INTERNATIONAL ATOMIC ENERGY AGENCY

NUCLEAR DATA SERVICES

DOCUMENTATION SERIES OF THE IAEA NUCLEAR DATA SECTION

IAEA-NDS-0013
Rev.5

ENDF/B-5 ACTINIDES (Rev. 86)

Abstract

This document summarizes the contents of the Actinides part of the ENDF/B-5 nuclear data library released by the US National Nuclear Data Center. This library or selective retrievals of it, are available cost free from the IAEA Nuclear Data Section upon request. The present version of the library is the Revision of 1986.

H.D. Lemmel

1986

Revised by P.K. McLaughlin IAEA/NDS Jan. 2005

The file was revised to conform with ENDF/B format standards. The merged file was corrected for format errors and processed through the code CHECKR to ensure, as far as possible, format compatibility.

Nuclear Data Section
International Atomic Energy Agency
P.O. Box 100
A-1400 Vienna
Austria

e-mail: services@iaeand.iaea.org
fax: (43-1) 26007
cable: INATOM VIENNA
telex: 1-12645
telephone: (43-1) 2600-21710
Web: http://www-nds.iaea.org

Citation guidelines:

THE ENDF/B-5 ACTINIDES LIBRARY, Rev. 86

The ENDFIB-5 Actinides Library contains neutron cross-sections and decay data for actinide isotopes evaluated in the USA during the period 1975-1978; it was first released in Dec. 1978. Since then, some modifications have been made. The main part of the present version is Rev. V.2 which was released in March 1984. This date of release should not be confused with the actual dates of revisions which were made in 1978/1979 after the closing date of the original version of ENDFIB-5. In 1986 several files were modified including minor corrections and, in some cases. updated evaluations for selected data-types.

The library is in ENDF-5 format. It is part of the ENDF/B-5 library maintained by the US National Nuclear Data Center at Brookhaven National Laboratory. The library contains data for 57 nuclides with atomic numbers from 81 to 99. For 19 nuclides, denoted by an asterisk in the Table 1 below, the library contains only decay data. For 34 other nuclides the library also contains neutron reaction data.

The size of the library is 70.135 records of 80 characters.

Detailed documentation of the ENDF/B-V format is given in the report BNL-NCS-50496 = ENDF-102, 3rd edition (1980). For quick reference of the ENDF/B format (File Numbers and Reaction Type Numbers of the most important data types) see the document IAEA-NDS-10.

Documentation of the evaluations is included within the data library at the beginning of each file (nuclide). For the accession-numbers (MAT-numbers) ranging from 1337-1396 a summary documentation can be taken from the report BNL-NCS-17541 = ENDF-201, 3rd edition (1979). For additional references see Table 3.

The neutron reaction data include resonance parameters, smooth cross sections (from 0 to 20 KeV) of elastic and inelastic scattering, total cross section, (n,2n) and (n,3n) reaction cross sections, fission cross sections and fission neutron-yields (when applicable), capture cross sections, angular distributions of scattered and secondary neutrons, secondary neutron energy distributions. For some of the nuclides the library contains additional data types as described in Table 2.

The laboratory where the evaluation was performed, the names of the evaluators, and the dates of evaluations are stated in Table 1.

The revised version (Rev. V.2) of the ENDF/B-V Actinide Library included the following modifications in comparison with the previous version:

complete re-evaluation of all quantities for MAT=8749 (97-Bk-249);

re-evaluation of resonance parameters for MAT=8642 (96-Cm-242);

re-evaluation of the decay data for MAT=8232 (92-U-232), 8444 (94-Pu-244), 8542 (95-Am-242), 8648 (96-Cm-248), 8853 (98-Cf-253);

small corrections for MAT=1831 (91-Pa-231), 8436 (94-Pu-236);

MAT=6398 (92-U-238), 6390 (90-Th-232) and 6399 (94-Pu-239) from ENDF/B-V Dosimetry File (Rev. V.2) were introduced by the lAEA Nuclear Data Section into ENDF/B-V actinides for completeness.

MAT-1395 (92-U-235) was not contained in the actinides tape received from NNDC but was taken over from the ENDF/B-5 Standards file for completeness.

The modifications made in 1986 are indicated in the last column of table 2.

Magnetic tape copies of the entire file or selective retrievals from it are available. free of charge. from the IAEA Nuclear Data Section upon request.

TABLE 1

Contents of the ENDF/B-V (Rev. V.2) Actinides Library

Explanations:

* An asterisk in the left-hand margin indicates that the file contains decay-data only. The other files contain neutron cross-sections and decay data.

Key to laboratory codes:

AI . . . Atomics International, Calif. USA Argonne National Laboratory
ANL . . . Argonne National Laboratory
BNL . . . Brookhaven National Laboratory
GE . . . General Electric Fast Breeder Reactor Project
HEDL . . . Hanford Engineering and Development Laboratory
INEL . . . Idaho Nuclear Engineering Laboratory
LLL . . . Lawrence Livermore Laboratory
SRL . . . Dupont Savanna River Laboratory

Date of evaluation or revision: This should be found in coded form at the beginning of each material, in the form "EVAL-AUG78 REV1-APR79". Unfortunately, this convention has not always been obvserved and the actual date of last revision is often hidden somewhere in the text-section.

MAT/Mod: For the materials which have been modified after their first release it is essential to quote them not only by their Material-Number but also by their modification number. This can be found for each material in the NMOD field, that is col. 66 of the record number 1. At the end of the text-section (MF/MT = 1451, index records) one can see also, which quantitites (=MF/MT) have been modified. Kindly distinguish carefully between the modification number for a given material (col. 66 in record 1), a given data type (col. 66 of index records) and the library revision number.

	Lab	Evaluator	Date of evaluation or last revision	Acc. No. MAT/Mod.	Date of Distrib.
* 81-T1-208	INEL	Reich	Aug78	8108	
* 82-Pb-212	INEL	Reich	Aug78	8212	
* 83-Bi-212	INEL	Reich	Nov78	8312	
* 84-Pu-216	INEL	Reich	Aug78	8416	
* 86-Rn-220	INEL	Reich	Aug78	8620	
* 88-Ra-224	INEL	Reich	Aug78	8824	
* 90-Th-228	INEL	Reich	Aug78	8028	
90-Th-230	HEDL	Mann	Nov77	8030	
* 90-Th-231	INEL	Reich	Aug78	8031	
90-Th-232	BNL	Bhat, Smith Leonard, DeSaussure	(1982)	6390/2	Mar.84

	Lab	Evaluator	Date of evaluation or last revision	Acc. No. MAT/Mod.	Date of distrib.	Mod. 86
* 90-Th-233	INEL	Reich	Aug78	8033		
91-Pa-231	HEDL	Mann	Aug78	8131/2	Mar84	
* 91-Pa-232	INEL	Reich	Aug78	8132		
91-Pa-233	HEDL, INEL	Mann,Schenter,Reich	May78	1391/2		+
92-U -232	HEDL	Mann	Apr78	8232/2	Mar84	
92-U -234	BNL, HEDL,+	Divadeenam, Mann, Drake,Reich, et.al	Jul78	1394/3		+
92-U -235	BNL+	Bhat	Apr77	1395/3		+
92-U -236	BNL, HEDL,+	Divadeenam,Mann, McCrosson,Reich,+	Jul78	1396/3		+
92-U -237	BNL, SRL, LLL	Kinsey-Assembler (see Comments)	Jul76	8237		
92-U -238	ANL,+	Pennington,Smith Poenitz	Mar79	6398/3	Mar84	
* 92-U -239	INEL	Reich	Aug78	8239		
* 92-Np-236	INEL	Reich	Aug78	8336		
* 92-Np-236-M	INEL	Reich	Aug78	8346		
93-Np-237	HEDL, SRL,+	Mann, Benjamin,Smith Stein,Reich,+	Apr78	1337/2		+
93-Np-238	SRL	Benjamin,McCrosson	Aug75	8338		
* 93-Np-239	INEL	Reich	Aug78	8339		
94-Pu-236	HEDL, SRL	Mann,Schenter, Benjamin,McCrosson	Aug78	8436/2	Mar84	
94-Pu-237	HEDL	Mann,Schenter(Fast)	Apr78	8437		
94-Pu-238	HEDL, AI,+	Mann,Schenter, Alter,Dunford,+	Apr78	1338/3		+
94-Pu-239	GE	Kujawski,Stewart Mann Benjamin	(1982)	6399/2	Mar84	
94-Pu-242	HEDL, SRL,+	Madland,Howerton,+	Oct78	1342/2		+
94-Pu-243	BNL, SRL, LLL	Kinsey-Assembler (see Comments)	Jul76	8443		
94-Pu-244	HEDL SRL	Mann,Schenter, Benjamin,McCrosson	Aug78	8444/2	Mar84	
* 95-Am-240	INEL	Reich	Aug78	8540		
95-Am-241	HEDL, ORNL	Mann,Schenter Weston	Apr78	1361/2		+
95-Am-242	SRL	Benjamin,McCrosson	Aug78	8542/2	Mar84	
95-Am-242-M	HEDL, SRL, LLL	Mann, Benjamin, Howerton,et.al	Apr78	1369		
95-Am-243	HEDL, SRL, LLL	Mann,Benjamin Howerton,et.al	Apr78	1363/2		+
* 95-Am-244	INEL	Reich	Aug78	8544		
* 95-Am-244-M	INEL	Reich	Aug78	8554		

TABLE 2

Additional Data-Types given for Specific Nuclei

Nuclide	Acc. No. MAT	Remarks
92-U -235	1395	Fission product yields, covariances
92-U -236	1396	(n,4n)
93-Np-237	1337	Fission product yields
94-Pu-242	1342	Fission product yields, photon production, covariances
95-Am-243	1363	(n,4n), photon production
96-Cm-243	1343	(n,4n)
96-Cm-244	1344	Photon production
96-Cm-245	1345	(n,4n), photon production
96-Cm-246	1346	(n,4n), photon production
96-Cm-248	8648	(n,4n)
97-Bk-249	8749	(n,4n)
98-Cf-249	8849	(n,4n)
98-Cf-250	8850	(n,4n)
98-Cf-251	8851	(n,4n)
98-Cf-252	8852	(n,4n), fission product yields

TABLE 3

Additional documentation of evaluations

Nuclide	Acc. No. MAT	Documentation
94-Pu-242	1342	Report LA-7663-MS, Jan. 1979
95-Am-241	1361	Report EPRI NP-1067
96-Cm-242	8642	Report EPRI NP-1067
96-Cm-245	1345	Report EPRI NP-1067
97-Bk-249	8749	Report EPRI NP-1067
90-Th-230	8030	Report HEDL-TME-78-100, Jan. 1979
91-Pa-231	8131	Report HEDL-TME-78-100, Jan. 1979
92-U -232	8232	Report HEDL-TME-78-100, Jan. 1979
94-Pu-236	8436	Report HEDL-TME-77-54, Aug. 1977
94-Pu-237	8437	Report HEDL-TME-77-54, Aug. 1977
93-Np-238	8338	Report EPRI-NP-161, Dec. 1975
95-Am-242	8542	Report EPRI-NP-161, Dec. 1975
98-Cf-253	8853	Report EPRI-NP-161, Dec. 1975
99-Es-253	8953	Report EPRI-NP-161, Dec. 1975

For the following evaluations no documentation is presently known to us except for the text given at the beginning of each data file.

92-U-237, 94-Pu-243,244, 96-Cm-241,247,248, 98-Cf-249,250,251,252.

	Lab	Evaluator	Date of evaluation or last revision	Acc. No. MAT/Mod.	Date of distrib.	Mod. 86
96-Cm-241	HEDL	Mann,Schenter	Aug78	8641		
96-Cm-242	HEDL, SRL, LLL	Mann,Benjamin, Howerton,et.al	Apr79	8642/2	Mar84	
96-Cm-243	HEDL, SRL, LLL	Mann,Benjamin, Howerton,et.al	Apr78	1343		
96-Cm-244	HEDL, SRL, LLL	Mann,Benjamin, Howerton,et.al	Apr78	1344/2		+
96-Cm-245	SRL	Benjamin,McCrosson	Sep75	1345/2		+
96-Cm-246	BNL, SRL, LLL	Kinsey-Assembler (see Comments)	Jul76	1346		
96-Cm-247	BNL, SRL, LLL	Kinsey-Assembler (see Comments)	Jul76	8647		
96-Cm-248	HEDL, SRL, LLL	Mann,Benjamin, Howerton,et.al	Aug78	8648/2	Mar84	
* 96-Cm-249	INEL	Reich	Aug78	8649		
97-Bk-249	SRL, LLL	Benjamin,Howerton	Apr79	8749/2	Mar84	
* 97-Bk-250	INEL	Reich	Aug78	8750		
98-Cf-249	BNL, SRL, LLL	Kinsey-Assembler (see Comments)	Jul76	8849		
98-Cf-250	BNL, SRL, LLL	Kinsey-Assembler (see Comments)	Jul76	8850		
98-Cf-251	BNL, SRL LLL	Kinsey-Assembler (see Comments)	Jul76	8851		
98-Cf-252	BNL, SRL, LLL	Kinsey-Assembler (see Comments)	Jul76	8852		
98-Cf-253	SRL	Benjamin,McCrosson	Aug78	8853/2	Mar84	
99-Es-253	BNL, SRL	Benjamin,McCrosson	Jul76	8953		

ENDF/B-V Summary Documentation

Isotope: 91-Pa-233 MAT- 1391

F .M. Mann (HEDL) Apr ' 78
C. R. Reich (INEL) Apr ' 78

No new cross section data have been measured since the last evaluation for ENDF/B-II by P.C. Young. That evaluation was checked against resonance data and systematics of near-by nuclei and made consistent with ENDF/B-V procedures. The summary documentation for that evaluation follows on the next page. C. R. Reich supplied the radioactive decay data .

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91-Pa-233
 MAT 1391

                                    EVAL-MAY78 MANN,SCHENTER,REICH
                                    DIST-MAR83
ENDF/B-V SAME AS EVALUATION OF P.C. YOUNG (JAN70) EXCEPT FOR
     DECAY DATA.  NO NEW DATA AVAILABLE. (N,G) ADEQUATE.
     *          *          *          *          *          *

 DATA MODIFIED OCTOBER 70 TO CONFORM TO ENDF/B-VERSION II FORMATS

     *          *          *          *          *          *
 DATA MODIFIED JAN 74 AT GENERAL ATOMIC(DRM) TO USE BNL-325 (ED.3)
 RESOLVED RESONANCE PARAMETERS BELOW 18EV.  0.0253EV CAPT XSECT =
 41.4605 B.
     *          *          *          *          *          *
 DATA MODIFIED MAY 74 AT BROOKHAVEN (BNL) BY R. KINSEY
  DECAY DATA ADDED, FILES EXTENDED TO 20 MEV, AND INITIAL POINT
     OF THRESHOLD REACTIONS CORRECTED.
     *          *          *          *          *          *
MF=1,MT=451  COMMENTS AND DICTIONARY
MF=1,MT=452  NU(E) BASED ON SYSTEMATICS OF HOWERTON (REF. 11)
MF=1,MT=458 ENERGY OF FISSION BASED ON SYSTEMATICS OF SHER(REF.12)
MF=2,MT=151  RESON PARAMETERS FROM * REF.1(28 RESON,UP TO 17.5EV),
   REF.2(12 RESON,17.5-37.5EV). RESOLVED RESON ENERGY RANGE- 0.001
   TO 38.5 EV. AVE RESON PARAMETERS DEDUCED FROM THE 27 POSITIVE
   RESON GIVEN IN REF.1. UNRESOLVED RESON ENERGY RANGE- 38.5 EV TO
   10 KEV. THE 12 GN0 FROM REF.2 ADJUSTED TO YIELD SAME RESON INT
   CONTRIB INPLIED BY THE AVE RESON PARAMETERS. THE RESULTING GN0
   FOR THE 40 RESOLVED RESON AND THE AVE GN0 FOR THE UNRESOLVED
   RESON ADJUSTED TO YIELD A CAPT RESON INT(0.5EV-10MEV)=859.96BN(
   INCLUDING THE CONTRIB OF THE MF=3,MT=102 DATA). THE GN0 FOR THE
   NEG RESON THEN ADJUSTED TO YIELD A 0.0253EV CAPT XSECT= 39.79BN
 FILE 3 CONTAINS SMOOTH DATA IN THE ENERGY RANGE 10 KEV TO 15 MEV
MF=3,MT=1    TOTAL CROSS SECTION - REQUIRED TO BE CONSISTENT IN
   BOTH MAGNITUDE AND ENERGY VARIATION WITH THE TOTAL X-SECTION
   OF NEIGHBORING NUCLIDES, E.G. TH232,U233,U235,U238, AND PU239.
MF=3,MT=2    ELASTIC SCATTERING CROSS SECTION = TOTAL X-SECTION
   MINUS NONELASTIC X-SECTION. IN ADDITION, REQUIRED TO BE CONSIS-
   TENT IN ENERGY VARIATION WITH ELASTIC SCATTERING X-SECTION OF
   NEIGHBORING NUCLIDES (TH232,U235,U238) AND TO JOIN SMOOTHLY AT
   10 KEV WITH A VALUE NEARLY EQUAL TO THE POTENTIAL SCATTERING
   X-SECTION (=9.995 BARNS, REF.2).
MF=3,MT=3    NONELASTIC CROSS SECTION = SUM OF THE (N,F),
   (N,NPRIME),(N,2N),(N,3N) AND (N,GAMMA) CROSS SECTIONS.
MF=3,MT=4    INELASTIC SCAT XSECT  - TAKEN FROM REF.3 . Q-VALUE =
   - 18.7 KEV ( ENERGY OF THE FIRST EXCITED STATE IN 91PA233 )
MF=3,MT=16 AND 17   (N,2N) AND (N,3N) XSECT - TAKEN FROM REF.3
   Q-VALUE CALCULATED USING ATOMIC MASSES FROM REF.4.
MF=3,MT=18   FISSION CROSS SECTION - COMPOSITE CURVE AS FOLLOWS -
   0.48-1.00MEV 233PA(N,F)= 238U(N,F) FROM REF.5.
   1.00-1.50MEV LOG(233PA(N,F)) LINEAR IN LOG(E)
   1.50-5.00MEV 233PA(N,F)= (C1/C2)*238U(N,F) FROM REF.5.
   C1=0.832 = CALC. PLATEAU VALUE OF 233PA(N,F) REF.6.
   C2=0.511 = AVG. VALUE OF 238U(N,F) (REF.5),2.6-5.6 MEV
   5.00-9.00MEV 233PA(N,F) HAS ENERGY VARIATION SIMILAR TO THAT
   FOR (N,F) OF U234,U236 AND NP237 FROM REF.5.
   9.00-12.5MEV 233PA(N,F)=(C1/C2)*238U(N,F) FROM REF.7.
   C1=1.56 = DERIVED VALUE OF 233PA(N,F) FOR THE SECOND PLATEAU
             NEAR 9.0 MEV.
   C2=1.02 = 238U(N,F)(REF.7) AT THE SECOND PLATEAU.
   12.5-15.0MEV 233PA(N,F) HAS SAME ENERGY VARIATION AS THAT FOR
   236U(N,F)(REF.7)
   Q-VALUE = CALCULATED ENERGY RELEASE PER FISSION
MF=3,MT=51,52,53,54,55,91  PARTIAL INELASTIC SCAT XSECT-FROM REF.3
     MT'S REVISED IN VER. 5, CORRECTING DISCONTINUITY AT 200 KEV 3
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MF=3,MT=102  CAPTURE CROSS SECTION - COMPOSITE CURVE AS FOLLOWS -
   0.01-0.08MEV 233PA(N,GAMMA) SELECTED TO JOIN SMOOTHLY WITH THE
   (N,GAMMA) CALCULATED FROM AVERAGE RESONANCE PARAMETERS
   0.08-15.0MEV 233PA(N,GAMMA) = 2*238U(N,GAMMA) FROM REF.8.
   NORMALIZATION FACTOR(=2) CHOSEN SO THAT 233PA(N,GAMMA) =
   236U(N,GAMMA)(REF.8) AT 0.9 MEV
MF=3,MT=251  MU-BAR (AVG.COSINE OF THE SCATTERING ANGLE IN THE LAB
   SYSTEM FOR ELASTIC SCATTERING), CALCULATED FROM THE U(1,M) AND
   LEGENDRE COEFFICIENTS GIVEN IN FILE 4
MF=3,MT=252  XI (AVG.LOGARITHMIC ENERGY DECREMENT).
MF=3,MT=253  GAMMA (SLOWING DOWN PARAMETER).
   THE ENERGY DEPENDENCE OF THE TWO ABOVE QUANTITIES IS DETERMINED
   BY THE LEGENDRE COEFFICIENTS GIVEN IN FILE 4.  COMPLETELY
   GENERAL EXPRESSIONS IN POWERS OF AWR**-1 HAVE BEEN DERIVED FOR
   THE CONSTANTS WHICH DETERMINE THE CONTRIBUTION OF EACH OF THE
   LEGENDRE COEFFICIENTS.
MF=4,MT=2    TRANSFER MATRIX U (FROM C.M. TO LAB). A GENERAL EX-
   PRESSION FOR U(L,M) IN POWERS OF AWR**-1 HAS BEEN DERIVED.  THE
   LEGENDRE COEFFICIENTS WERE TAKEN DIRECTLY FROM REF.3, AND ARE
   BASED ON THE DATA FOR TH232.
MF=4,MT=51,52,53,54,55   ANG DIST OF NEUTRONS SCAT INELASTICALLY
   FROM 5 DISCRETE LEVELS ASSUMED ISOTROPIC IN THE CM SYSTEM
MF=5,MT=16,17,91   ENERGY DEPENDENCE OF SECONDARY NEUTRONS DEFINED
   BY AN EVAPORATION SPECTRUM . ENERGY DEPENDENCE OF THETA CALCU-
   LATED USING THE FORMULATION IN REF.9
MF=5,MT=18   SIMPLE FISSION SPECTRUM - THETA (CONSTANT) CALCULATED
   USING THE FORMULATION GIVEN IN REF.10.
MF=8,MT=457  DECAY DATA  EVAL-AUG78 C.W.REICH  ANC
 REFERENCES  Q(BETA)- A.H. WAPSTRA AND K. BOS, AT. DATA AND NUCL.
                      DATA TABLES 19, 175 (1977).
             OTHER-  Y.A. ELLIS, NUCL. DATA SHEETS 6,NO.3, 257
                     (1971) AND TABLE OF ISOTOPES, 7TH ED. (PRE-
                     LIMINARY DATA, PRIV. COMM. FROM C.M. LEDERER)
       NOTE  THE K-X-RAY INTENSITIES REPRESENT MEASURED VALUES.
       NOTE  THE GAMMA-RAY DATA SUMMARIZED BY Y.A. ELLIS (NUCL.
             DATA SHEETS, TO BE PUBLISHED) HAVE BEEN NORMALIZED TO
             A VALUE OF (38.6+/-0.5)" FOR THE INTENSITY OF THE
             311.9-KEV GAMMA RAY.  THIS VALUE HAS RECENTLY BEEN
             MEASURED BY R.J. GEHRKE AND R.G. HELMER (PRIV. COMM.
             FROM R.J. GEHRKE, MARCH, 1978).
 TRANSLATED INTO ENDF/B-V FORMAT BY MANN AND SCHENTER (HEDL)  8/78
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ENDF/B-5 Summary Documentation
Isotope: 92-U -234 MAT = 1394

M.DIVADEEN	(BNL)	Aug. '78
F.M.MANN & R.E.Schenter	(HEDL)	Apr. '78
C.R.REICH	(INEL)	Apr. '78
M.K.DRAKE & P.F.NICHOLS	(GCA)	Jan. '67

The present work supersedes the ENDF/B-IV evaluation, MAT = 1043 by Drake and Nichols. Neutron and photon production data are given between 10^{-5} eV and 20 MeV. The cross sections included are total, elastic, inelastic, (n, f), (n,2n), (n,3n), (n, n'γ) and (n.γ), and are described in HEDL-TME-77-54. The photon data include multiplicities and transition probabilities, photon production cross sections, and secondary energy spectra. File 2 has been evaluated for this version. Details will be published in a BNL report.

MF=1: GENERAL INFORMATION

MT=452 MATHER ET. AL'S NU-BAR DATA(REF.9) NORMALIZED TO CF252 Nu. Least squares fit to a straight line.
NU-BAR = 3.75
MT=458 ENERGY FROM FISSION, BASED ON SHER (REF. 10)

MF=2: RESONANCE PARAMETERS

MT=151 RESOLVED RESONANCE PARAMETERS FROM REF.7.BOUND LEVEL PARAMETERS MODIFIED TO FIT BNL-325 VOL I (REF.11) THERMAL AND RESONANCE INTEGRAL CROSS SECTIONS. UNRESOLVED RESONANCE PARAMETERS OBTAINED BY FITTING AVERAGED (N,F) DATA OF JAMES ET.AL.(REF.7) AND ENDF-IV CAPTURE CROSS SECTIONS FROM 1.5 KEV TO 100 KEV.CODE UR (REF.12)WAS USED FOR THIS PURPOSE.

