEV. ABOVE 30 KEV, THE RECOMMENDED CURVE WAS DRAWN ON THE LOW SIDE OF VALUES MEASURED BY TOLSTIKOV ⁵⁴ AND STAVISSKII AND TOLSTIKOV ⁵⁵. BETWEEN 600 KEV AND 3 MEV, THE DATA MEASURED BY ZAIKIN, ET.AL, WERE USED.

* * * * * INELASTIC SCATTERING CROSS SECTIONS ¹MT#4,51,52,...,91 * * *

THE INELASTIC SCATTERING CROSS SECTION WAS MADE UP OF 11 DISCRETE LEVELS AND A CONTINUUM. SEVERAL SETS OF INELASTIC SCATTERING AND GAMMA RAY PRODUCTION CROSS SECTION MEASUREMENTS WERE USED TO OBTAIN THE LEVEL EXCITATION CROSS SECTIONS FOR NEUTRON ENERGIES UP TO 1.5 MEV ^{14,56,57,58,59} FOR THE 0.67 AND 0.912 MEV LEVELS IN CU-63 AND THE 0.77 AND 1.115 MEV LEVELS IN CU-65. THE HELENE CODE WAS USED TO OBTAIN LEVEL EXCITATION FUNCTIONS FOR THE HIGHER ENERGY LEVELS. THE DWUCK CODE WAS USED TO ESTIMATE DIRECT INTERACTION CONTRIBUTIONS. ABOVE 1.5 MEV THE MODEL CODES WERE USED TO ESTIMATE ALL LEVEL EXCITATION CROSS SECTIONS AND THE CONTINUUM PART.

* * * * * FILE 4 ANGULAR DISTRIBUTIONS FOR SECONDARY NEUTRONS

* * * * * ELASTIC SCATTERING ¹MT#2 * * * * *

BELOW 100 KEV THE ANGULAR DISTRIBUTIONS FOR ELASTICALLY SCATTERED NEUTRONS WERE TAKEN TO BE ISOTROPIC. ABOVE 100 KEV THE ANGULAR DISTRIBUTIONS WERE OBTAINED BY FITTING EXPERIMENTAL DATA WITH LEGENDRE COEFFICIENTS. BETWEEN 100 KEV AND 600 KEV THE DATA OF LANE, ET.AL ⁶⁰ WERE USED. BETWEEN 600 KEV AND 1.2 MEV, THE DATA MEASURED BY COX ⁶¹ WERE USED AND BETWEEN 1.5 AND 8 MEV THE MEASUREMENT MADE BY HOLMQUIST ¹⁷ WAS USED. NEAR 14 MEV THE RESULTS FROM SEVERAL MEASUREMENTS WERE USED ^{62,63,64}. FROM 8

COPPER SAI EVAL-1972 M.K. DRAKE, M.P. FRICKE
 MATERIAL= 4529 ZA= 29000. AWF = 62.9940 FILE= 1 SECTION= 451

TO 14 MEV AND ABOVE 15 MEV, THE ANGULAR DISTRIBUTIONS WERE CALCULATED USING THE HELENE AND DWUCK CODES.

* *NON-ELASTIC REACTION %MT#51,52,...,91,22,28,16< * * * * *

ANGULAR DISTRIBUTIONS FOR NEUTRONS FROM INELASTIC LEVEL REACTIONS WERE OBTAINED FROM THE HELENE CODE %COMPOUND NUCLEUS PART< AND THE DWUCK CODE %DIRECT INTERACTION PART<. CALCULATIONS WERE MADE FOR THE FIRST 3 LEVELS IN EACH ISOTOPE. THERE WAS REASONABLY GOOD AGREEMENT BETWEEN THE CALCULATED DISTRIBUTIONS FOR THE 0.77 AND 1.115 MEV LEVELS AT 2.33 MEV AND A MEASUREMENT BY ROGERS ET.AL.%65<. ALL OTHER LEVELS, THE CONTINUUM, AND ALL OTHER NEUTRON PRODUCING REACTIONS WERE ASSUMED TO HAVE ISOTROPIC DISTRIBUTIONS IN THE C.M. SYSTEM.

* * * * * FILE 5 %ENERGY DISTRIBUTIONS FOR SECONDARY NEUTRONS<

THE ENERGY DISTRIBUTIONS FOR INELASTIC SCATTERING CONTINUUM %MT#91< AND %N,2N< %MT#16< WERE BASED ON THE STATISTICAL MODEL. AN EFFECTIVE NUCLEAR TEMPERATURE OF 1.02 MEV AT 14.1 MEV WAS USED. THE EFFECTIVE NUCLEAR TEMPERATURE OF THE SECOND NEUTRON FOR THE %N,2N< REACTION WAS 0.4 MEV AT 14 MEV.

* * * * * FILE 12 %MULTIPLICITIES FOR RADIATIVE CAPTURE< * * * * *

THE MULTIPLICITIES FOR RADIATIVE CAPTURE GAMMA RAYS WAS TAKEN FROM A THERMAL NEUTRON MEASUREMENT MADE BY ORPHAN, ET.AL.%66<. THE MULTIPLICITIES WERE INCREASED AS A FUNCTION OF THE NEUTRON ENERGY TO PRESERVE TOTAL ENERGY RELEASED.

* * * * * FILE 13 %N,N-G< AND %N,2N-G< GAMMA RAY PRODUCTION

CROSS SECTIONS * * * * *

THE TOTAL PRODUCTION CROSS SECTION DUE TO THE %N,N-G< REACTION WAS MADE UP OF 5 DISCRETE LINES AND A CONTINUUM PART. THE GAMMA RAY PRODUCTION CROSS SECTIONS AND THE ENERGY DISTRIBUTIONS OF THE SECONDARY GAMMA RAYS WERE OBTAINED BY USING A MODIFIED VERSION OF THE SPECT10 CODE. CALCULATIONS WERE MADE FOR EACH ISOTOPE USING THE EVALUATED DISCRETE LEVEL EXCITATION CROSS SECTIONS, THE CONTINUUM CROSS SECTION, BRANCHING RATIOS, AND NUCLEAR LEVEL DENSITY DATA. THE CALCULATED PRODUCTION CROSS SECTIONS FOR THE DISCRETE LINES WERE INCREASED SLIGHTLY %ABOUT 20 PERCENT< NEAR 15 MEV TO OBTAIN AGREEMENT WITH A MEASUREMENT MADE BY JONSSON, ET. AL. %67<.

SIMILAR CALCULATIONS WERE MADE FOR THE %N,2N-G< REACTION. ALL GAMMA RAYS WERE TREATED AS A CONTINUUM.

* * * * * FILE 15 %ENERGY DISTRIBUTIONS FOR SECONDARY GAMMA RAYS<

THE SPECT10 CODE WAS USED TO ESTIMATE THE ENERGY DISTRIBUTIONS FOR ALL SECONDARY GAMMA RAYS FROM INELASTIC SCATTERING AND %N,2N< REACTIONS. THE ENERGY DISTRIBUTIONS FOR GAMMA RAYS FROM RADIATIVE CAPTURE WERE TAKEN FROM A MEASUREMENT MADE BY ORPHAN, ET. AL. %66<.

%1< J.M.CTTER,ET.AL., REPORT AI-AEC-1271 %1968<

%2< M.D.GOLDBERG, ET.AL., BNL-325, 2ND ED., SUPPL. 2, VOL IIA %1966<

%3< J.B.GARG, J.RAINWATER, AND W.W.HAVENS,JR., REPORT EANDC%US<- 54 L %1964<

%4< J.W.MEADOWS AND J.F. WHALEN %ANIK FRI.COMM. %1972<

- %5< M.N.NIKLAYEV, ET.AL., PHYS OF FAST AND INTERMEDIATE
REACTORS, VOL.I, %1961<
- %6< D.W.MILLER, ET.AL., PHYS.REV. 88, 1042 %1952<
- %7< D.G.FOSTER, JR. AND D.W. GLASGOW, PHYS.REV. 3, C576 %1971<
- %8< J.C.ALBERTGOTTI AND J.M.FERGUSON, NUCL.PHYS. 82, 652 %1966<
- %9< W.K.ROBINSON, ET.AL., AMERICAN J.PHYS. 37, 482 %1969<
- %10< P.H.BOWEN, ET.AL., NUCL.PHYS. 22, 640 %1960<
- %11< J.M.PETERSON, ET.AL., PHYS.REV. 120, 521 %1960<
- %12< R.B.DAY AND R.L.HENKEL, PHYS.REV. 92, 358 %1958<
- %13< M.MAZAFI, ET.AL., PHYS. REV. 100, 972 %1955<
- %14< A.B.SMITH, ET.AL., PHYS. REV. 135, 76 %1964<
- %15< I.A.KORZH, ET.AL., AT. EN. 16, 260 %1964<
- %16< L.YA.KASAKOVA, ET.AL., CONF. ON NUCLEAR STRUCTURE STUDY
WITH NEUTRONS, P 200, ANTWERP %1965<
- %17< B.HOLMQVIST, ARKIV FYSIK 38, 403 %1968<
- %18< J.R.BEYSTER, ET.AL., PHYS.REV. 104, 1319 %1956<
- %19< H.L.TAYLOR, ET.AL., PHYS.REV. 100, 174 %1955<
- %20< W.P.BALL, ET.AL., PHYS.REV. 110, 1392 %1958<
- %21< T.W.BONNER AND J.C. SLATTERY, PHYS.REV. 113, 1088 %1959<
- %22< G.M.HAAS AND P.L.OKHUYSEN, PHYS.REV. 132, 1211 %1963<
- %23< D.D.PHILLIPS, ET.AL., PHYS.REV. 88, 600 %1952<
- %24< M.H.MAC GREGOR, ET.AL., PHYS.REV. 108, 726 %1957<
- %25< D.DIDIER, ET.AL., REPORT FANIC%F< - 49 L %1963<
- %26< A.CHATTERJEE AND A.M.GHOSH, PHYS.REV. 161, 1181 %1967<
- %27< YU.G.DEGTYAREV AND V.G.NADICCHII, AT.EN. 11, 397 %1961<
- %28< D.R.KOCHLER AND W.L.ALFORD, REPORT ACMC-RR-62-1 %1969<
- %29< A.V.COHEN AND P.H.WHITE, NUCL.PHYS. 1, 73 %1956<
- %30< J.C.CSIKAI AND G.PETO, ACTA PHYS. ACAD. SCI. HUNGARICAE
23, 87 %1967<
- %31< L.A.RAYBURN, PHYS.REV. 130, 731 %1963<
- %32< R.N.GILVER AND E.WEIGOLD, NUCL.PHYS. 29, 309 %1962<
- %33< W.E.THOMSON AND J.M.FERGUSON, PHYS.REV. 118, 228 %1960<
- %34< M.BORMANN, ET.AL., Z.PHYSIK 166, 477 %1962<
- %35< H.LISKIEN AND A.PAULSEN, J.NUCL.ENERGY A/B 19, 73 %1965<
- %36< M.BORMANN AND B.LAMMERS, NUCL.PHYS. A130, 195 %1969<
- %37< D.C.SANTRY AND J.P.BUTLER, CAN.J.PHYS. 44, 1183 %1966<
- %38< R.J.PRESTWOOD AND E.P.EAYHURST, PHYS.REV. 121, 1438 %1961<
- %39< A.PAULSEN AND H.LISKIEN, NUKLEONIK 7, 117 %1965<
- %40< D.L.ALIAN, NUCL.PHYS. 24, 274 %1961<
- %41< R.S.STORFY, ET.AL., PROC.PHYS.SOC. 75, 526 %1960<
- %42< L.COLLI, ET.AL., NUOVO CIMENTO 13, 730 %1959<
- %43< D.L.ALIAN, PROC.PHYS.SOC. 70, 195 %1957<
- %44< A.PAULSEN, NUKLEONIK 10, 91 %1967<
- %45< M.IRFAN AND W.JACK, PROC.PHYS.SOC. 81, 808 %1963<
- %46< E.T.BRAMLITT AND R.W.FINK, PHYS.REV. 131, 2649 %1963<
- %47< I.L.PRIESS AND R.W.FINK, NUCL.PHYS. 15, 626 %1960<
- %48< D.L.CLAYTOR, DISSERTATION ABSTR. 30B, 2850 %1969<
- %49< J.KANTELE AND D.G.GARDNER, NUCL.PHYS. 35, 353 %1962<
- %50< A.G.DOVHENKO, ET.AL., REPORT INDC-260 F, P 11 %1969<
- %51< G.G.ZAIKIN, ET.AL., AT.EN. 25, 526 %1968<

COPPER SAI EVAL-1972 M.K. DEAKE, M.P. FRICKE
MATERIAL= 4529 ZA= 29000. AWR = 62.9940 FILE= 1 SECTION= 451

%52< J.I.PERKIN, PROC.PHYS.SOC. 72, 505 %1958<
%53< M.STAMATELATOS, PRI.COMM. %1972<
%54< V.A.TOISTIKOV, ET.AL., AT.EN. 17, 505 %1964<
%55< YU.YA.SIAVISSKII AND V.A.TOISTIKOV, AT.EN. 10, 508 %1961<
%56< N.P.GIAZKOV, AT.EN. 15,416 %1963<
%57< A.B.TUCKER, ET.AL., PHYS.REV. 137, 1181 %1965<
%58< B.HOLMQVIST AND T.WIEDLING, ARKIV FYSIK 35, 71 %1967<
%59< K.NISHIMURA, ET.AL., NUCL.PHYS. 70, 421 %1965<
%60< R.C.LANE, ET.AL., ANN.PHYS. 12, 135 %1961<
%61< S.A.COX, BULL.AM.PHYS.SOC 8, 478 %1963<
%62< J.H.COON, ET.AL., PHYS.REV. 111, 250 %1958<
%63< S.BERKE, ET.AL., NUCL.PHYS. 6, 210 %1958<
%64< B.YA.GUZHOVSKI, AT.EN. 11, 395 %1961<
%65< W.L.ROGERS, ET.AL., REPORT CCC-1573-33 %1967<
%66< V.J.OREHAN, ET.AL., REPORT GA-10248 %1970<
%67< B.JONSSON, ET.AL., ARKIV FYSIK 39, 295 %1969<

COPPER SAI EVAL-1972 M.K. DRAKE, M.P. FRICK
MATERIAL= 4529 ZA= 29000. AWR = 62.9940 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	GENERAL COMMENTS	381
2	151	RESONANCE DATA	57
3	1	TOTAL	177
3	2	ELASTIC	170
3	3	NON-ELASTIC	171
3	4	TOTAL INELASTIC	66
3	16	(N,2N)	10
3	17	(N,3N)	4
3	22	(N,N*) ALPHA	10
3	28	(N,N*) E	11
3	51	(N,N*) 1-ST EXCITED	54
3	52	(N,N*) 2-ND EXCITED	47
3	53	(N,N*) 3-RD EXCITED	40
3	54	(N,N*) 4-TH EXCITED	34
3	55	(N,N*) 5-TH EXCITED	29
3	56	(N,N*) 6-TH EXCITED	27
3	57	(N,N*) 7-TH EXCITED	27
3	58	(N,N*) 8-TH EXCITED	25
3	59	(N,N*) 9-TH EXCITED	25
3	60	(N,N*) 10-TH EXCITED	22
3	61	(N,N*) 11-TH EXCITED	22
3	91	(N,N*) CONTINUUM	22
3	102	(N,GAMMA)	139
3	103	(N,E)	72
3	104	(N,D)	11
3	106	(N,HE3)	9
3	107	(N,ALPHA)	17
3	251	MU BAR	18
3	252	XI	18
3	253	GAMMA	18
4	2	ELASTIC	188
4	16	(N,2N)	10
4	17	(N,3N)	10
4	22	(N,N*) ALPHA	10
4	28	(N,N*) E	10
4	51	(N,N*) 1-ST EXCITED	91
4	52	(N,N*) 2-ND EXCITED	91
4	53	(N,N*) 3-RD EXCITED	91
4	54	(N,N*) 4-TH EXCITED	91
4	55	(N,N*) 5-TH EXCITED	85
4	56	(N,N*) 6-TH EXCITED	10
4	57	(N,N*) 7-TH EXCITED	85
4	58	(N,N*) 8-TH EXCITED	10
4	59	(N,N*) 9-TH EXCITED	10
4	60	(N,N*) 10-TH EXCITED	10
4	61	(N,N*) 11-TH EXCITED	10
4	91	(N,N*) CONTINUUM	10
5	16	(N,2N)	91
5	17	(N,3N)	7
5	22	(N,N*) ALPHA	7

COPPER SAI EVAL-1972 M.K. DRAKE, M.P. FRICKE
 MATERIAL= 4529 ZA= 29000. AWF = 62.9940 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
5	28	(N,N*) E	7
5	91	(N,N*) CONTINUUM	199
12	102	(N,GAMMA)	6
13	3	NCN-ELASTIC	180
14	3	NCN-ELASTIC	1
14	102	(N,GAMMA)	1
15	3	NCN-ELASTIC	203
15	102	(N,GAMMA)	22
23	501	TOTAL PHCTCN	18
23	502	RAYLEIGH SCATTERING	18
23	504	COMPTON SCATTERING	18
23	516	PAIR PRODUCTION	9
23	602	PHOTOELECTRIC EFFECT	18

ZN ORNL EVAL-1973 C Y FU, F G PEREY
MATERIAL= 4530 ZA= 30000. AWR = 64.8080 FILE= 1 SECTION= 451

DIST-JAN74 MCD 0-JAN74

***** DNA 4530 MCD 0 *****

THIS EVALUATION CONTAINS ONLY THE GAMMA-RAY-PRODUCTION CROSS-SECTION FILES FOR SPECIAL APPLICATIONS.

THE (N,XGAMMA) CROSS SECTION (FILE 13) AND SECONDARY GAMMA-RAY ENERGY DISTRIBUTION (FILE 15) FOR INCIDENT NEUTRON ENERGIES FROM 0.84 MEV TO 20 MEV ARE TAKEN FROM MEASUREMENT (1). THE MEASUREMENT WAS MADE AT AN ANGLE OF 125 DEGREES FROM THE INCIDENT NEUTRON BEAM, USING TIME-OF-FLIGHT TECHNIQUES (ORELA) AND GE(LI) DETECTOR. THE RESULT IS FOUND TO BE IN GOOD AGREEMENT WITH AN EARLIER MEASUREMENT (1) USING NAI DETECTOR ON A VAN DE GRAAF ACCELERATOR. THE ANGULAR DISTRIBUTION (FILE 14) IS ASSUMED TO BE ISOTROPIC.

THE PRODUCTION OF GAMMA RAYS BY 0.00001 EV - 0.84 MEV NEUTRONS IS ASSUMED TO BE DUE TO CAPTURE ONLY. THE THERMAL-NEUTRON-CAPTURE GAMMA-RAY SPECTRUM GIVEN BY RASMUSSEN ET. AL. (2) AGREES WELL WITH THAT OF MAERKER AND MACKENTHALER (3) AND IS ADOPTED. THE FEW PRIMARY GAMMA LINES GIVEN BY BIRD ET. AL. (4) FOR 10-80 KEV NEUTRON CAPTURE STRONGLY POPULATE SOME FINAL STATES DIFFERENT FROM THOSE RESULTING FROM THERMAL CAPTURE. HOWEVER, THE GROSS SHAPES OF THE TWO SPECTRA ARE SIMILAR. WE THEN CONSTRUCT TWO NONTHERMAL-CAPTURE GAMMA-RAY SPECTRA, AT 250 KEV AND 500 KEV NEUTRON ENERGIES RESPECTIVELY, BY ADJUSTING THE ENERGIES OF THE PRIMARY GAMMA RAYS OF THE THERMAL SPECTRUM TO CONSERVE ENERGY. ABOUT HALF OF THE ADJUSTED PRIMARY TRANSITIONS IS ASSUMED.

