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TRANSLATION TO ENDF/B AND "PHYSICS" CHECKING OF CROSS SECTIONS FOR SHIELDING

Final Report

Contract No. DASA01-69-C-0029
Defense Atomic Support Agency
Washington, D.C. 20305

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Submitted by:

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Charlottesville

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ABSTRACT

Evaluations of neutron interaction and photon production cross sections for sodium, magnesium, chlorine, potassium, and calcium have been translated from a modified-UK format into ENDF/B format. The data have been reviewed and revised to a minor extent, and can be used by the LAPH code to generate multigroup photon production cross section matrices. All data sets have been transmitted to the University of California, Los Alamos Scientific Laboratory, to the National Neutron Cross Section Center at BNL, and to the Radiation Shielding Information Center at ORNL. Several "physics" checks have been proposed for the photon data, and a FORTRAN IV code, PHOX, has been written to incorporate some of these checks.

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1. Introduction And Summary

As part of the ENDF/B[1] effort, a format[2] was devised for storing photon production and photon interaction data. In order to de-bug the photon production format, sodium data from a recent evaluation by Drake et al.[3] were translated from a modified UK Data File format into the ENDF/B Data File format (cf. Ref. 2 for a listing of this translation). The translation was performed by a special-purpose FORTRAN IV code called LUTE. Because the entire sodium evaluation was of interest to the Shielding Subcommittee of the Cross Section Evaluation Working Group (CSEWG), the University of California, Los Alamos Scientific Laboratory undertook the translation of the neutron interaction data also. This latter translation[4] was performed with the LATEX code, an extended version of the LATE code which had been previously used for translations of ^{6}Li and ^{7}Li.[5] Later, the Los Alamos Scientific Laboratory undertook the translation[4] of the calcium evaluation by Drake et al.,[3] as well as a preliminary analysis of the translation procedures for chlorine, potassium and calcium.

This report describes in §2 the procedures and data revisions for the translations of Na, Mg, Cl, K, and Ca. Details of the revisions are given in Appendices A and B. Proposals for "physics" and internal consistency checks which might, in part, be incorporated in a checking code are given in §3. Particular emphasis is placed on checks which are applicable to the photon data. A code called PHOX was written to perform checks on the photon data. It is described in detail in §4, and a listing is given in Appendix C. The translation codes, LUTE and LATEX, are described in a separate report.[6] For purposes of the present report the modified and extended UK Data File format used by Drake et al. will be referred to as simply the "UK format", and the entirety of their data as the "UK Data File".

2. Translations Of Na, Mg, Cl, K, and Ca To ENDF/B Format

The materials which were translated are identified on each UK-format card image by a nuclide identification number (NIN), and on each ENDF/B-format card image by a material number (MAT). Listed below in Table I are the materials and their corresponding NIN and MAT numbers.

TABLE I

Material Identifying Numbers

Material	NIN(UK)	MAT(ENDF/B)
Na	205	5001
Mg	206	5002
Cl	221	5004
K	227	5005
Ca	231	5006

2.1 Procedures

The translation procedure used was to start with the materials on data tapes in UK format, and attempt a run thru the LUTE and LATEX codes. Several iterations were required for each material before the UK-format tape had been corrected sufficiently to allow a successful translation. After correcting as many errors as the translation codes could detect (generally clerical errors, mispunches, cards out of sequence or missing, etc.), the data in both listed and plotted form were scanned visually for any obvious inconsistencies or other errors. Appendix A documents in minute detail the corrections and alterations to the UK Data File which have been made since July 1968. Appendix B documents similar information for the ENDF/B Data File.

Construction of a corresponding ENDF/B Data File for each material required several changes and additions (as opposed to corrections), which are described in detail in reference 6. In summary, these primarily consisted of the three changes described below.

2.1.1. Additions to Files 1 and 3

A complete File 1 was created for each material, including a table of contents and an index. A tabular section for the average cosine of the angle of elastic scattering in the laboratory system was automatically created by LATEX for File 3. This latter table of $\bar{\mu}_{LAB}$ values was calculated using the angular distributions of secondary neutrons from elastic scattering, as given in File 4 (MF = 4, MT = 2). The values of $\bar{\mu}_{LAB}$ were extended down to the lowest energy for which an elastic scattering cross section is given in File 3 (MF = 3, MT = 2), using a value $\bar{\mu}_{LAB} = \frac{2}{3(AWR)}$ at this lowest energy. This value was also used at 0.75 E_3, where E_3 is the lowest incident neutron energy for which an angular distribution is given in File 4.