MF=3: SMOOTH CROSS SECTIONS

MT=1 TOTAL SUM OF PARTIAL CROSS SECTIONS
MT=2 ELASTIC SAME AS U-238 (REF. 1)
MT=4 INELASTIC FROM PARKER (REF. 2)
MT=16 (N-2N) FROM PARKER (REF. 2)
MT=17 (N-3N) FROM PARKER (REF. 2)
MT=18 FISSION ABOVE 100 KEV BASED ON BEHRENS ET AL (REF. 3) NORMALIZED TO U-235 (ENDF/B-V)
MT=19 SAME AS MT=18, UNTIL (N,NF) THRESHOLD, THEREAFTER CONSTANT
MT=20 IS (MT=18)-(MT=19) UNTIL (N,NNF) THRESHOLD, CONSTANT THERAFTER.
MT=21 IS (MT=18)-(MT=19)-(MT=20)
MT=51,....56,91 FROM PARKER (REF. 2)
MT=102 (N-GAMMA) (REF. 5) ALSO MT=27 ABSORPTION
MT=251,252,253 CALCULATED BY CHAD

MF=4: ANGULAR DISTRIBUTIONS

MT=2 DIFF ELASTIC (REF. 5) SAME AS THORIUM (REF. 6)
MT>2 ASSUMED ISOTROPIC

MF=5: ENERGY DISTRIBUTIONS

MT=16,17,18,19,20,21,91 FROM REF. 5

MF=8 MT=457

RADIOACTIVE DECAY DATA. REFERENCES Q(ALPHA)-1974 VERSION OF WAPSTRA-BOSGOVE MASS TABLE: HALF-LIFE- SEE R. VANINBROUKX, EURATOM REPORT EUR-5194E (1974). OTHER - SEE Y.A. ELLIS, NUCLEAR DATA SHEETS B 4, NO. 6, 581 (1970) AND TABLE OF ISOTOPES, 7TH ED.,(PRELIMINARY DATA, PRIV. COMM. FROM C.M. LEDERER). NOTE THE L-X-RAY DATA REPRESENT MEASURED VALUES. SEE C.E. BEMIS, JR. AND L. TUBBS, ORNL-5297, 93 (SEPT., 1977). NOTE THE GAMMA-RAY INTENSITY NORMALIZATION AND ITS UNCERTAINTY HAVE BEEN DERIVED FROM INTENSITY-SUM CONSIDERATIONS, USING THEORETICAL VALUES FOR THE INTERNAL-CONVERSION COEFFICIENTS.
TRANSLATED INTO ENDF/B-V FORMAT BY MANN AND SCHENTER (HEDL) 8/78

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23(1976)546 AND TO BE PUBLISHED
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11. S.F.MUGHABGHAB AND D.I.GARBER,BNL-325 VOL I(1973
12. UR:E.PENNINGTON,PRIVATE COMMUNICATION.

Summary Documentation for ^{235}U

Isotope: 92-U -235 MAT = 1395

M.R. Bhat

1. Introduction

The present evaluation of ^{235}U for ENDF/B-V is based on the ENDF/B-IV evaluation by L. Stewart (LASL), B. Alter (A.I.) and R. Hunter (LASL) [1] except for changes and updates in the following sections discussed below. These changes represent the work of many people either as individuals or as a group such as The Normalization and Standards Subcommittee of CSEWG. Some of these contributions have been discussed in separate reports by the authors. These will be referred to here and their contents will not be discussed in detail.

2. F11e 1

(i) Nu-bar Total (MT = 452)

These values were changed to reflect changes made in the $\bar{\nu}$ prompt and $\bar{\nu}_{delayed}$

(ii) Nu-bar Delayed (MT = 455)

The delayed neutron yields ~ere evaluated by Kaiser and Carpenter [2] where the details of the evaluation are discussed.

(iii) Nu-bar Prompt (MT = 456)

The data sets [3-19] were used. They were first normalized to ^{252}Cf $\bar{\nu}_{prompt}$ = 3235± 0.15 and ^{235}U $\bar{\nu}_{prompt}$ (0.0253 eV)=2.420:± .012 as recommended by the Normalization and Standards Subcommittee [20]. Data were fitted with straight lines in the energy region 0-2 MeV, 2-5.5 MeV, 6-20 MeV with a join from 5.5 to 6.0 MeV. A plot of the renormalized data indicates that there is a step in the $\bar{\nu}_p$ from 5.5 to 6 MeV, and this was included in the evaluation. The details of the evaluation and data plots are in Ref. 21.

(iv) Energy Released in Fission (MT=458)
The energy released in fission and its partition into the different modes of decay was evaluated by R. Sher et al., [22].

3. File 2

(i) The Resolved Resonance Region (MT=151)(1.0-82.0 eV).

The resolved resonance parameters are the same as those evaluated by Smith and Young [23] for ENDF/B-III.

(ii) The Unresolved Resonance Region (MT=151)(82.0-2.5E+O4 eV).

Evaluat1on of the bin averaged fission and capture cross-sections is described 1n Ref. [21,23]. The fine structure in fission cross-section was a consensus structure arrived at by energy shifting the data of Blons [24], ORNL-RPI [25], Gwin [26] with respect to the Lemley [27] data. Similarly, the fine structure as well as the bin average of the capture cross-section were determined. Results of the analysis of Moore [28] were used and the unresolved resonance region parameters were extracted using the code UR by Pennington [29].

4. File 3

(1) The Thermal Energy Region (1.0E-05 -1.0 eV)
The total scattering capture and fission cross-sections in this energy region were obtained by Leonard [30]. This evaluation was modified between 0.85 and 1 eV to join smoothly with the resolved resonance region at 1 eV. The 0.0253 eV values for capture and fission are 98.38 ± 0.76b and 583.54 ± 1.70b respectively.

(ii) Fission Cross-Section (25 keV-1OO keV).
The structure in the fission cross-section as given in ENDF/B-IV and based on Gwin data was preserved by multiplying the ENDF/B-IV cross-section by 0.9781 to give the average cross-section evaluated in Ref. 23.

(iii) Fission Cross-Section (100 keV-20 MeV)
This evaluation is by Poenitz [31].

(iv) Capture Cross-Section (25 keV-20 MeV).
This was obtained by multiplying the evaluated ENDF/B-V fission cross-section by the capture-to-fission ratio of ENDF/B-IV.

5. File 4
The angular distributions are the same as in ENDF/B-IV {1).

6. File 5

(1) Fiss1on Neutron Spectra
The energy dependent Watt spectrum representation is used for fission neutrons. The procedure used was to take the a and b parameters for an energy dependent Watt spectrum as given by Kujawski and Stewart for their Pu-239 evaluation (for the fission part of file 1399/5/19) calculate the mean energy $\bar{E}$ and divide it by 1.04, the value obtained by Adams [32] for the $\bar{E}_{PU-239}/\bar{E}_{U-235}$ to give $\bar{E}$ for U-235 as a function of energy. From these values, and assuming a=0.988 MeV as given by Adams at low energies, b is calculated. These are assumed to be constant for E_n=1.OE^{-5} eV to 1.5x1O^{6} eV and a small energy dependence is built into a and b to give the correct $\bar{E}$. The pre-fission part of sections 5/20 and 5/21 are given as an evaporation spectrum with a temperature obtained from section 5/91, i.e., at a particular energy E_n one finds (E_n – $E_{thresh\ 2nd}$) chance fission or (E_n– $E_{thresh\ 3rd}$) chance fission and the corresponding temperature above the 5/91 threshold is given. Having fixed these parameters, the mean energy corresponding to section 5/18 could be calculated knowing $\sigma_{f\ Total}$, $\sigma_{nn'f}$, $\sigma_{n,2nf}$ and $\overline{\nu}_p$, and the energy dependent parameters a and b calculated.

(ii)

Delayed Neutron Spectra

The evaluation is by Kaiser and Carpenter [2].

7. File 8

(i) Fission Product Yield Data (MT=454 and 459)

The fission product yield data were reviewed and recommended by the Fission Products Yields Subcommittee and the data files prepared by T.R.England[33].

(ii) Radioactive Decay Data (MT=457)

Radioactive decay data were evaluated by C.W. Reich. The Q (alpha)- values are from [34] and the half-life data are from Jaffey et al., [35], and also Vaninbroukx [36]. Alpha energies and intensities are from Ref., [37,38], and the gamma-ray and L x-ray data are from Ref. [37].

8. File 13

(i) Gamma-ray Production Cross-Section from E .1.09 -20 MeV (MT-3)
This was re-evaluated to include the new data of Drake et al., [39,40]. These were compared with the earlier data of Nellis and Morgan [41], and Buchanan et al., [42] above E_γ = 0.5 MeV and are found to be in good agreement. The Drake data in Ref. [39] have a low-energy cut-off of E_γ = 0.25 MeV and for their 14.2 data [40] it is E_γ = 0.3 MeV. The low- energy part of the spectrum was obtained by a simple extrapolation of the data.

9. File 15

(i) Energy Distribution of the Gamma-rays E_n = 1.09 -20 MeV (MT-3)
These are based on the Drake data [39,40].

10. Files 31 & 33

(1) Data Variance -Covariance Files (MT-452.18.102)

The evaluation of these files for $\bar{\nu}_{Total}$, σ_f and $\sigma_{n\gamma}$ is by R.W. Peelle [43]

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ENDF/B-5 Summary Documentation
Isotope: 92-U -236 MAT = 1396

M.DIVADEEN (BNL) Aug. '78
F.M.MANN & R.E.Schenter (HEDL) Apr. '78
C.R.REICH (INEL) Apr. '78
M.K.DRAKE & P.F.NICHOLS (GCA) Jan. '71

The present work supersedes the ENDF/B-IV evaluation, MAT = 1163 by McCresson. Neutron and photon production data are given between 10^{-5} eV and 20 MeV. The cross sections included are total, elastic, inelastic, (n, f), (n,2n), (n,3n), (n, n'γ) and (n.γ), and are described in HEDL-TME-77-54. The photon data include multiplicities and transition probabilities, photon production cross sections, and secondary energy spectra. File 2 has been evaluated for this version. Details will be published in a BNL report.

MF=1: GENERAL INFORMATION

MT=452 CONDE+HOLMBERG'S NU-BAR DATA RENORMALIZED TO CF252 NU=3.75
MT=458 ENERGY FROM FISSION BASED ON SHER (REF. 11)

MF=2: RESONANCE PARAMETERS

MT=151 RESOLVED RESONANCE PARAMETERS FROM REFS.2A TO 2D. BOUND LEVEL PARAMETERS MODIFIED TO FIT BNL-325 VOL I (REF.13) THERMAL AND RESONANCE INTEGRAL CROSS SECTIONS. UNRESOLVED RESONANCE PARAMETERS OBTAINED BY FITTING CARLSON’S AVERAGED CAPTURE DATA (REF.2A) ENERGY DEPENDENT UNRESOLVED PARAMETERS RANGE FROM 4.11 keV to 100 keV. CODE UR (REF.12) WAS USED TO OBTAIN THE PARAMETERS.

MF=3: SMOOTH CROSS SECTIONS

MF=3	SMOOTH BACKGROUND CROSS SECTION (DUE TO MISSED P-WAVE LEVELS) CALCULATED WITH AVERAGE PARAMETERS USING UR CODE(REF.14).
MT= 1	TOTAL TAKEN FROM REF. 1 AND 4.
MT= 2	ELASTIC, REF. 1 AND 4.
MT= 4	INELAS., REF. 1 AND 4, Q-VALUE, REF. 5.
MT= 16	(N,2N), REF. 1 AND 4, Q-VALUE, REF. 6.
MT= 17	(N,3N), REF. 1 AND 4, Q-VALUE, REF. 7.
MT= 18	FISSION, ABOVE 100 KEV DATA OF BEHRENS ET AL (REF. 8) WAS USED, NORMALIZED TO U-235 (N,F) OF ENDF/B-V.
MT=19	SAME AS MT=18 BELOW (N,NF) THRESHOLD, THEREAFTER CONSTANT
MT=20	IS DIFFERENCE OF MT=18 AND MT=19 UNTIL (N,2NF) THRESHOLD, THEREAFTER A CONSTANT.
MT=21	DIFFERENCE OF MT=18 AND MT=19 AND 20
MT=51,...56,91	REF. 1 AND 4
MT=102	(N,GAMMA), REF. 1.
MT=251,252,253	CALCULATED BY CHAD

MF=4: ANGULAR DISTRIBUTIONS

MT = 2 DIFF. ELAST. SAME AS FOR TH-232, REF. 10.
MT > 2 ASSUMED ISOTROPIC

MF=5: ENERGY DISTRIBUTIONS

MT=16 (N,2N) ENERGY DIST DESCRIBED BY MAXWELLIAN.
MT=17 (N,3N) ENERGY DIST DESCRIBED BY MAXWELLIAN.
MT=18,19,20 NEUTRON ENERGY DISTRIBUTION GIVEN BY SIMPLE FISSION SPECTRUM PLUS MAXWELLIAN.
MT=91 EVAPORATION TEMP. FROM GILBERT AND CAMERON (REF. 12)

MF=8: RADIOACTIVITY INFORMATION

MT = 454 FISSION YIELD DATA. FISSION PRODUCT YIELD DATA FOR PHASE ONE REVIEW FOR ENDF/B-V SET 5E,7/78. VALUES OBTAINED FROM THE RECOMMENDATIONS OF THE YIELDS SUBCOMMITTEE, T R ENGLAND (CHAIRMAN).

MT=457: RADIOACTIVE DECAY DATA

REFERENCES Q(ALPHA)-1974 VERSION OF WAPSTRA-BOS-GOVE MASS TABLE HALF-LIFE- K.F. FLYNN ET AL., J. INORG. NUCL. CHEM.34, 1121 (1972). OTHER - SEE M.R. SCHMORAK, NUCLEAR DATA SHEETS B 4, NO. 6, 623 (1970), AND TABLE OF ISOTOPES, 7TH ED.,(PRELIMINARY DATA, PRIV. COMM. FROM C.M. LEDERER). SEE ALSO M.R. SCHMORAK, NUCLEAR DATA SHEETS 20, 192 (1977).

NOTE THE ENERGIES AND INTENSITIES OF THE TWO HIGHEST- ENERGY ALPHA GROUPS ARE THOSE RECOMMENDED BY A. RYTZ, AT. DATA AND NUCL. DATA TABLES 12, NO. 5, 479 (1973).

NOTE THE GAMMA-RAY INTENSITY NORMALIZATION HAS BEEN DERIVED FROM INTENSITY-BALANCE CONSIDERATIONS AT THE GROUND STATE. WHILE THIS GIVES AGREEMENT BETWEEN THE ALPHA AND 49.3-KEV GAMMA-RAY INTENSITIES, THE CORRESPONDING DATA FOR THE 112-KEV GAMMA ARE NOT CONSISTENT.

TRANSLATED INTO ENDF/B-V FORMAT BY MANN AND SCHENTER (HEDL) 8/78

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ENDF/B-V Summary Documentation

Isotope: 93-Np-237 MAT = 1337

F.M. Mann and R.E. Schenter (HEDL) Apr. '78
R. Benjamin (SRL) Oct. '75
C.R. Reich (INEL) Apr. '78
J.R. Smith (ANC) June '73
W.E. Stein (LASL) June '73

The present work supersedes the ENDF/B-IV evaluation, MAT = 1263 by Smith and Stein. Neutron and photon production data are given between 10-5 eV and 20 MeV. The cross sections included are total, elastic, inelastic, (n, f) , (n,2n), (n,3n), (n, n' γ), and (n, γ) and are described in HEDL-TME-77-54 (ref. 23). The proton data include multip1icities and transition probabilities, photon production cross sections, and secondary energy spectra.

MF=1 MT=452
BASED ON REF 1.

MT=458 ENERGY FROM FISSION BASED ON SHER (REF. 22)

MF=2 MT=151
BELOW 10-EV RESUBMITTED BY MANN(HEDL) REENTERED BY MAGURNO(BNL)
FOR ENDF/B-V.2.RESOLVED PARAMETERS BELOW 10-EV ARE TAKEN FROM THE EVAL. OF DERRIEN ET.AL.(23).THE THERMAL GAMMA CROSS SECT. IS 181 BNS.FROM 10-130
EV,RESOLVED PARAMETERS OF PAYA(2) ARE USED WITH FISSION WIDTHS MULTIPLIED

BY 0.625 IN KEEPING WITH THE RENORMALIZATION RECOMMENDED BY PAYA IN A PRIVATE COMMUNICATION. UNRESOLVED PARAMETERS WERE FITTED BY J.R.SMITH AND

M.K.BHAT TO THE PAYA DATA FROM 130 EV TO 5 KEV, USING THE UR CODE DEVELOPED BY E.PENNINGTON (ANL). THE UNRESOLVED PARAMETERS ARE DESIGNED TO YIELD HISTOGRAMS IN THE FISSION CROSS SECTION, WITH AREAS EQUAL TO THOSE OF THE -CLASS 2- RESONANCE AREAS DETERMINED BY PAYA (RENORMALIZED BY FACTOR 0.625).

MF=3 MT=1
FROM 10*E-05 EV TO 40 KEV THE RESOLVED
AND UNRESOLVED PARAMETERS YIELD THE TOTAL XSEC, WITH A SMALL CORRECTION FOR INELASTIC SCATTERING BEGINNING AT 33.34 KEV. FROM 40 KEV TO 1 MEV THE TOTAL IS THE SUM OF THE PARTIALS. ABOVE 1 MEV, THE TOTAL IS ALSO THE SUM OF THE PARTIALS, BUT ALL CROSS SECTIONS HAVE BEEN CONSTRAINED TO KEEP THE TOTAL CLOSE TO THE RECENT MEASUREMENTS MADE AT RPI ON PU-239 (3).

MT=2
A 10.5 BARN POTENTIAL SCATTERING CROSS SECTION IS ASSUMED. ABOVE THE RESONANCE RANGE THE ELASTIC XSEC FOLLOWS AN EXTRAPOLATION OF THE UNRESOLVED CALCULATION TO 1 MEV, ABOVE WHICH IT FOLLOWS A CURVE BASED ON CROSS SECTIONS OF NEIGHBORING NUCLEI.

MT=4

THE INELASTIC CROSS SECTIONS FOR ENDF/B-I WERE BASED ON A CALCULATION BY D.T.GOLDMAN(4). THEY HAVE BEEN PROGRESSIVELY MODIFIED SINCE. FOR VERSION III THE INELASTIC CROSS SECTIONS WERE REDUCED SO THE TOTAL CROSS SECTION WOULD BE CONSISTENT WITH MEASUREMENTS ON NEIGHBORING NUCLEI ABOVE 1 MEV. FOR VERSION IV THE INELASTIC CROSS SECTIONS HAVE AGAIN BEEN ADJUSTED TO INSURE THAT THE TOTAL INELASTIC WAS EQUAL TO THE SUM OF ITS PARTS, AND TO ACCOMMODATE REEVALUATED (N,2N),(N,3N),AND CAPTURE CROSS SECTIONS IN THE CONSTRAINED TOTAL CROSS SECTION. FOR VERSION V, THE CROSS SECTIONS WERE SMOOTHLY CONTINUED ABOVE 1.0 MEV (STEWART AND YOUNG,LASL)

<u>MT=16</u>
BOTH (N.2N) AND (N,3N) CROSS SECTIONS ARE BASED ON MT=17 CALCULATIONS MADE BY S.PEARLSTEIN(4). THE (N,2N) CROSS SECTION WAS NORMALIZED TO THE INTEGRAL MEASUREMENT OF PAULSON AND HENNELLY (REF. 6, TO OBTAIN CROSS SECTION TO SHORT LIVED STATE) AND OF MYERS ET AL (REF. 7, TO OBTAIN RATIO OF SHORT-LIVED TO LONG-LIVED STATE). MT=16 - CONTAINS (N,2N) ONLY TO STATES WHICH POPULATE PU-236. SUCH AN EVALUATION DIFFERS FROM DIFFERENTIAL MEASUREMENTS OF LINDEKE ET AL (REF. 8) AND OF LANDRUM ET AL (REF. 9) AS WELL AS HAUSER FESHBACH CALCULATIONS (REF. 10) ***** THE (N,3N) CROSS SECTION KEEPS THE PEARLSTEIN SHAPE AND WAS RENORMALIZED TO A MAXIMUM VALUE OF .203 BARN TO MAINTAIN THE CONSTRAINTS ON THE TOTAL CROSS SECTION.

<u>MT=18</u>
BELOW 40 KEV THE CROSS SECTION IS CALCULATED FROM RESOLVED AND UNRESOLVED RESONANCE PARAMETERS. ABOVE 40 KEV THE DATA IS AN AVERAGE OF EXPERIMENTAL DATA (REF. 11-19)

<u>MT=51,...61,91</u>
SEE COMMENT UNDER MT=4

<u>MT=102</u>
THE CAPTURE CROSS SECTIONMT=181 B. FROM 10*E-05 EV TO 40 KEV THE CAPTURE IS GIVEN BY THE RESOLVED AND UNRESOLVED RESONANCE PARAMETERS. FROM 120 KEV TO 20 MEV THE CAPTURE IS FROM A SMOOTH CURVE DRAWN THROUGH THE MEASUREMENTS OF NAGLE ET AL (20). BETWEEN 40 AND 120 KEV THE CAPTURE IS POINTWISE, TAKEN FROM AN UNRESOLVED CALCULATION WHICH HAD BEEN EXTENDED TO 120 KEV USING PARAMETERS ADJUSTED TO YIELD THE EVALUATED CAPTURE CROSS SECTION AT THAT POINT. THE NAGLE MEASUREMENTS ARE APPRECIABLY LOWER THAN THE STUPEGIA DATA ON WHICH PREVIOUS ENDF/B FILES WERE BASED, AND TIE IN MUCH MORE SMOOTHLY WITH THE EXTRAPOLATION OF THE UNRESOLVED CALCULATION.

<u>MF=4 MT=2</u>
ANGULAR DISTRIBUTIONS WERE SUPPLIED BY H. ALTER, THEN OF AI. BASED ON OPTICAL MODEL CALCULATIONS MADE ON NEIGHBORING NUCLEI.

<u>MF=4 MT>2</u>
ASSUMED ISOTROPIC

<u>MF=5 MT=16</u>
NUCLEAR TEMP CALCULATED FOR MAXWELL DIST, LF=9. CALC. AND 17 OF TEMP DISTRIBUTION FOLLOWS PRESCRIPTION USED FOR THE PU240 FILE OF ENDF/B-I.

<u>MF=5 MT=18</u>
FISSION SPECTRUM HAS MAXWELLIAN DENSITY WITH THE TEMP BASED ON TERRELLS PRESCRIPTION (20).

<u>MT=91</u>
INELASTIC SECONDARIES BASED ON D.T. GOLDMAN DATA (11).
BOTH DISCRETE LEVEL AND EVAPORATION SPECTRA ARE INCLUDED.

<u>MF=8 MT=16</u>
BASED ON ENDF/B-V DECAY DATA OF NP-237(S) AND (L)

<u>MT = 454 AND 459</u>
FISSION YIELD DATA SET 5E,7/78. VALUES OBTAINED FROM THE RECOMMENDATIONS OF THE YIELDS SUBCOMMITTEE, T R ENGLAND (CHAIRMAN), D M GILLIAM, Y HARKER, J R LIAW, W J MAECK, D G MADLAND, V MCLANE MAY, P L REEDER, B F RIDER,

R E SCHENTER, B I SPINRAD, J P UNIK, A WAHL, W WALKER, B W WEHRING, K WOLFSBERG

UNCERTAINTIES ARE BASED ON THE TOTAL YIELD TO EACH ZA. WHEN THERE IS AN ISOMERIC STATE,THE INDEPENDENT NUCLIDE YIELD TO EACH STATE HAS A LARGER UNCERTAINTY THAN THE TOTAL YIELD IN STATE DISTRIBUTIONS (UNCERTAINTIES AVERAGE APPROXIMATELY 50 PERCENT BUT CAN BE LARGER),ANY YIELD HAVING A LARGER UNCERTAINTY (45-64 PERCENT) MAY BE A MODEL ESTIMATE OR A VALUE ASSIGNED TO THE YIELDS ON THE WINGS OR VALLEY OF THE MASS YIELD DISTRIBUTION. THESE SMALL YIELDS MAY ONLY BE ACCURATE TO WITHIN A FACTOR OF 2.

MT454
CONTAINS DIRECT YIELDS BEFORE DELAYED NEUTRON EMISSION

MT459
CONTAINS CUMULATIVE YIELDS ALONG EACH ISOBARIC CHAIN
AFTER DELAYED NEUTRON EMISSION.

DIRECT AND CUMULATIVE YIELDS ARE NORMALIZED BY THE SAME FACTORS BASED ON B.F.RIDER EVALUATION. THE ISOMERIC STATE MODEL, LA-6595-MS (ENDF-241), AND DELAYED NEUTRON EMISSION BRANCHINGS (PN VALUES) FOR 102 EMITTERS, LA-UR-78-688, AND A PAIRING EFFECTS,LA-6430-MS (ENDF-240), HAVE BEEN INCORPORATED.