THE GAMMA-RAY-PRODUCTION CROSS SECTION FROM 0.00001 EV TO 0.84 MEV IS ASSUMED TO BE 2.3933 (THE MULTIPLICITY OF THE THERMAL SPECTRUM (3)) TIMES THE CAPTURE CROSS SECTION. THE 0.0253 EV CAPTURE CROSS SECTION IS TAKEN TO BE 1.10 BARNS (5). THE 1/V LAW IS ASSUMED TO HOLD UP TO 20 EV. FROM 20 EV TO 15 KEV THE CAPTURE RESONANCES ARE CALCULATED USING THE AVAILABLE PARAMETERS (5) AND SOME ASSUMED WIDTHS. THE RESULT IS ADOPTED ONLY UP TO 5 KEV WHERE THE RESONANCES ARE MOSTLY RESOLVED AND THE PARAMETERS REASONABLY CERTAIN. THE 1/V TAIL IS ADDED TO THESE RESONANCES TO COMPENSATE FOR THE MISSING RESONANCES AND THE EFFECTS OF THE DISTANT RESONANCES NOT INCLUDED IN THE CALCULATION. FROM 5 KEV TO 100 KEV ALLEN (6) HAS DONE AN UNRESOLVED-RESONANCE CALCULATION WHICH AGREES WITH THE FEW SCATTERED DATA POINTS (5). WE ADOPTED HIS RESULT FOR THE 10 TO 20 KEV RANGE WHERE NO MEASUREMENT HAS BEEN MADE, AND DRAW A SMOOTH CURVE FROM HIS VALUE AT 10 KEV TO JOIN THE RESOLVED-RESONANCE REGION. FROM 20 KEV TO 0.84 MEV THE EVALUATION IS BASED ON THE AVAILABLE DATA (5). THE PRODUCTION CROSS SECTION OBTAINED IN THIS WAY AT 0.84 MEV IS FOUND TO BE CONSISTENT WITH DICKEN'S MEASURED VALUE FOR THE 0.84-0.99 MEV BIN, WHERE CAPTURE REMAINS THE PREDOMINANT REACTION. THIS SEEMS TO INDICATE THAT THE CONSTANCY OF THE GAMMA-RAY MULTIPLICITY

ZN ORNL EVAL-1973 C Y FU, F G PEREY
MATERIAL= 4530 ZA= 30000. AWE = 64.8080 FILE= 1 SECTION= 451

FROM NEUTRON CAPTURE IS A REASONABLE ASSUMPTION IN THE PRESENT SITUATION.

1. J. K. DICKENS, PRIVATE COMMUNICATION(1973).
2. N. C. RASMUSSEN ET. AL., GA-10248(1970).
3. R. E. MAERKER AND P. J. MUCKENTHALER, OENL-4475(1970).
4. J. R. BIRD ET. AL., NUCLEAR DATA TABLES, VOL 11, NO 6(1973).
5. M. D. GOLDBERG ET. AL., ENL-325(1966).
6. B. J. ALLEN, AAEC/TM565(1970).

ZN ORNL EVAL-1973 C Y FU, F G PEREY
MATERIAL= 4530 ZA= 30000. AWR = 64.8080 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	GENERAL COMMENTS	65
13	3	NCN-ELASTIC	58
14	3	NCN-ELASTIC	1
15	3	NCN-ELASTIC	1000

PU-239 IASL EVAL-MAY72 R. HUNTER AND J. STEWART
MATERIAL= 4539 ZA= 94239. AWR = 236.9990 FILE= 1 SECTION= 451

DIST-MAR73 MCD 0-MAR73

***** DNA 4539 MCD 0 *****

FILE 23 DATA - PHOTON INTERACTION - TAKEN FROM RSIC
DATA LIBRARY %DLC-7 D< IS BASED ON DATA FROM
UCRL-50174 SEC. II, REV. 1969 BY MCMASTER ET AL.
AND UCRL-50400, VOL. VI BY PLECHATY AND TERRALL.

PU-239 CROSS SECTIONS CONTAINED IN THE LASL TD-DIVISION LIBRARY.
EVALUATION IN THE ENERGY RANGE OF 7.85 KEV TO 20.0 MEV WAS
CARRIED OUT BY R. HUNTER AT LASL.

GENERAL DESCRIPTION

ALL CROSS SECTIONS BELOW 25.0 KEV, EXCEPT FOR INELASTIC
SCATTERING WERE TAKEN FROM ENDF/B-III %MAT1159<. TOTAL CROSS
SECTION BASED ON DATA OF FOSTER AND GLASGOW %P.R.C3,576%71<<,
HIRDON AND LANGSDORF %ANL-5175<, AND MEADE %AERE-NP/R1643<.
DATA OF SCHWARTZ WERE RECEIVED TOO LATE TO BE INCLUDED IN
THIS EVALUATION BUT WILL BE CONSIDERED IN THE NEXT UPDATE.

ELASTIC CROSS SECTION AND ANGULAR DISTRIBUTIONS WERE TAKEN
FROM COPPOLA AND KNITTER %Z.PHYS. 232, 286%70< 228, 286%69<<
AND KAMMERDIENER %UCRL-51232<.

FISSION CROSS SECTION SEPARATED INTO FIRST, SECOND, AND THIRD
CHANCE FISSION %MT#19, 20, 21<, WITH MT#18 BEING SUM OF
THESE. PREFISSION NEUTRONS ARE DISTRIBUTED ACCORDING TO
EVAPORATION SPECTRUM. NU-BAR IS BASED ON DATA OF SOLEILAC ET
AL. %J. NUCL. EN. 23, 257%69<<.

FIVE DIRECT-INTERACTION INELASTIC LEVELS ARE INCLUDED BETWEEN
1.0 AND 3.0 MEV, WITH FORWARD-PEAKED ANGULAR DISTRIBUTIONS,
AS INDICATED BY DATA OF KAMMERDIENER.

PHOTON PRODUCTION DATA EVALUATED BY STEWART AND HUNTER IN
MAY 1972. %LA-4901<

FOR DETAILS OF EVALUATION BELOW 25.0 KEV, SEE FILE 1
INFORMATION FOR MAT 1159.

COMPLETE REPORT OF EVALUATION, INCLUDING INTEGRAL TESTING,
WILL BE PUBLISHED AS LA REPORT.

PU-239 IASL EVAL-MAY72 R. HUNTER AND L. STEWART
 MATERIAL= 4539 ZA= 94239. AWR = 236.9990 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	GENERAL COMMENTS	154
1	452	NEUTRONS PER FISSION	4
1	453	DECAY CHAIN DATA	11
1	454	FISSION YIELD DATA	243
2	151	RESONANCE DATA	357
3	1	TOTAL	272
3	2	ELASTIC	90
3	4	TOTAL INELASTIC	41
3	16	(N,2N)	15
3	17	(N,3N)	9
3	18	TOTAL FISSION	251
3	19	(N,F)	240
3	20	(N,N* F)	9
3	21	(N,2N F)	10
3	51	(N,N*) 1-ST EXCITED	27
3	52	(N,N*) 2-ND EXCITED	17
3	53	(N,N*) 3-FD EXCITED	21
3	54	(N,N*) 4-TH EXCITED	18
3	55	(N,N*) 5-TH EXCITED	17
3	56	(N,N*) 6-TH EXCITED	15
3	57	(N,N*) 7-TH EXCITED	15
3	58	(N,N*) 8-TH EXCITED	15
3	59	(N,N*) 9-TH EXCITED	14
3	60	(N,N*) 10-TH EXCITED	13
3	61	(N,N*) 11-TH EXCITED	13
3	62	(N,N*) 12-TH EXCITED	13
3	63	(N,N*) 13-TH EXCITED	13
3	64	(N,N*) 14-TH EXCITED	12
3	65	(N,N*) 15-TH EXCITED	12
3	66	(N,N*) 16-TH EXCITED	11
3	67	(N,N*) 17-TH EXCITED	10
3	68	(N,N*) 18-TH EXCITED	10
3	69	(N,N*) 19-TH EXCITED	10
3	70	(N,N*) 20-TH EXCITED	10
3	71	(N,N*) 21-TH EXCITED	18
3	72	(N,N*) 22-TH EXCITED	17
3	73	(N,N*) 23-TH EXCITED	16
3	74	(N,N*) 24-TH EXCITED	15
3	75	(N,N*) 25-TH EXCITED	15
3	91	(N,N*) CONTINUUM	25
3	102	(N,GAMMA)	95
3	103	(N,P)	11
3	104	(N,D)	4
3	105	(N,T)	5
3	107	(N,ALPHA)	16
3	251	MU BAE	12
3	252	XI	12
3	253	GAMMA	12
4	2	ELASTIC	168
4	16	(N,2N)	10

PU-239 LASL EVAL-MAY72 R. HUNTER AND L. STEWART
 MATERIAL= 4539 ZA= 94239. AWR = 236.9990 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
4	17	(N,3N)	10
4	18	TOTAL FISSION	10
4	19	(N,F)	10
4	20	(N,N* F)	10
4	21	(N,2N F)	10
4	51	(N,N*) 1-ST EXCITED	10
4	52	(N,N*) 2-ND EXCITED	10
4	53	(N,N*) 3-RC EXCITED	10
4	54	(N,N*) 4-TH EXCITED	10
4	55	(N,N*) 5-TH EXCITED	10
4	56	(N,N*) 6-TH EXCITED	10
4	57	(N,N*) 7-TH EXCITED	10
4	58	(N,N*) 8-TH EXCITED	10
4	59	(N,N*) 9-TH EXCITED	10
4	60	(N,N*) 10-TH EXCITED	10
4	61	(N,N*) 11-TH EXCITED	10
4	62	(N,N*) 12-TH EXCITED	10
4	63	(N,N*) 13-TH EXCITED	10
4	64	(N,N*) 14-TH EXCITED	10
4	65	(N,N*) 15-TH EXCITED	10
4	66	(N,N*) 16-TH EXCITED	10
4	67	(N,N*) 17-TH EXCITED	10
4	68	(N,N*) 18-TH EXCITED	10
4	69	(N,N*) 19-TH EXCITED	10
4	70	(N,N*) 20-TH EXCITED	10
4	71	(N,N*) 21-TH EXCITED	31
4	72	(N,N*) 22-TH EXCITED	31
4	73	(N,N*) 23-TH EXCITED	31
4	74	(N,N*) 24-TH EXCITED	31
4	75	(N,N*) 25-TH EXCITED	28
4	91	(N,N*) CONTINUUM	10
5	16	(N,2N)	9
5	17	(N,3N)	9
5	18	TOTAL FISSION	10
5	19	(N,F)	10
5	20	(N,N* F)	27
5	21	(N,2N F)	22
5	91	(N,N*) CONTINUUM	9
12	4	TOTAL INELASTIC	140
12	18	TOTAL FISSION	4
12	102	(N,GAMMA)	4
13	3	NCN-ELASTIC	6
14	3	NCN-ELASTIC	1
14	4	TOTAL INELASTIC	1
14	18	TOTAL FISSION	1
14	102	(N,GAMMA)	1
15	3	NCN-ELASTIC	123
15	4	TOTAL INELASTIC	30
15	18	TOTAL FISSION	58
15	102	(N,GAMMA)	43

PH-239 IASL EVAL-MAY72 R. HUNTER AND L. STEWART
 MATERIAL= 4539 ZA= 94239. AWR = 236.9990 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
23	501	TOTAL PHOTON	25
23	502	RAYLEIGH SCATTERING	25
23	504	COMPTON SCATTERING	25
23	516	PAIR PRODUCTION	10
23	602	PHOTOELECTRIC EFFECT	25

PU-240 IASL EVAL-MAY72 R. HUNTER AND L. STEWART
MATERIAL= 4540 ZA= 94240. AWR = 237.9920 FILE= 1 SECTION= 451

DIST-MAR73 MCD 0-MAR73

***** DNA 4240 MCD 0 *****

FILE 23 DATA - PHOTON INTERACTION - TAKEN FROM RSIC
DATA LIBRARY %DLC-7 D< IS BASED ON DATA FROM
UCRL-50174 SEC. II, REV. 1969 BY MCMASTER ET AL.
AND UCRL-50400, VOL. VI BY PLECHATY AND TERRALL.

PU-240 CROSS SECTIONS CONTAINED IN THE IASL TD-DIVISION
LIBRARY. EVALUATION IN THE ENERGY RANGE OF 40 KEV TO 20 MEV
WAS CARRIED OUT BY R. HUNTER AT IASL.

GENERAL DESCRIPTION

ALL CROSS SECTIONS BELOW 40 KEV WERE TAKEN FROM ENDF/B-III
%MAT1105<. TOTAL, ELASTIC, AND INELASTIC CROSS SECTIONS
BASED ON DATA OF SMITH ET AL. %NSE 47, 19%72<<. FISSION CROSS
SECTION BASED ON DATA OF SAVIN ET AL. %AT. EN. 29, 938%70<
AND INDC%CCP<-8/U%70<< PLUS CIDER DATA. NU-BAR BASED ON
DATA OF SAVIN ET AL. PLUS DE VROEY ET AL. %JNE20, 191%66<<.

FISSION CROSS SECTION SEPARATED INTO FIRST, SECOND, AND THIRD
CHANCE FISSION %MT#19, 20, 21<, WITH MT#18 BEING SUM OF
THESE. PREFISSION NEUTRONS ARE DISTRIBUTED ACCORDING TO
EVAPORATION SPECTRUM.

FOUR DIRECT - INTERACTION INELASTIC LEVELS ARE INCLUDED
BETWEEN 2.0 AND 5.0 MEV, WITH FORWARD-PEAKED ANGULAR
DISTRIBUTIONS, AS INDICATED BY DATA ON PU-239 REPORTED BY
KAMMERDIENER %UCRL-51232<.

PHOTON PRODUCTION DATA EVALUATED BY HUNTER AND STEWART IN
MAY 1972 %LA-4901<.

FOR DETAILS OF EVALUATION BELOW 40 KEV, SEE FILE 1
INFORMATION FOR MAT 1105.

PU-240
MATERIAL= 4540

IASL
ZA= 94240.

EVAL-MAY72 R. HUNTER AND L. STEWART
AWR = 237.9920

FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	GENERAL COMMENTS	115
1	452	NEUTRONS PER FISSION	4
1	453	DECAY CHAIN DATA	11
2	151	RESONANCE DATA	224
3	1	TOTAL	97
3	2	ELASTIC	91
3	4	TOTAL INELASTIC	35
3	16	(N,2N)	13
3	17	(N,3N)	9
3	18	TOTAL FISSION	96
3	19	(N,F)	86
3	20	(N,N* F)	7
3	21	(N,2N F)	9
3	51	(N,N*) 1-ST EXCITED	24
3	52	(N,N*) 2-ND EXCITED	19
3	53	(N,N*) 3-ED EXCITED	16
3	54	(N,N*) 4-TH EXCITED	14
3	55	(N,N*) 5-TH EXCITED	11
3	56	(N,N*) 6-TH EXCITED	11
3	57	(N,N*) 7-TH EXCITED	11
3	58	(N,N*) 8-TH EXCITED	10
3	59	(N,N*) 9-TH EXCITED	14
3	60	(N,N*) 10-TH EXCITED	12
3	61	(N,N*) 11-TH EXCITED	11
3	62	(N,N*) 12-TH EXCITED	11
3	91	(N,N*) CONTINUUM	22
3	102	(N,GAMMA)	95
3	251	MU BAR	11
3	252	XI	11
3	253	GAMMA	11
4	2	ELASTIC	148
4	16	(N,2N)	10
4	17	(N,3N)	10
4	18	TOTAL FISSION	10
4	19	(N,F)	10
4	20	(N,N* F)	10
4	21	(N,2N F)	10
4	51	(N,N*) 1-ST EXCITED	10
4	52	(N,N*) 2-ND EXCITED	10
4	53	(N,N*) 3-ED EXCITED	10
4	54	(N,N*) 4-TH EXCITED	10
4	55	(N,N*) 5-TH EXCITED	10
4	56	(N,N*) 6-TH EXCITED	10
4	57	(N,N*) 7-TH EXCITED	10
4	58	(N,N*) 8-TH EXCITED	10
4	59	(N,N*) 9-TH EXCITED	31
4	60	(N,N*) 10-TH EXCITED	31
4	61	(N,N*) 11-TH EXCITED	31
4	62	(N,N*) 12-TH EXCITED	28
4	91	(N,N*) CONTINUUM	10

PU-240 LASL EVAL-MAY72 R. HUNTER AND L. STEWART
 MATERIAL= 4540 ZA= 94240. AWR = 237.9920 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
5	16	(N,2N)	9
5	17	(N,3N)	8
5	18	TOTAL FISSION	10
5	19	(N,F)	10
5	20	(N,N* F)	25
5	21	(N,2N F)	19
5	91	(N,N*) CONTINUUM	10
12	4	TOTAL INELASTIC	58
12	18	TOTAL FISSION	4
12	102	(N,GAMMA)	4
13	3	NCN-ELASTIC	6
14	3	NCN-ELASTIC	1
14	4	TOTAL INELASTIC	1
14	18	TOTAL FISSION	1
14	102	(N,GAMMA)	1
15	3	NCN-ELASTIC	123
15	18	TOTAL FISSION	58
15	102	(N,GAMMA)	42
23	501	TOTAL PHOTON	24
23	502	RAYLEIGH SCATTERING	24
23	504	COMPTON SCATTERING	24
23	516	PAIR PRODUCTION	9
23	602	PHOTOELECTRIC EFFECT	24

AG-NAT IASL EVAL-NOV73 P. G. YOUNG
MATERIAL= 4547 ZA= 47000. AWR = 106.9400 FILE= 1 SECTION= 451

DIST-JAN74 MCD 0-JAN74

***** DNA 4547 MCD 0 *****

NAT. AG GAMMA-RAY PRODUCTION EVAL., NOV.1973, P.G.YOUNG, LASL

MF#13----- GAMMA-RAY PRODUCTION CROSS SECTIONS -----

MT#3 GAMMA RAYS FROM ALL REACTIONS

0 TO 0.1 MEV, OBTAINED BY CONSTRUCTING MT#102 CROSS SECTIONS FOR AG-107%51.83 PER CENT< AND AG-109 %48.17 PERCENT< FROM THE RESONANCE PARAMETERS GIVEN IN ENDF/B%3<, DOPPLER BROADENING FOR T#300 DEG.K, AND COMBINING TO GET A MT#102 FOR NATURAL AG. THE RESULTS WERE MULTIPLIED BY APPROPRIATE MULTIPLICITY FACTORS TO OBTAIN THE GAMMA-RAY PRODUCTION FROM RADIATIVE CAPTURE. THE MULTIPLICITY WAS ASSUMED TO VARY LINEARLY FROM 2.856 PHOTONS/CAPTURE NEAR THERMAL ENERGIES TO 2.787 PHOT/CAPT AT 0.1 MEV. THE FORMER VALUE IS BASED ON THE SPECTRUM MEASUREMENT OF OR70, AND THE LATTER VALUE WAS OBTAINED BY A CRUDE ANALYSIS OF THE MEASUREMENT OF DI73 NEAR EN#0.9 MEV %SEE MF#15 DISCUSSION BELOW<.

0.1 TO 20 MEV, THE THRESHOLD FOR INELASTIC SCATTERING IS NEAR 0.1 MEV. ABOVE 0.1 MEV, THE MT#3 X/S CURVE WAS JOINED SMOOTHLY TO EXPERIMENTAL PCINTS FROM THE DATA OF DI73 FOR EN#0.84 TO 19.9 MEV. THE EXPERIMENTAL POINTS WERE OBTAINED BY EXTRAPOLATING THE SPECTRUM DATA TO EG#0 AS DESCRIBED BELOW AND INTEGRATING OVER THE ENTIRE SPECTRUM, ASSUMING AN ISCTROPIC ANGULAR DISTRIBUTION FOR ALL GAMMA RAYS.