2.1.2. Transition Probability Arrays

Because of an inherent difference between the allowable UK and ENDF/B formats for photon production cross sections, the photon production from inelastic scattering to discrete levels was not translated completely by the code LUTE. The ENDF/B format[2] allows not only photon production cross sections (slightly disguised) or yields, as in the UK format, but also allows the alternate use of transition probability arrays when the level energies are well established. Thus, these arrays were entered for all levels up to the highest level for which the level energy and decay scheme are well established. However, photon production data were often given in the UK Data File for incident neutron energies above the energy of this highest level (denoted E_d), so other provisions had to be made for storing these data in ENDF/B format. The method chosen was to use photon production cross sections for incident neutron energies above E_d, exactly as they are given in the UK format. In order to accomplish this conveniently, a new reaction type number was defined for ENDF/B, as discussed in the next section.

2.1.3. Residual Photon Production (MT = 110)

A new reaction type number, MT = 110, was defined and used for residual photon production by incident neutrons with energies greater than E_d. Any inelastic scattering reaction (MT = 5 thru 14 and 51 thru 80) section with incident neutron energies greater than E_d automatically has the photon production cross sections above this energy translated by LUTE to a subsection of photon production cross sections within MT = 110. Also, the first time this case is encountered by LUTE, an MT = 110 section for File 3, with unit cross section, is generated. Thus, the photon production cross sections appear in File 15 under the guise of yields, but processing codes such as LAPH(7) will properly construct photon production cross sections from the combined data of Files 3 and 15.

2.2. Major Modifications of the Data

Only the three major changes requiring discussion are given in this section. These changes were made in converting to ENDF/B format, but the UK Data File was not altered. Detailed minor corrections or alterations to the UK Data File are given in Appendix A. Minor changes to the ENDF/B Data File are given in Appendix B, and minor alterations for consistency and format purposes are discussed in §2.3.

2.2.1. Photon Production from Inelastic Scattering by ^{37}Cl

Level excitation cross sections for reaction types 5 through 14 and 51 through 53 are for the 1.22 MeV through 6.10 MeV levels, respectively, of ^{35}Cl. However, photon production cross sections in the UK Data File are given for the corresponding levels only for reaction types up to 51. Reaction types 52 through 54 are used to present photon production cross sections for three levels of ^{37}Cl (viz., 1.728, 3.087 and 3.71 MeV). Since the transition probability arrays in the ENDF/B Data File for chlorine do not contain the ^{37}Cl levels, the photon production cross sections for these levels were included in their entirety in the residual photon production section (MT = 110). That is, the parameter E_d was zero for MT = 52, 53 and 54. Photon production for incident neutron energies below 5.22 MeV (E_d for ^{35}Cl) would thus be given only for ^{35}Cl by the transition probability arrays and corresponding excitation cross sections. Excitation cross sections for the levels of ^{37}Cl are not explicitly given in the UK Data File, but are included in the section for total inelastic scattering, reaction type number (RTN) 1004. They presumably are not included in the section for inelastic scattering to the continuum, RTN = 1015.

2.2.2. Photon Production by the (n,p) and (n,α) Reactions in Potassium

Photon production data for the (n,p) reaction in potassium are identified in the UK Data File by reaction type numbers 13121 and 13122. These RTN's are for the (n,p_1) and (n,p_2) reactions in ^{39}K; i.e., leaving the residual ^{39}Ar nucleus in the first or second excited states, respectively. Because neutron interaction cross section were given only for the total (n,p) reaction, data for RTN = 13121 and 13122 were combined into one section with MT = 103. This is the ENDF/B reaction type number for the total (n,p) reaction. Angular distributions for these photons were likewise assigned to MT = 103 in File 14.

A similar case occurred for the (n,α_1) reaction in ^{39}K; i.e., to the first excited state of ^{36}Cl. Photon production data for this reaction were given in the UK Data File by RTN = 13141, and the angular distribution by RTN = 11141. The data were placed in the ENDF/B Data File under MT = 107.