DATA PREPARED FOR FILES BY T.R.ENGLAND (LASL LTS. T-2-L-2891)
DATA FOR 93-NP-237 DECAYS BY REICH
INSERTED INTO FILE AT BNL BY R. KINSEY IN SEP 1978

MF=8, MT=457 RADIOACTIVE DECAY DATA

REFERENCES Q(ALPHA)-1974 VERSION OF WAPSTRA-BOS-GOVE MASS TABLE
OTHER- SEE Y.A. ELLIS, NUCLEAR DATA SHEETS 6, NO. 6, 539 (1971) AND ALSO TABLE OF ISOTOPES, 7TH ED. (PRELIMINARY DATA, PRIV. COMM. FROM C.M. LEDERER).
THE GAMMA-RAY ENERGY AND RELATIVE-INTENSITY VALUES ARE THOSE OF M. SKALSEY AND R.D. CONNOR, CAN. J. PHYS. 54, 1409 (1976).

NOTE THE DATA ON THE MORE PROMINENT ALPHA GROUPS ARE THOSE RECOMMENDED BY A. RYTZ, AT. DATA AND NUCL. DATA TABLES 12,NO. 5, 479 (1973).

NOTE THE K X-RAY INTENSITIES REPRESENT MEASURED VALUES
TRANSLATED INTO ENDF/B-V FORMAT BY MANN AND SCHENTER (HEDL) 8/78

MF=9 MT=16
BASED ON MEYERS ET AL (REF.35). HAUSER FESHBACH CALCULATIONS (REF. 38) GIVE ENERGY DEPENDENT RATIOS

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93-Np-237
MAT 1337

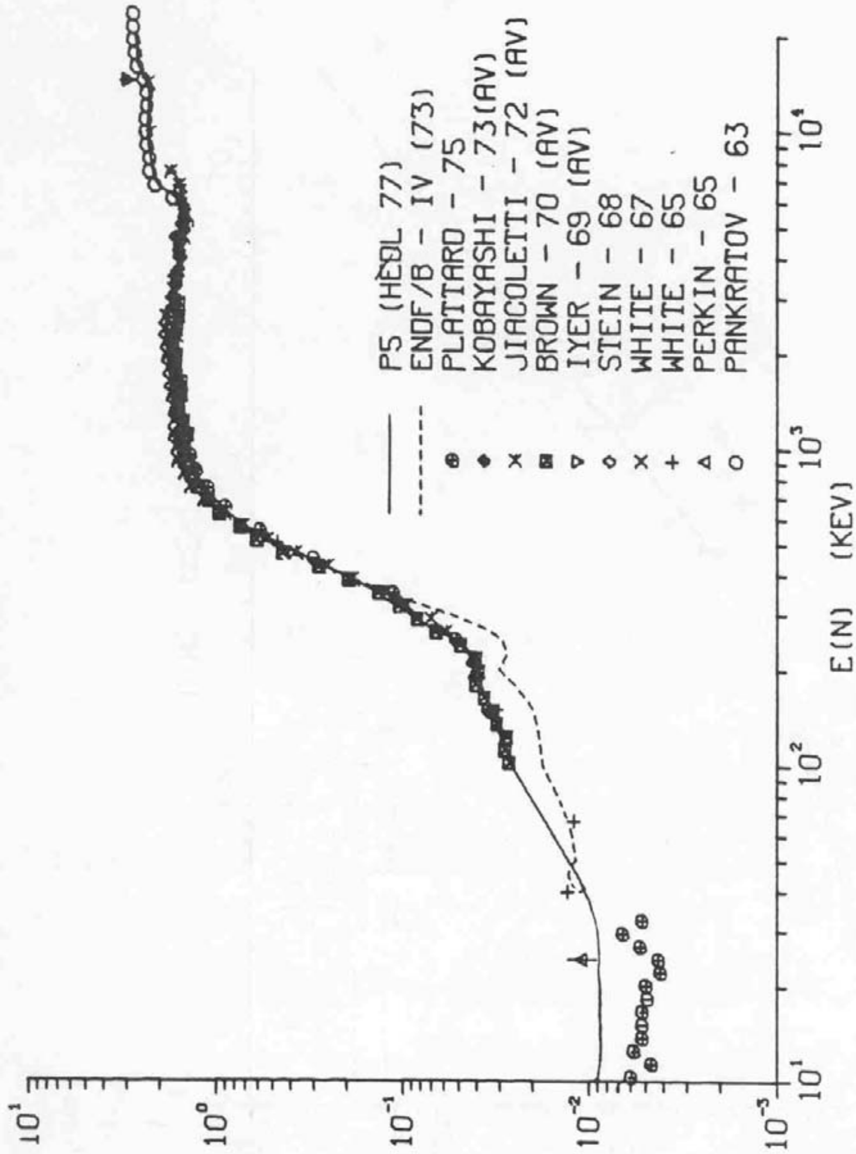

Figure 93-237-1
Np-237 (N,F)

93-Np-237
MAT 1337

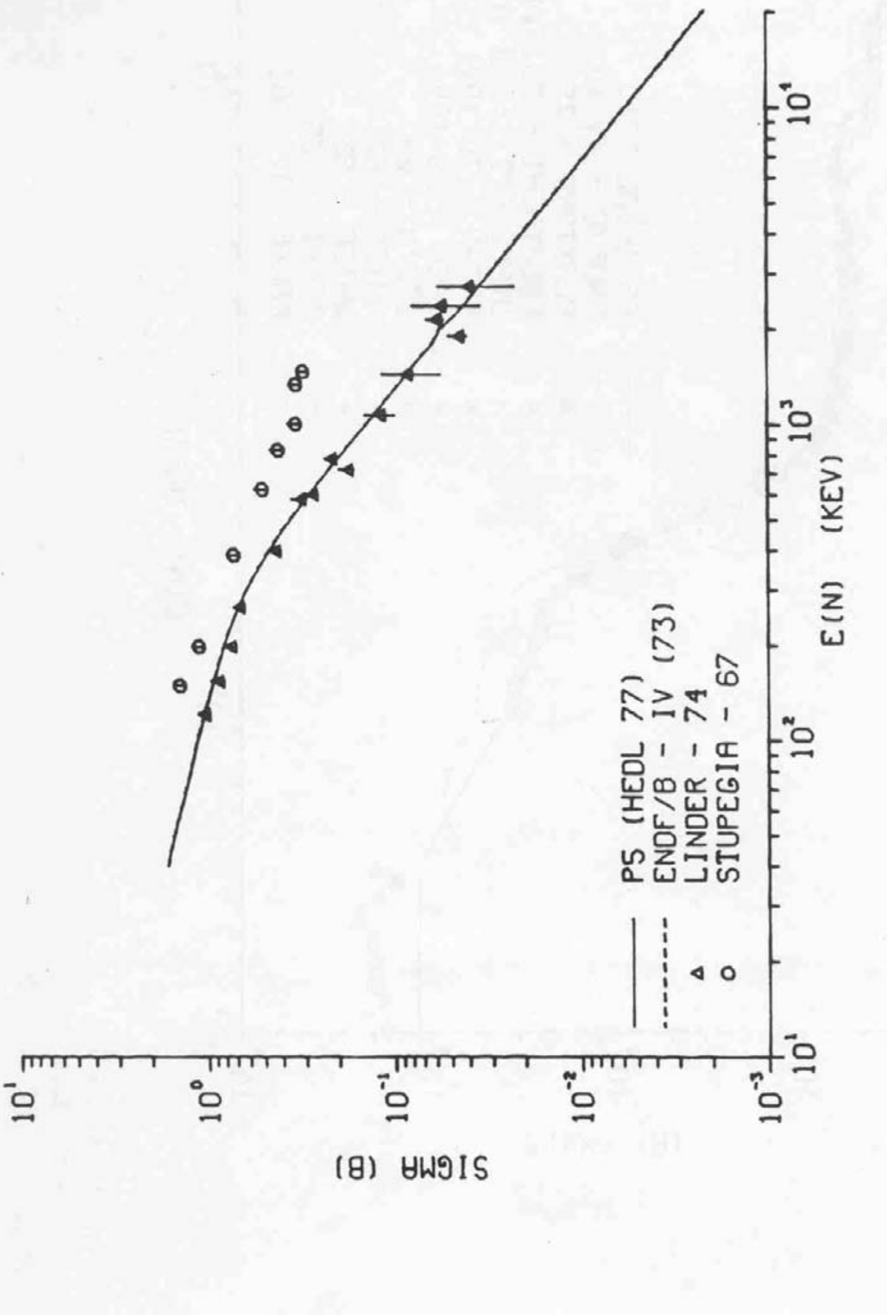

Figure 93-237-2
NP-37 (N,Gamma)

F.M. Mann and R.E. Schenter	(HEDL)	Apr. '78
C.R. Reich	(INEL)	Apr. '78
H. Alter and C. Dunford	(AI)	May. '67

The present work supersedes the ENDF/B-IV evaluation, MAT = 1050 by A1ter and Dunford. Neutron and photon production data are given between 10^{-5} eV and 20 MeV. The cross sections included are total, elastic, inelastic, (n, f) , (n,2n), (n,3n), (n, n'γ), and (n, γ) and are described in HEDL-TME-77-54 (ref. 15). The proton data include multip1icities and transition probabilities, photon production cross sections, and secondary energy spectra.

MF= 1 General Information:

MT=452

NU. THERMAL VALUE BASED ON JAFFEY ET AL (REF. 16) AND KROSHKIN ET AL (REF.17). ENERGY DEPENDENCE FROM HOWERTON (REF. 1)

MT=458
ENERGY FROM FISSION BASED ON SHER (REF. 18)

MF=2
RESONANCE PARAMETERS

MT=151
RESOLVED PARAMETERS TAKEN FROM YOUNG ET AL (REF. 2) UNRESOLVED PARAMETERS ARE FROM RESOLVED REGION AND OPTICAL MODEL (UNCHANGED FROM ENDF/B-1)

THERMAL CROSS SECTION

TOTAL = 590. B (REF.5 = 590)

CAPTURE = 552.4 B

FISSION = 17.0 B (REF.7 = 16.6)

RESONANCE INTEGRAL (0.5 EV CUTOFF)

CAPTURE = 276.3

FISSION = 14.3

MF=3
SMOOTH CROSS SECTIONS

MT=1 TOTAL FROM OPTICAL MODEL

MT=2 ELASTIC FROM OPTICAL MODEL

MT=4 INELASTIC SCATTERING DATA RESULTS FROM THE SCATTERING TO 15 LEVELS PLUS CONTINUUM. STATISTICAL COMPOUND NUCLEUS MODEL IS USED (REF. 15).

MT=16 N,2N BASED ON STATISTICAL MODEL CALCULATIONS (REF. 15)

MT=17 N,3N BASED ON STATISTICAL MODEL CALCULATIONS (REF. 15)

MT=18 FISSION BASED ON EXPERIMENTS OF ERMAGAMBETOV(REF. 11), FOMUSHKIN (REF. 12), DRAKE (REF. 13), AND SILBERT (REF. 14)

MT=51,...,65,91 INELASTIC SCATTERING DATA RESULTS FROM THE

SCATTERING TO 15 LEVELS PLUS CONTINUUM. STATISTICAL COMPOUND NUCLEUS MODEL IS USED (REF. 15).

MT=102 CAPTURE FROM STATISTICAL MODEL (REF. 16)

MT=251 MUBAR CALCULATED FROM DOM ANGULAR DISTRIBUTIONS

MT=252 XIBAR CALCULATED FROM DOM ANGULAR DISTRIBUTIONS

MT=253 GAMMA CALCULATED FROM DOM ANGULAR DISTRIBUTIONS

MF=4 LEGENDRE POLYNOMIALS

MT=2 ELASTIC SCATTERING LEGENDRE COEFFICIENTS FOR 15TH ORDER FIT TO CALCULATED ANGULAR DISTRIBUTIONS (DOM) ARE PROVIDED BETWEEN 10 KEV AND 11 MEV AND 19TH ORDER BETWEEN 12 AND 15 MEV.

MT>2 ARE ASSUMED ISOTROPIC

MF=5
SECONDARY ENERGY DISTRIBUTIONS

MT=16 N,2N NUCLEAR TEMPERATURE WITH ENERGY DEPENDENCE AS IN REFERENCE 9.

MT=17 SAME,AS MT=17

MT=18 FISSION MAXWELLIAN WITH CONSTANT TEMPERATURE FROM CORRELATION OF REF. 1.

MT=19,20 SAME AS MT=18

MT=91 (N,N) TEMPERATURE FROM GILBERT AND CAMERON (REF. 6)
DATA FOR 94-PU-238 DECAYS BY REICH INSERTED INTO FILE AT BNL BY R. KINSEY IN SEP 1978

MF=8, MT=457 RADIOACTIVE DECAY DATA

REFERENCES Q(ALPHA)-1974 VERSION OF WAPSTRA-BOS-GOVE MASS TABLE.

SPONTANEOUS-FISSION BRANCHING RATIO FROM DATA OF J.D. HASTINGS AND W.W. STROHM, J. INORG. NUCL. CHEM. 34, 25 (1972). OTHER- SEE TABLE OF ISOTOPES, 7TH ED. (PRELIMINARY DATA, PRIV. COMM. FROM C.M. LEDERER) AND Y.A. ELLIS, NUCLEAR DATA SHEETS B 4, NO. 6, 635 (1970).

NOTE THE INTENSITY VALUES OF THE K-X-RAYS AND OF THE GAMMA RAYS BELOW 852 KEV (EXCEPT THOSE AT 258 AND 299 KEV) ARE THOSE OF R. GUNNINK, J.E. EVANS AND A.L.PRINDLE, UCRL-52139 (1976).

NOTE THE L-X-RAY DATA REPRESENT MEASURED VALUES. SEE C.E. BEMIS, JR. AND L. TUBBS, ORNL-5297, 93 (SEPT., 1977). TRANSLATED INTO ENDF/B-V FORMAT BY MANN AND SCHENTER (HEDL) 8/78

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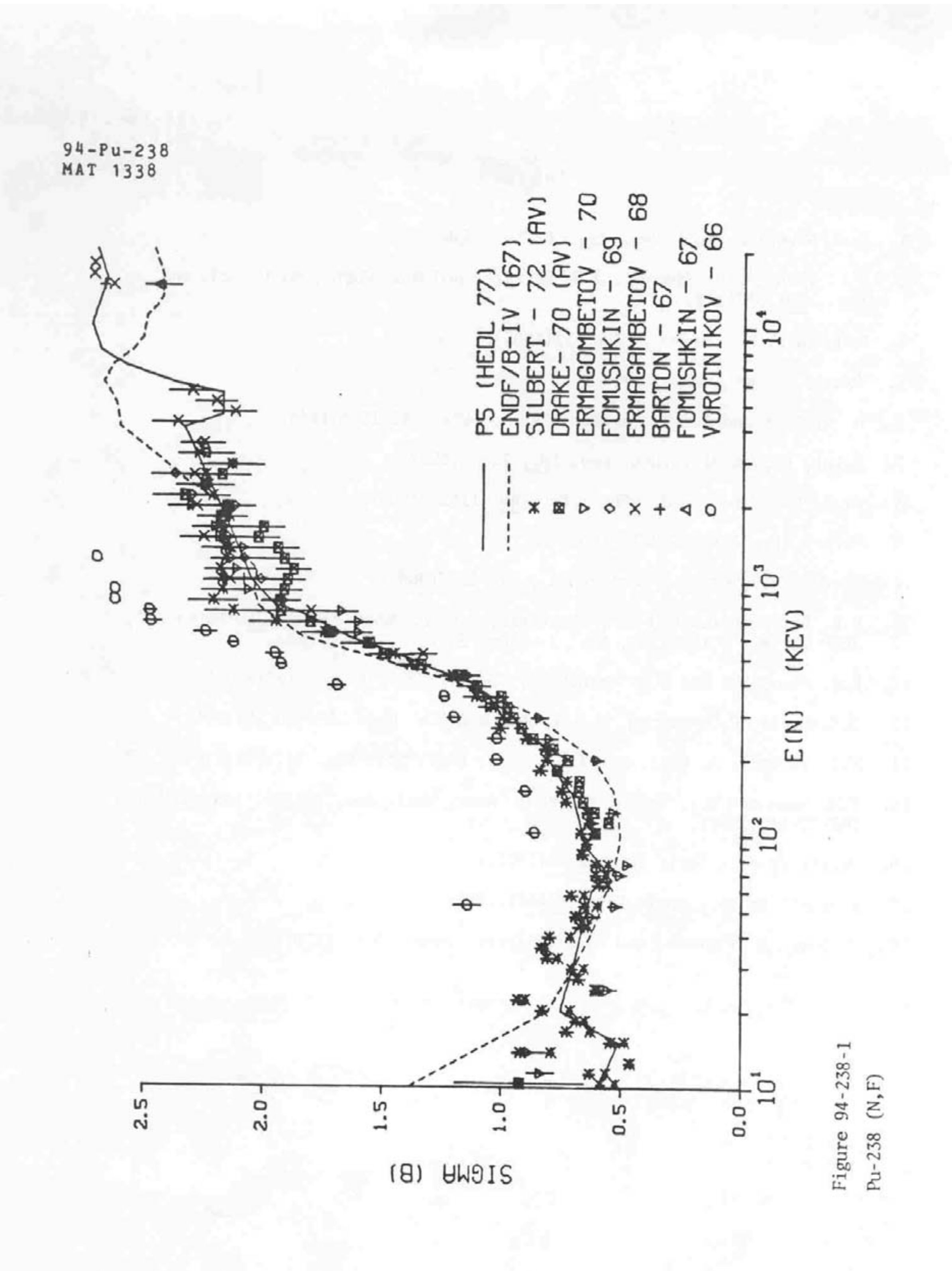

Figure 94-238-1
Pu-238 (N,F)

94-Pu-242
MAT 1342

SUMMARY DOCUMENTATION FOR ^{242}Pu

By

F. Mann and R. Schenter
Hanford Engineering and Development Laboratory
Richland, Washington

And

D. G. Madland and p. G. Young
Los Alamos Scientific Laboratory
Los Alamos, New Mexico

I. SUMMARY

A new evaluation of neutron-induced reactions on ^{242}Pu was performed for Version V of ENDF/B (MAT 1342). The analysis was divided between HEDL, where the resolved and unresolved resonance regions were evaluated, and LASL, where the data above a neutron energy of 10 keV were evaluated. These evaluations are documented in HEDL-TME-77-54 (Ma77B) and LASL-7533-MS (Ma78). Additionally, decay data were provided by C. Reich (INEL), thermal data by R. Benjamin (SRL), and gamma-ray production data by R. Howerton (LLL). The evaluation covers the energy range 10-5 eV to 20 MeV and includes covariance data at all energies.

II. ENDF/B-V FILES

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MF=1           GENERAL INFORMATION
  MT=452  NUBAR TOTAL. SUM OF MT=456 AND A DELAYED NUBAR OF 0.015
     FROM THE MEASUREMENT OF KR70 AS COMPILED BY MA72.
  MT=456  NUBAR PROMPT.BASED ON A FIT TO PU-240 EXP. DATA BY FR74,
     USING SYSTEMATICS TO INFER DELTA NUBAR TO PU-242, AND RENOR-
     MALIZED TO CF-252 THERMAL NUBAR OF 3.757.
  MT=458  ENERGY OF FISSION.  BASED ON WORK OF SH83.
MF=2    RESONANCE  PARAMETERS  (0 TO 10 KEV)
    MT=151  RESOLVED RESONANCES   67 RESOLVED RESONANCES AND ONE
       BOUND LEVEL DESCRIBE THE CROSS SECTION DATA FROM ZERO TO
       986 EV.  EXCEPT FOR THE BOUND AND 2.68 EV LEVELS, PARA-
       METERS ARE FROM BNL-325 (MU76).  PARAMETERS FOR THE BOUND
       AND 2.68 EV LEVELS HAVE BEEN MODIFIED TO PRESERVE
       THE CROSS SECTION VALUES AND SHAPES IN THE THERMAL REGION
       AS DESCRIBED BY YO70 AND YO71, ALONG WITH THE HIGHER RESO-
       NANCE CAPTURE INTEGRAL SUGGESTED BY INTEGRAL AND PRODUCTION
       EXPERIMENTS(BU57, HA64, BE75). RESOLVED REGION 0 TO 986 EV.
            UNRESOLVED RESONANCES.  AVERAGE RESONANCE PARAMETERS
       FOR L=0 RESONANCES FROM RESOLVED RESONANCES.  THE REST ARE
       FROM MAT 1161.  UNRESOLVED REGION - 986 EV TO 10 KEV.
MF=3     SMOOTH CROSS SECTIONS
  GENERAL.  EVALUATION FROM 0.01 - 20 MEV DESCRIBED IN MA78.
          STATISTICAL COMPOUND NUCLEUS AND DIRECT REACTION
       THEORY CALCULATIONS PERFORMED WITH LASL VERSIONS OF
          COMNUC (DU70, 3/29/78 VERSION) AND JUKARL (RE71). ALL
          CALCULATIONS USED LASL PRELIMINARY GLOBAL ACTINIDE OP-
          TICAL POTENTIAL (MA77). COMPLETE SET OF CALCULATIONS
          PERFORMED BUT ELASTIC AND FISSION CROSS SECTION EVALUA-
          TIONS DIFFER SLIGHTLY (LESS THAN 5PC) FROM CALCULATIONS
          BECAUSE OF INFLUENCE OF FISSION MEASUREMENTS. (N,F),
          (N,NF), AND (N,2NF) X/S CALCULATED SUBJECT TO CONSTRAINT
          THAT THEIR SUM EQUALS MEASURED (BE78) TOTAL FISSION X/S
          WITHIN 5PC. DISCRETE FISSION CHANNELS (UP TO 12) AND
          DEFORMED LEVEL DENSITY CONTINUUM FISSION CHANNELS USED.