MF#14----- GAMMA-RAY ANGULAR DISTRIBUTIONS -----

MT#3 GAMMA RAYS FROM ALL REACTIONS

0 TO 20 MEV, ASSUMED ISOTROPIC IN THE LAB SYSTEM

MF#15----- GAMMA-RAY ENERGY DISTRIBUTIONS-----

MT#3 GAMMA RAYS FROM ALL REACTIONS

0 TO 0.1 MEV, NEAR THERMAL ENERGIES, THE SPECTRUM MEASUREMENT OF OR70 WAS USED WITHOUT MODIFICATION. THE SPECTRUM AT 0.1 MEV WAS OBTAINED BY EXTRAPOLATING THE CAPTURE PORTION OF THE DI73 MEASUREMENT FOR EN# 0.84-0.99 MEV TO EG#0 MEV USING THE EMPIRICAL FORMULA FROM H068.

0.1 TO 20 MEV, BASED ON THE EXPERIMENTAL DATA OF DI73, EXTRAPOLATED TO ZERO GAMMA ENERGY WITH THE EMPIRICAL FORMULA FROM H068.

----- REFERENCES -----

AG-NAT IASL EVAL-NOV73 P. G. YOUNG
MATERIAL= 4547 ZA= 47000. AWR = 106.9400 FILE= 1 SECTION= 451

DI73 J.K.DICKENS ET AL., PRIVATE COMMUNICATION 1973<.
HO68 R.J.HOWERTON AND E.F.PLECHATY, NUCL.SCI.ENG. 32,1781968<.
OR70 V.J.ORPHAN ET AL., GA-10248 1970<.

AG-NAT IASL EVAL-NOV73 P. G. YOUNG
MATERIAL= 4547 ZA= 47000. AWR = 106.9400 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	GENERAL COMMENTS	61
13	3	NCN-ELASTIC	371
14	3	NCN-ELASTIC	1
15	3	NCN-ELASTIC	645

SN-NAT LASL EVAL-NOV73 F. G. YOUNG
MATERIAL= 4550 ZA= 50000. AWR = 117.7000 FILE= 1 SECTION= 451

DIST-JAN74 MCD 0-JAN74

***** DNA 4550 MCD 0 *****

NAT. SN GAMMA-RAY PRODUCTION EVAL., NOV.1973, P.G.YOUNG, LASL

MP#13----- GAMMA-RAY PRODUCTION CROSS SECTIONS -----

MT#3 GAMMA RAYS FROM ALL REACTIONS

0 TO 0.75 MEV, SMOOTH CURVE THROUGH EXPERIMENTAL %N,GAMMA< CROSS SECTIONS COMPILED BY GC66 AND THROUGH THERMAL POINT FROM GO70 WAS MULTIPLIED BY AN APPROPRIATE PHOTON MULTIPLICITY FACTOR TO OBTAIN THE GAMMA-RAY PRODUCTION CROSS SECTION FROM RADIATIVE CAPTURE. THE MULTIPLICITY WAS ASSUMED TO VARY LINEARLY FROM 3.087 PHOT/CAP NEAR THERMAL ENERGIES TO 3.590 PHOT/CAP AT 0.75 MEV. THE FORMER VALUE IS BASED ON THE SPECTRUM MEASUREMENT OF OR70, AND THE LATTER VALUE WAS OBTAINED BY A CRUDE ANALYSIS OF THE MEASUREMENT OF DI73 NEAR EN#0.9 MEV %SEE MP#15 DISCUSSION BELOW.

0.75 TO 20 MEV, THE THRESHOLD FOR INELASTIC NEUTRON SCATTERING IS NEAR 1.2 MEV FOR THE ABUNDANT EVEN-A ISOTOPES OF SN, AND NEAR 0.1 MEV FOR THE ODD-A ISOTOPES. AN EFFECTIVE THRESHOLD OF 0.75 MEV WAS ASSUMED HERE. THE MT#3 CURVE WAS JOINED SMOOTHLY TO THE MEASUREMENTS OF DI73 FOR EN#0.75 TO 19.9 MEV. THE EXPERIMENTAL POINTS WERE OBTAINED BY EXTRAPOLATING THE SPECTRUM DATA TO EG#C AS DESCRIBED BELOW AND INTEGRATING OVER THE ENTIRE SPECTRUM, ASSUMING AN ISOTROPIC ANGULAR DISTRIBUTION FOR ALL GAMMA RAYS.

MP#14----- GAMMA-RAY ANGULAR DISTRIBUTIONS -----

MT#3 GAMMA RAYS FROM ALL REACTIONS

0 TO 20 MEV, ASSUMED ISOTROPIC IN THE LAB SYSTEM

MP#15----- GAMMA-RAY ENERGY DISTRIBUTIONS -----

MT#3 GAMMA RAYS FROM ALL REACTIONS

0 TO 0.75 MEV, NEAR THERMAL ENERGIES, THE SPECTRUM MEASUREMENT OF OR70 WAS USED WITHOUT MODIFICATION. THE SPECTRUM AT 0.75 MEV WAS OBTAINED BY EXTRAPOLATING THE CAPTURE PORTION OF THE DI73 MEASUREMENT FOR EN# 0.75-0.99 MEV TO EG#0 MEV USING THE EMPIRICAL FORMULA FROM HO68.

0.75 TO 20 MEV, BASED ON THE EXPERIMENTAL DATA OF DI73, EXTRAPOLATED TO ZERO GAMMA ENERGY WITH THE EMPIRICAL FORMULA FROM HO68.

----- REFERENCES -----

SN-NAT IASL EVAL-NCV73 F. G. YPUNG
MATERIAL= 4550 ZA= 50000. AWR = 117.7000 FILE= 1 SECTION= 451

DI73 J.K.DICKENS ET AL., ORNL-TM-4406 *1973<
GO66 M.D.GOLDBERG ET AL., BNL-325, SUPPL.2,*1966<.
GO70 D.T.GOLDMAN ET AL., PRIVATE COMMUNICATION TO L.STEWART,
*1970<.
HO68 R.J.HCWERTON AND E.F.PLECHATY, NUCL.SCI.ENG. 32,178*1968<.
OR70 V.J.ORPHAN ET AL., GA-10248 *1970<.

SN-NAT IASL EVAL-NOV73 F. G. YPUNG
 MATERIAL= 4550 ZA= 50000. AWR = 117.7000 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	GENERAL COMMENTS	64
13	3	NCN-ELASTIC	34
14	3	NCN-ELASTIC	1
15	3	NCN-ELASTIC	474

W-182 LASL, AI EVAL-JUN73 YOUNG, RCSE
MATERIAL= 4582 ZA= 74182. AWR = 18C.3900 FILE= 1 SECTION= 451

DIST-JUL73 MCD 2-MAR74

***** DNA 4582 MCD 2 *****

1. MF#12, MT#102 GAMMA RAY MULTIPLICITIES AT THE FIRST THREE NEUTRON ENERGIES WERE REPLACED WITH VALUES BASED ON THE FINAL RESULTS FROM JOURNEYS THERMAL MEASUREMENT.
2. MF#15, MT#102 GAMMA RAY SPECTRA AT THE FIRST TWO NEUTRON ENERGIES WERE MODIFIED TO REFLECT JOURNEYS FINAL RESULTS.
3. MF#1, MT#451 MODIFIED FOR THE ABOVE CHANGES.

***** DNA 4582 MCD 1 *****

1. MF#4, MT#28 ADDED TO FILE - ASSUMED ISOTROPIC IN LAB. MT#16, 17 REPRESENTED BY LEGENDRE COEFFICIENTS.
2. MF#5, MT#28 ADDED TO FILE. TEMPERATURES BASED ON THE SAME LEVEL DENSITY PARAMETERS THAT WERE EMPLOYED FOR THE ${}^A_ZX + n \rightarrow {}^A_ZY + n$ AND ${}^A_ZX + n \rightarrow {}^A_ZY + p$ REACTIONS ARE USED FOR MT#28.

***** DNA 4582 MCD 0 *****

TUNGSTEN-182 ASSEMBLED BY P. ROSE A_ZX AND P. YOUNG A_ZX

NEUTRON FILES A_ZX MAT 1128<
EVALUATION OF FILE 2 - J. COTTER, ATOMICS INTERNATIONAL
EVALUATION OF FILE 4 - E. COTTEWITTE, ATOMICS INTERNATIONAL
EVALUATION OF REMAINING FILES - P. ROSE, ATOMICS INTERNATIONAL
NEUTRON FILE ASSEMBLY BY P. ROSE, ATOMICS INTERNATIONAL
COMPLETED APRIL 1973 A_ZX REF< TI-707-130-026

GAMMA RAY PRODUCTION FILES
EVALUATION AND ASSEMBLY OF FILES 12 THRU 15 - P. YOUNG,
LOS ALAMOS SCIENTIFIC LABORATORY, MAY 1973

FILE 23 DATA - PHOTON INTERACTION - TAKEN FROM RSIC
DATA LIBRARY A_ZX IS BASED ON DATA FROM
UCRL-50174 SEC. II, REV. 1969 BY MCMASTER ET AL.
AND UCRL-50400, VOL. VI BY PLECHATY AND TERRALL.

W-182 LASL, AI EVAL-JUN73 YCUNG, RCSE
MATERIAL= 4582 ZA= 74182. AWR = 18C.3900 FILE= 1 SECTION= 451

MF#1 MT#451 DESCRIPTIVE INFORMATION
ATOMIC MASS AND Q VALUES A.H. WAPSTRA AND N.B. GOVE
NUCLEAR DATA TABLES 9, 267 %1971<

MF#2 MT#151 RESONANCE PARAMETERS

RESOLVED RESONANCE EVALUATION

POTENTIAL SCATTERING XSEC # 8.0E-1.0 E AT E#0
2200 M/S CROSS SECTIONS %PARNS<
CALC MEAS %REF-1<
CAP 20.5 20.7E-0.5
SCAT 11.6

RESOLVED RESONANCE PARAMETERS

-100 EV FROM FIT TO CAPTURE
4.16 EV FROM REFERENCE 1
5 - 250 EV FROM EVALUATION, REFERENCE 1, 2, AND 3
250 - 1250 EV FROM EVALUATION, REFERENCE 2 AND 3
1250 - 4500 EV FROM REFERENCE 3 EXCEPT BELOW
1920 , 2198 EV FROM REFERENCE 2

UNRESOLVED RESONANCE EVALUATION

POTENTIAL SCATTERING XSEC # 8.5E-1.0 E AT E#0
TOTAL XSEC # 8.85 B AT E#100 KEV %CALCULATED<

UNRESOLVED RESONANCE PARAMETERS FROM AUTOMATED OPTIMIZED FIT TO
THE EVALUATED MEASURED CAPTURE CROSS SECTION.

AV L#0 LEVEL SPACING %E#0< # 57.45 EV, ENERGY DEP. FROM REF 4.
AV CAPTURE LEVEL WIDTH # 0.0901 EV, ENERGY INDEPENDENT
L#0 STRENGTH FUNCTION # 1.8E-4 , ENERGY INDEPENDENT
L#1 STRENGTH FUNCTION # 0.272E-4 , ENERGY INDEPENDENT
L#2 STRENGTH FUNCTION # 0.0

AVERAGE CAPTURE CROSS SECTION UNCERTAINTY AT ENERGY E
E %KEV< UNC. %%<

100	15
90	10
10	10
4.5	17

RESONANCE INTEGRAL%CAPT.< 596 B CALC., 590E-10 B MEAS. %REF-5<

REFERENCES

1. BNL-325, 2ND EDITION, SUPPLEMENT 2, GOLDBERG ET AL %1966<

W-182 LASL, AI EVAL-JUN73 YCUNG, RCSF
MATERIAL= 4582 ZA= 74182. AWR = 180.3900 FILE= 1 SECTION= 451

2. Z.M.BARTCLCME ET AL, NUCL.SCI.ENG. 37, P137 %1969<
3. F.J.RAHN AND H.CAMARDA, PERSONAL COMMUNICATION, COLUMBIA%1970<
4. J.L.COCK ET AL AAEC/TM-392 %1967<
5. M.DRAKE, %1968< FOR AMERICAN INSTITUTE OF PHYS. HANDBOOK%1972<

MF#3 MT#1 TOTAL CROSS SECTION

THE TOTAL CROSS SECTION WAS EVALUATED USING A LEAST SQUARES SPLINE FIT TO EXPERIMENTAL DATA FOR THIS ISOTOPE. SPLINE FITS OF EXPERIMENTAL DATA FOR NATURAL TUNGSTEN WERE ALSO FACTORED INTO THE EVALUATION %SEE MAT 1129 FOR REFERENCES<. THE TOTAL CROSS SECTION CURVE WAS SMOOTHLY JOINED TO THE EVALUATED TOTAL CROSS SECTION IN THE UNRESOLVED RESONANCE RANGE BELOW 100 KEV.

ISOTOPIC DATA REFERENCES FOR TOTAL CROSS SECTION-

- 1.%100KEV-650KEV< J.F.WHALEN,ANL-7210,16%1966<
 - 2.%650KEV-20MEV< R.C.MARTIN,PHD THESIS,FEI%1967<
 - 3.%2.5MEV-15MEV< D.G.FOSTER AND I.W.GLASGOW,PHYS.REV.3C,576%71<
- GENERAL REFERENCES FOR TOTAL CROSS SECTION-
- 1 M.D.GOLDBERG ET AL,BNL-325,SECOND EDITION,SUPPLEMENT#2 %1966<
 2. J.J.DEVANEY AND D.G.FOSTER,JR,IOS AIAACS REPT. LA-4928 %1972<

THE UNCERTAINTY IN THE TOTAL CROSS SECTION IS PROBABLY BETTER THAN 7% OVER THE ENERGY RANGE FROM 600 KEV TO 20 MEV. BETWEEN 300KEV AND 600 KEV THE UNCERTAINTY INCREASES TO 10% AND FROM 100 TO 200KEV THE UNCERTAINTY IS ESTIMATED TO BE 15%.

MF#3 MT#2 ELASTIC CROSS SECTION.

THE ELASTIC CROSS SECTION WAS OBTAINED BY SUBTRACTING THE NON-ELASTIC CROSS SECTIONS FROM THE EVALUATED TOTAL CROSS SECTION.

THE ELASTIC CROSS SECTION IS IN GOOD AGREEMENT WITH THE DATA OF D.LISTER ET AL %ANL-7288,1967< BETWEEN 300 KEV AND 1.5 MEV.

BETWEEN 1 MEV AND 9 MEV THE EVALUATED CURVE LIES ABOVE 2PLUS-COMNUC RESULTS. AT 4.3 MEV THE CROSS SECTION IS SOME 15% LOWER THAN THE EXPERIMENTAL DATA POINT OF W.E.KINNEY AND F.G.PEREY FOR NATURAL TUNGSTEN %ORNL-4803,1973<. OUR EVALUATION IS, HOWEVER, IN AGREEMENT WITH THEIR DATA ABOVE 5 MEV.

MF#3 MT#4 TOTAL INELASTIC CROSS SECTION.

EQUAL TO THE SUM OF THE LEVEL EXCITATION AND CONTINUUM CROSS SECTIONS. THE TOTAL INELASTIC CROSS SECTION FOR THIS ISOTOPE IS IN GENERAL AGREEMENT WITH THE DATA OF R.C.OWENS ET AL FOR NATURAL TUNGSTEN BETWEEN 5 AND 7 MEV %NUCL.PHYS.A112,337%1968<<.

MF#3 MT#16 N-2N CROSS SECTION.

THE SEMI-EMPIRICAL TECHNIQUES OF S.PEARLSTEIN %NSE 23,238< AND

W-182 LASL, AI EVAL-JUN73 YCUNG, RCSE
MATERIAL= 4582 ZA= 74182. AWR = 18C.3900 FILE= 1 SECTION= 451

W.D.LU ET AL %PHYS.REV. C1,350%1970<< WERE USED TO DEDUCE THE N-2N CROSS SECTION.

THE EVALUATED CURVE AT 14.8 MEV IS IN AGREEMENT WITH DILG ET AL %NUCL.PHYS. A118,9%1968<< AND DRUZHININ ET AL %SOVIET J.NUCL. PHYS. 4,515%1966<<.

MF#3 MT#17 N-3N CROSS SECTION.

THE N-3N CROSS SECTIONS WERE DEDUCED USING THE SEMI-EMPIRICAL TECHNIQUES OF S.PEARLSTEIN AND W.D.LU. AN EFFECTIVE THRESHHOLD FOR THE N-3N REACTION WAS SET 1.25 MEV ABOVE THE THEORETICAL THRESHHOLD.

MF#3 MT#28 N-PN CROSS SECTION.

THE SHAPE OF THE N-PN EXCITATION CURVE IS BASED UPON THE EXPERIMENTAL DATA OF J.F.BARRY ET AL FOR W-186 %SEE MAT 1131<. THE CURVE HAS BEEN SHIFTED IN ENERGY BY THE DIFFERENCE IN THE REACTION Q FOR THIS ISOTOPE AND W-186. THE CROSS SECTION CONTAINS CONTRIBUTIONS FROM THE N-NP AND N-D REACTIONS.

MF#3 MT#51 INELASTIC EXCITATION %DIRECT AND COMPOUND NUCLEUS< TO THE 26 LEVEL.

THE CROSS SECTIONS WERE CALCULATED USING 2PLUS-COMNUC. THEY HAVE BEEN RENORMALIZED VIA A LEAST SQUARES FIT TO DATA OF D.LISTER ET AL %PHYS.REV. 162,1077%1967<< WITH A 10% UNCERTAINTY IN THE ADJUSTED CURVE.

MF#3 MT#52-58,91 INELASTIC EXCITATION %COMPOUND NUCLEUS ONLY<.

CALCULATION BY THE COMNUC CODE FOR THE 329,680,1220,1258,1289, 1331, AND 1374 KEV LEVELS PLUS THE CONTINUUM. THE 329 KEV LEVEL EXCITATION CURVE WAS RENORMALIZED TO THE DATA OF D.LISTER. %10% UNCERTAINTY IN THE ADJUSTED CROSS SECTIONS<.

MF#3 MT#102 RADIATIVE CAPTURE CROSS SECTION.

THE RADIATIVE CAPTURE CROSS SECTION WAS EVALUATED BETWEEN 10 KEV AND 150 KEV USING A LEAST SQUARES FIT TO EXPERIMENTAL DATA %SEE MF#2 MT#151<.

THIS FIT WAS COMBINED AND JOINED TO THE THEORETICAL CROSS SECTIONS COMPUTED BETWEEN 100 KEV AND 4 MEV USING THE COMNUC CODE. ABOVE 4 MEV THE COMNUC RESULTS WERE JOINED TO THE COLLECTIVE AND DIRECT INTERACTION CAPTURE CROSS SECTIONS CALCULATED USING THE THEORY OF V.BENZI AND G.REFFO %CCDN-NW10, ENEA NEUTRON COMPILATION CENTER, 1969<.

THE UNCERTAINTY IN THE RADIATIVE CAPTURE CROSS SECTION IS PROBABLY BETTER THAN 15% FOR ENERGIES BETWEEN 100 KEV AND 200 KEV. ABOVE 200 KEV THE CROSS SECTION IS RELIABLE ONLY TO THE

W-182 LASL, AT EVAL-JUN73 YCUNG, RCSE
MATERIAL= 4582 ZA= 74182. AWR = 18C.3900 FILE= 1 SECTION= 451

EXTENT OF THE VALIDITY OF THE THEORETICAL MODELS.