2.2.3. Photon Production by the (n,p) Reaction in Calcium

Photon production data for the (n,p) reaction in calcium are identified in the UK Data File by reaction type numbers 13060, 13061, and 13062. These RTN's are for the (n,p_1), (n,p_2), and (n,p_3) reactions in ^{40}Ca; i.e., leaving the residual ^{40}K nucleus in one of its first three excited states. Also, photon production data for inelastic scattering to the continuum are given in RTN = 13015 for incident neutron energies from 6.0 to 20.0 MeV, whereas the corresponding excitation cross sections (RTN = 1015) are given for incident neutron energies from 9.0 to 20.0 MeV. Thus, after consulting with Drake,[8] the photon production from 6.0 to 9.0 MeV was assigned to the (n,p) reaction in ENDF/B (MT = 103). Also, as with potassium, the neutron interaction cross sections were given in the UK Data File only for the total (n,p) reaction, so the data in RTN = 13060, 13061, and 13062 were included in the ENDF/B reaction type number for the (n,p) reaction, MT = 103. In a similar manner, angular distributions of photons from the (n,p_1), (n,p_2), and (n,p_3) reactions were assigned to MT = 103.

2.3. Alterations to the Data During Translation to ENDF/B Format

All alterations which were made to the data in UK format were also carried through during translation to ENDF/B format. Since the changes in the UK Data File are documented in detail in Appendix A, they will not be repeated here. There is, however, a class of changes which appears only in the ENDF/B Data File, and those are the ones discussed here. Such changes are typically ones of normalization, consistency between level energies (Q values) and photon energies, etc. The details of the changes appear in Appendix B.

In translating neutron and photon angular distributions to ENDF/B format it was assumed that a zero appearing in the second field of a one-card section with a general classification number (GCN) of 2 or 11 implies an isotropic distribution. The isotropy is explicitly stated for most such cases listed in Tables 4 thru 8 of Reference 3. It was assumed and verified[8] that the UK-format is consistent in this regard.

2.3.1. Normalizations

Data in the UK Data File were never altered to force normalization of neutron and photon angular distributions, or of neutron secondary energy distributions and photon energy distributions. However, all of these data are required in the ENDF/B Data File to be normalized to probability density functions. Thus, all of these normalizations were automatically performed in the translation procedure. Appendix A lists an example of the integrals of the photon angular distributions as they were determined for the

UK Data File. These re-normalization constants are given for information only; they were not used to alter the UK Data File. Assuming a linear interpolation between μ (i.e., cos θ) values, the original distributions were usually normalized to unity, within 1%. Re-normalizations constants are not listed for the secondary neutron angular distributions, but they were usually within about 1% of unity. Some, however, differed from unity by up to about 15% (e.g., in RTN = 2002 for chlorine).