MT=1  TOTAL.  SPHERICAL OPTICAL MODEL CALCULATION WITH NUCLEAR
     DEFORMATION EFFECTS ACCOUNTED FOR BY COUPLED-CHANNEL CALCU-
     LATIONS OF UP TO 5 STATES OF GROUND STATE BAND.
  MT=2  ELASTIC.  DIFFERENCE BETWEEN MT=1 AND MT=4+16+17+18+102.
     AGREES WITH MODEL CALCULATION TO WITHIN FEW PERCENT.
```

MT=4 INELASTIC SCATTERING. SUM OF MT=51-69 AND MT=91.
MT=16,17 (N,2N) AND (N,3N). BASED ON COMPOUND NUCLEUS STATISTICAL MODEL CALCULATIONS.
MT=18 FISSION. BELOW 100 KEV BASED ON EXP. DATA OF AU71. FROM 0.1 TO 20 MEV, BASED ON EXP. DATA OF BE78.
MT=51-54 DISCRETE INELASTIC. BASED ON HAUSER-FESHBACH COMPOUND NUCLEUS CALCULATION AND COUPLED-CHANNEL CALCULATION OF DIRECT INELASTIC SCAT. FOR FIRST 5 LEVELS OF GROUND STATE ROTATIONAL BAND USING DEFORMATION PARAMETERS OF BE73.
MT=55-69 DISCRETE INELASTIC. BASED ON HAUSER-FESHBACH COMPOUND NUCLEUS CALCULATION.
MT=102 CAPTURE. BASED ON COMPOUND NUC. STATISTICAL CALCULATION WITH GAMMA STRENGTH FUNCTION ADJUSTED TO AGREE WITH HO75 MEASUREMENTS (2*PI*GAMMA/D = 0.01045, MU73). ABOVE 4 MEV, SEMI-DIRECT CONTRIBUTION ADDED FROM PREEQUILIBRIUM CASCADE CALCULATION WITH GAMMA-RAY EMISSION PROB. CALCULATED AT EACH STAGE (AR78).

MF=4   ANGULAR DISTRIBUTIONS (LEGENDRE COEFFICIENTS)
MT=2 SHAPE ELASTIC COMPONENT BASED ON DEFORMED OPTICAL MODEL CALCULATION. COMPOUND NUCLEUS COMPONENT ASSUMED ISOTROPIC.
MT=16,17,18 ASSUMED ISOTROPIC IN LAB SYSTEM
MT=51-54 DIRECT COMPONENT TAKEN FROM DEFORMED OPT. MOD. CALC. COMPOUND NUCLEUS COMPONENT ASSUMED ISOTROPIC.
MT=55-69 ASSUMED ISOTROPIC IN C.M. SYSTEM.
MT=91 ASSUMED ISOTROPIC IN LAB SYSTEM.

MF=5   SECONDARY NEUTRON ENERGY DISTRIBUTIONS
MT=16,17 NUCLEAR TEMPERATURES CALCULATED FROM LEVEL DENSITY PARAMETERS USED IN MODEL CALCULATIONS (GI65,CO67).
MT=18 FISSION MAXWELLIAN USING ENERGY-DEPENDENT TEMPERATURES FROM TERRELL (TE65).
MT=91 SAME COMMENT AS FOR MT=16,17

MF=32
MT=151 FROM BNL-325 (REF. 4)

MF=33   SMOOTH X/S COVARIANCES (HEDL AND LASL)
APPROXIMATE ERROR FILES DETERMINED FROM ESTIMATED UNCERTAINTIES IN MODEL CALCULATIONS (MT=1,2,4,16,17,102) AND IN EXPERIMENTAL UNCERTAINTIES (MT=18,102).

MF=8
MT = 454 AND 459 INSERTED INTO FILE AT BNL BY R. KINSEY 9/78

ENDF/B-V YIELD DATA

SET 5E,7/78. VALUES OBTAINED FROM THE RECOMMENDATIONS OF THE YIELDS SUBCOMMITTEE, T.R.ENGLAND (CHAIRMAN), D.M.GILLIAM, Y.HARKER, J.R.LIAW, W.J.MAECK, D.G.MADLAND, V.MCLANE MAY, P.L.REEDER, B.F.RIDER, R.E.SCHENTER, B.I.SPINRAD, J.P.UNIK, A.WAHL, W.WALKER, B.W.WEHRING, K.WOLFSBERG

UNCERTAINTIES ARE BASED ON THE TOTAL YIELD TO EACH ZA. WHEN THERE IS AN ISOMERIC STATE, THE INDEPENDENT NUCLIDE YIELD TO EACH STATE HAS A LARGER UNCERTAINTY THAN THE TOTAL YIELD IN STATE DISTRIBUTIONS (UNCERTAINTIES AVERAGE APPROXIMATELY 50 PERCENT BUT CAN BE LARGER). ANY YIELD HAVING A LARGE UNCERTAINTY (45-64 PERCENT) MAY BE A MODEL ESTIMATE OR A VALUE ASSIGNED TO THE YIELDS ON THE WINGS OR VALLEY OF THE MASS YIELD DISTRIBUTION. THESE SMALL YIELDS MAY ONLY BE ACCURATE TO WITHIN A FACTOR OF 2.

MT454 CONTAINS DIRECT YIELDS BEFORE DELAYED NEUTRON EMISSION

MT459 CONTAINS CUMULATIVE YIELDS ALONG EACH ISOBARIC CHAIN AFTER DELAYED NEUTRON EMISSION.

DIRECT AND CUMULATIVE YIELDS ARE NORMALIZED BY THE SAME FACTOR BASED ON B.F.RIDER EVALUATION. THE ISOMERIC STATE MODEL, LA-6595-MS (ENDF-241), AND DELAYED NEUTRON EMISSION BRANCHINGS (PN VALUES) FOR 102 EMITTERS, LA-UR-78-688, AND PAIRING EFFECTS,LA-6430-MS (ENDF-240), HAVE BEEN INCORPORATED.

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   DATA PREPARED FOR FILES BY T.R.ENGLAND (LASL LTR. T-2-L-2891)
  *        *          *          *          *          *

94-PU-242  INEL       EVAL-AUG78 REICH
 DATA ADDED TO FILE BY R. KINSEY AT BNL 9/78
MF=8, MT=457   RADIOACTIVE DECAY DATA
 REFERENCES  A(ALPHA)- A.H. WAPSTRA AND K. BOS, AT. DATA AND NUCL.
                       DATA TABLES 19, 175(1977).
             OTHER- SEE TABLE OF ISOTOPES, 7TH ED. (PRELIMINARY
                    DATA, PRIV. COMM. FROM C.M. LEDERER ) AND
                    Y.A. ELLIS AND R.L. HAESE, NUCLEAR DATA SHEETS
                     21, 615 (1977).
       NOTE  THE L-X-RAY DATA REPRESENT MEASURED VALUES. SEE C.E.
             BEMIS, JR. AND L. TUBBS, ORNL-5297, 93 (SEPT., 1977).
 TRANSLATED INTO ENDF/B-V FORMAT BY MANN AND SCHENTER (HEDL)  8/78
MF=12,13,14,15     PHOTON PRODUCTION
     FILES TAKEN FROM THE LLL ELAVUATIONS OF R. HOWERTON
     DOCUMENTED IN UCRL 50400, VOL. 15, PART A (METHODS) SEPT 75
     AND PART B (CURVES) APR 76. FILES EXTENDED TO THE ENERGY
     RANGE 1.-5 EV TO 20 MEV AND MERGED TO THIS EVALUATION
     AT BNL BY R. KINSEY.
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GI65 A. GILBERT AND A.G.W. CAMERON, CAN. J. PHYS. 43(1965)1446

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MA77 D.MADLAND, LA-7066-PR, 1977, P12

MA78 D.G.MADLAND, P.G.YOUNG, TO BE ISSUED IN LASL REPORT, 1978

MU73 MUGHABGHAB, S., GARBER, D., BNL-325,THIRD ED.,VOL.1, 1973

RE71 H.REBEL, G.W.SCHWEIMER, KFK-133,1971

SH83 SHER+BECK EPRI NP-1771/81 +REV.1 1/83 +PC TO MAGURNO 2/83

YO70 YOUNG, T., REEDER, S., NUCL.SCI.ENG.40,389(1970)

YO71 YOUNG, T., ET AL., NUCL.SCI.ENG.43,341(1971)

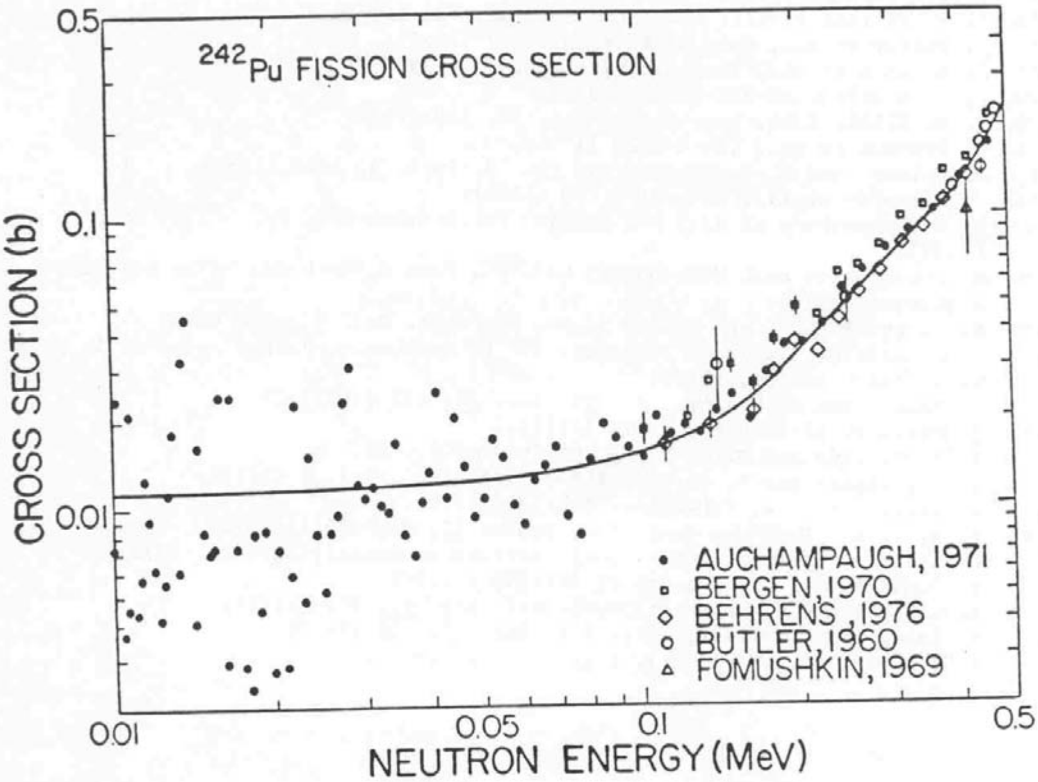

Fig. 1.

Experimental and evaluated cross sections for the $^{242}Pu(n,f)$ reaction from 10 keV to 0.5 MeV. The evaluated curve is based upon the Auchampaugh (Au71) and Behrens (Be76) ratio measurements relative to the $^{235}U(n,f)$ reaction. The values shown here were converted using a preliminary evaluation of the $^{235}U(n,f)$ cross section and will be adjusted by up to 4% in the final evaluation.

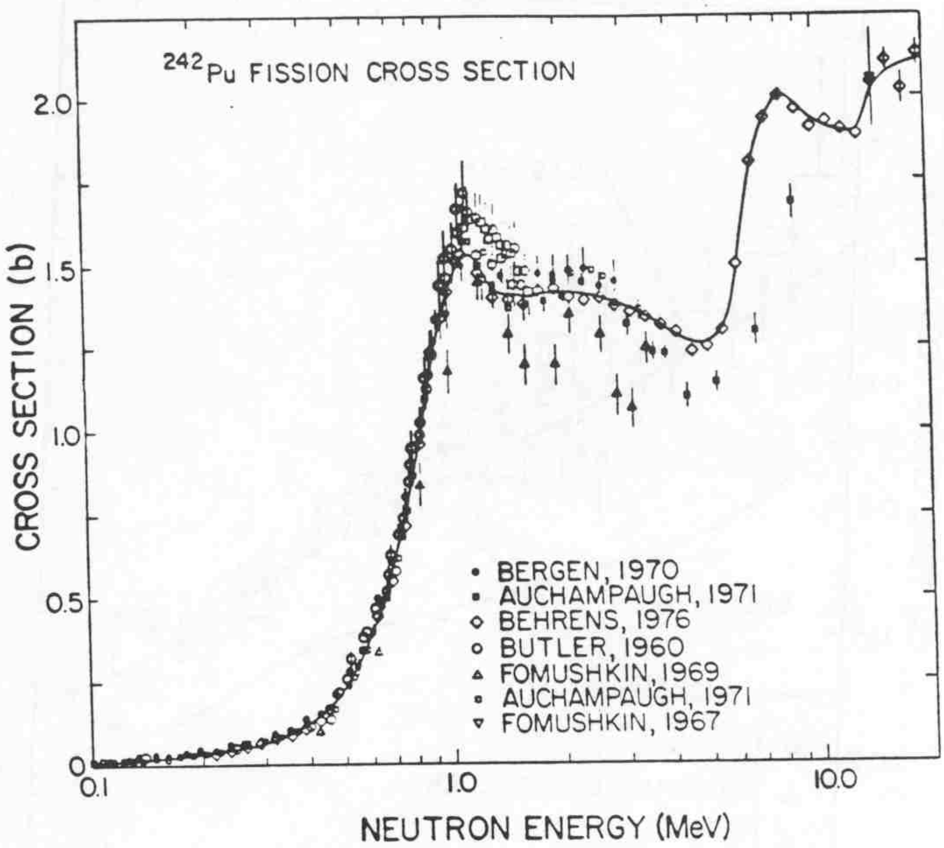

Fig. 2.

Experimental and evaluated cross sections for the $^{242}Pu(n,f)$ reaction from 0.1 to 20 MeV. See caption for Fig. 1.

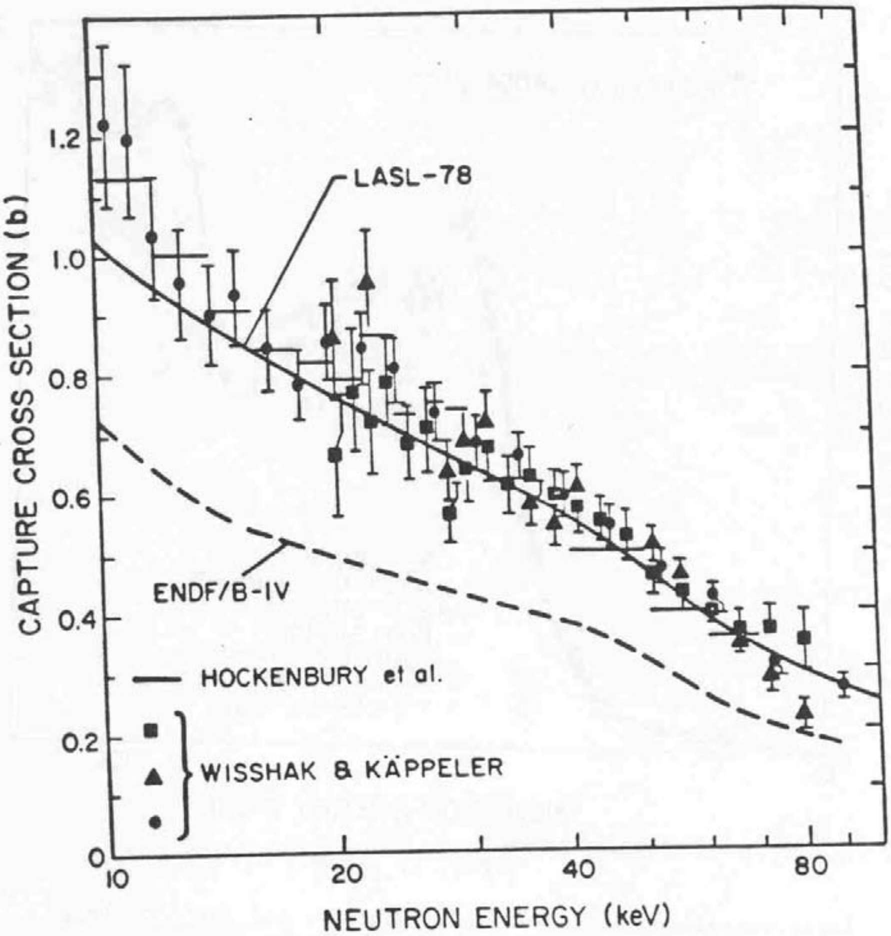

Fig. 3.

Experimental and evaluated cross section for the $^{242}Pu(n,\gamma)$ reaction between 10 and 100 keV. The experimental data are from Hockenbury (Ho75) and Wisshak and Käppeler (Wi78).

Isotope: 95-Am-241 MAT = 1361

F.M. Mann and R.E. Schenter (HEDL) Apr. '78
L. Weston (ORNL) Apr. '78
C.R. Reich (INEL) Apr. '78
R.J. Howerton (LLL) Apr. '78

The present work supersedes the ENDF/B-IV evaluation, MAT = 1056 by Smith and Grimesey. Neutron and photon production data are given between 10^{-5} eV and 20 MeV. The cross sections included are total, elastic, inelastic, (n, f) , (n,2n), (n,3n), (n, n' γ), and (n, γ) and are described in HEDL-TME-77-54 (ref. 3). The proton data include multip1icities and transition probabilities, photon production cross sections, and secondary energy spectra.

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MF=1  GENERAL INFORMATION

  MT=452    NU. A WEIGHTED AVERAGE OF THE INDIVIDUAL DETERMINATIONS OF NU
  ASSIGNS MOST OF THE WEIGHT TO THE DATA OF V.I. LEBEDEV ET. AL. (REF. 1).
  USING THE VALUE OF NU FOR 235 OF 2.43, NU=3.09 IS OBTAINED FOR THE CONSTANT
  TERM. THE SLOPE IS THAT OF THE UNIVERSAL CURVE  OF J.C. HOPKINS AND B.C.
  DIVEN (REF. 2) FROM ENDF/B-I SMITH GRIMESEY EVAL.

  MT=458 ENERGY FROM FISSION BASED ON SHER (REF. 13)

MF=2  RESONANCE  INFORMATION

  MT=151   RESOLVED RESONANCE PARAMETERS (0-50 EV) FROM REF. 10 AND 11.
  UNRESOLVED PARAMETERS OBTAINED USING METHODS FROM REF. 3 AND DATA FROM REF.
  10 AND 11.
MF=3  SMOOTH CROSS SECTION

  MT=1   TOTAL SUM OF PARTIAL CROSS SECTIONS

  MT=2   ELASTIC.     RESULT OF OPTICAL MODEL CALCULATION (REF. 5)

  MT=4   INELASTIC. RESULT OF STATISTICAL MODEL CALCULATIONS. 18 LEVELS WERE
         INCLUDED (REF. 3)

  MT=16  N,2N BASED ON STATISTICAL MODEL CALCULATIONS (REF. 3)

  MT=17  N,3N BASED ON STATISTICAL MODEL CALCULATIONS (REF. 3)

  MT=18  FISSION. BELOW  400 KEV, RESULT OF STATISTICAL MODEL CALCULATION
         (REF. 3) GUIDED BY DATA OF  BOWMAN ET. AL. (REF. 4) AND SPHAK ET, AL.
         (REF. 5). ABOVE 400 KEV, AVERAGE OF DATA OF SPHAK ET. AL. (REF. 5),
         SEEGER ET. AL. (REF.6), FOMUSHKIN ET. AL. (REF. 7,8), AND IVER ET. AL.
         (REF. 9)

  MT=19  (N,F) SAME AS MT=18 UNTIL (N,NF) THRESHOLD, CONSTANT THEREAFTER.

  MT=20  (N,NF)  DIFFERENCE BETWEEN MT=18 AND 19.

  MT=51,...,68,91  RESULT OF STATISTICAL MODEL CALCULATIONS USING 18 EXCITED
                   LEVELS PLUS CONTINUUM (REF. 3)

  MT=102  CAPTURE. STATISTICAL MODEL CALCULATION (REF. 3) BASED ON DATA OF
          WESTON AND TODD (REF. 10).  IN RESOLVED RESONANCE BACKGROUND OF
          20.5/SQRT(E) FROM REF. 10.


MF=4  ANGULAR DISTRIBUTIONS

  MT=2  EVALUATION BASED ON OPTICAL MODEL (REF. 3)
```

MT>2 INELASTIC ASSUMED ISOTROPIC

MF=5 ENERGY DISTRIBUTION

MT=16 EVAPORATION TEMP. FROM GILBERT AND CAMERON (REF. 12)

MT=17 SAME REFERENCE AS MT=16

MT=18 SIMPLE MAXWELLIAN WITH ENERGY DEPENDENT TEMPERATURE

MT=19 SAME REFERENCE AS MT=18

MT=20 SAME REFERENCE AS MT=18

MT=91 SAME REFERENCE AS MT=16

MF=8 RADIOACTIVITY

MT=102 (N,G) DECAY CHAIN FROM ENDF/B-V DATA FOR 95-AM-241 DECAYS BY REICH INSERTED INTO FILE AT BNL BY R. KINSEY IN SEP 1978

MF=8, MT=457 RADIOACTIVE DECAY DATA

REFERENCES Q(ALPHA)-1974 VERSION OF WAPSTRA-BOS-GOVE MASS TABLE

HALF-LIFE- WEIGHTED AVERAGE OF DATA OF H. RAMTHUN AND W. MULLER, INT L. J. APPL. RAD. AND ISOTOPES **26**, 589 (1975) AND OF F.L. OETTING AND S.R. GUNN, J. INORG. NUCL. CHEM. **29**, 2659 (1967). SPONTANEOUS-FISSION BRANCHING RATIO DERIVED FROM LISTED HALF-LIFE AND WEIGHTED AVERAGE OF S.-F. HALF-LIFE VALUES OF R. GOLD ET AL., PHYS. REV. **C 1**, 738 (1970) AND OF D. GALLIKER ET AL., HELV. PHYS. ACTA **43**, 593 (1970). OTHER- SEE TABLE OF ISOTOPES, 7TH. ED. (PRELIMINARY DATA, PRIV. COMM. FROM C.M. LEDERER) AND Y.A. ELLIS, NUCLEAR DATA SHEETS **6**, NO. 6, 621(1971)

NOTE THE K-X-RAY INTENSITIES LISTED ARE MEASURED VALUES.

NOTE ENERGIES AND INTENSITIES OF THE GROUND-STATE ALPHA AND THE TWO MOST INTENSE ALPHAS ARE TAKEN FROM A. RYTZ, AT. DATA AND NUCL. DATA TABLES **12, NO. 5**,479 (1973).

NOTE THE L-X-RAY DATA ARE THOSE OF J.L. CAMPBELL AND L.A. MCNELLES, NUCL. INSTRUM. AND METHODS **117**, 519 (1974).

NOTE THE GAMMA-RAY INTENSITIES (EXCEPT THOSE OF THE 55- AND 67-KEV GAMMAS) ARE THOSE REPORTED BY R. GUNNINK, J.E. EVANS AND A.L. PRINDLE, UCRL-52139 (OCT.,;976). THOSE OF THE 55- AND 67-KEV GAMMAS ARE DEDUCED FROM THE INTERNAL-CONVERSION COEFFICIENTS AND INTENSITY-BALANCE CONSIDERATIONS.

TRANSLATED INTO ENDF/B-V FORMAT BY MANN AND SCHENTER (HEDL) 8/78

MF=9 CROSS SECTION BRANCHING

MT=102 (N,G) FROM STATISTICAL MODEL CALCULATION (REF. 3)

MF=12,13,14,15 PHOTON PRODUCTION

FILES TAKEN FROM THE LLL EVALUATIONS OF R. HOWERTON DOCUMENTED IN UCRL 50400, VOL. 15, PART A (METHODS) SEPT 75 AND PART B (CURVES) APR 76. FILES EXTENDED TO THE ENERGY RANGE 1.-5 EV TO 20 MEV AND MERGED TO THIS EVALUATION AT BNL BY R. KINSEY.

MF=32,33 ERROR FILES

MT=1,2,4,16,17,18,102, AND 151

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2. J.C. HOPKINS AND B.C. DIVEN, NUCL. PHYS. **48**(1963)433.
3. F.M.MANN AND R.E. SCHENTER, TRANS.AMER.NUCL.SOC. **23**(1976)546 AND HEDL TME 77-54 (1977)
4. C.D. BOWMAN, M.S. COOPS, G.F. AUCHAMPAUGH, AND S.C. FULTZ. PHYS REV **137B**(1965)326
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7. E.F. FOMUSHKIN ET.AL. YF **5**(1967)966
8. V.F. FOMUSHKIN AND E.K. GUTNIKOVA, SOV.J NUCL.PHYS.**10**(1970)529
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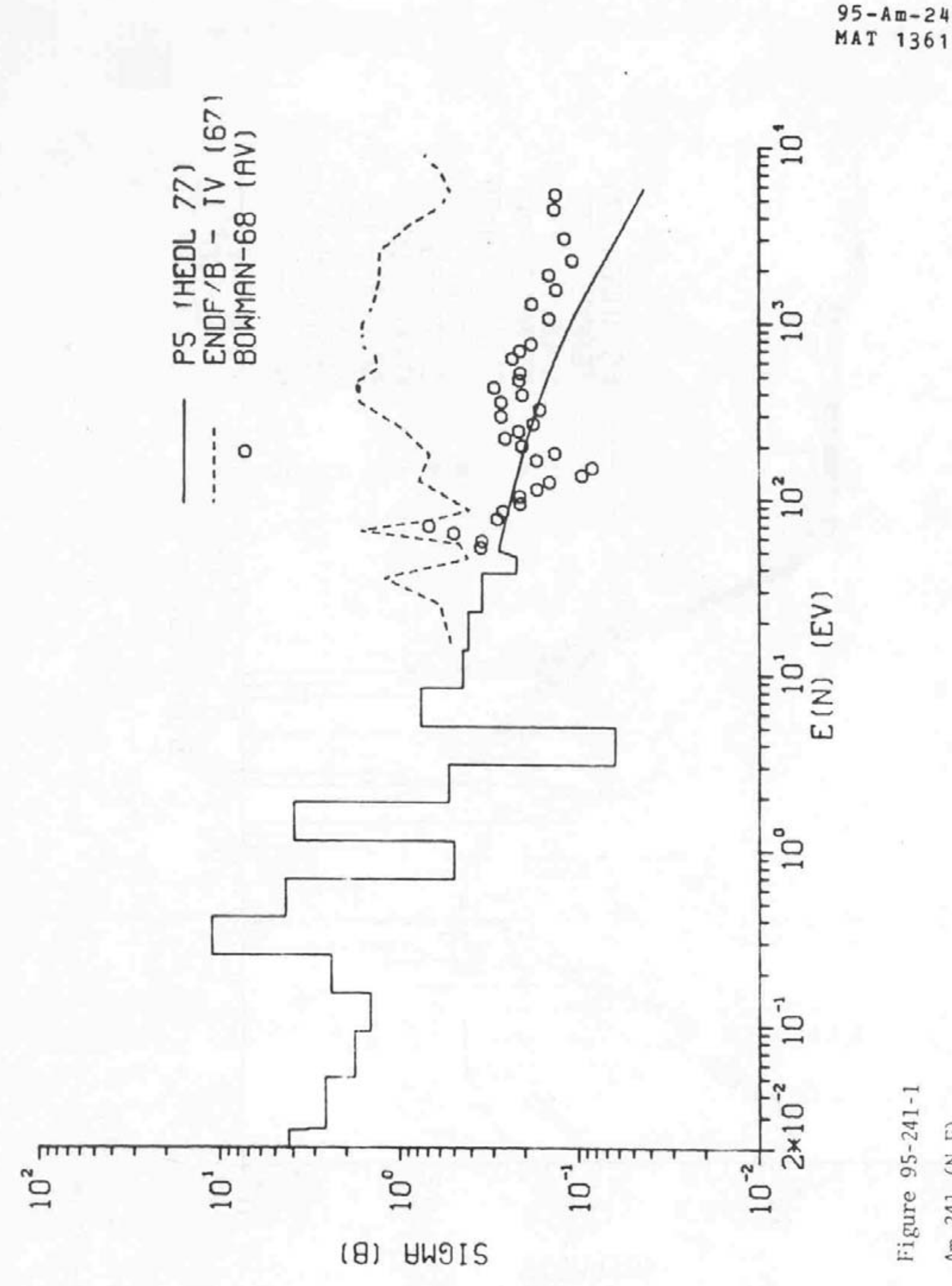