MF#3 MT#103 N-P CROSS SECTION.

THE SHAPE OF THE N-P EXCITATION CURVE IS BASED UPON THE EXPERIMENTAL DATA OF J.F. BARRY ET AL FOR W-186 %SEE MAT 1131<. THE CURVE HAS BEEN SHIFTED IN ENERGY TO PASS THROUGH THE DATA POINT REPORTED BY M. LINDNER ET AL %LRL, PRIVATE COMMUNICATION, # 3.58-0.35 MB AT 14.1 MEV<.

MF#3 MT#107 N-ALPHA CROSS SECTION.

THE N-ALPHA CROSS SECTION EVALUATION IS BASED UPON DATA OF A. RUBINO AND D. ZUBKE %NUCL. PHYS. 85,606%1966<< FOR TA-181. THE FEW EXPERIMENTAL DATA POINTS FOR ISOTOPE OF TUNGSTEN BETWEEN 14 AND 15 MEV QUALITATIVELY SUBSTANTIATES THE USE OF THIS CURVE. THE EVALUATION HAS NOT BEEN EXTENDED BELOW 11 MEV.

MF#4 MT#2 ANGULAR DISTRIBUTION OF ELASTICALLY SCATTERED NEUTRONS

THE ANGULAR DISTRIBUTIONS FOR ELASTIC SCATTERING ARE GIVEN AS LEGENDRE POLYNOMIAL COEFFICIENTS IN THE CM SYSTEM. THESE DATA WERE CALCULATED BY 2PLUS-COMNUC CODES FOR EACH ISOTOPE. AS LITTLE ISOTOPIC EXPERIMENTAL DATA EXISTED, THE CALCULATED DATA WERE AVERAGED ACCORDING TO ABUNDANCE AND COMPARED TO NATURAL TUNGSTEN DATA. THE COMPARISON INDICATED THAT THE EXPERIMENTAL DATA CONTAINED DIRECT INELASTIC REACTIONS TO THE FIRST LEVEL. WITH THE CALCULATED FIRST-LEVEL DIRECT INELASTIC INCLUDED, AGREEMENT WITHIN EXPERIMENTAL ERROR WAS GENERALLY INDICATED OVER ALL ENERGIES. THIS AGREEMENT ALSO SUPPORTS THE VALIDITY OF THE INELASTIC ANGULAR FILE BECW.

THE NATURAL TUNGSTEN EXPERIMENTAL DATA WERE DERIVED FROM THE FOLLOWING SOURCES-

1. BUL AFS 5,409%1960< %ANL<
2. PHYS. REV. 176,1405%1968< %ANL<
3. PHYS. REV. 93,1062%1954< %U. WISC<
4. NUCL. PHYS. A125,641%1966< %JAPAN AEBI<
5. PHYS. REV. 109,2105%1958< %WEST. PESCH<
6. W. KINNEY, PVT. COMM. %1972< %ORNL<
7. PHYS. REV. 129,1649%1963< %LASL<
8. NUCL. PHYS. 2,124%1956< %GRONINGEN, NETHERLANDS<

ERROR ESTIMATES FOR THIS SECTION ARE DIFFICULT BECAUSE IT APPEARS THAT PURE ELASTIC SCATTER HAS NOT BEEN MEASURED EXCEPT AT LOW ENERGIES. BECAUSE OF THE GOOD AGREEMENT OVERALL WITH THE COMBINED DATA, THIS FILE IS ESTIMATED TO BE ACCURATE TO 15 % AT ENERGIES BELOW 1 MEV, AND WITHIN A FACTOR OF TWO AT ENERGIES ABOVE 1 MEV FOR ALL SCATTERING ANGLES.

W-182 LASL, AI EVAL-JUN73 YOUNG, RCSE
MATERIAL= 4582 ZA= 74182. AWR = 180.3900 FILE= 1 SECTION= 451

MF#4 MT#51-58, 91 ANG. DISTRIBUTION OF INEL. SCATTERED NEUTRONS.
ANGULAR DISTRIBUTIONS ARE GIVEN AS LEGENDRE POLYNOMIAL
COEFFICIENTS IN THE LABORATORY FRAME OF REFERENCE.
THESE DATA ARE BASED UPON 2PLUS-COMNUC CALCULATIONS. THEY
INCLUDE ANISOTROPIC CONTRIBUTIONS FROM DIRECT INEL. EXCITATION
OF THE TWO PLUS LEVEL. COMPOUND LEVEL AND CONTINUUM
EXCITATIONS ARE ISOTROPIC IN THE LABORATORY SYSTEM.
ERRORS ARE SMALL SIMPLY DUE TO THE PREDOMINANCE OF ISOTROPY.

MF#5 MT#16, 17 NUCLEAR TEMPS FOR THE N-2N AND N-3N REACTIONS.

TEMPERATURE OF FIRST EMITTED NEUTRON SAME AS FOR MT#91.
TEMPERATURES OF SECOND AND THIRD EMITTED NEUTRONS DEDUCED BY
CONSERVATION OF ENERGY ASSUMING THE KINETIC ENERGY OF AN EMITTED
NEUTRON IS 2*KT.

MF#5 MT#91 NUCLEAR TEMPERATURE - INELASTIC CONTINUUM.

LEAST SQUARES WEISSKOPF LEVEL SPACING FIT TO NATURAL TUNGSTEN
DATA. ISOTOPIC DATA ADJUSTED USING DEFORMED NUCLEUS LEVEL
DENSITY FORMULA OF GILBERT AND CAMERON.

REFERENCES -

1. S.G. BUCCINO ET AL, NUCL. PHYS. 60, 177 1964<
2. R.O. OWENS AND J.H. TOWLE, NUCL. PHYS. A112, 337 1968<
3. W.E. KINNEY, ORNL, PRIVATE COMMUNICATION 1972<
4. A. GILBERT AND A.G.W. CAMERON, CAN. J. PHYS. 43, 1446 1965<

MF#12 MT#102 MULTIPLICITIES FOR GAMMA RAY PRODUCTION FROM
RADIATIVE CAPTURE

MULTIPLICITIES AT NEUTRON ENERGIES BELOW 1 EV ARE BASED ON A
PRELIMINARY THERMAL MEASUREMENT FOR NATURAL W BY JUNEY AND
FROM 1 EV TO 1000 EV ON CALCULATIONS BY YCST ET AL. AT HIGHER
ENERGIES THE MULTIPLICITIES ARE BASED ON AN ANALYSIS OF NATURAL
W MEASUREMENTS BY DICKENS, EN#1-20 MFV< USING STATISTICAL
CALCULATIONS SIMILAR TO THOSE DESCRIBED BY TROUBETZKOY, WITH
THE MULTIPLICITIES CHOSEN TO GIVE ROUGH AGREEMENT WITH THE
MEASUREMENTS. GAMMA-RAYS FROM $\pi N, G, N'$ WERE INCLUDED IN THESE
CALCULATIONS. THE THEORY WAS USED AT ALL ENERGIES TO DIVIDE THE
NATURAL W DATA INTO ISOTOPIC COMPONENTS.

MF#13 MT#4 GAMMA RAY PRODUCTION CROSS SECTIONS FROM INELASTIC,
 $\pi N, 2N$, AND $\pi N, 3N$ REACTIONS

THE CROSS SECTIONS FOR DISCRETE PHOTONS ARE BASED ON THE LEVEL
EXCITATION CROSS SECTIONS IN MF#3, MT#51-58, MAINLY USING THE
LEVEL DECAY SCHEME OF WAY. THE CROSS SECTIONS FOR CONTINUUM

W-182 LASL, AI EVAL-JUN73 YOUNG, RCSE
MATERIAL= 4582 ZA= 74182. AWR = 180.3900 FILE= 1 SECTION= 451

GAMMA RAYS ARE BASED ON A STATISTICAL THEORY ANALYSIS OF THE DICKENS MEASUREMENTS ON NATURAL W. THE THEORY WAS USED FOR INTERPOLATION, SMOOTHING, AND SEPARATION OF THE DATA INTO ISOTOPIC COMPONENTS.

MF#14 MT#4, 102 ANGULAR DISTRIBUTIONS OF GAMMA RAYS FROM RADIATIVE CAPTURE, INELASTIC, $n, 2n$, AND $n, 3n$ REACTIONS

GAMMA RAYS FROM ALL REACTIONS ARE ASSUMED ISOTROPIC IN THE LABORATORY SYSTEM.

MF#15 MT#4 ENERGY DISTRIBUTIONS OF GAMMA RAYS FROM INELASTIC, $n, 2n$, AND $n, 3n$ REACTIONS

THE SPECTRA AT ALL ENERGIES ARE BASED ON A STATISTICAL THEORY ANALYSIS OF THE DICKENS MEASUREMENTS WITH NATURAL W. THE THEORY WAS USED AS DESCRIBED ABOVE MF#13 MT#4. ARBITRARY ADJUSTMENTS WERE MADE TO THE THEORETICAL FITS IN REGIONS WHERE AGREEMENT WITH EXPERIMENT WAS POOR MAINLY BELOW EN#5 MEV.

MF#15 MT#102 ENERGY DISTRIBUTIONS OF GAMMA RAYS FROM RADIATIVE CAPTURE

SPECTRA AT NEUTRON ENERGIES BELOW 1 EV ARE BASED ON A PRELIMINARY THERMAL MEASUREMENT BY JURNEY AND FROM 1 EV TO 1000 EV ON CALCULATIONS BY YOST ET AL. AT HIGHER ENERGIES THE SPECTRA ARE BASED ON STATISTICAL CALCULATIONS USING PARAMETERS OBTAINED BY ANALYZING THE DICKENS MEASUREMENT FOR EN#1-3 MEV. THE THEORY WAS USED AT ALL ENERGIES TO DIVIDE THE NATURAL W DATA INTO SEPARATE ISOTOPIC COMPONENTS.

REFERENCES FOR MF#12,13,14,15 DATA

1. E. T. JURNEY, PRIVATE COMMUNICATION 1973.
2. K. J. YOST, J. E. WHITE, C. Y. FU, AND W. E. FORD, NUCL. SCI. ENG. 47, 209 1972.
3. E. S. TROUBETZKOY, PHYS. REV. 122, 212 1961.
4. J. K. DICKENS, PRIVATE COMMUNICATION 1972.
5. K. WAY, NUCLEAR DATA B1-1-1 1966.

***** NOTE. NO INFORMATION IS PROVIDED IN THIS EVALUATION ON ELECTRON PRODUCTION FROM INTERNAL CONVERSION. SUCH INFORMATION MIGHT BE IMPORTANT FOR CERTAIN LOCAL HEATING PROBLEMS.

W-182 LASL, AI EVAL-JUN73 YCUNG, RCSE
 MATERIAL= 4582 ZA= 74182. AWR = 18C.3900

FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	GENERAL COMMENTS	400
2	151	RESONANCE DATA	99
3	1	TOTAL	71
3	2	ELASTIC	70
3	4	TOTAL INELASTIC	68
3	16	(N,2N)	22
3	17	(N,3N)	11
3	28	(N,N*)E	17
3	51	(N,N*) 1-ST EXCITED	68
3	52	(N,N*) 2-ND EXCITED	32
3	53	(N,N*) 3-RD EXCITED	23
3	54	(N,N*) 4-TH EXCITED	16
3	55	(N,N*) 5-TH EXCITED	16
3	56	(N,N*) 6-TH EXCITED	15
3	57	(N,N*) 7-TH EXCITED	15
3	58	(N,N*) 8-TH EXCITED	14
3	91	(N,N*) CONTINUUM	43
3	102	(N,GAMMA)	71
3	103	(N,P)	18
3	107	(N,ALPHA)	19
3	251	MU BAR	14
3	252	XI	14
3	253	GAMMA	14
4	2	ELASTIC	190
4	16	(N,2N)	8
4	17	(N,3N)	8
4	28	(N,N*)E	8
4	51	(N,N*) 1-ST EXCITED	103
4	52	(N,N*) 2-ND EXCITED	8
4	53	(N,N*) 3-RD EXCITED	8
4	54	(N,N*) 4-TH EXCITED	8
4	55	(N,N*) 5-TH EXCITED	8
4	56	(N,N*) 6-TH EXCITED	8
4	57	(N,N*) 7-TH EXCITED	8
4	58	(N,N*) 8-TH EXCITED	8
4	91	(N,N*) CONTINUUM	8
5	16	(N,2N)	49
5	17	(N,3N)	40
5	28	(N,N*)E	19
5	91	(N,N*) CCNTINUUM	37
12	102	(N,GAMMA)	15
13	4	TOTAL INELASTIC	214
14	4	TOTAL INELASTIC	1
14	102	(N,GAMMA)	1
15	4	TOTAL INELASTIC	883
15	102	(N,GAMMA)	409
23	501	TOTAL PHOTON	23
23	502	RAYLEIGH SCATTERING	23
23	504	COMPTON SCATTERING	23
23	516	PAIR PRODUCTION	9

W-182 LASL, AI EVAL-JUN73 YCUNG, ROSE
MATERIAL= 4582 ZA= 74182. AWR = 18C.3900 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
23	602	PHOTOELECTRIC EFFECT	23

W-183 LASL, AI EVAL-JUN73 YOUNG, RCSE
MATERIAL= 4583 ZA= 74183. AWF = 181.3800 FILE= 1 SECTION= 451

DIST-JUL73 MOD 2-MAR74

***** DNA 4583 MOD 2 *****

1. MF#12, MT#102 GAMMA RAY MULTIPLICITIES AT THE FIRST THREE NEUTRON ENERGIES WERE REPLACED WITH VALUES BASED ON THE FINAL RESULTS FROM JOURNEYS THERMAL MEASUREMENT.
2. MF#15, MT#102 GAMMA RAY SPECIRA AT THE FIRST TWO NEUTRON ENERGIES WERE MODIFIED TO REFLECT JOURNEYS FINAL RESULTS.
3. MF#1, MT#451 MODIFIED FOR THE ABOVE CHANGES.

***** DNA 4583 MOD 1 *****

1. MF#4, MT#28 ADDED TO FILE - ASSUMED ISOTROPIC IN LAB. MT#16, 17 REPRESENTED BY LEGENDRE COEFFICIENTS.
2. MF#5, MT#28 ADDED TO FILE. TEMPERATURES BASED ON THE SAME LEVEL DENSITY PARAMETERS THAT WERE EMPLOYED FOR THE ${}^N_{2N}$ AND ${}^N_{3N}$ REACTIONS ARE USED FOR MT#28.

***** DNA 4583 MOD C *****

TUNGSTEN-183 ASSEMBLED BY P. ROSE %AI< AND P. YOUNG %LASL<

NEUTRON FILES %ENDF/B MAT 1129<

EVALUATION OF FILE 2 - J. OTTER, ATOMICS INTERNATIONAL
EVALUATION OF FILE 4 - E. OTTEWITTE, ATOMICS INTERNATIONAL
EVALUATION OF REMAINING FILES - P. ROSE, ATOMICS INTERNATIONAL
NEUTRON FILE ASSEMBLY BY P. ROSE, ATOMICS INTERNATIONAL
COMPLETED APRIL 1973 %AI REF< TI-707-130-026

GAMMA RAY PRODUCTION FILES

EVALUATION AND ASSEMBLY OF FILES 12 THRU 15 - P. YOUNG,
LOS ALAMOS SCIENTIFIC LABORATORY, MAY 1973

FILE 23 DATA - PHOTON INTERACTION - TAKEN FROM RSIC
DATA LIBRARY %DLC-7.D< IS BASED ON DATA FROM
UCRL-50174 SEC. II, REV. 1969 BY MCMASTER ET AL.
AND UCRL-50400, VOL. VI BY PLECHATY AND TERRALL.

W-183 LASL, AI EVAL-JUN73 YOUNG, RCSE
MATERIAL= 4583 ZA= 74183. AWR = 181.3800 FILE= 1 SECTION= 451

MF#1 MT#451 DESCRIPTIVE INFORMATION

ATOMIC MASS AND Q VALUES A.H. WAPSTRA AND N.B. GOVE
NUCLEAR DATA TABLES 9, 267 %1971<

MF#2 MT#151 RESONANCE PARAMETERS

RESOLVED RESONANCE EVALUATION

POTENTIAL SCATTERING XSEC # 8.06-1.0 E AT E#0
2200 M/S CROSS SECTION %BARN<
CALC MEAS %REF-1<
CAP 10.0 10.26-3.0
SCAT 3.4

RESOLVED RESONANCE PARAMETERS

-1.5 EV FROM FIT TO CAPTURE
0 - 150 EV FROM REFERENCE 1
150 - 175 EV FROM EVALUATION, REFERENCE 1 AND 2
175 - 760 EV FROM REFERENCE 2

UNRESOLVED RESONANCE EVALUATION

POTENTIAL SCATTERING XSEC # 8.58-1.0 E AT E#0
TOTAL XSEC # 11.3 B AT E# 45 KEV %CALCULATED<

UNRESOLVED RESONANCE PARAMETERS FROM AUTOMATED OPTIMIZED FIT TO
THE EVALUATED MEASURED CAPTURE CROSS SECTION. THE COMPETITIVE
REACTION WIDTH FOR L#2, J#1 IS FOR THE L TO L-2 ELASTIC
SCATTERING PROCESS.

AV L#0 LEVEL SPACING %E#0< # 12.53 EV, ENERGY DEP. FROM REF 3.
AV CAPTURE LEVEL WIDTH # 0.0801 EV, ENERGY INDEPENDENT
L#0 STRENGTH FUNCTION # 2.125E-4 EV, ENERGY INDEPENDENT
L#1 STRENGTH FUNCTION # 0.227E-4 EV, ENERGY INDEPENDENT
L#2 STRENGTH FUNCTION # 2.56E-4 EV, ENERGY INDEPENDENT

AVERAGE CAPTURE CROSS SECTION UNCERTAINTY AT ENERGY E

E %KEV< UNC. %%<
45 11
10 12
5 20
2.5 40

RESONANCE INTEGRAL %CAPT.< 355 E CALC., 3806-15 B MEAS. %REF-4<

REFERENCES

W-183 LASI, AI EVAL-JUN73 YOUNG, RCSE
MATERIAL= 4583 ZA= 74183. AWF = 181.3800 FILE= 1 SECTION= 451

1. BNL-325, 2ND EDITION, SUPPLEMENT 2, GOLDBERG ET AL %1966<
2. Z.M.BARTLOME ET AL NUCI.SCI.ENG. 37, F137 %1969<
3. J.L.COOK ET AL, AAEC/TM-392 %1967<
4. M.DRAKE, %1968< FOR AMERICAN INSTITUTE OF PHYS. HANDBOOK%1972<

MF#3 MT#1 TOTAL CROSS SECTION

THERE IS NO EXPERIMENTAL DATA FOR W-183. THE TOTAL CROSS SECTION WAS EVALUATED USING A LEAST SQUARES SPLINE FIT TO EXPERIMENTAL DATA FOR NATURAL TUNGSTEN. THE TOTAL CROSS SECTION CURVE WAS SMOOTHLY JOINED TO THE EVALUATED TOTAL CROSS SECTION IN THE ENERGY RANGE BELOW 100KEV. THE LACK OF DIRECT EXPERIMENTAL DATA INTRODUCES A LARGE UNCERTAINTY IN THE TOTAL CROSS SECTION BETWEEN 100KEV AND 700KEV %SEE REF. 6<.