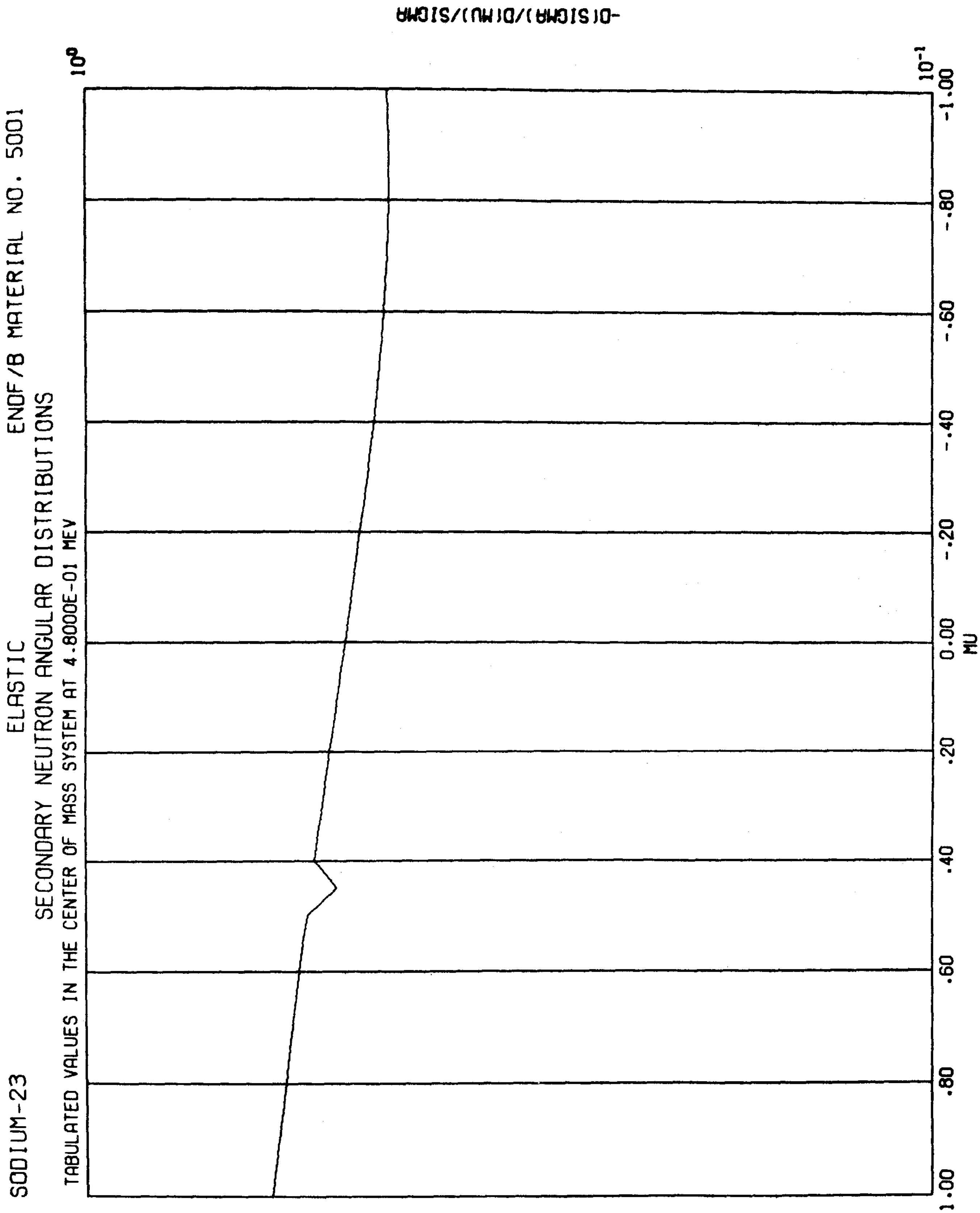
Figures 1 and 2 show typical plots of data for neutron angular distributions, where the value at μ = 0.45 for an incident neutron energy of 4.8 E - 1 MeV apparently was in error. Correcting this error then introduced a slight error in the normalization, which was in turn corrected.

2.3.2. Miscellaneous

Certain alterations listed in Appendix B were tailored for the LAPH code.[7] They involve no substantive changes in the data, but are necessary to satisfy the ENDF/B format requirements or to structure the data in an optional form which is simpler or more convenient. Examples of this type change are:

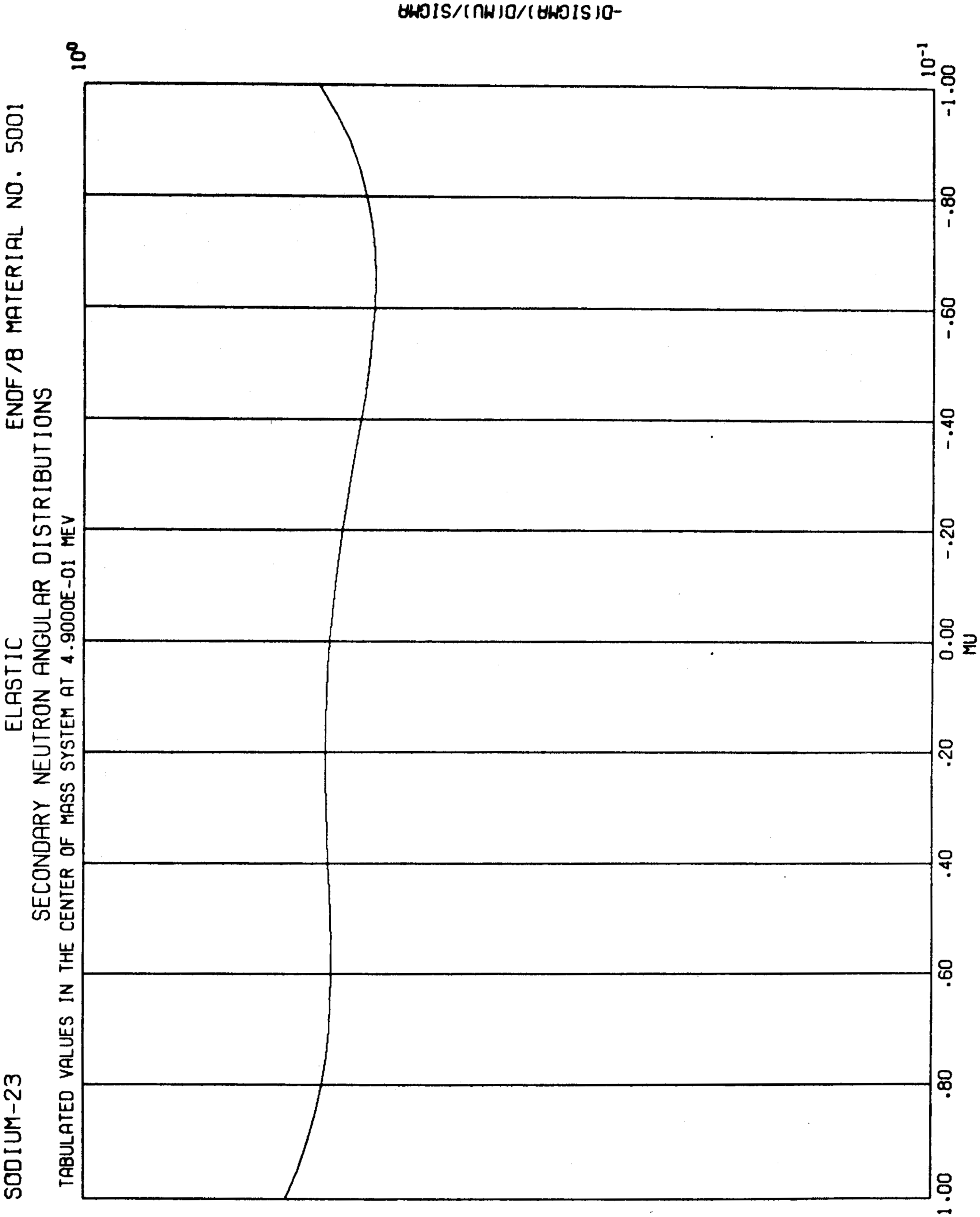
(1) Level energies or Q values in Files 3 and 15 (Option 2), principally in sodium and magnesium, were made consistent with photon energies in File 14. This is required to allow processing codes to correlate level transitions with the angular distributions of the corresponding photons. Any changes of Q value in File 3 were for purely esthetic reasons. A standardization on a particular value was not based upon any new physical data or revelation concerning the correct value among conflicting data. In no case was the difference between conflicting data significant for either data file (i.e., for normal nuclear engineering purposes). In many cases the PHQX code found threshold values lower than theoretically allowed by the Q values, but the values were consistent to within three significant figures so no changes were made in the UK Data File.

(2) In the magnesium data, section (MT) numbers 11, 12, and 13 correspond to the 2.565, 2.736 and 2.803 MeV levels of ^{25}Mg, for which the decay



SODIUM-23
ELASTIC
ENDF/B MATERIAL NO. 5001
SECONDARY NEUTRON ANGULAR DISTRIBUTIONS
TABULATED VALUES IN THE CENTER OF MASS SYSTEM AT 4.8000E-01 MEV
-D(SIGMA)/D(MU)/SIGMA
10^0
10^-1
-1.00
-.80
-.60
-.40
-.20
0.00
.20
.40
.60
.80
1.00
MU

FIGURE 1



SODIUM-23
ELASTIC
ENDF/B MATERIAL NO. 5001
SECONDARY NEUTRON ANGULAR DISTRIBUTIONS
TABULATED VALUES IN THE CENTER OF MASS SYSTEM AT 4.9000E-01 MEV
-D(SIGMA)/D(MU)/SIGMA
10^0
10^{-1}
-1.00
-.80
-.60
-.40
-.20
0.00
.20
.40
.60
.80
1.00
MU

FIGURE 2

schemes are not known. However, MT = 14 corresponds to the 2.94 MeV level of ^{26}Mg, and MT = 51 thru 55 correspond to the 4.12 thru 6.44 MeV levels of ^{24}Mg, all of which have known decay schemes. In order not to preclude the use of transition probability arrays for these latter levels (MT = 14 and 51 thru 55), the levels of ^{25}Mg with unknown decay schemes were assigned zero transition probabilities. Such unorthodox transition probability arrays will be flagged by the photon "physics" checking code, PHQX, but will be acceptable to LAPH. They allow a simple, accurate and concise representation of all photon production from well-known level decay schemes.