Figure 95-241-1

Am 241 (N,F)

95-Am-241
MAT 1361

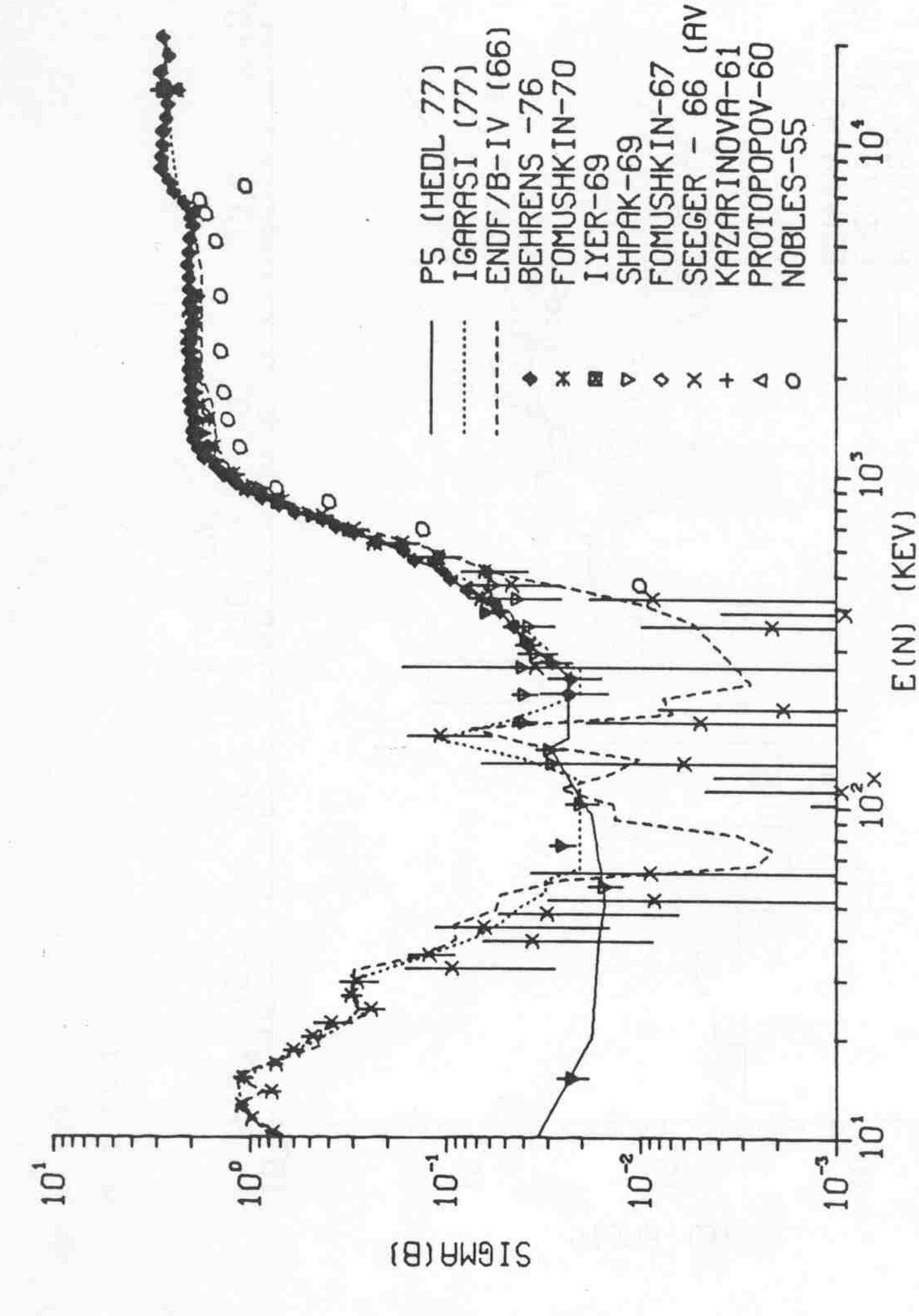

Figure 95-241-2
Am 241 (N,F)

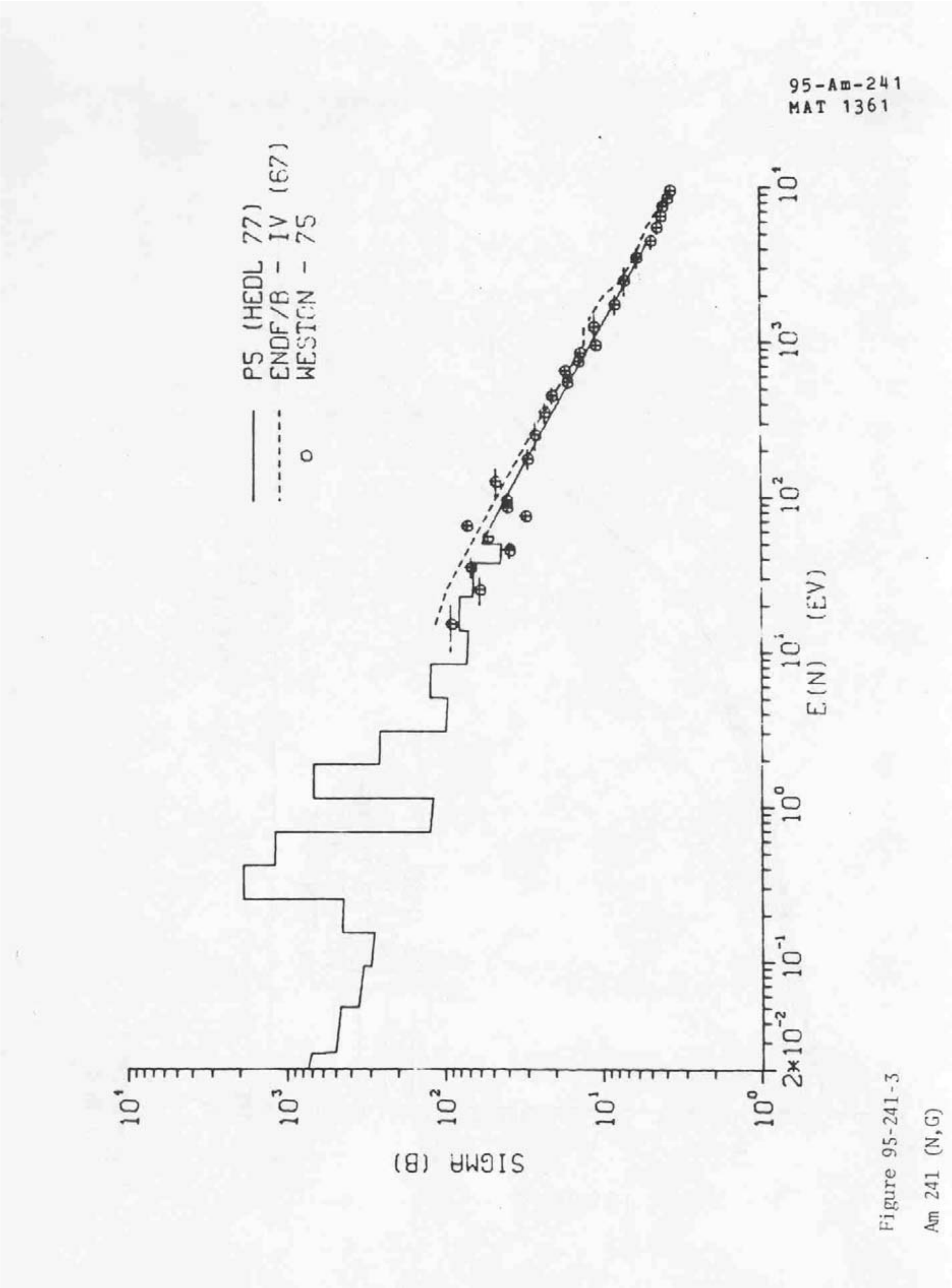

Figure 95-241-3

Am 241 (N,G)

95-Am-241
MAT 1361

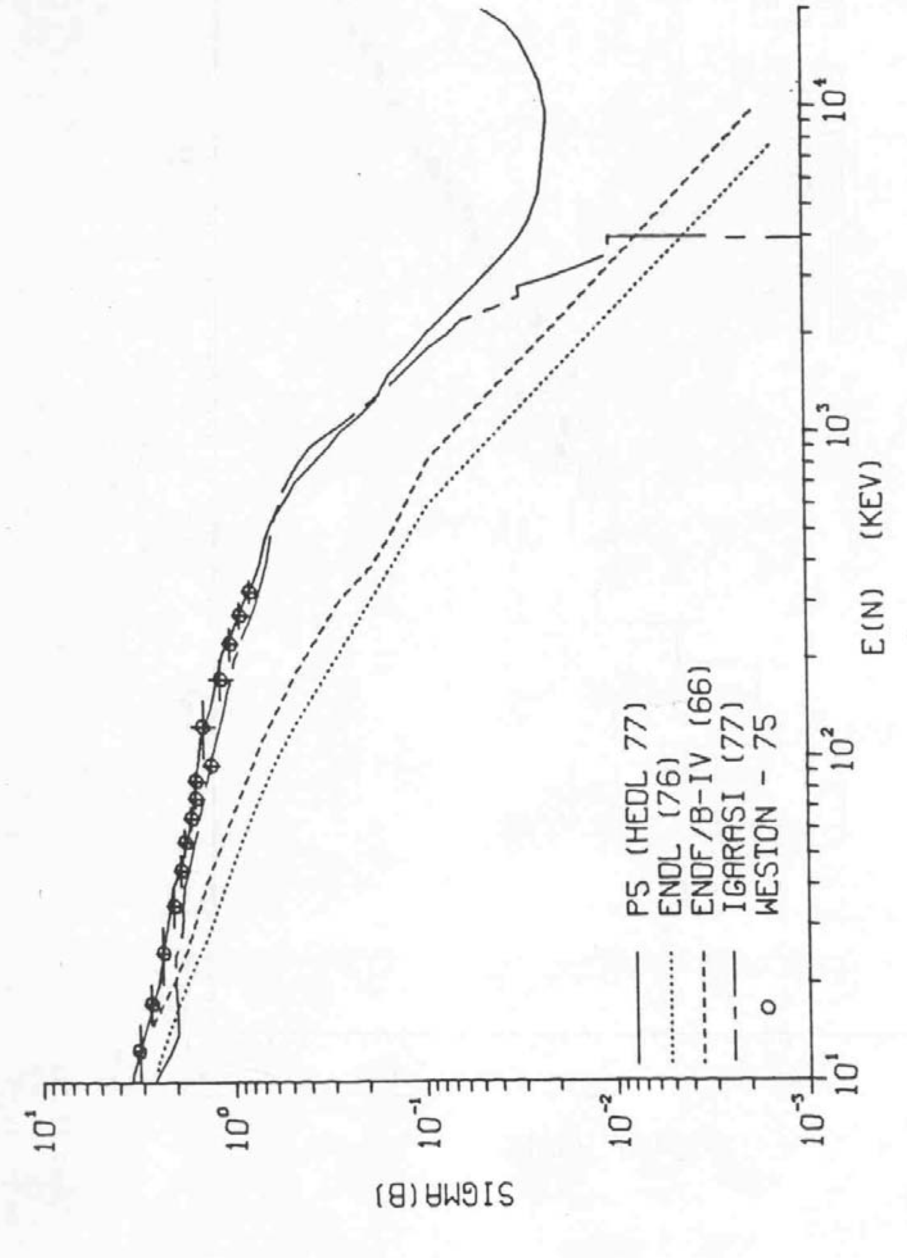

Figure 95-241-4
Am 241 (N,G)

ENDF/B-V Summary Documentation

Isotope: 95-Am-241 MAT = 1361

F.M. Mann and R.E. Schenter	(HEDL)	Apr. '78
R. Benjamin	(SRL)	Apr. '75
R.J. Howerton	(LLL)	Apr. '78
C.R. Reich	(INEL)	Apr. '78

This is the first evaluation for ENDF/B for this isotope. Neutron and photon production data are given between 10^{-5} eV and 20 MeV. The cross sections included are total, elastic, inelastic, (n, f) , (n,2n), (n,3n), (n, 4n), and (n, γ) and are described in HEDL-TME-77-54 (ref. 7). The proton data include multip1icities and transition probabilities, photon production cross sections, and secondary energy spectra.

MF=1 GENERAL INFORMATION

MT=452 NUBAR. THERMAL VALUE FROM MEASUREMENTS OF JAFFEY AND LERNER(REF.1). ENERGY DEPENDENCE BASED ON WORK OF HOWERTON (REF.2).

MT=458 ENERGY OF FISSION. SYSTEMATICS OF SHER (REF.11)

MF=2 RESONANCE PARAMETERS(0 TO 10 KEV)

MT=151 RESOLVED RESONANCES
RESONANCE PARAMETERS FOR SIX RESOLVED RESONANCES FROM WORK OF BOWMAN ET AL.(REF. 5). RESOLVED REGION - 0 TO 3.55 EV. UNRESOLVED RESONANCES AVERAGE PARAMETERS FROM REF. 5. UNRESOLVED RESONANCE REGION - 3.55 EV TO 10 KEV.

MF=3 SMOOTH CROSS SECTIONS(0 TO 20 MEV)

MT=1 TOTAL SUM OF PARTIAL CROSS SECTIONS

MT=2 ELASTIC OPTICAL MODEL CALCULATIONS (REF. 7)

MT=4 INELASTIC STATISTICAL MODEL CALCULATIONS TO 13 EXCITED LEVELS PLUS CONTINUUM (REF. 7)

MT=16 N,2N BASED ON STATISTICAL MODEL CALCULATIONS (REF. 7)

MT=17 N,3N BASED ON STATISTICAL MODEL CALCULATIONS (REF. 7)

MT=18 FISSION STATISTICAL MODEL CALCULATION BASED ON DATA OF BOWMAN ET.AL. (REF. 8) AND SEEGER ET.AL. (REF. 9)

MT=19 SAME AS MT=18 UNTIL (N,NF) THRESHOLD, THEN CONSTANT

MT=20 IS (MT=18) - (MT=19)

MT=37 N,4N BASED ON STATISTICAL MODEL CALCULATIONS (REF. 7)

MT=51,...,63,91 STATISTICAL MODEL CALCULATIONS TO 13 EXCITED LEVELS PLUS CONTINUUM (REF. 7)

MT=102 CAPTURE STATISTICAL MODEL CALCULATION (REF. 7)

MT=251,252,253 BASED ON DATA IN MF=4, MT=2.

MF=4 ANGULAR DISTRIBUTIONS

MT=2 BASED ON OPTICAL MODEL CALCULATIONS (REF. 7)

MT>2 ASSUMED ISOTROPIC

MF=5 SECONDARY NEUTRON ENERGY DISTRIBUTIONS

MT=16 BASED ON PARAMETERS OF GILBERT AND CAMERON (REF. 10)

MT=17 SAME REFERENCE AS MT=16

MT=18 FISSION   SIMPLE FISSION MAXWELLIAN WITH ENERGY-DEPENDENT TEMPERATURE.

MT=19,20 SAME AS MT=18

MT=37 SAME REFERENCE AS MT=16

MT=91 BASED ON PARAMETERS OF GILBERT AND CAMERON (REF. 10)
DATA FOR 95-AM-242M DECAYS BY REICH
INSERTED INTO FILE AT BNL BY R. KINSEY IN SEP 1978

MF=8, MT=457 RADIOACTIVE DECAY DATA

REFERENCES Q-VALUES-1974 VERSION OF WAPSTRA-BOS-GOVE MASS TABLE. OTHER- SEE TABLE OF ISOTOPES, 7TH ED. (PRELIMINARY DATA, PRIV. COMM. FROM C.M. LEDERER) AND Y.A. ELLIS, NUCLEAR DATA SHEETS B 4, NO.6, 683 (1970).

NOTE THE ENERGY AND INTENSITY DATA FOR THE GROUND-STATE ALPHA AND THE TWO MOST INTENSE ALPHA GROUPS ARE THE RECOMMENDED VALUES OF A. RYTZ, AT. DATA AND NUCL. DATA TABLES 12, NO. 5, 479 (1973).

TRANSLATED INTO ENDF/B-V FORMAT BY MANN AND SCHENTER (HEDL) 8/78

MF=12,13,14,15 PHOTON PRODUCTION
FILES TAKEN FROM THE LLL EVALUATION OF R. HOWERTON DOCUMENTED IN UCRL 50400, VOL. 15, PART A (METHODS) SEPT. 75 AND PART B (CURVES) APR. 76. FILES EXTENDED TO THE ENERGY RANGE 1.-5 EV TO 20 MEV AND MERGED TO THIS EVALUATION AT BNL BY R. KINSEY.

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11. R. SHER, S. FIARMAN, AND C. BECK (PRIV. COMM., OCT. 1976)

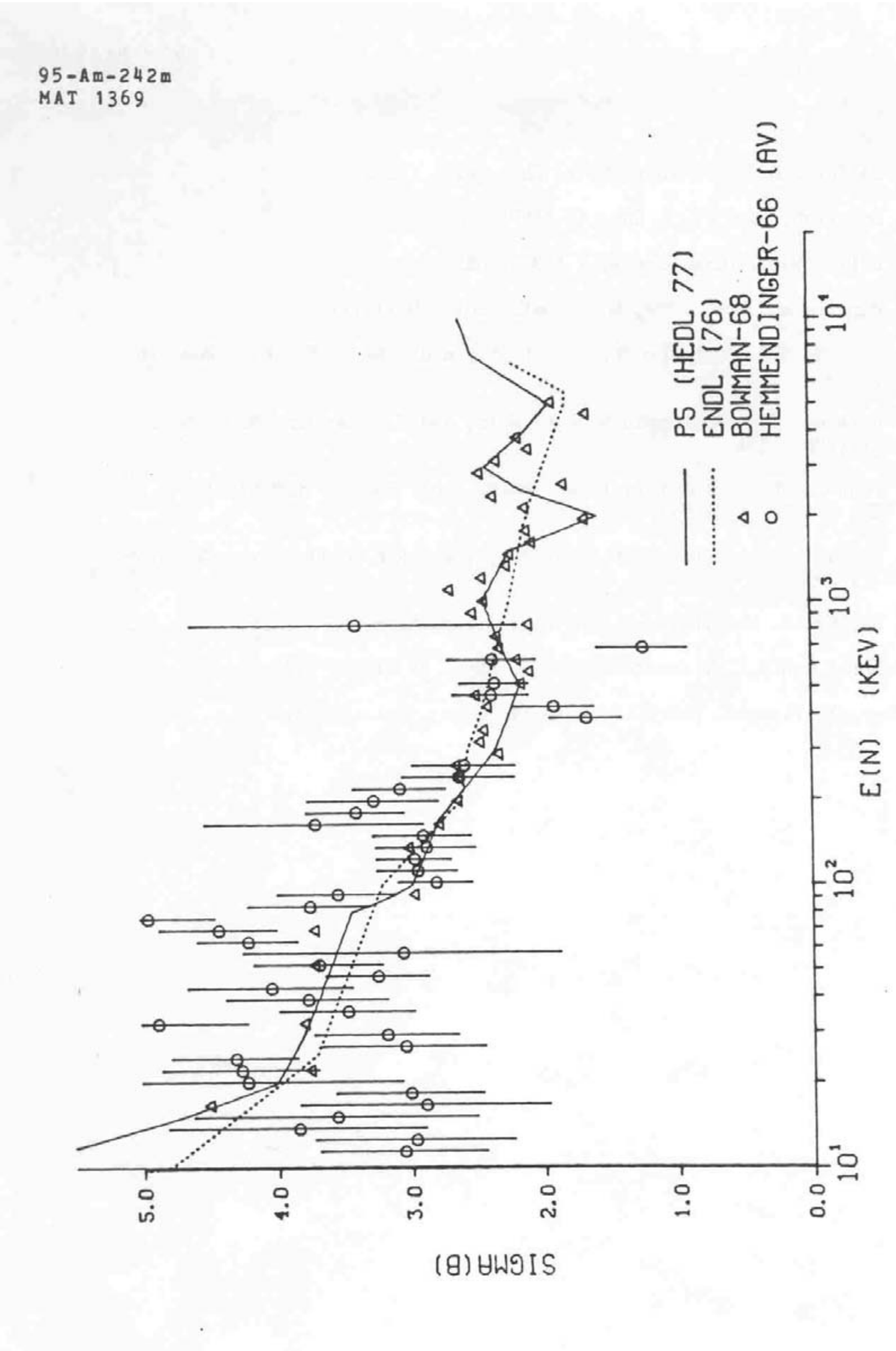

Figure 95-242*-1
Am 242* (N,F)

ENDF/B-V Summary Documentation

Isotope: 95-Am-243 MAT = 1363

F.M. Mann and R.E. Schenter (HEDL) Apr. '78
R. Benjamin (SRL) Oct. '75
R.J. Howerton (LLL) Apr. '78
C.R. Reich (INEL) Apr. '78

The present work supersedes the ENDF/B-IV evaluation, MAT = 1057 by Smith And Grimesey. Neutron and photon production data are given between 10^{-5} eV and 20 MeV. The cross sections included are total, elastic, inelastic,(n, f), (n,2n), (n,3n), (n,4n) and (n.γ), and are described in HEDL-TME-77-54 (Ref. 13). The photon data include multiplicities and transition probabilities, photon production cross sections, and secondary energy spectra.

MF=1 GENERAL INFORMATION

MT=452 NUBAR THERMAL VALUE COMPUTED FROM SEMI-EMPIRICAL WORK OF GORDEEVA AND SMIRENKIN(REF.1) AS REVISED BY MANERO AND KONSHIN(REF.2). ENERGY DEPENDENCE BASED ON WORK OF HOWERTON (REF.3).

MT=458 ENERGY FROM FISSION BASED ON SHER (REF. 12)

MF=2 RESONANCE PARAMETERS(0 TO 10 KEV)

MT=151 RESOLVED RESONANCES 219 RESOLVED RESONANCES PLUS ONE BOUND LEVEL ARE INCLUDED BASED UPON THE TOTAL CROSS SECTION MEASUREMENTS OF SIMPSON ET AL.(REF.4) AND THE PRODUCTION RESULTS OF BENJAMIN ET AL.(REF. 5). RESOLVED REGION - 0 TO 250 EV. UNRESOLVED RESONANCES AVERAGE RESONANCE PARAMETERS BASED ON THE MEASUREMENTS OF SIMPSON ET AL.(REF.4) WERE USED. UNRESOLVED REGION - 250 EV TO 10 KEV.

MF=3 SMOOTH CROSS SECTIONS(0 TO 20 MEV)

MT=1 TOTAL SUM OF PARTIAL CROSS SECTIONS

MT=2 ELASTIC BASED UPON OPTICAL MODEL CALCULATIONS (REF. 7)

MT=4 INELASTIC BASED ON STATISTICAL MODEL CALCULATIONS TO 17 EXCITED LEVELS PLUS CONTINUUM (REF. 7)

MT=16 N,2N BASED ON STATISTICAL MODEL CALCULATION (REF. 7)

MT=17 N,3N BASED ON STATISTICAL MODEL CALCULATIONS (REF. 7)

MT=18 FISSION BASED ON DATA OF SEEGER ET AL (REF. 8)

MT=19 SAME AS MT=18 UNTIL (N,NF) THRESHOLD, AFTER WHICH CROSS SECTION CONSTANT.

MT=20 IS (MT=18) - (MT=19)

MT=37 N,4N BASED ON STATISTICAL MODEL CALCULATIONS (REF. 7)

MT=51,...,67,91 BASED ON STATISTICAL MODEL CALCULATIONS TO 17 EXCITED LEVELS PLUS CONTINUUM (REF. 7)

MT=102 CAPTURE BASED ON STATISTICAL MODEL CALCULATIONS NORMALIZED TO DATA OF WISSHAK AND KAPPELER (REF.13)

MT=251,252,253 MU-BAR(L-SYSTEM),XI,GAMMA CALCULATED BY CHAD

MF=4 SECONDARY NEUTRON ANGULAR DISTRIBUTIONS

MT=2 ELASTIC ANGULAR DISTRIBUTIONS SUPPLIED BY H.ALTER OF AI, COMPOSED OF A MIXTURE OF MEASURED DATA FOR U235,U238, AND PU-239,VALUES OF GAMMA SLOWING DOWN PARAMETER ABOVE 10 KEV ARE SUSPECT AND ARE NOT TO BE USED WITHOUT STUDY.

MT>2 ASSUMED ISOTROPIC

MF=5 SECONDARY NEUTRON ENERGY DISTRIBUTIONS

MT=16 BASED ON PARAMETERS OF GILBERT AND CAMERON (REF. 9)

MT=17 SAME REFERENCE AS MT=16

MT=18 FISSION SPECTRUM HAS MAXWELLIAN DENSITY WITH THE TEMP BASED ON TERRELL S PRESCRIPTION (REF. 6) THE THERMAL VALUE OF NU WAS USED TO DETERMINE THE TEMPERATURE.