REFERENCES FOR NATURAL TUNGSTEN TOTAL CROSS SECTIONS-

1. M.D.GOLDBERG ET AL, BNL-325, SECOND EDITION, SUPPLEMENT#2 %1966<
2. J.F.WHALEN, ANI-7210, 16%1966<
3. M.DIVADDEENAM, PHD THESIS DUKE UNIVERSITY %1967<
4. W.H.KAO ET AL, CHINESE J.PHYS. 5, 43%1967<
5. J.M.PETERSON ET AL, PHYS.REV. 120, 521%1960<
6. J.J.DEVANEY AND D.G.FOSTER, JR, LOS ALAMOS REPT. LA-4928 %1972<

MF#3 MT#2 ELASTIC CROSS SECTION.

THE ELASTIC CROSS SECTION WAS OBTAINED BY SUBTRACTING THE NON-ELASTIC CROSS SECTIONS FROM THE EVALUATED TOTAL CROSS SECTION. BETWEEN 1 MEV AND 9 MEV THE EVALUATED CURVE LIES ABOVE 2 PLUS-COMNUC RESULTS. AT 4.3 MEV THE CROSS SECTION IS SOME 15% LOWER THAN THE EXPERIMENTAL DATA POINT OF W.F.KINNEY AND F.G.PEREY FOR NATURAL TUNGSTEN %ORN-4803, 1973<. OUR EVALUATION IS, HOWEVER, IN AGREEMENT WITH THEIR DATA ABOVE 5 MEV.

MF#3 MT#4 TOTAL INELASTIC CROSS SECTION.

EQUAL TO THE SUM OF THE LEVEL EXCITATION AND CONTINUUM CROSS SECTIONS. THE TOTAL INELASTIC CROSS SECTION FOR THIS ISOTOPE IS IN GENERAL AGREEMENT WITH THE DATA OF R.C.OWENS ET AL FOR NATURAL TUNGSTEN BETWEEN 5 AND 7 MEV %NUCI.PHYS.A112, 337%1968<<.

MF#3 MT#16 N-2N CROSS SECTION.

THE SEMI-EMPIRICAL TECHNIQUES OF S.PEARLSTEIN %NSE 23, 238< AND W.D.LU ET AL %PHYS.REV. C1, 350%1970<< WERE USED TO DEDUCE THE N-2N CROSS SECTION.

MF#3 MT#17 N-3N CROSS SECTION.

THE N-3N CROSS SECTIONS WERE DEDUCED USING THE SEMI-EMPIRICAL

W-183 LASL, AI EVAL-JUN73 YCUNG, RCSE
MATERIAL= 4583 ZA= 74183. AWR = 181.3800 FILE= 1 SECTION= 451

TECHNIQUES OF S. PEARLSTEIN AND W.D. LU. AN EFFECTIVE THRESHOLD FOR THE N-3N REACTION WAS SET 1.25 MEV ABOVE THE THEORETICAL THRESHOLD.

MF#3 MT#28 N-PN CROSS SECTION.

THE SHAPE OF THE N-PN EXCITATION CURVE IS BASED UPON THE EXPERIMENTAL DATA OF J.F. BARRY ET AL FOR W-186 %SEE MAT 1131<. THE CURVE HAS BEEN SHIFTED IN ENERGY BY THE DIFFERENCE IN THE REACTION Q FOR THIS ISOTOPE AND W-186. THE CROSS SECTION CONTAINS CONTRIBUTIONS FROM THE N-NP AND N-D REACTIONS.

MF#3 MT#51,52 INELASTIC EXCITATION %DIRECT AND COMPOUND NUCLEUS< TO THE 46.5 AND 99 KEV LEVELS.

THE CROSS SECTIONS WERE CALCULATED USING THE 2PLUS-COMNUC CODES. NO EXPERIMENTAL DATA HAS BEEN REPORTED.

MF#3 MT#53-59,91 INELASTIC EXCITATION %COMPOUND NUCLEUS ONLY<.

CALCULATION BY THE COMNUC CODE FOR THE 207,209,292,309,412, 453, AND 595 KEV LEVELS PLUS THE CONTINUUM. THE THEORETICAL CROSS SECTIONS WERE USED WITHOUT MODIFICATION.

MF#3 MT#102 RADIATIVE CAPTURE CROSS SECTION.

THE RADIATIVE CAPTURE CROSS SECTION WAS EVALUATED BETWEEN 10 KEV AND 100 KEV USING A LEAST SQUARES FIT TO EXPERIMENTAL DATA %SEE MF#2 MT#151<.

THIS FIT WAS COMBINED AND JOINED TO THE THEORETICAL CROSS SECTIONS COMPUTED BETWEEN 100 KEV AND 4 MEV USING THE COMNUC CODE. ABOVE 4 MEV THE COMNUC RESULTS WERE JOINED TO THE COLLECTIVE AND DIRECT INTERACTION CAPTURE CROSS SECTIONS CALCULATED USING THE THEORY OF V. BENZI AND G. REFFO %CCDN-NW10, ENEA NEUTRON COMPILATION CENTER, 1969<.

THE UNCERTAINTY IN THE RADIATIVE CAPTURE CROSS SECTION IS 11% BETWEEN 45 KEV AND 90 KEV. BETWEEN 90 KEV AND 200 KEV THE UNCERTAINTY IS PROBABLY BETTER THAN 25%. ABOVE 200 KEV THE CROSS SECTION IS RELIABLE ONLY TO THE EXTENT OF THE VALIDITY OF THE THEORETICAL MODELS.

MF#3 MT#103 N-P CROSS SECTION.

THE SHAPE OF THE N-P EXCITATION CURVE IS BASED UPON THE EXPERIMENTAL DATA OF J.F. BARRY ET AL FOR W-186 %SEE MAT 1131<. THE CURVE HAS BEEN SHIFTED IN ENERGY TO PASS THROUGH THE DATA POINT REPORTED BY M. LINDNER ET AL %LRL, PRIVATE COMMUNICATION, # 4.28-0.42 MB AT 14.1 MEV<.

MF#3 MT#107 N-ALPHA CROSS SECTION.

W-183 LASL, AI EVAL-JUN73 YOUNG, ROSE
MATERIAL= 4583 ZA= 74183. AWR = 181.3800 FILE= 1 SECTION= 451

THE N-ALPHA CROSS SECTION EVALUATION IS BASED UPON DATA OF A. RUBINO AND D. ZUBKE %NUCL. PHYS. 85,606%1966<< FOR TA-181. THE FEW EXPERIMENTAL DATA POINTS FOR ISOTOPES OF TUNGSTEN BETWEEN 14 AND 15 MEV QUALITATIVELY SUBSTANTIATES THE USE OF THIS CURVE. THE EVALUATION HAS NOT BEEN EXTENDED BELOW 11 MEV.

MF#4 MT#2 ANGULAR DISTRIBUTION OF ELASTICALLY SCATTERED NEUTRONS

THE ANGULAR DISTRIBUTIONS FOR ELASTIC SCATTERING ARE GIVEN AS LEGENDRE POLYNOMIAL COEFFICIENTS IN THE CM SYSTEM. THESE DATA WERE CALCULATED BY 2PLUS-CCMNUC CODES FOR EACH ISOTOPE. AS LITTLE ISOTOPIC EXPERIMENTAL DATA EXISTED, THE CALCULATED DATA WERE AVERAGED ACCORDING TO ABUNDANCE AND COMPARED TO NATURAL TUNGSTEN DATA. THE COMPARISON INDICATED THAT THE EXPERIMENTAL DATA CONTAINED DIRECT INEL. REACTIONS TO THE FIRST 2 LEVELS. WITH THE CALCULATED FIRST AND SECOND DIRECT INEL. INCLUDED, AGREEMENT WITHIN EXPERIMENTAL ERROR WAS GENERALLY INDICATED OVER ALL ENERGIES. THIS AGREEMENT ALSO SUPPORTS THE VALIDITY OF THE INELASTIC ANGULAR FILE BELOW.

THE NATURAL TUNGSTEN EXPERIMENTAL DATA WERE DERIVED FROM THE FOLLOWING SOURCES-

1. BUL APS 5,409%1960< %ANL<
2. PHYS. REV. 176,1405%1968< %ANL<
3. PHYS. REV. 93,1062%1954< %U. WISC<
4. NUCL. PHYS. A125,641%1966< %JAPAN AERI<
5. PHYS. REV. 109,2105%1958< %WEST. RESCH<
6. W. KINNEY, PVT. COMM. %1972< %ORNL<
7. PHYS. REV. 129,1649%1963< %IASL<
8. NUCL. PHYS. 2,124%1956< %GRONINGEN, NETHERLANDS<

ERROR ESTIMATES FOR THIS SECTION ARE DIFFICULT BECAUSE IT APPEARS THAT PURE ELASTIC SCATTER HAS NOT BEEN MEASURED EXCEPT AT LOW ENERGIES. BECAUSE OF THE GOOD AGREEMENT OVERALL WITH THE COMBINED DATA, THIS FILE IS ESTIMATED TO BE ACCURATE TO 15 % AT ENERGIES BELOW 1 MEV, AND WITHIN A FACTOR OF TWO AT ENERGIES ABOVE 1 MEV FOR ALL SCATTERING ANGLES.

MF#4 MT#51-59,91 ANG. DISTRIBUTION OF INEL. SCATTERED NEUTRONS.

ANGULAR DISTRIBUTIONS ARE GIVEN AS LEGENDRE POLYNOMIAL COEFFICIENTS IN THE LABORATORY FRAME OF REFERENCE.

THESE DATA ARE BASED UPON 2PLUS-COMNUC CALCULATIONS. THEY INCLUDE ANISOTROPIC CONTRIBUTIONS FROM DIRECT INEL. EXCITATION OF THE 3/2- AND 5/2- LEVELS. COMPOUND LEVEL AND CONTINUUM EXCITATIONS ARE ISOTROPIC IN THE LABORATORY SYSTEM.

ERRORS ARE SMALL SIMPLY DUE TO THE PREDOMINANCE OF ISOTROPY.

W-183 LASL, AI EVAL-JUN73 YCUNG, RCSE
MATERIAL= 4583 ZA= 74183. AWR = 181.3800 FILE= 1 SECTION= 451

MF#5 MT#16, 17 NUCLEAR TEMPS FOR THE N-2N AND N-3N REACTIONS.

TEMPERATURE OF FIRST EMITTED NEUTRON SAME AS FOR MT#91.
TEMPERATURES OF SECOND AND THIRD EMITTED NEUTRONS DEDUCED BY
CONSERVATION OF ENERGY ASSUMING THE KINETIC ENERGY OF AN EMITTED
NEUTRON IS 2*KT.

MF#5 MT#91 NUCLEAR TEMPERATURE - INELASTIC CONTINUUM.

LEAST SQUARES WEISSKOPF LEVEL SPACING FIT TO NATURAL TUNGSTEN
DATA. ISOTOPIC DATA ADJUSTED USING DEFORMED NUCLEUS LEVEL
DENSITY FORMULA OF GILBERT AND CAMERON.

REFERENCES -

1. S.G. BUCCINO ET AL, NUCL. PHYS. 60, 171 1964<
2. R.O. OWENS AND J.H. TOWIE, NUCL. PHYS. A112, 337 1968<
3. W.E. KINNEY, CRNL, PRIVATE COMMUNICATION 1972<
4. A. GILBERT AND A.G.W. CAMERON, CAN. J. PHYS. 43, 1446 1965<

MF#12 MT#102 MULTIPLICITIES FOR GAMMA RAY PRODUCTION FROM
RADIATIVE CAPTURE

MULTIPLICITIES AT NEUTRON ENERGIES BELOW 1 EV ARE BASED ON A
PRELIMINARY THERMAL MEASUREMENT FOR NATURAL W BY JUNEY AND
FROM 1 EV TO 1000 EV ON CALCULATIONS BY YCST ET AL. AT HIGHER
ENERGIES THE MULTIPLICITIES ARE BASED ON AN ANALYSIS OF NATURAL
W MEASUREMENTS DICKENS, EN#1-20 MEV< USING STATISTICAL
CALCULATIONS SIMILAR TO THOSE DESCRIBED BY TROUBETZKOY, WITH
THE MULTIPLICITIES CHOSEN TO GIVE ROUGH AGREEMENT WITH THE
MEASUREMENTS. GAMMA-RAYS FROM γ , γ , γ WERE INCLUDED IN THESE
CALCULATIONS. THE THEORY WAS USED AT ALL ENERGIES TO DIVIDE THE
NATURAL W DATA INTO ISOTOPIC COMPONENTS.

MF#13 MT#4 GAMMA RAY PRODUCTION CROSS SECTIONS FROM INELASTIC,
 γ , γ , AND γ , γ REACTIONS

THE CROSS SECTIONS FOR DISCRETE PHOTONS ARE BASED ON THE LEVEL
EXCITATION CROSS SECTIONS IN MF#3, MT#51-59, MAINLY USING THE
LEVEL DECAY SCHEME OF ARTNA. THE CROSS SECTIONS FOR CONTINUUM
GAMMA RAYS ARE BASED ON A STATISTICAL THEORY ANALYSIS OF THE
DICKENS MEASUREMENTS ON NATURAL W. THE THEORY WAS USED FOR
INTERPOLATION, SMOOTHING, AND SEPARATION OF THE DATA INTO
ISOTOPIC COMPONENTS.

MF#14 MT#4, 102 ANGULAR DISTRIBUTIONS OF GAMMA RAYS FROM RADIATIVE
CAPTURE, INELASTIC, γ , γ , AND γ , γ REACTIONS

GAMMA RAYS FROM ALL REACTIONS ARE ASSUMED ISOTROPIC IN THE
LABORATORY SYSTEM.

W-183 LASL, AI EVAL-JUN73 YOUNG, RCSE
MATERIAL= 4583 ZA= 74183. AWR = 181.3800 FILE= 1 SECTION= 451

MF#15 MT#4 ENERGY DISTRIBUTIONS OF GAMMA RAYS FROM INELASTIC,
%N,2N<, AND %N,3N< REACTIONS

THE SPECTRA AT ALL ENERGIES ARE BASED ON A STATISTICAL THEORY
ANALYSIS OF THE DICKENS MEASUREMENTS WITH NATURAL W. THE THEORY
WAS USED AS DESCRIBED ABOVE %MF#13 MT#4<. ARBITRARY ADJUSTMENTS
WERE MADE TO THE THEORETICAL FITS IN REGIONS WHERE AGREEMENT
WITH EXPERIMENT WAS POOR %MAINLY BELOW EN#5 MEV<.

MF#15 MT#102 ENERGY DISTRIBUTIONS OF GAMMA RAYS FROM RADIATIVE
CAPTURE

SPECTRA AT NEUTRON ENERGIES BELOW 1 EV ARE BASED ON A PRELIM-
INARY THERMAL MEASUREMENT BY JURNEY AND FROM 1 EV TO 1000 EV ON
CALCULATIONS BY YOST ET AL. AT HIGHER ENERGIES THE SPECTRA ARE
BASED ON STATISTICAL CALCULATIONS USING PARAMETERS OBTAINED BY
ANALYZING THE DICKENS MEASUREMENT FOR EN#1-3 MEV. THE THEORY
WAS USED AT ALL ENERGIES TO DIVIDE THE NATURAL W DATA INTO
SEPARATE ISOTOPIIC COMPONENTS.

REFERENCES FOR MF#12,13,14,15 DATA

1. E. I. JURNEY, PRIVATE COMMUNICATION %1973<.
2. K. J. YOST, J. E. WHITE, C. Y. FU, AND W. E. FORD, NUCL.
SCI. ENG. 47, 209%1972<.
3. E. S. TROUBETZKOY, PHYS. REV. 122, 212%1961<.
4. J. K. DICKENS, PRIVATE COMMUNICATION %1972<.
5. A. ARTINA, NUCLEAR DATA B1-1-37 %1966<.

***** NOTE. NO INFORMATION IS PROVIDED IN THIS EVALUATION ON
ELECTRON PRODUCTION FROM INTERNAL CONVERSION. SUCH
INFORMATION MIGHT BE IMPORTANT FOR CERTAIN LOCAL
HEATING PROBLEMS.

W-183 LASL, AI EVAL-JUN73 YOUNG, RCSE
 MATERIAL= 4583 ZA= 74183. AWR = 181.3800

FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	GENERAL COMMENTS	392
2	151	RESONANCE DATA	123
3	1	TOTAL	62
3	2	ELASTIC	62
3	4	TOTAL INELASTIC	60
3	16	(N,2N)	22
3	17	(N,3N)	11
3	28	(N,N*) P	15
3	51	(N,N*) 1-ST EXCITED	60
3	52	(N,N*) 2-ND EXCITED	54
3	53	(N,N*) 3-ED EXCITED	28
3	54	(N,N*) 4-TH EXCITED	27
3	55	(N,N*) 5-TH EXCITED	24
3	56	(N,N*) 6-TH EXCITED	23
3	57	(N,N*) 7-TH EXCITED	21
3	58	(N,N*) 8-TH EXCITED	20
3	59	(N,N*) 9-TH EXCITED	17
3	91	(N,N*) CONTINUUM	38
3	102	(N,GAMMA)	62
3	103	(N,P)	18
3	107	(N,ALPHA)	18
3	251	MU BAR	14
3	252	XI	14
3	253	GAMMA	14
4	2	ELASTIC	190
4	16	(N,2N)	8
4	17	(N,3N)	8
4	28	(N,N*) P	8
4	51	(N,N*) 1-ST EXCITED	105
4	52	(N,N*) 2-ND EXCITED	103
4	53	(N,N*) 3-ED EXCITED	8
4	54	(N,N*) 4-TH EXCITED	8
4	55	(N,N*) 5-TH EXCITED	8
4	56	(N,N*) 6-TH EXCITED	8
4	57	(N,N*) 7-TH EXCITED	8
4	58	(N,N*) 8-TH EXCITED	8
4	59	(N,N*) 9-TH EXCITED	8
4	91	(N,N*) CONTINUUM	8
5	16	(N,2N)	55
5	17	(N,3N)	43
5	28	(N,N*) P	21
5	91	(N,N*) CONTINUUM	42
12	102	(N,GAMMA)	15
13	4	TOTAL INELASTIC	359
14	4	TOTAL INELASTIC	1
14	102	(N,GAMMA)	1
15	4	TOTAL INELASTIC	842
15	102	(N,GAMMA)	451
23	501	TOTAL PHOTON	23
23	502	RAYLEIGH SCATTERING	23

W-183 LASL, AI EVAL-JUN73 YOUNG, RCSE
MATERIAL= 4583 ZA= 74183. AWR = 181.3800 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
23	504	COMPTON SCATTERING	23
23	516	PAIR PRODUCTION	9
23	602	PHOTOELECTRIC EFFECT	23

W-184 LASL, AI EVAL-JUN73 YOUNG, RCSE
MATERIAL= 4584 ZA= 74184. AWR = 182.3700 FILE= 1 SECTION= 451

DIST-JUL73 MCD 2-MAR74

***** DNA 4584 MOD 2 *****

1. MF#12, MT#102 GAMMA RAY MULTIPLICITIES AT THE FIRST THREE NEUTRON ENERGIES WERE REPLACED WITH VALUES BASED ON THE FINAL RESULTS FROM JUNEYS THERMAL MEASUREMENT.
2. MF#15, MT#102 GAMMA RAY SPECTRA AT THE FIRST TWO NEUTRON ENERGIES WERE MODIFIED TO REFLECT JUNEYS FINAL RESULTS.
3. MF#1, MT#451 MODIFIED FOR THE ABOVE CHANGES.

***** DNA 4584 MCD 1 *****

1. MF#4, MT#28 ADDED TO FILE - ASSUMED ISOTROPIC IN LAB. MT#16, 17 REPRESENTED BY LEGENDRE COEFFICIENTS.
2. MF#5, MT#28 ADDED TO FILE. TEMPERATURES BASED ON THE SAME LEVEL DENSITY PARAMETERS THAT WERE EMPLOYED FOR THE ${}^A_ZX, 2N <$ AND ${}^A_ZX, 3N <$ REACTIONS ARE USED FOR MT#28.