(3) In the calcium transition probability arrays, MT = 6 corresponds to the first level of ^{40}Ca (3.35 MeV), which decays by electron-positron emission. In order to correctly compute the resulting annihilation photon source, the energy of this level is listed in File 15 as 0.51 MeV. and the transition probability is assigned the value 2.0. These will be flagged by PHQX as suspicious data.

2.4. Unresolved Inconsistencies

During review of the data several inconsistencies were noted between the UK Data File and the documentation of the data in the Appendices of GA-7829. Also, what seem to be clerical errors appear in these appendices. No changes were made on either the UK or ENDF/B Data File where a question concerning the correct data could not be resolved from the source documentation. However, the questionable data are noted below for possible future revision when time permits.

2.4.1. Sodium

Angular distribution data for secondary neutrons from inelastic scattering to the second (2.08 MeV) level differ considerably between the UK Data File and the documentation (GA-7829, Vol. II, p. A-53). This discrepancy occurs at 8.5 and 9.0 MeV incident neutron energies, where the documentation lists angular distributions identical to that at 8.0 MeV. The UK Data File (RTN = 2006), on the other hand, lists substantially different distributions, peaking strongly and irregularly about $\mu = 0$. Plots of the data indicate they are also irregular at 7.5 and 8.0 MeV.

Similarly, for the first excited state (0.4392 MeV level) the document and the UK Data File disagree at various incident energies between 6.0 and 9.0 MeV. Also, even where the data agree it appears from the plots that a discrepancy may occur at $\mu = -1.0$. Though the data were not altered it appears as if a simple extrapolation of the smooth curves to $\mu = -1.0$ would be satisfactory.

2.4.2. Magnesium

Plots of the angular distributions of secondary neutrons from elastic scattering showed irregularities which were not obvious errors, or which were apparently errors but did not seem to be rectifiable by a simple linear interpolation between neighboring points. These occurred at incident neutron energies of 0.19 and 0.68 MeV. A similar case existed at 0.21 MeV, but the data were smoothed for $0.1 \leq \mu \leq 0.4$. A comparison with the original documentation in GA-7829, Vol. III, will show the alterations performed.

2.4.3. Chlorine

A plot of the angular distribution of secondary neutrons from elastic scattering shows an irregularity at $\mu = 1.0$ for an incident neutron energy of 15 MeV. At this point the probability density drops abruptly, whereas at adjacent incident energies the probability rather smoothly approaches a maximum at $\mu = 1.0$.

2.4.4. Potassium

Angular distributions for secondary neutrons from inelastic scattering to the 10th through 17th levels (MT = 51 through 57) are not given at all in the UK Data File. However, Vol. I of GA-7829 states in Table 7, under "Remarks," that these are isotropic. Thus, isotropic angular distributions were not created by LATEX because of no entry being present in the UK Data File. It may be desireable to add these distributions to both data files in the future. There seems to be no distinction between isotropic distributions which appear in the UK Data File in the form of a single-card section and those which do not appear at all. Secondary neutron angular distributions at 9.5, 10, 10.5, and 11.5 MeV show radical fluctuations at around $\mu = 0.3$. It was not obvious whether these are real or due to clerical errors, and the fluctuations occur for 2 to 3 consecutive data points. Thus, the data were not altered.

2.4.5. Calcium

Data for inelastic level excitation cross sections for the first four levels seem to be displaced in energy between the tabulations in the document and in the UK Data File. This displacement generally occurs for energies above about 3.6 MeV

2.5. Distribution of the Data

Copies of the corrected UK Data File were sent to the Radiation Shielding Information Center (RSIC) at Oak Ridge National Laboratory (ORNL), where a general UK ⇄ ENDF/B translation code is under consideration. These data were also sent to the Los Alamos Scientific Laboratory (LASL) for the Cross Section Data Library (Dr. R. B. Lazarus). Copies of the ENDF/B Data Files were sent to the National Neutron Cross Section Center at Brookhaven National Laboratory (BNL), in addition to RSIC and the Reactor (K) Division at LASL. At LASL the data will be used by the LAPH code[(7)] to generate multigroup photon production cross section matrices.

2.6. Translation Codes: LUTE and LATEX

The two codes, LUTE and LATEX, for translation from UK to ENDF/B format, are described in detail elsewhere.[(6)] Briefly, LUTE translates the photon production data insofar as possible, and punches a data-card deck. File 1 data for ENDF/B, as well as the transition probability arrays, must be punched separately and used as input to LATEX. The LATEX code then reads these input cards along with the LUTE output deck, translates the neutron interaction data, creates a File 3 section for $\bar{\mu}_{LAB}$, and then outputs a complete ENDF/B tape for the material.