MT=19,20 SAME AS MT=18

MT=37 SAME REFERENCE AS MT=16

MT=91 SAME REFERENCE AS MT=16

MF=8

MT=102 USED DECAY DATA OF ENDF/B-V, MAT NUMBERS = 7544 AND 7554

MT=454 USED AM-241 YIELD CURVE (REF. 10,11) DATA FOR 95-AM-243 DECAYS BY REICH INSERTED INTO FILE AT BNL BY R. KINSEY IN SEP 1978

MF=8, MT=457 RADIOACTIVE DECAY DATA

REFERENCES Q(ALPHA)-1974 VERSION OF WAPSTRA-BOS-GOVE MASS TABLE OTHER- SEE TABLE OF ISOTOPES, 7TH ED. (PRELIMINARY DATA, PRIV. COMM. FROM C.M. LEDERER). SEE ALSO Y.A. ELLIS AND A.H.WAPSTRA, NUCLEAR DATA SHEETS B, 3,NO.2, 1(1969) AND Y.A. ELLIS,IBID. 19, NO. 1, 103 (1976) SPONTANEOUS-FISSION BRANCHING RATIO DERIVED FROM LISTED HALF-LIFE VALUE AND S.-F. HALF-LIFE DATA OF B.M. ALEKSANDROV ET AL., SOV. AT.ENERGY 20, 352 (1966).

NOTE THE LISTED L-X-RAY INTENSITY IS A MEASURED VALUE.

NOTE THE ENERGIES AND INTENSITIES OF THE GROUND-STATE ALPHA AND THE TWO MOST INTENSE ALPHA GROUPS ARE THE RECOMMENDED VALUES OF A. RYTZ, AT. DATA AND NUCL. DATA TABLES 12, NO. 5, 479 (1973).

TRANSLATED INTO ENDF/B-V FORMAT BY MANN AND SCHENTER (HEDL) 8/78

MF=9, MT = 102 BASED ON STATISTICAL MODEL CALCULATIONS (REF. 7)

MF=12,13,14,15 PHOTON PRODUCTION

FILES TAKEN FROM THE LLL EVALUATIONS OF R. HOWERTON DOCUMENTED IN UCRL 50400, VOL. 15, PART A (METHODS) SEPT 75 AND PART B (CURVES) APR 76. FILES EXTENDED TO THE ENERGY RANGE 1.-5 EV TO 20 MEV AND MERGED TO THIS EVALUATION AT BNL BY R. KINSEY.

REFERENCES

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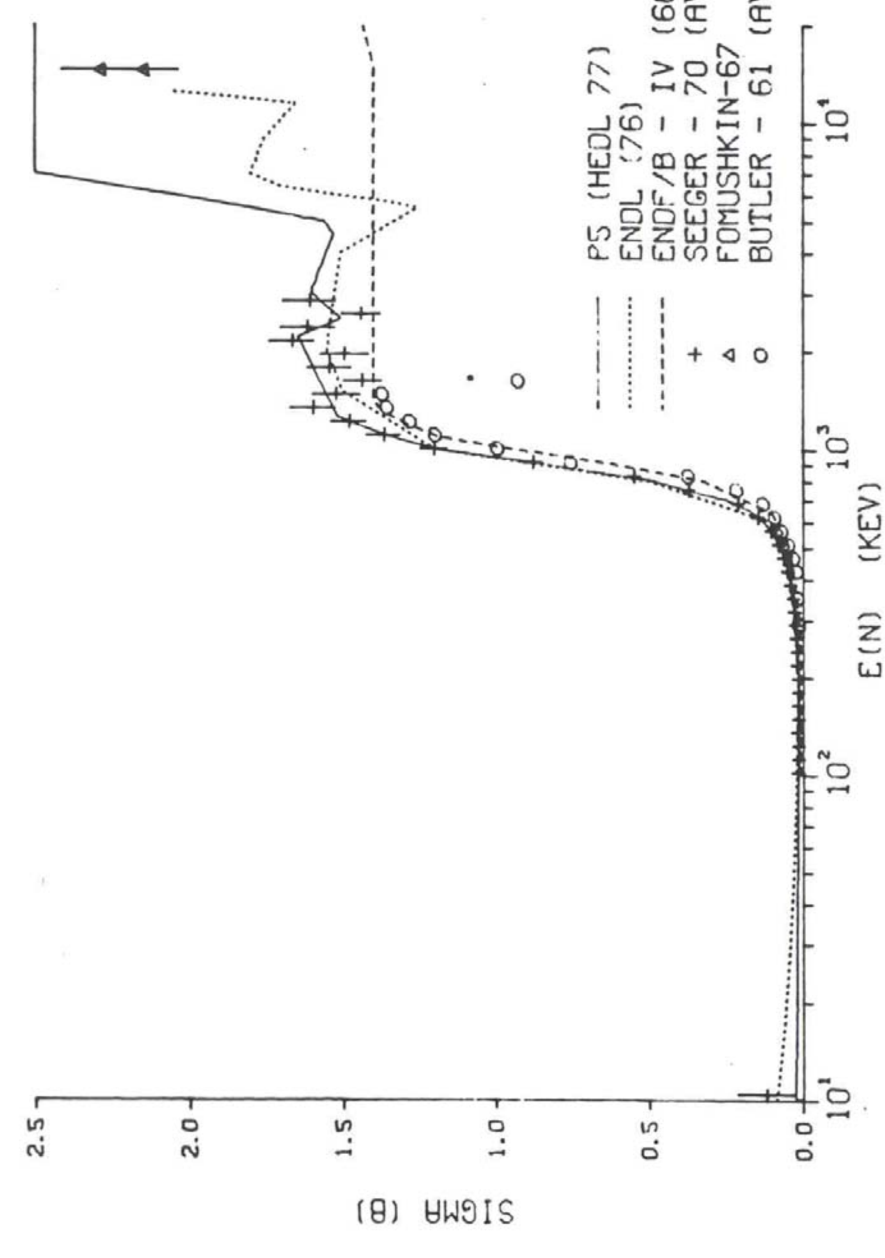

Figure 95-243-1
Am 243 (N,F)

ENDF/B-V Summary Documentation

Isotope: 96-Cm-243 MAT = 1343

F.M. Mann and R.E. Schenter (HEDL) Apr. '78
R. Benjamin (SRL) Aug. '75
R.J. Howerton (LLL) Apr. '78
C.R. Reich (INEL) Apr. '78

This is the first evaluation for ENDF/B for this isotope. Neutron and photon production data are given between 10^{-5} eV and 20 MeV. The cross sections included are total, elastic, inelastic, (n, f) , (n,2n), (n,3n), (n, 4n), and (n, γ) and are described in HEDL-TME-77-54 (ref. 6). The proton data include multip1icities and transition probabilities, photon production cross sections, and secondary energy spectra.

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MF=1  GENERAL INFORMATION

  MT=452 NUBAR   THERMAL VALUE FROM WORK OF JAFFEY AND LERNER (REF.1). ENERGY
         DEPENDENCE BASED ON WORK OF HOWERTON(REF.2).

  MT=458 ENERGY OF FISSION. SYSTEMATICS OF SHER (REF.9)

MF=2  RESONANCE PARAMETERS(0 TO 10 KEV)

  MT=151 RESOLVED RESONANCES.   15 RESOLVED RESONANCES FROM WORK OF BERRETH
         ET AL.(REF.4)  ONE BOUND LEVEL ADDED  WITH AVERAGE RESONANCE
PARAMETERS
         TO FIT THERMAL FISSION CROSS SECTION OF HULET ET AL.(REF.5). RESOLVED
         REGION - 0 TO 27 EV. UNRESOLVED RESONANCES   UNRESOLVED PARAMETERS ARE
         AN AVERAGE OF THE RESOLVED PARAMETERS OF BERRETH ET AL.(REF.4).
         UNRESOLVED REGION - 27 EV TO 10 KEV

MF=3  SMOOTH CROSS SECTIONS(0 TO 20 MEV)

  MT=1  TOTAL  SUM OF PARTIAL CROSS SECTIONS

  MT=2  ELASTIC  OPTICAL MODEL CALCULATION (REF. 6)

  MT=4  INELASTIC  STATISTICAL MODEL CALCULATION TO 15 EXCITED LEVELS AND
        CONTINUUM (REF. 6)

  MT=16 N,2N BASED ON STATISTICAL MODEL CALCULATIONS (REF. 6)

  MT=17 N,3N BASED ON STATISTICAL MODEL CALCULATIONS (REF. 6)

  MT=18  FISSION   CROSS SECTIONS ARE BASED ON STATISTICAL MODEL CALCULATIONS
         (REF 6). THE FISSION CROSS SECTION AGREES WELL WITH DATA OF FULLWOOD
         ET AL (REF 7).

  MT=19 (N,F) SAME AS MT=18 UNTIL (N,NF) THRESHOLD, CONSTANT THEREAFTER.

  MT=20 (N,NF) DIFFERENCE BETWEEN MT=18 AND MT=20

  MT=37 N,4N BASED ON STATISTICAL MODEL CALCULATIONS (REF. 6)

  MT=51,...,65,91 INELASTIC STATISTICAL MODEL CALCULATION TO 15 EXCITED LEVELS
                  AND CONTINUUM (REF. 6)

  MT=102 CAPTURE  STATISTICAL MODEL CALCULATIONS (REF. 6)