***** DNA 4584 MOD C *****

TUNGSTEN-184 ASSEMBLED BY P. ROSE %AI< AND P. YOUNG %LASL<

NEUTRON FILES %ENDF/B MAT 1130<

EVALUATION OF FILE 2 - J. CTTER, ATOMICS INTERNATIONAL
EVALUATION OF FILE 4 - E. OTTEWITTE, ATOMICS INTERNATIONAL
EVALUATION OF REMAINING FILES - P. ROSE, ATOMICS INTERNATIONAL
NEUTRON FILE ASSEMBLY BY P. ROSE, ATOMICS INTERNATIONAL
COMPLETED APRIL 1973 %AI REF< TI-707-130-026

GAMMA RAY PRODUCTION FILES

EVALUATION AND ASSEMBLY OF FILES 12 THRU 15 - P. YOUNG,
LOS ALAMOS SCIENTIFIC LABORATORY, MAY 1973

FILE 23 DATA - PHOTON INTERACTION - TAKEN FROM RSIC
DATA LIBRARY %DLC-7 D< IS BASED ON DATA FROM
UCRL-50174 SEC. II, REV. 1969 BY MCMASTER ET AL.
AND UCRL-50400, VOL. VI BY PLECHATY AND TERRALL.

W-184 LASL, AI EVAL-JUN73 YOUNG, RCSE
MATERIAL= 4584 ZA= 74184. AWF = 182.3700 FILE= 1 SECTION= 451

MF#1 MT#451 DESCRIPTIVE INFORMATION

ATOMIC MASS AND Q VALUES A.H. WAFFRA AND N.B. GOVE
NUCLEAR DATA TABLES 9, 267 %1971<

MF#2 MT#151 RESONANCE PARAMETERS

RESOLVED RESONANCE EVALUATION

POTENTIAL SCATTERING XSEC # 8.08-1.0 E AT E#0
2200 M/S CROSS SECTION %BARN<

	CALC	MEAS %REF-1<
CAP	1.8	1.88-0.2
SCAT	3.9	

RESOLVED RESONANCE PARAMETERS

		FROM	FIT TO CAPTURE
	-11.76 EV	FROM	EVALUATION, REFERENCE 1 AND 2
150 -	2060 EV	FROM	EVALUATION, REFERENCE 1, 2, AND 3
2080 -	2110 EV	FROM	REFERENCE 2
2200 -	2650 EV	FROM	REFERENCE 3

UNRESOLVED RESONANCE EVALUATION

POTENTIAL SCATTERING XSEC # 8.58-1.0 E AT E#0
TOTAL XSEC # 9.1 B AT E#100 KEV %CALCULATED<

UNRESOLVED RESONANCE PARAMETERS FROM AUTOMATED OPTIMIZED FIT TO
THE EVALUATED MEASURED CAPTURE CROSS SECTION.

AV L#0 LEVEL SPACING %E#0<	# 80.3 EV, ENERGY DEP. FROM REF 4
AV CAPTURE LEVEL WIDTH	# 0.0731 EV, ENERGY INDEPENDENT
L#0 STRENGTH FUNCTION	# 2.3E-4, ENERGY INDEPENDENT
L#1 STRENGTH FUNCTION	# 0.18E-4, ENERGY INDEPENDENT
L#2 STRENGTH FUNCTION	# 1.45E-4, ENERGY INDEPENDENT

AVERAGE CAPTURE CROSS SECTION UNCERTAINTY AT ENERGY E
E %KEV< UNC. %%<

100	15
90	10
10	10
4.5	20

RESONANCE INTEGRAL%CAPTURE< 16.2E CALC., 138-2B MEASURED %REF-5<

REFERENCES

1. BNL-325, 2ND EDITION, SUPPLEMENT 2, GOLDBERG ET AL %1966<

W-184 LASL, AI EVAL-JUN73 YCUNG, RCSE
MATERIAL= 4584 ZA= 74184. AWR = 182.3700 FILE= 1 SECTION= 451

2. Z.M.BARTOLOME ET AL, NUCL.SCI.ENG. 37, P137 %1969<
3. F.J.RAHN AND H.CAMARDA, PERSONAL COMMUNICATION, COLUMBIA%1970<
4. J.L.COOK ET AL AAEC/TM-392 %1967<
5. M.DRAKE, %1968< FOR AMERICAN INSTITUTE OF PHYS. HANDBOOK%1972<

MF#3 MT#1 TOTAL CROSS SECTION

THE TOTAL CROSS SECTION WAS EVALUATED USING A LEAST SQUARES SPLINE FIT TO EXPERIMENTAL DATA FOR THIS ISOTOPE. SPLINE FITS OF EXPERIMENTAL DATA FOR NATURAL TUNGSTEN WERE ALSO FACTORED INTO THE EVALUATION %SEE MAT 1129 FOR REFERENCES<. THE TOTAL CROSS SECTION CURVE WAS SMOOTHLY JOINED TO THE EVALUATED TOTAL CROSS SECTION IN THE UNRESOLVED RESONANCE RANGE BELOW 100 KEV.

ISOTOPIC DATA REFERENCES FOR TOTAL CROSS SECTION-

- 1.%100KEV-650KEV< J.F.WHALEN,ANL-7210,16%1966<
- 2.%650KEV-20MEV< R.C.MARTIN,PHD THESIS,FEI%1967<
- 3.%2.5MEV-15MEV< D.G.FOSTER AND I.W.GIASGCW,PHYS.REV.3C,576%71<

GENERAL REFERENCES FOR TOTAL CROSS SECTION-

- 1 M.D.GOLEBERG ET AL,BNL-325,SECOND EDITION,SUPPLEMENT#2 %1966<
2. J.J.DEVANEY AND D.G.FOSIER,JR,ICS AIAMCS REPT. LA-4928 %1972<

THE UNCERTAINTY IN THE TOTAL CROSS SECTION IS PROBABLY BETTER THAN 7% OVER THE ENERGY RANGE FROM 600 KEV TO 20 MEV. BETWEEN 300KEV AND 600 KEV THE UNCERTAINTY INCREASES TO 10% AND FROM 100 TO 200KEV THE UNCERTAINTY IS ESTIMATED TO BE 15%.

MF#3 MT#2 ELASTIC CROSS SECTION.

THE ELASTIC CROSS SECTION WAS OBTAINED BY SUBTRACTING THE NON-ELASTIC CROSS SECTIONS FROM THE EVALUATED TOTAL CROSS SECTION.

THE ELASTIC CROSS SECTION IS IN GOOD AGREEMENT WITH THE DATA OF D.LISTER ET AL %ANL-7288,1967< BETWEEN 0.3 AND 0.8 MEV. BETWEEN 0.8 MEV AND 1.5 MEV THE ELASTIC CROSS SECTION IS SOMEWHAT HIGHER THAN THE EXPERIMENTAL DATA.

BETWEEN 1 MEV AND 9 MEV THE EVALUATED CURVE LIES ABOVE 2PLUS-COMNUC RESULTS. AT 4.3 MEV THE CROSS SECTION IS SOME 15% LOWER THAN THE EXPERIMENTAL DATA POINT OF W.F.KINNEY AND F.G.PEREY FOR NATURAL TUNGSTEN %ORNL-4803,1973<. OUR EVALUATION IS, HOWEVER, IN AGREEMENT WITH THEIR DATA ABOVE 5 MEV.

MF#3 MT#4 TOTAL INELASTIC CROSS SECTION.

EQUAL TO THE SUM OF THE LEVEL EXCITATION AND CONTINUUM CROSS SECTIONS. THE TOTAL INELASTIC CROSS SECTION FOR THIS ISOTOPE IS IN GENERAL AGREEMENT WITH THE DATA OF R.O.OWENS ET AL FOR NATURAL TUNGSTEN BETWEEN 5 AND 7 MEV %NUCL.PHYS.A112,337%1968<<.

MF#3 MT#16 N-2N CROSS SECTION.

W-184 LASL, AT EVAL-JUN73 YOUNG, ROSE
MATERIAL= 4584 ZA= 74184. AWR = 182.3700 FILE= 1 SECTION= 451

THE SEMI-EMPIRICAL TECHNIQUES OF S. PEARLSTEIN %NSE 23,238< AND W.D. LU ET AL %PHYS. REV. C1,350%1970<< WERE USED TO DEDUCE THE N-2N CROSS SECTION.

MF#3 MT#17 N-3N CROSS SECTION.

THE N-3N CROSS SECTIONS WERE DEDUCED USING THE SEMI-EMPIRICAL TECHNIQUES OF S. PEARLSTEIN AND W.D. LU. AN EFFECTIVE THRESHOLD FOR THE N-3N REACTION WAS SET 1.25 MEV ABOVE THE THEORETICAL THRESHOLD.

MF#3 MT#28 N-PN CROSS SECTION.

THE SHAPE OF THE N-PN EXCITATION CURVE IS BASED UPON THE EXPERIMENTAL DATA OF J.F. BARRY ET AL FOR W-186 %SEE MAT 1131<. THE CURVE HAS BEEN SHIFTED IN ENERGY BY THE DIFFERENCE IN THE REACTION Q FOR THIS ISOTOPE AND W-186. THE CROSS SECTION CONTAINS CONTRIBUTIONS FROM THE N-NE AND N-D REACTIONS.

MF#3 MT#51 INELASTIC EXCITATION %DIRECT AND COMPOUND NUCLEUS< TO THE 28 LEVEL.

THE CROSS SECTIONS WERE CALCULATED USING 2PLUS-COMNUC. THEY HAVE BEEN RENORMALIZED VIA A LEAST SQUARES FIT TO DATA OF D. LISTER ET AL %PHYS. REV. 162,1077%1967<< WITH A 10% UNCERTAINTY IN THE ADJUSTED CURVE.

MF#3 MT#52-59,91 INELASTIC EXCITATION %COMPOUND NUCLEUS ONLY<.

CALCULATION BY THE COMNUC CODE FOR THE 365,748,904,1007,1135, 1223,1270, AND 1287 KEV LEVELS PLUS THE CONTINUUM. THE 365,904, AND 1007 KEV LEVELS WERE RENORMALIZED TO THE DATA OF D. LISTER % 10% UNCERTAINTY IN THE 365 KEV LEVEL, AND 15% UNCERTAINTY ESTIMATED FOR THE 904 AND 1007 KEV LEVELS<.

MF#3 MT#102 RADIATIVE CAPTURE CROSS SECTION.

THE RADIATIVE CAPTURE CROSS SECTION WAS EVALUATED BETWEEN 10 KEV AND 150 KEV USING A LEAST SQUARES FIT TO EXPERIMENTAL DATA %SEE MF#2 MT#151<.

THIS FIT WAS COMBINED AND JOINED TO THE THEORETICAL CROSS SECTIONS COMPUTED BETWEEN 100 KEV AND 4 MEV USING THE COMNUC CODE. ABOVE 4 MEV THE COMNUC RESULTS WERE JOINED TO THE COLLECTIVE AND DIRECT INTERACTION CAPTURE CROSS SECTIONS CALCULATED USING THE THEORY OF V. BENZI AND G. REFFO %CCDN-NW10, ENEA NEUTRON CORRELATION CENTER, 1969<.

THE UNCERTAINTY IN THE RADIATIVE CAPTURE CROSS SECTION IS PROBABLY BETTER THAN 15% FOR ENERGIES BETWEEN 100 KEV AND 200 KEV. ABOVE 200 KEV THE CROSS SECTION IS RELIABLE ONLY TO THE EXTENT OF THE VALIDITY OF THE THEORETICAL MODELS.

W-184 LASL, AI EVAL-JUN73 YCUNG, RCSR
MATERIAL= 4584 ZA= 74184. AWR = 182.3700 FILE= 1 SECTION= 451

MF#3 MT#103 N-P CROSS SECTION.

THE SHAPE OF THE N-P EXCITATION CURVE IS BASED UPON THE EXPERIMENTAL DATA OF J.F.BARRY ET AL FOR W-186 %SEE MAT 1131<. THE CURVE HAS BEEN SHIFTED IN ENERGY TO AGREE WITH THE RATIO OF N-P MEASUREMENTS REPORTED BY R.F.COLEMAN FOR W-184 AND W-186 AT 14.5 MEV %PROC.PHYS.SOC. 73,215%1959<<.

MF#3 MT#107 N-ALPHA CROSS SECTION.

THE N-ALPHA CROSS SECTION EVALUATION IS BASED UPON DATA OF A.RUBINO AND D.ZUBKE %NUCL.PHYS. 85,606%1966<< FOR TA-181. THE FEW EXPERIMENTAL DATA POINTS FOR ISOTOPIES OF TUNGSTEN BETWEEN 14 AND 15 MEV QUALITATIVELY SUBSTANTIATES THE USE OF THIS CURVE. THE EVALUATION HAS NOT BEEN EXTENDED BELOW 11 MEV.

MF#4 MT#2 ANGULAR DISTRIBUTION OF ELASTICALLY SCATTERED NEUTRONS

THE ANGULAR DISTRIBUTIONS FOR ELASTIC SCATTERING ARE GIVEN AS LEGENDRE POLYNOMIAL COEFFICIENTS IN THE CM SYSTEM. THESE DATA WERE CALCULATED BY 2PLUS-COMNUC CODES FOR EACH ISOTOPE. AS LITTLE ISOTOPIC EXPERIMENTAL DATA EXISTED, THE CALCULATED DATA WERE AVERAGED ACCORDING TO ABUNDANCE AND COMPARED TO NATURAL TUNGSTEN DATA. THE COMPARISON INDICATED THAT THE EXPERIMENTAL DATA CONTAINED DIRECT INELASTIC FRACTIONS TO THE FIRST LEVEL. WITH THE CALCULATED FIRST-LEVEL DIRECT INELASTIC INCLUDED, AGREEMENT WITHIN EXPERIMENTAL ERROR WAS GENERALLY INDICATED OVER ALL ENERGIES. THIS AGREEMENT ALSO SUPPORTS THE VALIDITY OF THE INELASTIC ANGULAR FILE BELOW.

THE NATURAL TUNGSTEN EXPERIMENTAL DATA WERE DERIVED FROM THE FOLLOWING SOURCES-

1. BUL APS 5,409%1960< %ANL<
2. PHYS.REV. 176,1405%1968< %ANI<
3. PHYS.REV. 93,1062%1954< %U.WISC<
4. NUCL.PHYS. A125,641%1966< %JAFAN AFRIC<
5. PHYS.REV. 109,2105%1958< %WEST.RESCH<
6. W.KINNEY, PVT.COMM.%1972< %ORNL<
7. PHYS.REV. 129,1649%1963< %LASL<
8. NUCL.PHYS. 2,124%1956< %GRONINGEN, NETHERLANDS<

ERROR ESTIMATES FOR THIS SECTION ARE DIFFICULT BECAUSE IT APPEARS THAT PURE ELASTIC SCATTER HAS NOT BEEN MEASURED EXCEPT AT LOW ENERGIES. BECAUSE OF THE GOOD AGREEMENT OVERALL WITH THE COMBINED DATA, THIS FILE IS ESTIMATED TO BE ACCURATE TO 15 % AT ENERGIES BELOW 1 MEV, AND WITHIN A FACTOR OF TWO AT ENERGIES ABOVE 1 MEV FOR ALL SCATTERING ANGLES.

MF#4 MT#51-59,91 ANG. DISTRIBUTION OF INEL. SCATTERED NEUTRONS.

W-184 LASL, AT EVAL-JUN73 YOUNG, RCSE
MATERIAL= 4584 ZA= 74184. AWR = 182.3700 FILE= 1 SECTION= 451

ANGULAR DISTRIBUTIONS ARE GIVEN AS LEGENDRE POLYNOMIAL COEFFICIENTS IN THE LABORATORY FRAME OF REFERENCE.

THESE DATA ARE BASED UPON 2PLUS-COMNUC CALCULATIONS. THEY INCLUDE ANISOTROPIC CONTRIBUTIONS FROM DIRECT INEL. EXCITATION OF THE TWO PLUS LEVEL. COMPOUND LEVEL AND CONTINUUM EXCITATIONS ARE ISOTROPIC IN THE LABORATORY SYSTEM.

ERRORS ARE SMALL SIMPLY DUE TO THE PREDOMINANCE OF ISOTROPY.

MF#5 MT#16, 17 NUCLEAR TEMPS FOR THE N-2N AND N-3N REACTIONS.

TEMPERATURE OF FIRST EMITTED NEUTRON SAME AS FOR MT#91. TEMPERATURES OF SECOND AND THIRD EMITTED NEUTRONS DEDUCED BY CONSERVATION OF ENERGY ASSUMING THE KINETIC ENERGY OF AN EMITTED NEUTRON IS 2*KT.

MF#5 MT#91 NUCLEAR TEMPERATURE - INELASTIC CONTINUUM.

LEAST SQUARES WEISSKOPF LEVEL SPACING FIT TO NATURAL TUNGSTEN DATA. ISOTOPIC DATA ADJUSTED USING DEFORMED NUCLEUS LEVEL DENSITY FORMULA OF GILBERT AND CAMERON.

REFERENCES -

1. S.G. BUCCINO ET AL, NUCL. PHYS. 60, 17*1964<
2. R.O. OWENS AND J.H. TOWLE, NUCL. PHYS. A112, 337*1968<
3. W.E. KINNEY, ORNL, PRIVATE COMMUNICATION*1972<
4. A. GILBERT AND A.G.W. CAMERON, CAN. J. PHYS. 43, 1446*1965<

MF#12 MT#102 MULTIPLICITIES FOR GAMMA RAY PRODUCTION FROM RADIATIVE CAPTURE

MULTIPLICITIES AT NEUTRON ENERGIES BELOW 1 EV ARE BASED ON A PRELIMINARY THERMAL MEASUREMENT FOR NATURAL W BY JUNEY AND FROM 1 EV TO 1000 EV ON CALCULATIONS BY YOST ET AL. AT HIGHER ENERGIES THE MULTIPLICITIES ARE BASED ON AN ANALYSIS OF NATURAL W MEASUREMENTS *DICKENS, EN#1-20 MEV< USING STATISTICAL CALCULATIONS SIMILAR TO THOSE DESCRIBED BY TROUBETZKOY, WITH THE MULTIPLICITIES CHOSEN TO GIVE ROUGH AGREEMENT WITH THE MEASUREMENTS. GAMMA-RAYS FROM $\pi N, G, N'$ < WERE INCLUDED IN THESE CALCULATIONS. THE THEORY WAS USED AT ALL ENERGIES TO DIVIDE THE NATURAL W DATA INTO ISOTOPIC COMPONENTS.

MF#13 MT#4 GAMMA RAY PRODUCTION CROSS SECTIONS FROM INELASTIC, $\pi N, 2N$ <, AND $\pi N, 3N$ < REACTIONS

THE CROSS SECTIONS FOR DISCRETE PHOTONS ARE BASED ON THE LEVEL EXCITATION CROSS SECTIONS IN MF#3, MT#51-59, MAINLY USING THE LEVEL DECAY SCHEME OF MARTIN. THE CROSS SECTIONS FOR CONTINUUM GAMMA RAYS ARE BASED ON A STATISTICAL THEORY ANALYSIS OF THE

W-184 LASL, AI EVAL-JUN73 YOUNG, RCSE
MATERIAL= 4584 ZA= 74184. AWR = 182.3700 FILE= 1 SECTION= 451

DICKENS MEASUREMENTS ON NATURAL W. THE THEORY WAS USED FOR INTERPOLATION, SMOOTHING, AND SEPARATION OF THE DATA INTO ISOTOPIC COMPONENTS.