A listing of the translation codes is given in the documentation,[6] and copies of the codes were sent to the Radiation Shielding Information Center at ORNL, to the National Neutron Cross Section Center at BNL, and to the Reactor (K) Division at LASL.

3. Proposed "Physics" And Internal Consistency Checks

3.1. Introduction

Due to the difficulty of creating an error-free ENDF/B data set, with its inherent complexity and size, some systematic checking procedures must be devised. Any checking procedure should begin with tests which can be performed by a simple computerized analysis of the data. Only tests which require no interactive capability between the computer and the evaluator are considered here. These tests can be divided into two types. Type I is consistency or format syntax tests similar to those in CHECKER.[9] Some examples of Type I are tests to see that data lie within certain ranges, to see that the proper number of data points are present, and to determine that the data are in proper format. Type II is "physics" checks which will hopefully determine the physical realism and consistency of the data based upon known laws of physics. This type may print out processed data or plots for the program user to check against references or examine visually to detect questionable points. Any inconsistency or suspected error would be flagged by a comment on the output listing. Those checks which were incorporated into the PHOX Code are summarized in §4.

The symbols used in the following section refer to the ENDF/B format for neutron interaction, photon production, and photon interaction data.

3.2. File 3 Checks

Some of the "physics" and consistency checks proposed for File 3 are the following:

1. $E_i \geq E_{th}$, the incident neutron energy for a reaction should be greater than or equal to the threshold energy of that reaction. If $E_i < E_{th}$, flag the suspected energy and continue processing. E_{th} is calculated by the formula $E_{th} = (\frac{AWR + 1}{AWR})(-Q)$, for $Q \leq 0$. For $Q > 0$, $E_{th} = 0$.

2. $Q < 0.0$ for MT = 5 thru 14 and 51 thru 80. If $Q \geq 0.0$, flag the suspected Q value and attempt to continue processing.

3. 10^4 eV $\leq$ | Q | $\leq 2 \times 10^7$ for MT = 5 thru 14 and 51 thru 80. If not in this range, flag the suspected value and continue processing.

4. Q = 0.0 for MT = 15 or 110. If not, flag the suspected Q value, set Q = 0.0 and continue processing.

5. Q $\geq$ 0.0 for MT = 102. If Q < 0.0, flag the suspected Q value, set Q = 0.0 and continue processing.

6. 1.7×10^6 eV $\leq$ Q $\leq 1.2 \times 10^7$ eV for MT = 102 if Q $\neq$ 0.0. If Q is not in this range and $\neq$ 0.0, flag the suspected value, set Q = 0.0, and continue processing.

7. For MT = 102, interpolate to find the 2200 m/sec cross section and print it for the user to check against references.

8. There is some question as to the proper Q values for the elements. Consider, for example, the materials translated and reviewed for this report. Except for sodium, which is monoisotopic, the other elements have different Q values for their differing isotopes. The proper weighting of the isotopic Q values (e.g. by abundance or product of abundance and 2200 m/sec cross section) is indeterminable. Thus, Q is simply set equal to zero.

9. σ = 1.0 for MT = 110. By definition of this reaction type, the cross section must be unity.

3.3. File 14 Checks

Some "physics" and consistency checks that are proposed for File 14 are the following:

1. LTT should be either 1 or 2. If not, assume LTT = 2 and attempt to continue processing under the assumption that angular distributions are given as tabulations vice Legendre coefficients.

2. LI should be either 0 or 1. If not, assume LI = 0 (i.e., a non-isotropic distribution, and attempt to continue processing).

3. NC should be either 0 or 1. If not, assume NC = 0 (i.e., no continuous photon energy spectra are given) and attempt to continue processing.

4. If LI = 1, test to see that the next card is a SEND card. If not, then set LI = 0 and attempt to continue processing.

5. If LTT = 1, then use LEGCK[9] to test the Legendre coefficients. LEGCK is a computer code that checks Legendre coefficients for possibility and positivity. Any unreasonable or negative coefficients are flagged.

6. NE > NR, the number of neutron energy points given must be greater than the number of interpolates. If not, flag the suspected values, set NR = 1, and attempt to continue processing.