  MT=251,252,253 BASED UPON MF=4, MT=2
MF=4  ANGULAR DISTRIBUTIONS
```

MT=2 BASED UPON OPTICAL MODEL (REF. 6)

MT>2 ASSUMED ISOTROPIC

MF=5 SECONDARY NEUTRON ENERGY DISTRIBUTIONS

MT=16 BASED UPON PARAMETERS OF GILBERT AND CAMERON (REF. 8)

MT=17 SAME REFERENCE AS MT=16

MT=18 FISSION SIMPLE FISSION MAXWELLIAN WITH ENERGY-DEPENDENT TEMPERATURE.

MT=19 AND 20 SAME AS MT=18

MT=37 SAME REFERENCE AS MT=16

MT=91 BASED UPON PARAMETERS OF GILBERT AND CAMERON (REF. 8) DATA FOR 96-CM-243
DECAYS BY REICH INSERTED INTO FILE AT BNL BY R. KINSEY IN SEP 1978

MF=8, MT=457 RADIOACTIVE DECAY DATA

REFERENCES Q-VALUES-1974 VERSION OF WAPSTRA-BOS-GOVE MASS TABLE
HALF-LIFE- DERIVED FROM DATA OF G.R. CHOPPIN AND S.G.THOMPSON , J. INORG. NUCL. CHEM. 7, 197 (1958). THEIR REPORTED VALUE HAS BEEN CORRECTED TO THE CURRENT VALUE OF THE CM-244 HALF-LIFE.

OTHER- SEE TABLE OF ISOTOPES, 7TH ED. (PRELIMINARY DATA, PRIV. COMM. FROM C.M. LEDERER). SEE ALSO Y.A. ELLIS, NUCL. DATA SHEETS 19, 103 (1976).

NOTE THE LISTED VALUES OF THE GAMMA-RAY ENERGIES ARE THOSE AS DETERMINED FROM THE NP-239 DECAY. (SEE ALSO, A. ARTNA-COHEN, NUCLEAR DATA SHEETS B 6, NO. 6, 577 (1971) AND M.J. MARTIN. ORNL-5114 (1976)).THE GAMMA-RAY MULTIPOLARITIES ARE THOSE REPORTED BY G.T. EWAN ET AL., PHYS. REV. 116, 950 (1959). (SEE ALSO M.J. MARTI OP. CIT.).

NOTE THE ENERGIES AND INTENSITIES OF THE GROUND-STATE ALPHA AND THE THREE MOST INTENSE ALPHA GROUPS ARE THE RECOMMENDED VALUES OF A. RYTZ, AT. DATA AND NUCL. DATA TABLES 12, NO. 5, 479, (1973).

NOTE THE PU K-X-RAY INTENSITIES ARE MEASURED VALUES.

TRANSLATED INTO ENDF/B-V FORMAT BY MANN AND SCHENTER (HEDL) 8/78

MF=12,13,14,15 PHOTON PRODUCTION

FILES TAKEN FROM THE LLL EVALUATIONS OF R. HOWERTON DOCUMENTED IN UCRL 50400, VOL. 15, PART A (METHODS) SEPT 75 AND PART B (CURVES) APR 76. FILES EXTENDED TO THE ENERGY RANGE 1.-5 EV TO 20 MEV AND MERGED TO THIS EVALUATION AT BNL BY R. KINSEY.

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96-Cm-243
MAT 1343

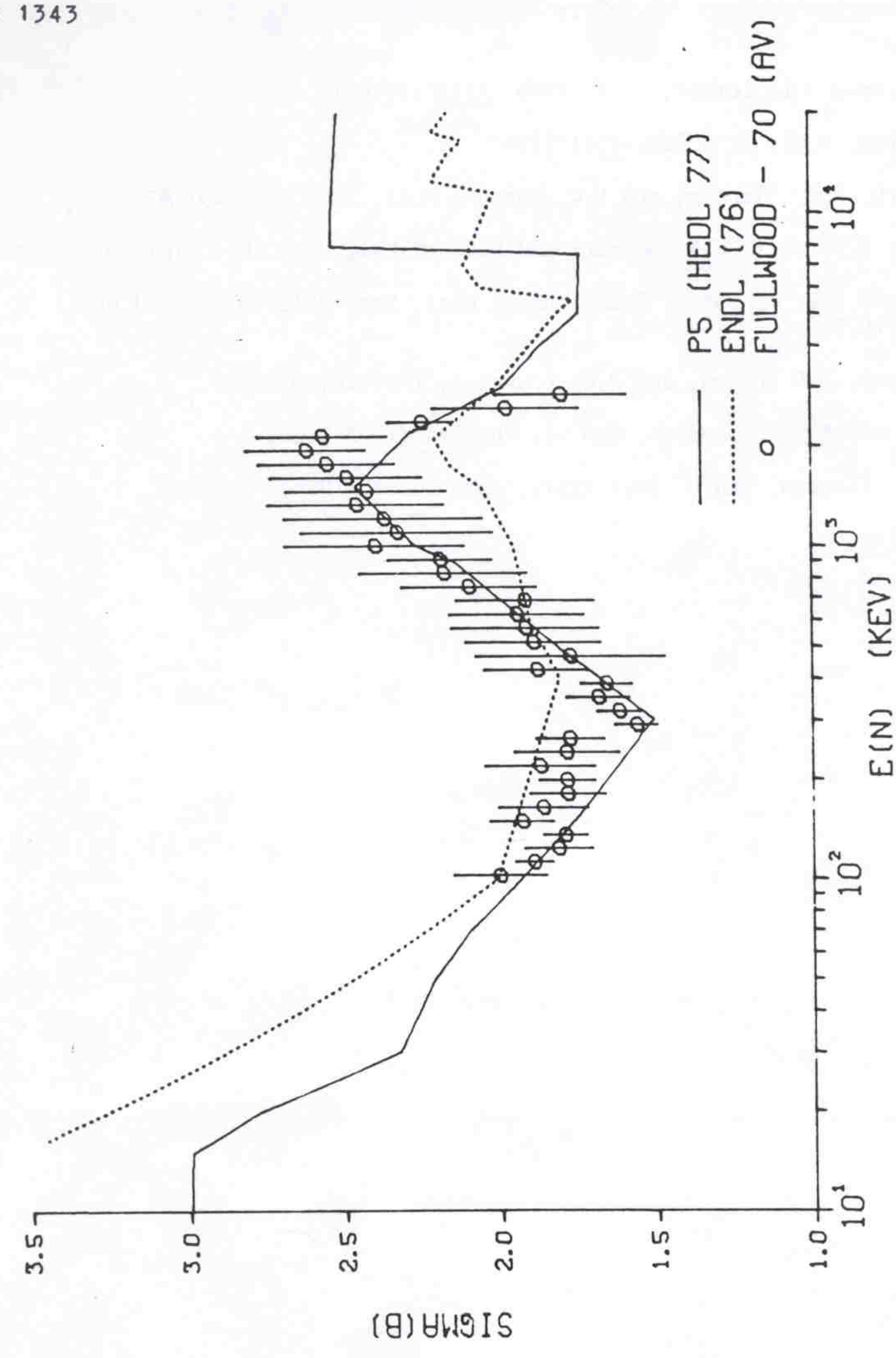

Figure 96-243-1
Cm 243 (N,F)

ENDF/B-V Summary Documentation

Isotope: 96-Cm-244 MAT = 1344

F.M. Mann and R.E. Schenter (HEDL) Apr. '78
R. Benjamin (SRL) July '75
R.J. Howerton (LLL) Apr. '78
C.R. Reich (INEL) Apr. '78
H. Alter and C. Dunford (AI) May. '67

The present work supersedes the ENDF/B-IV evaluation, MAT = 1162 by Alter and Dunford. Neutron and photon production data are given between 10^{-5} eV and 20 MeV. The cross sections included are total, elastic, inelastic,(n,f), (n,2n), (n,3n), (n, n'γ) and (n.γ), and are described in HEDL-TME-77-54 (Ref.12).
The photon data include multiplicities and transition probabilities, photon production cross sections, and secondary energy spectra.

MF=1 GENERAL INFORMATION

MT=452 NUBAR THERMAL VALUE COMPUTED FROM SEMI-EMPIRICAL WORK OF GORDEEVA AND SMIRENKIN(REF.1) AS REVISED BY MANERO AND KONSHIN(REF.2). ENERGY DEPENDENCE BASED ON WORK OF HOWERTON (REF.3).

MT=458 ENERGY FROM FISSION BASED ON SHER (REF. 17)

MF=2 RESONANCE PARAMETERS(0 EV TO 10 KEV)

MT=151 RESOLVED RESONANCES PARAMETERS ARE INCLUDED FOR 37 RESOLVED RESONANCES AND ONE BOUND LEVEL BASED ON ORELA, LASL, AND MTR MEASUREMENTS(REFS.4-6) UP TO 520 EV. PARAMETERS OF THE BOUND LEVEL AND THE FIRST RESONANCE WERE MODIFIED WITHIN REASONABLE EXPERIMENTAL LIMITS TO PROVIDE AGREEMENT WITH INTEGRAL DATA (REFS. 7 + 8) AND PRODUCTION STUDIES (REFS.9 + 10). THE POTENTIAL SCATTERING CROSS SECTION IS 10.32 BARNS FROM OPTICAL MODEL CALCULATIONS. 2200 M/S CROSS SECTIONS FROM RESONANCE PARAMETERS ARE CAPTURE- 10.4 B, FISSION- 0.60 B, ELASTIC- 7.16 B, TOTAL-18.13 B. THIS VALUE DIFFERS FROM THE TOTAL CROSS SECTION DETERMINED BY BERRETH ET AL. (23+-3 B), BUT BERRETH S DATA WAS NOT CORRECTED FOR SMALL ANGLE SCATTERING, A CORRECTION WHICH WOULD REDUCE THE MEASURED 2200 M/S TOTAL CROSS SECTION SIGNIFICANTLY. RESOLVED RANGE- 0 TO 525 EV. UNRESOLVED RESONANCES PARAMETERS FOR S-WAVE RESONANCES ARE AVERAGES FROM THE RESOLVED REGION, WITH THE FISSION WIDTH FROM MOORE S MORE EXTENSIVE DATA FOR THE FISSION RESONANCES(REF. 5). FOR THE P-WAVE RESONANCES- D, GG, AND GF ARE ALSO BASED ON THE RESOLVED REGION, WHILE GN0 IS DETERMINED FROM THE P-WAVE STRENGTH FUNCTIONS OF DUNFORD AND ALTER (REF. 11). UNRESOLVED RANGE- 525 EV TO 10 KEV.

MF=3 SMOOTH CROSS SECTIONS(ABOVE 10 KEV)

MT=1 TOTAL CROSS SECTION FAST REGION FROM AN OPTICAL MODEL CALCULATION (REF. 12).

MT=2 ELASTIC SCATTERING DATA OBTAINED IN PROCEDURE IDENTICAL TO MT=1.

MT=4 INELASTIC SCATTERING DATA RESULTS FROM THE SCATTERING TO 3 LEVELS PLUS CONTINUUM. AGAIN AN OM IS USED WITH A STATISTICAL COMPOUND NUCLEUS MODEL (REF. 12)

MT=16 N,2N BASED ON STATISTICAL MODEL CALCULATIONS (REF. 12)

MT=17 N,3N BASED ON STATISTICAL MODEL CALCULATIONS (REF. 12)

MT=18 FISSION THERMAL REGION DATA CALCULATED FROM RESONANCE PARAMETERS. FAST REGION BASED ON DATA OF MOORE (REF 13), WITH HIGHER ENERGY EVALUATIONS BASED ON STATISTICAL MODEL CALCULATIONS (REF 12).

MT=19 (N,F) SAME AS MT=18 UNTIL (N,NF) THRESHOLD, CONSTANT THEREAFTER.

MT=20 (N,NF) DIFFERENCE OF MT=18 AND MT=19

MT=51,52,53,91 INELASTIC SCATTERING DATA RESULTS FROM THE SCATTERING TO 3 LEVELS PLUS CONTINUUM. AGAIN AN OM IS USED WITH A STATISTICAL COMPOUND NUCLEUS MODEL (REF. 12)

MT=102 CAPTURE THERMAL DATA CALCULATED FROM RESONANCE PARAMETERS. FAST REGION DATA FROM A STATISTICAL MODEL ASSUMING DIPOLE RADIATION.

MT=251 MUBAR CALCULATED FROM DOM ANGULAR DISTRIBUTIONS

MT=252 XIBAR CALCULATED FROM DOM ANGULAR DISTRIBUTIONS

MT=253 GAMMA CALCULATED FROM DOM ANGULAR DISTRIBUTIONS

MF=4 LEGENDRE POLYNOMIALS

MT=2 ELASTIC SCATTERING LEGENDRE COEFFICINTS FOR 15^{TH} ORDER FIT TO CALCULATED ANGULAR DISTRIBUTIONS (DOM) ARE PROVIDED BETWEEN 10 KEV AND 11 MEV AND 19TH ORDER BETWEEN 12 AND 15 MEV.

MT>2 ASSUMED ISOTROPIC

MF=5 SECONDARY ENERGY DISTRIBUTIONS

MT=16 N,2N NUCLEAR TEMPERATURE WITH ENERGY DEPENDENCE AS IN REFEFERENCE 14.

MT=17 SAME REFERENCE AS MT=16

MT=18 FISSION MAXWELLIAN WITH CONSTANT TEMPERATURE FROM CORRELATION OF REF. 15.

MT=19 AND 20 SAME AS MT=18

MT=91 BASED ON PARAMETERS OF GILBERT AND CAMERON (REF. 16)

DATA FOR 96-CM-244 DECAYS BY REICH

INSERTED INTO FILE AT BNL BY R. KINSEY IN SEP 1978

MF=8, MT=457 RADIOACTIVE DECAY DATA

REFERENCES Q(ALPHA)-1974 VERSION OF WAPSTRA-BOS-GOVE MASS TABLE
HALF-LIFE- WEIGHTED AVERAGE OF VALUES REPORTED BY
W.C. BENTLEY, J. INORG. NUCL. CHEM. 30, 2007 (1968) AND
W.J. KERRIGAN AND R.S. DORSETT, J. INORG. NUCL. CHEM. 34,3603(1972)

OTHER- SEE M.R. SCHMORAK, NUCLEAR DATA SHEETS 17, NO. 3, 402 (1976) AND TABLE OF ISOTOPES, 7TH ED. (PRELIMINARY DATA, PRIV. COMM. FROM C.M. LEDERER). SEE ALSO M.R. SCHMORAK, NUCLEAR DATA SHEETS 20, 218 (1977).

NOTE THE L-X-RAY DATA REPRESENT MEASURED VALUES. SEE C.E. BEMIS, JR. AND L. TUBBS, ORNL-5297, 93 (SEPT., 1977).

NOTE THE INTENSITIES OF THE GAMMA RAYS ABOVE 153 KEV ARE TAKEN FROM NDS 20,218 (1977) (REF. ABOVE). THE ENERGY VALUES ARE AS MEASURED FROM THE NP-240M DECAY.

NOTE THE GAMMA-RAY INTENSITY NORMALIZATION WAS DERIVED FROM THE LISTED INFORMATION ON THE 42.8-KEV GAMMA RAY AND THE GROUND-STATE ALPHA BRANCH.

NOTE THE ENERGIES AND INTENSITIES OF THE TWO HIGHEST-ENERGY ALPHA GROUPS ARE THOSE RECOMMENDED BY A. RYTZ, AT. DATA AND NUCL. DATA TABLES 12, NO. 5, 479 (1973).

TRANSLATED INTO ENDF/B-V FORMAT BY MANN AND SCHENTER (HEDL) 8/78

MF=12,13,14,15 PHOTON PRODUCTION

FILES TAKEN FROM THE LLL EVALUATIONS OF R. HOWERTON DOCUMENTED IN UCRL 50400, VOL. 15, PART A (METHODS) SEPT 75 AND PART B (CURVES) APR 76. FILES EXTENDED TO THE ENERGY RANGE 1.-5 EV TO 20 MEV AND MERGED TO THIS EVALUATION AT BNL BY R. KINSEY.

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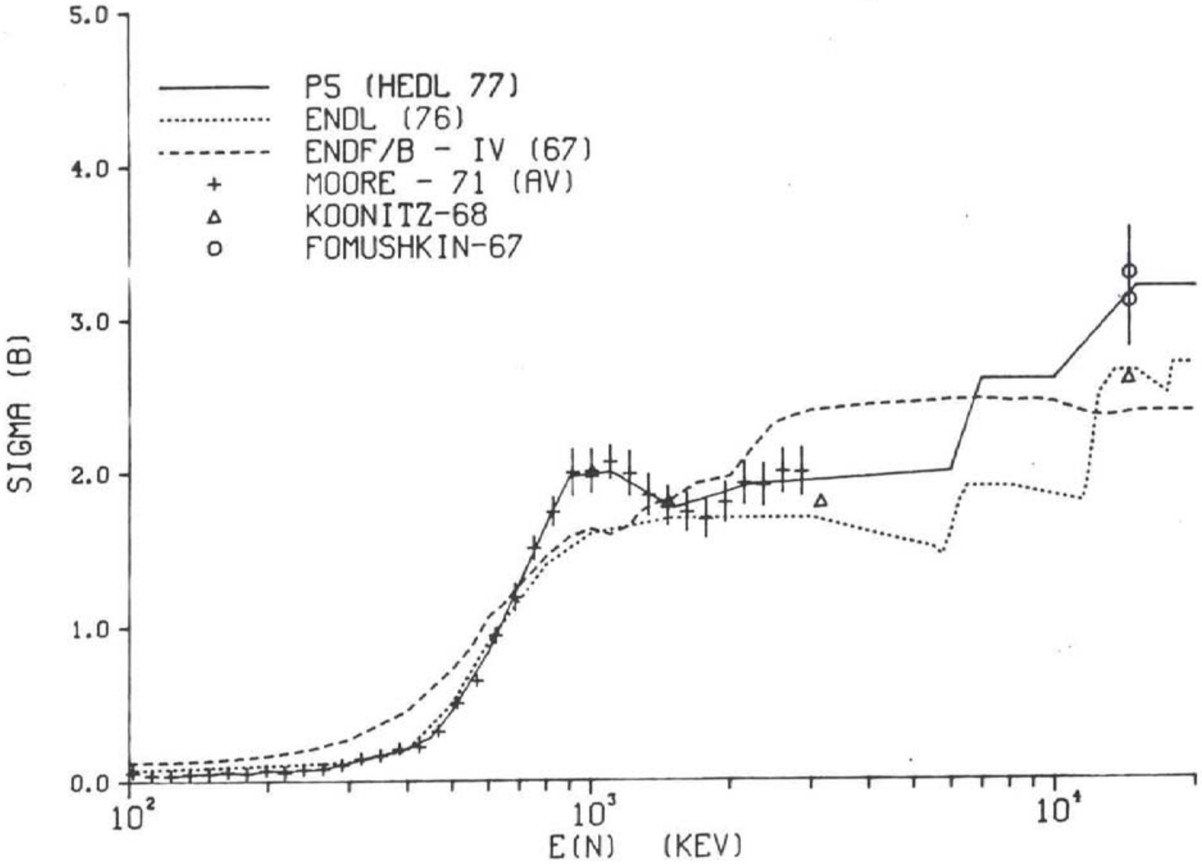

96-Cm-244
MAT 1344

Figure 96-244-1
Cm 244 (N,F)

Summary Documentation

^{245}Cm EVALUATION BELOW 10 keV

ENDF/B-V Mod II

MAT = 1345

R.W. Benjamin and R.J. Howerton

January 1979

96-Cm-245
MAT 1345

^{245}Cm Summary Documentation

This evaluation of ^{245}Cm supercedes the current ENDF/B-V evaluation (release date (1/79) below 10 keV. The major improvements are the inclusion of more recent results from the differential neutron fission measurements of Browne et al.[1] and Moore and Keyworth.[2] Cross sections included below 10 eV are total, elastic, capture and fission, and they are described entirely through the single-level Breit-Wigner resonance parameters. The only significant changes from ENDF/B-V are in Files 1, 2, and 3.

File 1 The Average Number of Neutrons per Fission

The average number of neutrons per fission $\overline{\nu}$ is described by

$$\overline{\nu}(E) = 3.83 + 0.190\ E\ (E \text{ in MeV})$$

The thermal value is from the compilation of Manero and Konshin,[3] who renormalized the work of Jaffey et al.[4] The energy dependence is based upon the work of Howerton.[5]

File 2 Resonance Parameters

The region from 10^{-5} eV to 60 eV is described entirely with resonance parameters for 38 resolved s-wave resonances and one bound level. The parameters are a blend of analyzed results from the LINAC measurements of Browne et al.[2] and the nuclear detonation measurements of Moore and Keyworth.[2] Other, more limited, recent data[6-8] have been examined, but References1 and 2 provide a consistent data base below 60 eV and sufficient resonance information to obtain reasonable unresolved resonance parameters from 60 eV to 10 keV. The only notable difference in the resolved range is a very small resonance at 3.207 eV reported in Reference 6. This resonance adds little to the strength and is implicitly accounted for in the resonance analysis of Reference 1. The resolved resonance parameters are listed in Table 1 with uncertainties derived from Reference 1 and recommended by M. S. Moore.[9] Associated with these resonance parameters is a potential (hard sphere) scattering cross section of 10.1 b from optical model calculations at 10 keV.

Unresolved resonance parameters for s- and p-wave neutrons have been determined from average parameters in the resolved region combined with a p-wave strength function $S_1 = 2.00 \times 10^{-4}$ obtained through extrapolation of Lynn's work.[10] The unresolved resonance parameters are summarized in Table 2. Upon expansion with the single-level Breit-Wigner formalism, these unresolved parameters provide a reasonable match below 10 keV to the recent fission measurements of Nakagome and Block.[11]

These resolved and unresolved resonance data combined with the ENDF/B-V evaluation of Howerton above 10 keV yield the thermal cross sections and infinitely dilute resonance integrals listed in Table 3 where they are compared with the best integral data.[12,13] The evaluation represents the best current description of the ^{245}Cm cross sections below 10 keV.

File 3 <u>Smooth Cross Sections</u>

There are no File 3 data below 10 keV.

File 4 <u>Angular Distributions</u>

The elastic angular distribution is from Howerton's LLL evaluation[4] and is identical with the current ENDF/B-V.

File 5 <u>Secondary Neutron Energy Distributions</u>

The fission neutron energy spectrum is a simple fission Maxwellian with an energy-dependent temperature.

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TABLE 1

RESOLVED RESONANCE PARAMETERS* FOR ^{245}Cm - 10^{-5} to 61.5 eV

E_o eV	ΔE_o eV	$2g\Gamma n$ meV	$\Delta 2g\Gamma n$ meV	Γ_f meV	$\Delta\Gamma_f$ meV
-0.1	-	0.144	0.004[a]	300	50
0.85	0.03	0.102	0.009	800	50
1.95	0.03	0.24	0.03	175	25
2.45	0.05	0.11	0.017	300	50
4.68	0.05	2.10	0.02	325	30
5.75	0.10	0.11	0.03	300	100
7.53	0.05	1.91	0.12	300	30
8.65	0.15	0.53	0.10	500	100
9.15	0.15	0.39	0.10	200	50
10.15	0.10	0.40	0.05	200	50
11.34	0.10	0.88	0.12	150	25
13.75	0.10	0.34	0.10	170	30
16.0	0.1	0.66	0.20	400	100
21.4	0.1	3.41	1.0	490	100
24.8	0.1	4.05	1.2	225	50
25.8	0.1	0.04	0.01	550	165
26.8	0.1	0.77	0.2	130	39
27.6	0.1	0.73	0.2	200	50
29.4	0.1	3.58	1.0	350	100
31.7	0.1	0.50	0.05	690	200
33.0	0.1	0.37	0.04	4	2
34.6	0.1	0.23	0.02	60	20
35.3	0.1	7.58	0.80	4195	1200
36.3	0.1	1.54	0.15	190	60
39.5	0.1	0.653	0.07	102	30
40.4	0.1	4.48	0.45	585	170
42.5	0.1	6.37	0.54	10	4
43.1	0.1	1.73	0.17	537	160
44.6	0.1	2.61	0.26	694	210
45.8	0.1	0.59	0.10	900	270
47.5	0.1	3.56	0.36	280	80
49.2	0.1	5.04	0.50	1399	420
50.5	0.1	1.79	0.18	751	225
51.6	0.1	0.625	0.08	207	60
53.6	0.1	12.35	1.24	896	270
54.6	0.1	0.33	0.05	1057	325
56.3	0.1	1.40	0.14	505	150
58.5	0.1	13.85	1.39	393	120
60.0	0.1	0.610	0.08	518	150

*A value of $\Gamma\gamma$ = 40 meV was used for all resonances except for the bound level at -0.1 eV where 50 eV was used. The uncertainty attributed to these values should be $\sim\pm 20\%$.

[a] For this (bound) level, $2g\Gamma_n^o$ is listed.

TABLE 2

UNRESOLVED RESONANCE PARAMETERS FOR ^{245}Cm - 61.5 eV to 10 keV

ℓ	J	$\overline{D}$ eV	S_ℓ x 10^4	$\overline{\Gamma_n^o}$ meV	$\overline{\Gamma_\gamma}$ meV	$\overline{\Gamma_f}$ meV
0	3	2.57	1.17	0.30	40	519
0	4	2.00	1.17	0.23	40	519
1	2	3.59	2.00	0.70	40	519
1	3	2.57	2.00	0.51	40	519
1	4	2.00	2.00	0.40	40	519
1	5	1.63	2.00	0.33	40	519

TABLE 3

THERMAL CROSS SECTIONS AND RESONANCE INTEGRALS FOR ^{245}Cm

	Thermal (2200 m/s) Cross Sections(b)		Resonance Integrals (b - eV)	
	σ_{nf}^{2200}	$\sigma_{n\gamma}^{2200}$	I_{nf} (>0.625 eV)	$I_{n\gamma}$ (>0.625 eV)
Calculated (this work)	2210	341	821.4	107.5
Measured	2143±58[1]	345±20[12]	772±40[13]	101±8[12]

SUMMARY DOCUMENTATION

^{246}Cm EVALUATION

ENDF/B-V

MAT = 1346

R.W. Benjamin and R.J. Howerton

October, 1978

This evaluation of ^{246}Cm combines the evaluation of Benjamin, McCrosson, and Gettys[1] (SRL) from 10-5 eV to 10 MeV with parts of the END1 evaluation of Howerton[2] (LLL) for neutron cross sections from 10 MeV to 20 MeV and photon production over the entire energy range. The evaluations were merged at BNL by R.R. Kinsey. The cross sections were adjusted near 10 MeV to provide a smooth curve between the two evaluations. The cross sections included are total, elastic, inelastic, (n,2n), (n,3n), fission, (n,4n), (n,n') and (n,γ).

File 1

The average number of neutron per fission v is described b

$$\bar{\nu}(E) = 3.48 + 0.196E \text{ (E in MeV)}$$

The thermal value is based upon the compilation of Manero and Konshin[3], and the energy dependence upon the work of Howerton[4].

File 2

The region form 10-5 eV to 385 eV is described entirely with parameters for 10 s-wave resolved resonances below 385 eV based on references 5, 6, and 7. The parameters of the first resonance were modified within the experimental uncertainties to give reasonable agreement with the integral data and production studies. A potential (hard sphere) scattering cross section of 10.466b associated with these parameters was obtained from spherical optical model calculations. Expansion of the resonance parameters yields 2200 m/s (0.0253 eV) cross section values of

$\sigma_{n\Gamma}$ = 11.04b, σ_{nn} = 9.68b, σ_{nf} = 0.06b and $\sigma_{n\gamma}$ = 1.30 b.

The region from 385 eV to 10 keV is described by s- and p-wave unresolved resonances. The $\iota = 0$ (s-wave) resonance parameters were derived from the PHYSICS-8 results[7]. The $\iota = I$ (p-wave) parameters were selected such that the capture cross section from the combination of $\iota = 0$ and $\iota = I$ parameters joins smoothly to the results of model calculations at 10 keV.

<u>File 3</u>

<u>Below 10 MeV</u>

Cross sections between 10 keV and 10 MeV were computed with nuclear model codes; only the fission cross sections have been measured[7]. The optical model calculations are described in detail in reference 1, as well as the variation of the fission parameters to give good agreement with the fast fission cross section data of Moore and Keyworth[7].

Level energies for the first three inelastic Levels were taken from the compilation of Lederer et al[8]. The remaining inelastic levels were inferred from similar, neighboring, even-even nuclei. Level schemes for the odd-mass curium isotopes needed for (n,2n) calculations were obtained from the work of Braid et al[9]. Cross Sections were determined for the excitation of discrete inelastic levels for incident neutron energies from 0.03 to 3.0 MeV. Between 0.5 and 3.0 MeV, the remaining (n,n') cross section was treated as a continuum of levels; above 3.0 MeV, the (n,n') reaction was treated wholly as a continuum.

<u>At 10 MeV</u>

The total, fission, inelastic continuum, and n,y cross sections were smoothly joined at 10 MeV by R. Kinsey.

<u>Above 10 MeV</u>

<u>MT=16</u> The n,2n cross section was done by R. Kinsey. A general n,2n cross section shape was used, adjusted to Howerton's 14MeV value.

<u>MT=17</u> The n,3n cross section was obtained entirely from nuclear systematics. The threshold is at 12.02 MeV and the excitation function rises in the usual sigmoid shape to a plateau of 900 mb, then falls due to the onset of the n,2nf reaction at about 17.5 MeV and the n,4n reaction at about 18.8 MeV, to a value of 250 mb at 20.0 MeV.

<u>MT = 18</u> The fission cross section was evaluated by Howerton for En ~ 13.0 MeV and is based entirely on systematics .

<u>MT = 37</u> The n,4n cross section thresholds at 18.84 MeV, rising from threshold to a value of 0.3 barns at 20.0 MeV.

<u>File 4</u>

Elastic scattering angular distributions are from the LL evaluations.Angular distributions for n,n' level reactions are assumed isotropic in the center of mass system. Angular distributions for other neutron producing reactions are assumed to be isotropic in the laboratory system.

<u>File 5</u>

Secondary neutron energy distributions for the inelastic-continuum and the (n,2n) reactions are assumed to be evaporation spectra. They are described by Maxwellian distribution with energy dependent temperatures consistent with the work of Drake and Nichols[10].

Energy distributions for secondary neutrons from the n,3n and n,4n are presented in tabular form and were done by Howerton. Fission neutron energy distribtions are described by a simple Maxwellian fission spectrum with energy dependent temperature.

File 8

The decay data included are from C. Reich (INEL). The a-particle Q values are from the unpublished 1974 Wapstra-Bos-Gove mass Tables and the alpha particle data are those recommended by Rytzll. Remaining data are from references 12 and 13.

File 12-15

The photon production data are as described below except that the calculations using the NXGAME1 code used an evaluation that was done by SRL below 10 MeV and 111 above 10 MeV. In the current evaluation the n,2n cross section (R. Kinsey) and the energy distributions for the n,2n and inelastic continuum (SRL) replaced the data used in the calculation. As a result the photon production cross. sections and spectrum will not conserve energy when used with the neutron interaction data of this evaluation.

MF=12 MT=18
MF=14 MT=18
MF=15 MT=18

The cross section for photon production from fission is entered as a mulitplicity applied to the fission cross section. The photon energy from fission of 6.2 MeV. This value is divided by the average energy in the photon spectrum, using the measured fission photon spectrum for U235. Photons from fission are assumed to be isotropic.

MF=12 MT=102
MF=14 MT=lO2
MF=15 MT=102

Photon production from the neutron capture reaction is handled by using multiplicities and normalized spectra. The photon mulitplicities for these reactions are derived by dividing the average photon energy into the total available energy. The spectrum of secondary photons is assumed to be the same as that for the measured U238 photon spectrum. Photons from neutron capture are assumed to be isotropic.

MF=13, MT=3
MF=14, MT=3
MF=15, MT=3

For energies below 43 keV, photon production is assumed to originate only from capture and fission processes. From 43 KeV to 20 MeV (in 96-246-4 the absence of measurements) the photon production cross sections.

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ATTACHMENT I

Proposal for a Generalized ENDF Format

C. L. Dunford

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The current status of the proposed Generalized ENDF format is summarized in this document. Initial guidelines developed by the CSEWG Special Task Force consisting of C. Dunford, R. MacFarlane, R. Howerton, F. Perey and R. Roussin were followed in this implementation.

Extensive testing of this format has already been accomplished by writing a program and successfully converting several ENDF/B-V materials to this format. The program was developed by R. Kinsey and C. Dunford.

Formats for some existing data types from ENDF/B have not yet been specified. In the near future, the system should be expanded to handle these data types.

I. Some Definitions

A. DATA SECTION -a collection of logical records containing data to describe a nuclear data type. It will be described by a set of descriptors or keys as given in Table I.

B. TEXT SECTION -a collection of logical records containing free text information describing the evaluation of a nuclear data type. It will be described by a set of descriptors or keys 1-7 or keys l-U of Table I.

C. LOGICAL RECORD -a set of logically related data fields.

D. PHYSICAL RECORD -a collection of words with a length characteristic of the storage or output medium. One logical record may be one or more physical records.

E. FIELD -a single piece of numerical data in E13.6 format (±N.NNNNNN±NN)

F. SECTION LEVEL -a logical subdivision of a section containing at least one control record. It may contain a data record.

G. CONTROL RECORD -a record containing only control fields.

H. DATA RECORD -a record containing a data table

II. Identification of a Section

Each section in the ENDF/C file will be uniquely identified by thirteen descriptors or keys. These keys have both a textual value and a numerical equivalent. The last nine descriptors uniquely determine the kind of nuclear data being described and the first £our the version 0£ that data. Table I lists the thirteen basic keys.

TABLE I
Section Descriptors

1. Library
2. Version number
3. Modification number
4. Data (YYMMDD)
5. Target
6. Target excitation
7. Projectile
8. Process
9. Residual nucleus
10. Residual nucleus excitation
11. Process modifier
12. Product described
13. Property described

A. Meaning and Coding of Descriptors

1. Library -any library identifier such as ENDF/B, CTR etc.
2. Version number - any character combination to identify the library version such as V, 1 etc.
3. Modification number - an integer to identify subsequent revisions to a section.
4. Date -date of entry into the master file in the form (YYMMDD) such as 780312 for March 12, 1978.
5. Target -target nucleus symbol (SY) and mass number (AAA) in the form SY-AAA such as PU-239 and FE-000.
6. Target excitation - excitation energy of the target in eV in the form 3.5+04. A blank means not relevant .
7. Projectile -incident particle (see table II). For all reactions the particle code is preceded by a left parenthesis,'('.
8. Process -nuclear reaction process being described. No code is used in this field to indicate nuclear structure information (see table III).
9. Residual nucleus -residual nucleus in reaction coded in the same manner as for the target but may be blank if not applicable.
10. Residual nucleus excitation -excitation energy of the residual nucleus code in the same manner as for the target nucleus.
11. Process modifier -any additional key required to completely define the process (see table IV).
12. Product described -the secondary particle for which the section tabulates some property (see table II).
13. Property described -the property described in the section (see table V).

Table II

Particle Codes

Numeric Value	Symbol	Meaning
0	(blank)	No particle or not relevant
1	N	Neutron
2	G	Gamma ray
3	E	Electron
4	p	Proton
5	D	Deuteron
6	T	Triton
7	HE-3	Helium-3
8	A	Alpha
9	FPROD	Fission products

Table III

Process Codes

Numeric Value	Symbol	Meaning
0	(blank)	Not relevant
2	MANY)	Many reactions (used for resonance parameters)
10	TOTAL)	Total
12	NONELASTIC)	Nonelastic
14	ABSORPTION)	Absorption
20	G)	Capture (eg. (n,γ))
30	INELASTIC)	Total Inelastic
40	N)	Single neutron emission (eg. (p,n), (n,2n'))
42	2N)	Two neutron emission (eg.(p,2n))
43	3N)	Three neutron emission (eg.(d,3n))
44	4N)	Four neutron emission (eg.(t,4n))
50	NP)	Neutron & proton emission (eg.(n,np))
60	ND)	Neutron & deuteron emission (eg.(n,nd))
65	ND2A)	Neutron, deuteron & 2 alpha emission (eg.$(n,nd2\alpha)$)
70	NT)	Neutron & triton emission (eg.(n,nt))
75	NT2A)	Neutron, triton & 2 alpha emission (eg.$(n,nt2\alpha)$)
80	NHE-3)	Neutron & He-3 emission (eg.$(n,n\ He^3)$)
90	NA)	Neutron & alpha emission (eg.$(n,n\alpha)$)
92	N2A)	Neutron & 2 alpha emission (eg.$(n,n2\alpha)$)
94	N3A)	Neutron & 3 alpha emission (eg.$(n,n3\alpha)$)
96	2NA)	Two neutrons & alpha emission (eg.$(p,2n\alpha)$)
98	2N2A)	Two neutrons & 2 alpha emission (eg.$(p,2n2\alpha)$)
99	3NA)	Three neutrons & alpha emission (eg.$(p,3n\alpha)$)
100	XP)	Proton emission (eg.(n,Xp))
105	P)	Single proton emission (eg.(n,p))
110	2P)	Two proton emission (eg.(n,2p))
140	PA)	Proton & alpha emission (eg.$(n,p\alpha)$)
200	XD)	Deuteron emission (eg.(n,Xd))
205	D)	Single deuteron emission (eg.(n,d))
250	D2A)	Deuteron & 2 alpha emission (eg.$(d,d2\alpha)$)

Table III, Process Codes (Cont'd)

Numeric Value	Symbol	Meaning
300	XT)	Triton emission (eg.(p,Xt))
305	T)	Single triton emission (eg.(p,t))
350	T2A)	Triton & 2 alpha emission (eg.(n,t2α))
400	XHE-3)	He^3 emission (eg.(n,XHe^3)
405	HE-3)	Single He^3 emission (eg.(n, He^3))
500	XA)	Alpha emission (eg.(n,Xα))
505	A)	Single α emission (eg.(n,α))
510	2A)	Double α emission (eg.(p,2α))
520	3A)	Triple α emission (eg.(d,3α))
900	FISSION)	Total fission
910	F)	Pure fission (eg.(n,f))
920	NF)	First chance fission (eg.(p,nf))
930	2NF)	Second chance fission (eg.(n,2nf))
940	3NF)	Third chance fission (eg.(n,3nf))

Table IV

Process Modifiers

Numeric Value	Symbol	Meaning
0	(blank)	Not relevant
1	ISOMER	Isomer production
2	PROMPT	Prompt emission
3	DELAYED	Delayed emission
4	CUM	Cumulative yield

Table V

Properties

Numeric Value	Symbol	Meaning
0	COMMENTS	Free text comments
1	COMPOSITION	Material nuclear composition and mass
2	STRUCTURE	Static properties, mass, levels, etc.
6	RESOLVED	Resolved resonance parameters
7	UNRESOLVED	Statistical resonance parameters
8	SIG(E)	Cross section
9	SIG(E).RATIO	Cross section ratio.
10	NU(E)	Product multiplicity
12	N(E;EP;MU)	Secondary energy-angle distribution function separable in energy and angle.
13	N(LAM;E;EP;MU)	Secondary energy-angle distribution function for delayed groups with separable energy and angle functions
14	P(E;MU;EP)	Secondary energy-angle distribution function where energy and angle are not separable.
18	NU*SIG(E)	Product production cross section
20	NU*SIG*N(E;EP;MU)	Energy-angle differential particle production cross section with energy and angle separable.
22	NU*SIG*P(E;MU;EP)	Energy-angle differential particle production cross section where energy and angle are not separable.
26	NU*N(E;EP;MU)	Energy-angle differential particle multiplicity with energy and angle separable.
28	NU*P(E;MU;EP)	Energy-angle differential particle multiplicity with energy and angle not separable.

III. Representation and Coding of Properties

A. Definition of Properties

The functional representation of dynamic reaction properties generally depends on the following variables.

1) E - incident particle energy
2) E'(EP) - outgoing particle energy
3) μ (MU) - outgoing particle angle (relative to incident particle)

In addition, functions used to describe secondary products requires specification of the reaction product (Z',A',EX')

In general, a property X(A,B,C) may be considered to be composed of the weighted sum of several functional representations.

$$X(A,B,C) = \sum_{i=1}^{NK} P_i(A)\ X_i(A,B,C) \qquad \text{III-1}$$

$$\text{where} \quad \sum_{i=1}^{NK} P_i(A) = 1 \quad \text{for all values of A}$$

Table V.A gives the relation between properties and MF,MT in the ENDF/B format.

a) SIG(E) - The cross section as a function energy is generally given as a single term in equation III-1.

$$\sigma(E) = \sigma_1(E)$$

However, an accurate representation of $\sigma(E) = \sigma_0 + \frac{\sigma_1}{\sqrt{E}}$ would require two terms in equation III-1.

$$\sigma(E) = \sum_{i=1}^{2} \sigma_i\ f_i(E) \quad \text{where} \quad f_1(E) = \text{const.}, \quad f_2(E) = \frac{1}{\sqrt{E}}$$

b) NU(E) - The particle multiplicity can be given for one or more products of a reaction. Each product must be identified by its charge (Z'), its mass (A') and its excitation energy (EX'). For a given reaction product, one may give the total multiplicity as a sum of parts in the same manner as for a cross section SIG(E).

c) NU*SIG(E). - A Secondary particle production cross section can be specified using this property. The function can be specified for each product.

$$\nu(E)\ \sigma(E) = \sum_{k=1}^{NK} \nu_k(E)\ \sigma_k(E)$$

d) N(E;EP;MU) - If the secondary particle energy-angle distribution function is separable in secondary energy and angle then one assumes the following form

$$N(E,E',\mu) = \sum_{k=1}^{NK} p_k(E)\ N_k(E,E')\ P_k(E,\mu)$$

where $N(E,E')$ is a secondary energy distribution function and $P(E,\mu)$ a secondary angular distribution function.

$N_k(E,E')$ may be δ_{E',E_o} when representing discrete final particle energies such as for a gamma ray distribution.

e) P(E;MU;EP) - If the secondary energy-angle distribution is not separable, then a general three dimensional function of the following form is used

$$P(E,\mu,E') = \sum_{k=1}^{NK} p_k(E)\ P_k(E,\mu,E')$$

f) Either representation of the secondary energy-angle distribution can be combined with $\sigma(E)$ and/or $\nu(E)$ to give a different property. This is accomplished by not requiring $\sum_{k=1}^{NK} p_k(E) = 1$.

Instead $p_k(E) = \sigma_k(E)$

or $p_k(E) = \nu_k(E)$

or $p_k(E) = \nu_k(E)\ \sigma_k(E)$

g) N(LAM;E;EP;MU) - The secondary energy-angle distribution of delayed particle groups can be represented with this properly. Each group is characterized by its decay constant λ_i. The property N(E;EP;MU) is given for each delayed group.

Other properties - The remaining properties listed in Table V represent non-dynamic properties. Each has its own format as given in more detail later.

TABLE V.A

ENDF/B ENDF/C Correspondences

File Section	Property
1-451	0
2-ALL	6,7
3-ALL,10-ALL	8
9-ALL	9
1-452,8-454,1-455,1-456,8-459	10
12-ALL (total multiplicity)	10
5-ALL, 4-ALL (except 455)	12
5-455,4-455	13
6-ALL	14
13-ALL (total production cross section)	18
13-ALL (partial production X sec), 15(cont), 14-ALL	20
12-ALL (partial multiplicities), 15(cont), 14-ALL	26

B. Functional Representation of Properties

All properties are assumed to be describable in terms of some simple functions. A property being represented in the range E1 to E2 must have the same functional form throughout the range E1 to E2.

a) One-dimensional functions allowed are tabulated in Table VI.A. The data to be coded are listed in the column labeled 'CODE' .The column headed 'NP ' gives the meaning of the control variable NP and 'NREP ' gives the meaning of the control variable NREP .The total number of entries in the data table is simply the product NP * NREP .

b) Two-dimensional functions are tabulated in Table VI.B. They may consist of a combination of parameterized and tabulated one-dimensional functions.

Tabulated functions are generally given as successive tabulations of the function, each tabulation for one variable held constant. Note that NPE is used to represent the number of successive tabulations of the function Z (X_i,Y). In addition to giving the function at each x_i' the method of interpolation in the x-dimension must be coded selecting a one-dimensional functional form from Table VI.A.

c) Three dimensional functions permitted are given in Table VI.C. Only a general tabulated three-dimensional function is currently allowed.

d) Special multi-parameter functions may also be used as the functional representation. At present, this is limited to resonance parameters (see Table VI.D.

e) The uncertainty of a function may be coded within the data table for that function. The manner for accomplishing this is illustrated in Table VI.E.

TABLE VI

Functional Representations

A. y = f (x)

Internal Code	Type	Code	NP	NREP
0	Constant	$y \ldots y_{NREP}$	1.0	# of Constants
1	Histogram	x,y	# pairs	2.0
2	Lin y - Lin x	x,y	# pairs	2.0
3	Lin y - ln x	x,y	# pairs	2.0
4	Ln y - lin x	x,y	# pairs	2.0
5	Ln y - ln x	x,y	# pairs	2.0
10	$y = \sum_{i=M}^{N} C_i x^i$	$M, C_M \ldots C_N$	1.0	N-M+1
15	Isotropic	_____	0.0	0.0
16	$y = \sum_{\ell=1}^{N} f_\ell P_\ell(x)$	$f \ldots f_N$	1.0	N

B. $Z = f(x,y)$

INTERNAL CODE	TYPE	CODE	NP	NREP	PARAMETERS	
21	General	$\left[x_i, Z(x_i, y)\right]$ i=1,NPE	according to representation selected from IV.A		—	
22	$Z = a_\ell(x)\delta(y-y_\ell)$	—	1.0	1.0(or 2.0 if Δa_ℓ	y_ℓ	
23.	Discrete channel	—			Q,LW	NPAR=1
24.	General evaporation	$g(y')$ where $y' = \frac{y}{\theta}$	according to representation selected from IV.A		$\theta(x)$	NPAR=1
25.	Evaporation	—			$\theta(x)$	NPAR=1
26.	Maxwellian	—			$\theta(x)$	NPAR=1
27.	Watt	$\left[x_i, a(x_i)\ b(x_i)\right]$ i=1, NPE	2		—	
		—			$a(x)$ $b(x)$	NPAR=2
31.	Isotropic	—			—	
32.	$Z = \sum_{\ell=1}^{N} f_\ell(x)\ P_\ell(y)$	$\left[x_i, f_\ell(x_i), \ell=1, NP\right]$ i=1,NPE	N	1.0(or 2.0 if Δf_ℓ)	—	
	or	—			$f_1(x), f_2(x)\ f_n(x)$	NPAR=N

C. W = f (x,y,z)

Internal Code	Type	Code	NP NRER
41	General	$[x_{i}, y_{j}, f(x_{i}, y_{j}, z)]$	according to representation selected from VI.A

D. $y = f(x, P_1 \ldots P_n)$ where P_i are parameters

Internal Code	Type	Code	NP	NREP
50	Scattering length only	-	-	-
51	SLBW	P_i, i=1,NREP	#resonances	#parameters/res
52	MLBW	P_i, i=1,NREP	#resonances	#parameters/res
53	Reich-Moore	P_i, i=1,NREP	#resonances	#parameters/res
54	Adler	P_i, i=1,NREP	#resonances	#parameters/res
55	R-function	P_i, i=1,NREP	#resonances	#parameters/res
56	R-matrix	P_i, i=1,NREP	#resonances	#parameters/res
57	Statistical SLBW	x_i, P_{j}, j=1,NREP-1	#energies	#parameters+1/energy

E. y = f(x) + uncertainty

100	Constant	& its uncertainty	y,Δy	2.0	# of Constan
101	Histogram	& its uncertainty	x,y,Δy	#triplets	3.0
102	Lin y - lin x	& its uncertainty	x,y,Δy	#triplets	3.0
103	Lin y - ln x	& its uncertainty	x,y,Δy	#triplets	3.0
104	Ln y - lin x	& its uncertainty	x,y,Δy	#triplets	3.0
105	Ln y - ln x	& its uncertainty	x,y,Δy	#triplets	3.0

IV. General Structure of a Section

A section consists of a series of logical records. The first record is the section identification record followed by a section control record. They are followed always by a section level I. The section level 1 may contain as many nested levels as it required to describe the data.

Type	Number in a section
Identification Record	(1)
Section Control Record (level 0)	(1)
Section Level 1	(Nl)
Section Level 2	(N2)
Section Level 3	(N3)
....	
Section Level M	(NM)
Section End Record	(1)

A. Format of an Identification Record

The identification record consists of free format fields separated by a comma (,) as a delimiter. The contents of the fields are the section descriptors (see table I).

1. Library
2. Version number
3. Modification (MOD) number
4. Date (YYMMDD)
5. Target
6. Target excitation
7. Projectile
8. Process
9. Residual nucleus
10. Residual nucleus excitation
11. Process modifier
12. Product described
13. Property described

EXAMPLES

1. ENDF, IV, 1,790312, FE-56, 0.0, (N, TOT)"",SIG(E)
   Total cross section for the reaction n on FE-56
2. CTR, It 0,810516, NB-93, 0.0, (N, NG)t ISOMER, NB-93,.029"SIG(E)
   Nb-93(n,n'y) isomer production of the .029 KeV level o (E)
3. ENDF/C, 1,0, 7801~4, ZR, 0.0, N""" COMMENTS
   Free text comments for all N-Zr reactions
4. ENDF/C, 1,0,771223, Pu-239, 0.0, (N, MANY)"",RESOLVED
   Resolved neutron resonance parameters for Pu-239
5. ENDF/C, 1,0,780124, ZR, 0.0, (N,N), ZR, 0.0"N, N(E;EP;MU)
   Secondary energy-angle distribution function for elastic scattering of neutrons by Zr.
6. ENDF/C, 1,0,780130, Li-6, (N,PN), He-4", NU(E)
   Multiplicity of all outgoing particles from the ^{6}Li (N, PN) reaction.
7. ENDF/C, 1,0,771223, Pu-239, 0.0, (N, NONELASTIC),,, G, NU*N(E;EP;MU)
   Secondary Gamma ray production energy-angle distribution from all non-elastic reactions
8. CPND, 1,0,740613, Si-28, 0.0, (P, N), P-28"" SIG(E)
   Si-28 (P, N) cross section

B. Format of a Section Control Record

The section control record contains a numerical equivalent for each field on the free format identification record. This information is followed by a field containing the number of LEVEL-l sections within the section. Optional succeeding fields may be used. Their meaning will depend on the property being described. At present these additional fields are used only for sections describing cross sections (SIG(E), NU*SIG*anything or SIG*anything).

Record 1

Field 1	NFSO	Number of fields
2	NLIB	Library
3	NVER	Version number of library
4	MOD	Version number of section within library
5	IDATE	Date (YYMMDD)
6	IA	Target
7	LIS	Target excitation
8	IP	Projectile (see Table II)
9	IPROC	Process (see Table III)
10	ZAP	Residual nucleus
11	LFS	Residual nucleus excitation
12	IPRM	Process modifier (see Table IV)
13	IPROD	Product described (see Table II)
14	IPROP	Property described (see Table V)
15	N1	Number of sections LEVEL-l

Optional fields required for properties 8, 18,20 and 22 are

Field 16	THRESH	Threshold energy
17	Q	True physics Q-Value
18	AT	Decay constant for final nucleus (stable AT=O.O)

Optional fields required for property 9

19	IAR	Target for ratio reaction
20	LISR	Target excitation for ratio reaction
21	IPR	Projectile for ratio reaction (see Table II)
22	IPROCR	Process for ratio reaction (see Table III)

C. Section Level-l

A section level-1 for reaction data describes data for a single target temperature and for a range of incident particle energies E1 to E2. The energy range must be selected such that the functional representation remains fixed over that incident energy range for each nested section level.

D. Sections Level-N

The structure of all subsequent vested sections level-N is determined by the property being described (Table II). These structures are described in detail in subsequent sections.

E. Section End Record

The Section End record is a totally blank record indicating the end of a section. This record can only be followed by an Identification record or an end-of-file.

V. Physical Formats

A <u>EXTERNAL FORMAT</u>

The format described in this document is what one would call an “external” format. It is designed to be manipulated external to the computer. Therefore the physical format in a Fortran sense must be specified. Format for standard card (80 characters/record) and line printer (132 characters/card) are available. Conversion between the two formats can be done by a simple computer program which is ignorant of the detail structure of the file.

All fields are floating point numbers (E13.6) except for the Identification record, comment records and two control characters at the end of each physical record.

TABLE VII

External Format Control Characters

Character	Use
I	Identification record
0-9	Level control record
H	Comment (text) record
D	Data record
E	End record
*	Indicates last physical record in the logical record

Format for 80 character physical record is

Col 1-78	Six floating point fields or 78 characters.
79	Blank or '*'
80	1,0-9, H, D or E

Format for 132 character physical record is

Coll-130 Ten floating point fields or 130 characters.

131 Blank or t*t

132 1,0-9, H, D, or E

B INTERNAL FORMAT

An internal binary format is also envisioned in which contents are identical to the external format. However each physical record is the same as a logical record.

Format for each internal format record

Fields 1-13	ID	Integer equivalents for section descriptors in Table I
14	RTYPE	Record Type*
15	NW	Number of fields to follow
Remaining Fields	A	Floating point data fields or text at 2 characters per word.

*

Note: RTYPE = 'E' is unnecessary and does not exist in the internal format.

Each record can be read with the following FORTRAN statements