MF#14 MT#4, 102 ANGULAR DISTRIBUTIONS OF GAMMA RAYS FROM RADIATIVE CAPTURE, INELASTIC, $n, 2n$, AND $n, 3n$ REACTIONS

GAMMA RAYS FROM ALL REACTIONS ARE ASSUMED ISOTROPIC IN THE LABORATORY SYSTEM.

MF#15 MT#4 ENERGY DISTRIBUTIONS OF GAMMA RAYS FROM INELASTIC, $n, 2n$, AND $n, 3n$ REACTIONS

THE SPECTRA AT ALL ENERGIES ARE BASED ON A STATISTICAL THEORY ANALYSIS OF THE DICKENS MEASUREMENTS WITH NATURAL W. THE THEORY WAS USED AS DESCRIBED ABOVE MF#13 MT#4. ARBITRARY ADJUSTMENTS WERE MADE TO THE THEORETICAL FITS IN REGIONS WHERE AGREEMENT WITH EXPERIMENT WAS POOR MAINLY BELOW EN#5 MEV.

MF#15 MT#102 ENERGY DISTRIBUTIONS OF GAMMA RAYS FROM RADIATIVE CAPTURE

SPECTRA AT NEUTRON ENERGIES BELOW 1 EV ARE BASED ON A PRELIMINARY THERMAL MEASUREMENT BY JURNEY AND FROM 1 EV TO 1000 EV ON CALCULATIONS BY YOST ET AL. AT HIGHER ENERGIES THE SPECTRA ARE BASED ON STATISTICAL CALCULATIONS USING PARAMETERS OBTAINED BY ANALYZING THE DICKENS MEASUREMENT FOR EN#1-3 MEV. THE THEORY WAS USED AT ALL ENERGIES TO DIVIDE THE NATURAL W DATA INTO SEPARATE ISOTOPIC COMPONENTS.

REFERENCES FOR MF#12, 13, 14, 15 DATA

1. E. T. JURNEY, PRIVATE COMMUNICATION 1973.
2. K. J. YOST, J. E. WHITE, C. Y. FU, AND W. E. FORD, NUCL. SCI. ENG. 47, 209 1972.
3. E. S. TROUBETZKOY, PHYS. REV. 122, 212 1961.
4. J. K. DICKENS, PRIVATE COMMUNICATION 1972.
5. M. J. MARTIN, NUCLEAR DATA B1-1-63 1966.

***** NOTE. NO INFORMATION IS PROVIDED IN THIS EVALUATION ON ELECTRON PRODUCTION FROM INTERNAL CONVERSION. SUCH INFORMATION MIGHT BE IMPORTANT FOR CERTAIN LOCAL HEATING PROBLEMS.

W-184 LASL, AI EVAL-JUN73 YOUNG, RCSE
 MATERIAL= 4584 ZA= 74184. AWR = 182.3700 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	GENERAL COMMENTS	401
2	151	RESONANCE DATA	86
3	1	TOTAL	71
3	2	ELASTIC	70
3	4	TOTAL INELASTIC	67
3	16	(N,2N)	23
3	17	(N,3N)	13
3	28	(N,N*) F	15
3	51	(N,N*) 1-ST EXCITED	67
3	52	(N,N*) 2-ND EXCITED	31
3	53	(N,N*) 3-RD EXCITED	22
3	54	(N,N*) 4-TH EXCITED	20
3	55	(N,N*) 5-TH EXCITED	18
3	56	(N,N*) 6-TH EXCITED	17
3	57	(N,N*) 7-TH EXCITED	16
3	58	(N,N*) 8-TH EXCITED	16
3	59	(N,N*) 9-TH EXCITED	15
3	91	(N,N*) CONTINUUM	43
3	102	(N,GAMMA)	71
3	103	(N,E)	18
3	107	(N,ALPHA)	19
3	251	MU BAR	14
3	252	XI	14
3	253	GAMMA	14
4	2	ELASTIC	190
4	16	(N,2N)	8
4	17	(N,3N)	8
4	28	(N,N*) F	8
4	51	(N,N*) 1-ST EXCITED	103
4	52	(N,N*) 2-ND EXCITED	8
4	53	(N,N*) 3-RD EXCITED	8
4	54	(N,N*) 4-TH EXCITED	8
4	55	(N,N*) 5-TH EXCITED	8
4	56	(N,N*) 6-TH EXCITED	8
4	57	(N,N*) 7-TH EXCITED	8
4	58	(N,N*) 8-TH EXCITED	8
4	59	(N,N*) 9-TH EXCITED	8
4	91	(N,N*) CONTINUUM	8
5	16	(N,2N)	51
5	17	(N,3N)	46
5	28	(N,N*) F	21
5	91	(N,N*) CONTINUUM	37
12	102	(N,GAMMA)	14
13	4	TOTAL INELASTIC	136
14	4	TOTAL INELASTIC	1
14	102	(N,GAMMA)	1
15	4	TOTAL INELASTIC	859
15	102	(N,GAMMA)	369
23	501	TOTAL PHOTON	23
23	502	RAYLEIGH SCATTERING	23

W-184 LASL, AI EVAL-JUN73 YOUNG, RCSE
MATERIAL= 4584 ZA= 74184. AWR = 182.3700 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
23	504	COMPTON SCATTERING	23
23	516	PAIR PRODUCTION	9
23	602	PHOTOELECTRIC EFFECT	23

W-186 LASL, AI EVAL-JUN73 YOUNG, RCFE
MATERIAL= 4586 ZA= 74186. AWR = 184.3600 FILE= 1 SECTION= 451

DIST-JUL73 MCD 2-MAR74

***** DNA 4586 MCD 2 *****

1. MF#12, MT#102 GAMMA RAY MULTIPLICITIES AT THE FIRST THREE NEUTRON ENERGIES WERE REPLACED WITH VALUES BASED ON THE FINAL RESULTS FROM JOURNEYS THERMAL MEASUREMENT.
2. MF#15, MT#102 GAMMA RAY SPECTRA AT THE FIRST TWO NEUTRON ENERGIES WERE MODIFIED TO REFLECT JOURNEYS FINAL RESULTS.
3. MF#1, MT#451 MODIFIED FOR THE ABOVE CHANGES.

***** DNA 4586 MCD 1 *****

1. MF#4, MT#28 ADDED TO FILE - ASSUMED ISOTROPIC IN LAB. MT#16, 17 REPRESENTED BY LEGENDRE COEFFICIENTS.
2. MF#5, MT#28 ADDED TO FILE. TEMPERATURES BASED ON THE SAME LEVEL DENSITY PARAMETERS THAT WERE EMPLOYED FOR THE ${}^N_{2N}$ AND ${}^N_{3N}$ REACTIONS ARE USED FOR MT#28.
3. MF#5, MT#16, 17 -- ERRORS IN U-CUTOFF AND IN FRACTIONAL PROBABILITIES ARRAY P< ARE CORRECTED.

***** DNA 4586 MCD 0 *****

TUNGSTEN-186 ASSEMBLED BY P. ROSE $\%AI$ AND P. YOUNG $\%LASL$

NEUTRON FILES $\%ENDF/B$ MAT 1131<

EVALUATION OF FILE 2 - J. COTTER, ATOMICS INTERNATIONAL
EVALUATION OF FILE 4 - E. OTTEWILL, ATOMICS INTERNATIONAL
EVALUATION OF REMAINING FILES - P. ROSE, ATOMICS INTERNATIONAL
NEUTRON FILE ASSEMBLY BY P. ROSE, ATOMICS INTERNATIONAL
COMPLETED APRIL 1973 $\%AI$ REF< TI-707-130-026

GAMMA RAY PRODUCTION FILES

EVALUATION AND ASSEMBLY OF FILES 12 THRU 15 - P. YOUNG,
LOS ALAMOS SCIENTIFIC LABORATORY, MAY 1973

FILE 23 DATA - PHOTON INTERACTION - TAKEN FROM RSIC

W-186 LASL, AI EVAL-JUN73 YOUNG, RCSE
MATERIAL= 4586 ZA= 74186. AWR = 184.3600 FILE= 1 SECTION= 451

DATA LIBRARY %DLC-7 D< IS BASED ON DATA FROM
UCRL-50174 SEC. II, REV. 1969 BY MCMASTER ET AL.
AND UCRL-50400, VOL. VI BY PLFCHATY AND TERRALL.

MF#1 MT#451 DESCRIPTIVE INFORMATION

ATOMIC MASS AND Q VALUES A.H. WAESTRA AND N.B. GOVE
NUCLEAR DATA TABLES 9, 267 %1971<

MF#2 MT#151 RESONANCE PARAMETERS

RESOLVED RESONANCE EVALUATION

POTENTIAL SCATTERING XSEC # 8.08-1.0 E AT E#0
2200 M/S CROSS SECTION %BARNS<
CALC MEAS %REF-1<
CAP 37.5 388-2
SCAT 0.39

RESOLVED RESONANCE PARAMETERS

18.81 EV FROM EVALUATION OF REF 1 AND 3 PLUS
ADJUSTMENT FROM FIT TO CAPTURE XSEC
100 - 250 EV FROM EVALUATION OF REFERENCES 1-3.
250 - 3200 EV FROM EVALUATION OF REFERENCES 2-3.

UNRESOLVED RESONANCE EVALUATION

POTENTIAL SCATTERING XSEC # 8.58-1.0 E AT E#0
TOTAL XSEC # 9.1 B AT E#100KEV %CALCULATED<

UNRESOLVED RESONANCE PARAMETERS FROM AUTOMATED OPTIMIZED FIT TO
THE EVALUATED MEASURED CAPTURE CROSS SECTION.

AV L#0 LEVEL SPACING %E#0< # 99.1 EV, ENERGY DEP. FROM REF 4
AV CAPTURE LEVEL WIDTH # 0.0530 EV, ENERGY INDEPENDENT
L#0 STRENGTH FUNCTION # 2.2E-4 , ENERGY INDEPENDENT
L#1 STRENGTH FUNCTION # 0.252E-4 , ENERGY INDEPENDENT
L#2 STRENGTH FUNCTION # 1.45E-4 , ENERGY INDEPENDENT

AVERAGE CAPTURE CROSS SECTION UNCERTAINTY AT ENERGY E

E %KEV< UNC. %%<

100	11
90	8
45	8
22.5	14
10	11
4.5	17

W-186 LASL, AT EVAL-JUN73 YOUNG, RCSE
MATERIAL= 4586 ZA= 74186. AWR = 184.3600 FILE= 1 SECTION= 451

RESONANCE INTEGRAL%CAPT.< 522 B CALC., 4908-50 B MEAS. %REF-5<

REFERENCES

1. BNL-325, 2ND EDITION, SUPPLEMENT 2, GOLDBERG ET AL %1966<
2. Z.M.BARTOLICME ET AL, NUCL.SCI.ENG. 37, F137 %1969<
3. F.J.BAHR AND H.CAMARCA, PERSONAL COMMUNICATION, COLUMBIA%1970<
4. J.L.COCK ET AL AAEC/TM-392 %1967<
5. M.DRAKE, %1968< FOR AMERICAN INSTITUTE OF PHYS. HANDBOOK%1972<

MF#3 MT#1 TOTAL CROSS SECTION

THE TOTAL CROSS SECTION WAS EVALUATED USING A LEAST SQUARES SPLINE FIT TO EXPERIMENTAL DATA FOR THIS ISOTOPE. SPLINE FITS OF EXPERIMENTAL DATA FOR NATURAL TUNGSTEN WERE ALSO FACTORED INTO THE EVALUATION %SEE MAT 1129 FOR REFERENCES<. THE TOTAL CROSS SECTION CURVE WAS SMOOTHLY JOINED TO THE EVALUATED TOTAL CROSS SECTION IN THE UNRESOLVED RESONANCE RANGE BELOW 100 KEV.

ISOTOPIC DATA REFERENCES FOR TOTAL CROSS SECTION-

- 1.%100KEV-650KEV< J.F.WHALEN,ANL-7210,16%1966<
- 2.%650KEV-20MEV< R.C.MARTIN,PHD THESIS,FEI%1967<
- 3.%2.5MEV-15MEV< D.G.FOSTER AND L.W.GLASGOW,PHYS.REV.3C,576%71<

GENERAL REFERENCES FOR TOTAL CROSS SECTION-

- 1 M.D.GOLDBERG ET AL,BNL-325,SECOND EDITION,SUPPLEMENT#2 %1966<
2. J.J.DEVANNEY AND D.G.FOSTER,JR,LOS ALAMOS REPT. LA-4928 %1972<

THE UNCERTAINTY IN THE TOTAL CROSS SECTION IS PROBABLY BETTER THAN 7% OVER THE ENERGY RANGE FROM 600 KEV TO 20 MEV. BETWEEN 300KEV AND 600 KEV THE UNCERTAINTY INCREASES TO 10% AND FROM 100 TO 200KEV THE UNCERTAINTY IS ESTIMATED TO BE 15%.

MF#3 MT#2 ELASTIC CROSS SECTION.

THE ELASTIC CROSS SECTION WAS OBTAINED BY SUBTRACTING THE NON-ELASTIC CROSS SECTIONS FROM THE EVALUATED TOTAL CROSS SECTION.

THE ELASTIC CROSS SECTION IS IN GOOD AGREEMENT WITH THE DATA OF D.LISTER ET AL %ANL-7288,1967< BETWEEN 0.3 AND 0.7 MEV. BETWEEN 0.7 MEV AND 1.5 MEV THE ELASTIC CROSS SECTION IS SOME 10% HIGHER THAN THE EXPERIMENTAL DATA.

BETWEEN 1 MEV AND 9 MEV THE EVALUATED CURVE LIES ABOVE 2PLUS-COMMUC RESULTS. AT 4.3 MEV THE CROSS SECTION IS SOME 15% LOWER THAN THE EXPERIMENTAL DATA POINT OF W.E.KINNEY AND F.G.PEREY FOR NATURAL TUNGSTEN %ORNL-4803,1973<. OUR EVALUATION IS, HOWEVER, IN AGREEMENT WITH THEIR DATA ABOVE 5 MEV.

MF#3 MT#4 TOTAL INELASTIC CROSS SECTION.

EQUAL TO THE SUM OF THE LEVEL EXCITATION AND CONTINUUM CROSS

W-186 LASL, AI EVAL-JUN73 YCUNG, RCSE
MATERIAL= 4586 ZA= 74186. AWF = 184.3600 FILE= 1 SECTION= 451

SECTIONS. THE TOTAL INELASTIC CROSS SECTION FOR THIS ISOTOPE IS IN GENERAL AGREEMENT WITH THE DATA OF R.C. OWENS ET AL FOR NATURAL TUNGSTEN BETWEEN 5 AND 7 MEV %NUCL. PHYS. A112, 337%1968<<.

MF#3 MT#16 N-2N CROSS SECTION.

THE SEMI-EMPIRICAL TECHNIQUES OF S. PEARLSTEIN %NSE 23, 238< AND W.D. LU ET AL %PHYS. REV. C1, 350%1970<< WERE USED TO DEDUCE THE N-2N CROSS SECTION.

THE EVALUATED CURVE AT 14.8 MEV IS IN AGREEMENT WITH DRUZHININ ET AL %SOVIET J. NUCL. PHYS. 4, 515%1966<<.

MF#3 MT#17 N-3N CROSS SECTION.

THE N-3N CROSS SECTIONS WERE DEDUCED USING THE SEMI-EMPIRICAL TECHNIQUES OF S. PEARLSTEIN AND W.D. LU. AN EFFECTIVE THRESHOLD FOR THE N-3N REACTION WAS SET 1.25 MEV ABOVE THE THEORETICAL THRESHOLD.

MF#3 MT#28 N-PN CROSS SECTION.

THE N-PN CROSS SECTION EVALUATION IS BASED UPON DATA OF J.F. BARRY ET AL %PROC. PHYS. SOC. 74, 632%1959<<. UNCERTAINTY IS 25% AT ENERGIES WELL ABOVE THE OBSERVED THRESHOLD. THE CROSS SECTION CONTAINS CONTRIBUTIONS FROM THE N-NP AND N-D REACTIONS.

MF#3 MT#51 INELASTIC EXCITATION %DIRECT AND COMPOUND NUCLEUS< TO THE 28 LEVEL.

THE CROSS SECTIONS WERE CALCULATED USING 2PLUS-COMNUC. THEY HAVE BEEN RENORMALIZED VIA A LEAST SQUARES FIT TO DATA OF D. LISTER ET AL %PHYS. REV. 162, 1077%1967<< WITH A 10% UNCERTAINTY IN THE ADJUSTED CURVE.

MF#3 MT#52-59, 91 INELASTIC EXCITATION %COMPOUND NUCLEUS ONLY<.

CALCULATION BY THE COMNUC CODE FOR THE 401, 730, 840, 850, 960, 1040, 1110, AND 1250 KEV LEVELS PLUS THE CONTINUUM. THE 401, 730, AND 942 KEV LEVELS WERE RENORMALIZED TO THE EXPERIMENTAL DATA OF D. LISTER %10% UNCERTAINTY IN THE ADJUSTED CROSS SECTIONS<. THE SUM OF THE 840 AND 850 KEV LEVEL COMNUC RESULTS WERE RENORMALIZED TO THE 8638-10 KEV EXCITATION DATA OF D. LISTER. LIKEWISE, THE SUM OF THE 1040 AND 1110 KEV LEVELS WERE RENORMALIZED TO THE 10358-10 KEV EXPERIMENTAL DATA. THE SUMMED LEVELS HAVE A 15% CROSS SECTION UNCERTAINTY.

MF#3 MT#102 RADIATIVE CAPTURE CROSS SECTION.

THE RADIATIVE CAPTURE CROSS SECTION WAS EVALUATED BETWEEN 10 KEV AND 4 MEV USING A LEAST SQUARES Spline FIT TO EXPERIM-

W-186 LASI, AI EVAL-JUN73 YCUNG, RCSE
MATERIAL= 4586 ZA= 74186. AWF = 184.3600 FILE= 1 SECTION= 451

ENTAL DATA. %SEE MF#2 MT#151<

COMPARISON WITH COMNUC THEORETICAL RESULTS WERE EXCELIENT. ADJUSTMENTS WERE MADE, HOWEVER, TO THE DATA FIT IN THE NEIGHBORHOOD OF THE 28 THRESHOLD TO BETTER FIT THE THEORETICAL CALCULATIONS. THESE ADJUSTMENTS IMPROVED THE RECONSTRUCTED NATURAL COMPARISON WITH EXPERIMENTAL DATA.

ABOVE 4 MEV THE DATA FIT WAS JOINED TO THEORETICAL CAPTURE CROSS SECTIONS CALCULATED BETWEEN 4 AND 20 MEV. THE THEORY OF V. BENZI AND G. REFFO %CCDN-NW10, ENEA NEUTRON DATA COMPILATION CENTER, 1969< WAS USED TO DETERMINE THE COLLECTIVE AND DIRECT INTERACTION CROSS SECTION.

DATA REFERENCES-

1. M.D. GOLDBERG ET AL, BNI-325, SECOND EDITION, SUPPLEMENT#2 %1966<
2. A.E. JCHNSEUD ET AL, PHYS. REV. 116, 927%1959<
3. YU.YA. STAVISSKII & V.A. TOLSTIKOV SOV. J. ATOM. ENERGY 9, 942%61<
4. G.G. ZAIKIN ET AL, SOVIET ATOMIC ENERGY 25, 1362%1968<
5. V.N. KONONOV ET AL, SOVIET J. NUCL. PHYS. 4, 282%1966<
6. J.A. MISKEL ET AL, PHYS. REV. 128, 2717%1962<
7. R.J. NAGLE ET AL, CONF-710301, KNOXVILLE, TENNESSEE%1971<
8. Z.M. BAPTOLOME ET AL, NUCL. SCI. ENG. 37, 137%1969<

THE UNCERTAINTY IN THE RADIATIVE CAPTURE CROSS SECTION IS PROBABLY BETTER THAN 11% FOR ENERGIES BELOW 400 KEV. BETWEEN 400 KEV AND 2 MEV THE UNCERTAINTY IS ESTIMATED TO BE 6%. ABOVE 2 MEV THE CROSS SECTION IS RELIABLE ONLY TO THE EXTENT OF THE VALIDITY OF THE THEORETICAL MODEL.

MF#3 MT#103 N-P CROSS SECTION.

THE N-P CROSS SECTION EVALUATION IS BASED UPON EXPERIMENTAL DATA OF J.F. BARRY ET AL %PROC. PHYS. SOC. 74, 632%1959<<. UNCERTAINTY IS 25% AT ENERGIES WELL ABOVE THE OBSERVED THRESHOLD.

MF#3 MT#107 N-ALPHA CROSS SECTION.

THE N-ALPHA CROSS SECTION EVALUATION IS BASED UPON DATA OF A. RUBINO AND D. ZUBKE %NUCL. PHYS. 85, 606%1966<< FOR TA-181. THE FEW EXPERIMENTAL DATA POINTS FOR ISOTOPES OF TUNGSTEN BETWEEN 14 AND 15 MEV QUALITATIVELY SUBSTANTIATES THE USE OF THIS CURVE. THE EVALUATION HAS NOT BEEN EXTENDED BELOW 11 MEV.

MF#4 MT#2 ANGULAR DISTRIBUTION OF ELASTICALLY SCATTERED NEUTRONS

THE ANGULAR DISTRIBUTIONS FOR ELASTIC SCATTERING ARE GIVEN AS LEGENDRE POLYNOMIAL COEFFICIENTS IN THE CM SYSTEM. THESE DATA WERE CALCULATED BY 2PLUS-COMNUC CODES FOR EACH ISOTOPE. AS LITTLE ISOTOPIC EXPERIMENTAL DATA EXISTED, THE CALCULATED DATA

W-186 LASL, AI EVAL-JUN73 YOUNG, RCSE
MATERIAL= 4586 ZA= 74186. AWE = 184.3600 FILE= 1 SECTION= 451

WERE AVERAGED ACCORDING TO ABUNDANCE AND COMPARED TO NATURAL TUNGSTEN DATA. THE COMPARISON INDICATED THAT THE EXPERIMENTAL DATA CONTAINED DIRECT INELASTIC REACTIONS TO THE FIRST LEVEL. WITH THE CALCULATED FIRST-LEVEL DIRECT INELASTIC INCLUDED, AGREEMENT WITHIN EXPERIMENTAL ERROR WAS GENERALLY INDICATED OVER ALL ENERGIES. THIS AGREEMENT ALSO SUPPORTS THE VALIDITY OF THE INELASTIC ANGULAR FILE BELOW.

THE NATURAL TUNGSTEN EXPERIMENTAL DATA WERE DERIVED FROM THE FOLLOWING SOURCES-

1. BUL AFS 5,409%1960< %ANL<
2. PHYS.REV. 176,1405%1968< %ANL<
3. PHYS.REV. 93,1062%1954< %U.WISC<
4. NUCL.PHYS. A125,641%1966< %JAPAN AERI<
5. PHYS.REV. 109,2105%1958< %WEST.RESCH<
6. W.KINNEY, PVT.COMM.%1972< %CENL<
7. PHYS.REV. 129,1649%1963< %IASL<
8. NUCL.PHYS. 2,124%1956< %GRONINGEN, NETHERLANDS<

ERROR ESTIMATES FOR THIS SECTION ARE DIFFICULT BECAUSE IT APPEARS THAT PURE ELASTIC SCATTER HAS NOT BEEN MEASURED EXCEPT AT LOW ENERGIES. BECAUSE OF THE GOOD AGREEMENT OVERALL WITH THE COMBINED DATA, THIS FILE IS ESTIMATED TO BE ACCURATE TO 15 % AT ENERGIES BELOW 1 MEV, AND WITHIN A FACTOR OF TWO AT ENERGIES ABOVE 1 MEV FOR ALL SCATTERING ANGLES.

MF#4 MT#51-59,91 ANG. DISTRIBUTION OF INEL. SCATTERED NEUTRONS.

ANGULAR DISTRIBUTIONS ARE GIVEN AS LEGENDRE POLYNOMIAL COEFFICIENTS IN THE LABORATORY FRAME OF REFERENCE.

THESE DATA ARE BASED UPON 2PLUS-COMNUC CALCULATIONS. THEY INCLUDE ANISOTROPIC CONTRIBUTIONS FROM DIRECT INEL. EXCITATION OF THE TWO PLUS LEVEL. COMPOUND LEVEL AND CONTINUUM EXCITATIONS ARE ISOTROPIC IN THE LABORATORY SYSTEM.

ERRORS ARE SMALL SIMPLY DUE TO THE PREDOMINANCE OF ISOTROPY.

MF#5 MT#16,17 NUCLEAR TEMPS FOR THE N-2N AND N-3N REACTIONS.

TEMPERATURE OF FIRST EMITTED NEUTRON SAME AS FOR MT#91. TEMPERATURES OF SECOND AND THIRD EMITTED NEUTRONS DEDUCED BY CONSERVATION OF ENERGY ASSUMING THE KINETIC ENERGY OF AN EMITTED NEUTRON IS 2*KT.

MF#5 MT#91 NUCLEAR TEMPERATURE - INELASTIC CONTINUUM.

LEAST SQUARES WEISSKOPF LEVEL SPACING FIT TO NATURAL TUNGSTEN DATA. ISOTOPIC DATA ADJUSTED USING DEFORMED NUCLEUS LEVEL DENSITY FORMULA OF GILBERT AND CAMERON.

W-186 LASL, AT EVAL-JUN73 YOUNG, ECSE
MATERIAL= 4586 ZA= 74186. AWR = 184.3600 FILE= 1 SECTION= 451

REFERENCES -

1. S.G. BUCCINO ET AL, NUCL. PHYS. 60, 177 1964<
2. R.O. OWENS AND J.H. TOWIE, NUCL. PHYS. A112, 337 1968<
3. W.E. KINNEY, ORNL, PRIVATE COMMUNICATION 1972<
4. A. GILBERT AND A.G.W. CAMERON, CAN. J. PHYS. 43, 1446 1965<

MF#12 MT#102 MULTIPLICITIES FOR GAMMA RAY PRODUCTION FROM
RADIATIVE CAPTURE

MULTIPLICITIES AT NEUTRON ENERGIES BELOW 1 EV ARE BASED ON A PRELIMINARY THERMAL MEASUREMENT FOR NATURAL W BY JUNEY AND FROM 1 EV TO 1000 EV ON CALCULATIONS BY YCST ET AL. AT HIGHER ENERGIES THE MULTIPLICITIES ARE BASED ON AN ANALYSIS OF NATURAL W MEASUREMENTS DICKENS, EN#1-20 MEV< USING STATISTICAL CALCULATIONS SIMILAR TO THOSE DESCRIBED BY TROUBETZKOY, WITH THE MULTIPLICITIES CHOSEN TO GIVE ROUGH AGREEMENT WITH THE MEASUREMENTS. GAMMA-RAYS FROM $\gamma_{N,G,N'}$ WERE INCLUDED IN THESE CALCULATIONS. THE THEORY WAS USED AT ALL ENERGIES TO DIVIDE THE NATURAL W DATA INTO ISOTOPIC COMPONENTS.

MF#13 MT#4 GAMMA RAY PRODUCTION CROSS SECTIONS FROM INELASTIC,
 $\gamma_{N,2N}$, AND $\gamma_{N,3N}$ REACTIONS

THE CROSS SECTIONS FOR DISCRETE PHOTONS ARE BASED ON THE LEVEL EXCITATION CROSS SECTIONS IN MF#3, MT#51-59, MAINLY USING THE LEVEL DECAY SCHEME OF GOVE. THE CROSS SECTIONS FOR CONTINUUM GAMMA RAYS ARE BASED ON A STATISTICAL THEORY ANALYSIS OF THE DICKENS MEASUREMENTS ON NATURAL W. THE THEORY WAS USED FOR INTERPOLATION, SMOOTHING, AND SEPARATION OF THE DATA INTO ISOTOPIC COMPONENTS.

MF#14 MT#4, 102 ANGULAR DISTRIBUTIONS OF GAMMA RAYS FROM RADIATIVE
CAPTURE, INELASTIC, $\gamma_{N,2N}$, AND $\gamma_{N,3N}$ REACTIONS

GAMMA RAYS FROM ALL REACTIONS ARE ASSUMED ISOTROPIC IN THE LABORATORY SYSTEM.

MF#15 MT#4 ENERGY DISTRIBUTIONS OF GAMMA RAYS FROM INELASTIC,
 $\gamma_{N,2N}$, AND $\gamma_{N,3N}$ REACTIONS

THE SPECTRA AT ALL ENERGIES ARE BASED ON A STATISTICAL THEORY ANALYSIS OF THE DICKENS MEASUREMENTS WITH NATURAL W. THE THEORY WAS USED AS DESCRIBED ABOVE MF#13 MT#4<. ARBITRARY ADJUSTMENTS WERE MADE TO THE THEORETICAL FITS IN REGIONS WHERE AGREEMENT WITH EXPERIMENT WAS POOR MAINLY BELOW EN#5 MEV<.

MF#15 MT#102 ENERGY DISTRIBUTIONS OF GAMMA RAYS FROM RADIATIVE
CAPTURE

SPECTRA AT NEUTRON ENERGIES BELOW 1 EV ARE BASED ON A PRELIM-

W-186 LASL, AT EVAL-JUN73 YOUNG, RCSE
 MATERIAL= 4586 ZA= 74186. AWF = 184.3600 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
1	451	GENERAL COMMENTS	428
2	151	RESONANCE DATA	90
3	1	TOTAL	70
3	2	ELASTIC	69
3	4	TOTAL INELASTIC	65
3	16	(N,2N)	23
3	17	(N,3N)	14
3	28	(N,N*)E	14
3	51	(N,N*) 1-ST EXCITED	65
3	52	(N,N*) 2-ND EXCITED	29
3	53	(N,N*) 3-RD EXCITED	22
3	54	(N,N*) 4-TH EXCITED	20
3	55	(N,N*) 5-TH EXCITED	20
3	56	(N,N*) 6-TH EXCITED	18
3	57	(N,N*) 7-TH EXCITED	17
3	58	(N,N*) 8-TH EXCITED	16
3	59	(N,N*) 9-TH EXCITED	15
3	91	(N,N*) CONTINUUM	41
3	102	(N,GAMMA)	70
3	103	(N,E)	17
3	107	(N,ALEHA)	19
3	251	MU BAE	14
3	252	XI	14
3	253	GAMMA	14
4	2	ELASTIC	190
4	16	(N,2N)	8
4	17	(N,3N)	8
4	28	(N,N*)E	8
4	51	(N,N*) 1-ST EXCITED	106
4	52	(N,N*) 2-ND EXCITED	8
4	53	(N,N*) 3-RD EXCITED	8
4	54	(N,N*) 4-TH EXCITED	8
4	55	(N,N*) 5-TH EXCITED	8
4	56	(N,N*) 6-TH EXCITED	8
4	57	(N,N*) 7-TH EXCITED	8
4	58	(N,N*) 8-TH EXCITED	8
4	59	(N,N*) 9-TH EXCITED	8
4	91	(N,N*) CONTINUUM	8
5	16	(N,2N)	51
5	17	(N,3N)	49
5	28	(N,N*)E	19
5	91	(N,N*) CONTINUUM	37
12	102	(N,GAMMA)	15
13	4	TOTAL INELASTIC	133
14	4	TOTAL INELASTIC	1
14	102	(N,GAMMA)	1
15	4	TOTAL INELASTIC	842
15	102	(N,GAMMA)	373
23	501	TOTAL PHOTON	23
23	502	RAYLEIGH SCATTERING	23

W-186 LASL, AI EVAL-JUN73 YOUNG, RCSE
MATERIAL= 4586 ZA= 74186. AWF = 184.3600 FILE= 1 SECTION= 451

INARY THERMAL MEASUREMENT BY JUNEY AND FROM 1 EV TO 1000 EV ON
CALCULATIONS BY YOST ET AL. AT HIGHER ENERGIES THE SPECTRA ARE
BASED ON STATISTICAL CALCULATIONS USING PARAMETERS OBTAINED BY
ANALYZING THE DICKENS MEASUREMENT FOR EN#1-3 MEV. THE THEORY
WAS USED AT ALL ENERGIES TO DIVIDE THE NATURAL W DATA INTO
SEPARATE ISOTOPIC COMPONENTS.

REFERENCES FOR MF#12,13,14,15 DATA

1. E. T. JUNEY, PRIVATE COMMUNICATION #1973<.
2. K. J. YOST, J. E. WHITE, C. Y. FU, AND W. F. FORD, NUCL.
SCI. ENG. 47, 209#1972<.
3. E. S. TROUBETZKOY, PHYS. REV. 122, 212#1961<.
4. J. K. DICKENS, PRIVATE COMMUNICATION #1972<.
5. N. B. GOVE, NUCLEAR DATA B1-2-1 #1966<.

***** NOTE. NO INFORMATION IS PROVIDED IN THIS EVALUATION ON
ELECTRON PRODUCTION FROM INTERNAL CONVERSION. SUCH
INFORMATION MIGHT BE IMPORTANT FOR CERTAIN LOCAL
HEATING PROBLEMS.

W-186 LASL, AI EVAL-JUN73 YOUNG, RCSE
MATERIAL= 4586 ZA= 74186. AWR = 184.3600 FILE= 1 SECTION= 451

FILE	SECTION	DESCRIPTION	NO OF CARDS
23	504	COMPTON SCATTERING	23
23	516	PAIR INDUCTION	9
23	602	PHOTOELECTRIC EFFECT	23

6. REPORTS DOCUMENTING DNA EVALUATIONS

Information about particular evaluations has been published for many of the materials in the DNA Working Cross Section Library. Reports of this nature give more detailed information than can be found from the brief summaries given in the File 1 comments given on a tape. However, the reports tend to be out of date with the current status of an evaluation which is undergoing frequent change.

Following is a list of reports which may be helpful in providing more detailed information about some DNA materials.

Nitrogen

P. G. Young, D. G. Foster, Jr., "An Evaluation of the Neutron and Gamma-Ray Production Cross Sections for Nitrogen," LA-4725; ENDF-173 (Sept. 1972). Available NTIS.

Oxygen

D. G. Foster, Jr., P. G. Young, "A Preliminary Evaluation of the Neutron and Photon-Production Cross Sections of Oxygen," LA-4780; ENDF-174 (Aug. 1972). Available NTIS.

Aluminum

P. G. Young, D. G. Foster, Jr., "A Preliminary Evaluation of the Neutron and Photon-Production Cross Sections for Aluminum," LA-4726; ENDF-175 (Dec. 1972). Available NTIS.

Lead

C. Y. Fu, F. G. Perey, "An Evaluation of Neutron and Gamma-Ray-Production Cross Sections for Lead," ORNL-4765 and Add. (Mar. 1972). Available NTIS.

Hydrogen

L. Stewart, R. J. LaBauve, P. G. Young, "Evaluated Nuclear Data for Hydrogen in the ENDF/B-II Format," LA-4574; ENDF-141; N71-37193. (Dec. 1970). Available Dep. and NTIS.

Silicon

M. R. Bhat, M. D. Goldberg, R. R. Kinsey, A. Prince, H. Takahashi, "Neutron and Gamma Ray Production Cross Sections for Silicon," BNL-50379; ENDF-186 (March 1973). Available NTIS.

Be-9

R. J. Howerton, S. T. Perkins, "Evaluated Neutron-Interaction and Gamma-Ray Production Cross Sections of 9-Be for the Defense Nuclear Agency Working Cross-Section Library MAT No. 4154," UCRL-51337 (Dec. 1972). Available NTIS.

Ta-181

R. J. Howerton, M. H. MacGregor, S. T. Perkins, "An Evaluated Data Set for Tantalum," UCRL-51306 (Dec. 1972). Available NTIS.

Iron

S. K. Penny, W. E. Kinney, "A Re-evaluation of Natural Iron Neutron and Gamma-Ray Production Cross Sections - ENDF/B Material 1124," ORNL-4617; ENDF-139; N72-10777 (April 1971). Available NTIS.

Uranium-238

R. J. Howerton, M. H. MacGregor, "Evaluated Neutron Reaction Data for Uranium-238," UCRL-51427 (July 1973). Available NTIS.

Uranium-235

R. J. Howerton, M. H. MacGregor, "Evaluated Neutron Reaction Data for Uranium 235," UCRL-51370 (March 1973). Available NTIS.

Magnesium

M. K. Drake, M. P. Fricke, "Preliminary Evaluation of the Neutron and Photon Production Cross Sections for Magnesium," DNA-3130F (May 1973). Intelcom Rad Tech, San Diego, Calif. 92138.

Copper

M. K. Drake, M. P. Fricke, "Preliminary Evaluation of the Neutron and Photon Production Cross Sections for Copper," DNA-3129F (May 1973). Intelcom Rad Tech, San Diego, Calif. 92138.

Pu-239 and Pu-240

R. E. Hunter, L. Stewart, T. J. Hirons, "Evaluated Neutron-Induced Cross Sections for 239-Pu and 240-Pu," LA-5172 (June 1973). Available NTIS.

Tungsten Isotopes

P. F. Rose, J. M. Otter, E. Ottewitte, "Evaluation of 182-W, 183-W, 184-W, and 186-W Cross Sections for the ENDF/B Data File," TI-707-130-026 (July 1973).

INTERNAL DISTRIBUTION

1. L. S. Abbott	15. A. Zucker
2. R. G. Alsmiller, Jr.	16. H. Feshbach (consultant)
3. C. E. Clifford	17. P. F. Fox (consultant)
4. D. F. Cope	18. W. W. Havens, Jr. (consultant)
5. N. M. Greene	19. A. F. Henry (consultant)
6. F. C. Maienschein	20-150. RSIC
7. F. R. Mynatt	151-153. Central Research Library
8. R. W. Peelle	154. ORNL - Y-12 Technical Library
9. F. G. Perey	Document Reference Section
10. H. Postma	155-156. Laboratory Records Department
11. M. W. Rosenthal	157. Laboratory Records, ORNL R.C.
12. D. Steiner	158. ORNL Patent Office
13. D. B. Trauger	
14. C. R. Weisbin	
159. W. H. Hannum, Division of Reactor Research and Development,
U. S. Atomic Energy Commission, Washington, D.C. 20545	
160. P. B. Hemmig, Division of Reactor Research and Development,
U. S. Atomic Energy Commission, Washington, D.C. 20545	
161. Capt. D. C. Kaul, Defense Nuclear Agency, Washington, D.C. 20305	
162. Lt. Col. L. G. Kirchner, Defense Nuclear Agency, Washington, D.C.	
163. L. Price, Division of Controlled Thermonuclear Research,
U. S. Atomic Energy Commission, Washington, D.C. 20545	
164-165. Technical Information Center, AEC, Oak Ridge, Tennessee	
166. National Technical Information Service, Department of Commerce,
Springfield, Virginia 22151	
167. Research and Technical Support Division, ORO, Oak Ridge, Tennessee	
168. Patent Office, AEC, Oak Ridge, Tennessee	
169-312. DNA Radiation Transport Distribution	

OAK RIDGE NATIONAL LABORATORY

OPERATED BY
UNION CARBIDE CORPORATION
NUCLEAR DIVISION

POST OFFICE BOX X
OAK RIDGE, TENNESSEE 37830

SPECIAL 4TH CLASS RATE BOOKS

If a change of address is needed, indicate the change, include the zip code, and identify the document; tear off this cover and return it to the above address.