```
DIMENSION ID (14) , A (10000)
EQUIVALENCE (RTYPE, ID (14))
READ (INP) ID , NW , (A (I) , I-I, NW)
```

A simple FORTRAN program RIGEL C has been written which will convert an 80 character external format to the internal binary format .

C. Detail formats

The detailed formats required for each property are given below. There is a one to one correspondence between logical records in the external and internal formats except for the following:

1) No Section End record is required in the internal format.

2) The LEVEL-l control record and text record in the comments sections are combined into a single text record.

0. Comments

A. Section Level-l

Record 1

Field 1	NFSl	Number of fields to follow.
2	NC	Number of characters of text to follow.

Record 2

NC characters of text.

1. Composition

A. Section level-1

Record 1

Field 1 NFS1 Number of fields
2 ZA 1000 * Z + A for material
3 MASS (1) Atomic mass in AMU (first 6 significant figures)
4 MASS (2) Atomic mass in AMU (next 6 significant figures)
5 N2 Number of components

B. Section level-2

Record 1

Field 1 NFS2 Number of fields
2 ZAI 1000 * Z + A for the component
3 MASSI(1) Atomic mass in AMU of the component
(first 6 significant figures)
4 MASSI(2) Atomic mass in AMU of the component
(second 6 significant figures)
5 ABUND Atom fraction of the component

2. Structure

A. Section Level-1

Record 1

Field 1 NFS1 Number of fields
2 NLEV Number of levels

B. Section Level-2

Record 1

Field 1 NFS2 Number of fields
2 ELEV Level energy
3 SPIN Level spin
4 PARITY Level parity
5 T12 Level half life
6 N3=ND Number of decay modes

6. Resolved

A. Section Level-1

Record 1

Field	1	NFSl	Number of follow1ng fields in record
	2	TEMP	Target temperature
	3	EL	Lower incident energy
	4	EH	Upper incident energy
	5	N2-NIS	Number of isotopes

B. Section Level-2

Record 1

Field	1	NFS2	Number of fields
	2	SPI	Spin
	3	PTY	Parity
	4	A	Scattering length
	5	IREP	Functional representation (Table VI.D)
	6	N3=NSP	Number of spins states (ι + j)

C. Section Level-3

Record 1

Field	1	NFS3	Number of fields
	2	L	Angular momentum
	3	J	Spin
	4	NRS	Number of resonances (or poles)
	5	NREP	Number of parameters per resonance

Record 2

Data table according to structure required by functional representation IREP

7. Unresolved

A. Section Level-1

Record 1

Field	1	NFS1	Number of following fields in record
	2	TEMP	Target temperature
	3	EL	Lower incident energy
	4	EH	Upper incident energy
	5	N2-NIS	Number of isotopes

B. Section Level-2

Record 1

Field	1	NFS2	Number of fields
	2	SPI	Spin
	3	PTY	Parity
	4	IREP	Functional representation (Table VI.D)
	5	N3=NSP	Number of spins states (ι + j)

C. Section Level-3

Field	1	NFS3	Number of fields
	2	L	Angular momentum
	3	J	Spin
	4	AMUN	ν_{n}
	5	AMUG	ν_{g}
	6	AMUF	ν_{f}
	7	AMUX	ν_{x}
	8	IE	Functional representation in energy space (Table VI.A)
	9	NP	Number of energy points
	10	NREP	Number of parameters per energy

Record 2

Data table according to structure required by functional representation IREP

A. Section Level-1

Record 1

Field 1	NFS1	Number of following fields in record
2	TEMP	Target temperature
3	EL	Lower incident energy
4	EH	Upper incident energy
S	N2	Number of sections level-2

B. Section Level-2

Each section level-2 describes a single functional representation of the property σ (E) between EL and EH. The property σ (E) is a linear sum of the values obtained from each level-2 section within a level-1 section.

Record 1

Field 1	NFS2	Number of fields
2	IE	Functional representation (Table VI.A, VI.D or VI.E)
3	NPE	Number of points
4	NREP	Number of values per point

Record 2

Data table for σ(E) according to structure required by functional representation.

1. Note: If IE between 51 and 54 no record 2 is required since the resonance parameters will be found in a Resonance Parameter Section.

A. Section Level-l

Record 1

Field 1 NFSl Number of follow1ng fields in record

2 TEMP Target temperature

3 EL Lower incident energy

4 EH Upper incident energy

5 N2 Number of sections level-2

B. Section Level-2

Each section level-2 describes a single functional representation of the property σ (E) between EL and EH. The property σ (E) is a linear sum of the values obtained from each level-2 section within a level-l section.

Record 1

Field 1 NFS2 Number of fields

2 IE Functional representation (Table VI.A,VI.D or VI.E)

3 NPE Number of points

4 NREP Number of values per point

Record 2

Data table for σ(E) according to structure required by functional representation.

10. ν(E)

A. Section Level-l

Record 1

Field 1 NFSl Number of following fields in record

2 TEMP Target temperature

3 EL Lower incident energy

4 EH Upper incident energy

5 N2-NPROD Number 0£ products described

B. Section Level-2

Record 1

Field 1 NFS2 Number of fields

2 Z Product charge

3 A Product mass

4 EX Product excitation

5 N3=NK number 0£ partial descriptions.

C. Section Level-3

Record 1

Field 1 NFS3 Number of fields

2 IE Functional representation (Table VI.A or VI.E)

3 NPE Number of points

4 NREP Number of values per point

Record 2

Data table for ν(E) according to structure required by functional representation.

12. N(E,E',μ)

A. Section Level-1

Record 1

Field 1 NFS1 Number of following fields in record
2 TEMP Target temperature
3 EL Lower incident energy
4 EH Upper incident energy
5 N2-NK Number of partial descriptions

B. Section Level-2

Record 1

Field 1 NFS2 Number of fields
2 IE Functional representation of $P_k(E)$
3 N3 2.0 (one level-3 for $N_k(E,E')$ and one for $P_k(E,\mu)$)
4 NPP Number of points in $P_k(E)$
5 NREP Number of values per point

Record 2

Data table for $P_k(E)$ according to structure required by functional representation

C. Section Level-3 (for $N_k(E,E')$)

Record 1

Field 1 NFS3N Number of fields
2 LF Functional representation of $N_k(E,E')$ (Table VI.B)
3 U Maximum value of secondary energy (E')
4 NPAR Number of parameters in $N_k(E,E')$

Record 2

Field 1 NFS3N1 Number of fields
2 IF Functional representation of parameter (Table VI.A)
3 NP1 Number of points in 'parameter k_1 (E)
4 NREP Number of values per point

Record 3

Data table for parameter $k_1(E)$ according to structure required by functional representation

(Repeat records 2 and 3, NPAR times)

Record 2*(NPAR + 1)

Field 1 NFS3NX Number of fields
2 IE Functional representation of incident energy variable (Table VI.A)
3 NPEKN3 Number of energy points

D. Section Level-4

Record 1

Field 1 N4 Number of fields
2 IEP Functional representation of secondary energy variable (Table VI.A)
3 E_i Incident energy variable
4 NP Number of points
5 NREP Number of values per point

Record 2

Data table for $N_k(E_i,E')$ according to structure required by functional Representation

E. Section Level-3 (for $P_k(E,\mu)$)

Record 1
Field 1 NFS3P Number of fields
2 LF Functional representation of P(E,μ) (Table VI.B)
3 LCM Laboratory-center of mass flag
4 NPAR Number of parameters in P(E,μ)

Record 2
Field 1 NFS3Pl Number of fields
2 IF Functional representation of parameter (Table IV.A)
3 NPl Number of points in parameter k_l (E)
4 NREP Number of values per point

Record 3
Data table for parameter $k_l(E)$ according to structure required by functional representation

(Repeat records 2 and 3 , NPAR times)

Record 2* (NPAR + 1)
Field 1 NFS3PX Number of fields
2 IE Functional representation of incident energy variable
3 NPE-N3 Number of energy points

F. Section Level-4 (for P(E,μ)

Record 1
Field 1 NFSP4 Number of fields
2 IEP Functional representation of angular variable (Table VI.A)
3 E_1 Incident energy variable values
4 NP Number of points
5 NREP Number of values per point

Record 2
Data table for $P_k(E_1'\mu)$ according to structure required by functional representation.

13. N,(λ,E,E',μ)

A. Section Level-1

Record 1

```
      Field 1  NFS1    Number of following fields in record
            2  TEMP    Target temperature
            3  EL      Lower incident energy
            4  EH      Upper incident energy
            5  N2=NLAM Number of delayed groups
```

B. Section Level-2

Record 1

```
      Field 1  NFS2   Number of fields
            2  λ      Delayed group constant
            3  N3=NK  Number of partial descriptions
```

C. Other sections Level-N

See description of N(E,E',μ) for Level-(N-1)

14. (E,μ,E')

A. Section Level-1

Record 1

```
      Field 1  NFS1   Number of following fields in record
            2  TEMP   Target temperature
            3  EL     Lower incident energy
            4  EH     Upper incident energy
            5  N2-NK  Number of partial descriptions
```

B. Section Level-2

Record 1

```
      Field 1  NFS2   Number of fields
            2  IE     Functional representation of Pk(E)
            3  LF     Functional representation of Pk(E,μ,E') (Table VI.C)
            4  NPP    Number of points in Pk(E)
            5  NREP   Number of values per point
```

Record 2

Data table for $P_k(E)$ according to structure required by functional representation.

Record 3

```
      Field 1  NFS21   Number of fields
            2  IE      Functional representation in E-space (Table VI.A)
            3  NP=N3   Number of incident energy values
```

C. Section Level-3

Record 1

```
      Field 1 NFS3 Number of fields
            2 IA Functional representation in E-space (Table VI.A)
            3 E1 Incident energy
            4 NP=N4 Number of angle cosine values
```

D. Section Level-4

Record 1

Field	1	NFS4	Number of fields
	2	IEP	Functional representation in E' space (Table VI.A)
	3	μ_j	Value of angle cosine
	4	NP	Number of points in E' space
	5	NREP	Number of values /points

Record 2

Data table for $P(E_1'\mu_j,E')$ according to structure required by functional representation.

18. $\nu\sigma\{E)$

A. Section Level-l

<u>Record 1</u>

Field	1	NFSl	Number of following fields in record
	2	TEMP	Target temperature
	3	EL	Lower incident energy
	4	EH	Upper incident energy
	5	N2-NPROD	Number of products described

B. Section Level-2

<u>Record 1</u>

Field	1	NFS2	Number of fields
	2	Z	Product charge
	3	A	Product mass
	4	EX	Product excitation
	5	N3=NK	number of partial descriptions.

C. Section Level-3

<u>Record 1</u>

Field	1	NFS3	Number of fields
	2	IE	Functional representation (Table VI.A or VI.E)
	3	NPE	Number of points
	4	NREP	Number of values per point

<u>Record 2</u>

Data table for $\nu\sigma(E)$ according to structure required by functional representation.

20. νσ(E) N(E,E′,μ)
22. νσ(E) P(E,μ,E')

A. Section Level-l

Record 1

Field	1	NFSl	Number of follow~ fields in record
	2	TEMP	Target temperature
	3	EL	Lower incident energy
	4	EH	Upper incident energy
	5	N2=NPROD	Number of products described

B. Section Level-2

Record 1

Field	1	NFS2	Number of fields
	2	Z	Product charge
	3	A	Product mass
	4	EX	Product excitation
	S	N3=NK	Number of partial descriptions

C. Other sections Level-N

See description of N(E,E',μ) or P(E,μ,E') for Level-(N-l) where P_k(E) is replaced by νσ(E).

26. ν N(E,E',μ)
28. ν P(E,μ,E')

A. Section Leve1-1

Record 1

Field	1	NFSl	Number of following fields in record
	2	TEMP	Target temperature
	3	EL	Lower incident energy
	4	EH	Upper incident energy
	5	N2-NPROD	Number of products described

B. Section Level-2

Record 1-

Field	1	NFS2	Number of fields
	2	Z	Product charge
	3	A	Product mass
	4	EX	Product excitation
	5	N3=NK	Number of partial descriptions

C. Other sections Level-N

See description of N(E,E',μ) or P(E,μ,E') for Level-(N-l) where P_k(E) is replaced by P_k(E)

ATTACHMENT II

Summary of Changes to Proposal of Jan. 31, 1978

1. Resonance region containing only a scattering length is now permitted.
2. All structure information appears before reaction data comments in the output file.
3. All continuum reaction components are indicated not in the process field but in the residual nucleus field in the identifier record.
4. New ENDF/B-V fission product yield format (nuclide, yield, 6 yield) is handled properly and the new 8-454, cumulative yields, is distinquished in the process modifier field.
5. Isomer ratios and isomer production cross sections CMF=9 and-1O respectively) are now included in the format .