7. NR > 0. If not, flag the suspected value, set NR = 1 and attempt to continue processing.

8. $INT(m) \neq INT(m-1)$. No two consecutive regions should have the same interpolation scheme. If two regions have the same scheme, flag the suspected region and attempt to continue processing.

9. $ES \geq 0$. If $ES < 0$, flag the suspected value, set ES = 0 and continue processing.

10. $EG_i \leq ES$ when $ES > 0$. The ith discrete photon energy is less than or equal to the energy of the state excited to produce the photon (when $ES > 0$). If not, flag the suspected value, set $EG_i = ES$ and continue processing.

11. $EG_i > 0$. If not, test that $ES = EG_i = 0$ and NC = 1. If this is not the case, flag the suspected value and continue processing.

12. ES does not change within any MT number for inelastic scattering to a discrete level. If ES does change, assume ES to have the first value given, flag the inconsistency, and continue processing.

13. If ND > 1, the EG_i must change and must be in decreasing order. If not, flag the suspected values and continue processing.

14. $ES = |Q|$ for MT = 5 thru 14 and 51 thru 80. If not, flag the suspected value, set $ES = |Q|$ and continue processing.

15. $10^4 \text{ eV} \leq ES \leq 2 \times 10^7$ eV for MT = 5 thru 14 and 51 thru 80. If not, flag the suspected value and continue processing.

3.4. File 15 Checks

Some "physics" and consistency checks that are proposed for File 15 are the following:

1. The ES values must be the same as in File 14 for a given MT number. If not, flag the suspected value and continue processing.

2. All the tests for ES listed in File 14, Section 3.3 also apply in File 15.

3. The EG_i must have the same values as in File 14 for a given MT number. Under option 2 of File 15 all possible EG_i must be determined from the cascade and matched to an EG_i in File 14. The existence of a particular value of EG_i in File 14 requires a corresponding value in File 15, but not vice versa. If values differ or a File 14 subsection has no correspondent whatsoever in File 15, flag the suspected values and continue processing.

4. All the tests for EG_i listed in File 14, Section 3.3 also apply in File 15.

5. LO should be either 1 or 2. If not, flag the suspected value, set LO = 1 and attempt to continue processing with the assumption that data are given as photon production multiplicities.

6. LF should be either 1 or 2. If not, flag the suspected value, set LF = 2 and attempt to continue processing with the assumption that data are given by discrete photon energies instead of by tabulated distributions.

7. NT $\leq$ NS, the number of transitions must be less than or equal to the number of levels below the present level (includes ground state). If not, flag the suspected values, set NT = NS and attempt to continue processing.

8. Under option 2, NS = MT - 4 for MT = 5 thru 14 and NS = MT - 40 for MT = 51 thru 80. If not, flag the suspected value, set NS = MT - 4 or MT - 40, as appropriate, and continue processing.

9. NR < NP is the same test as listed in File 14, Section 3.3.

10. The sum of the probabilities in a cascade should add to unity. If the sum differs from unity by more than 10^{-4}, flag the suspected cascade and continue processing.

11. $E_t \leq E_c + Q$ for reactions in which the neutron disappears. For neutron disappearance reactions, in which a compound nucleus is formed, the total energy of the emitted photons, denoted E_t, is less than or equal to the Q value plus the kinetic energy of the neutron, in the center of mass system, denoted E_c. It is assumed that the tabulated neutron energy in the laboratory system is a sufficiently accurate approximation of E_c. If $E_t > (E_c + Q)$, flag the suspected value and continue processing. This can be calculated by the following:

$$[\overline{E}_\gamma (E_i) \cdot y_k(E_i) + \sum_k (EG_i)_k \cdot y_k(E_i)] \leq Q + E_i$$

where $\overline{E}_\gamma = \int dE_\gamma g(E_\gamma \leftarrow E_i) E_\gamma$, the $y_k(E_i)$ are the photon multiplicities, and the $g(E_\gamma \leftarrow E_i)$ are the probability density functions.

12. $E_t \leq |Q|$ for reactions in which the neutron does not disappear. The total energy of the emitted photons, E_t, should be less than or equal to magnitude of the Q value. If $E_t > |Q|$, flag the suspected value and continue processing. This is calculated in the same manner as above.

13. If Lo = 1, $Y(E) = \sum_{k=1}^{Nk} y_k(E)$, the total photon yield should equal the sum of the integrals over the secondary energies. These values should agree to within the fourth significant figure. If not, flag the suspected value and continue processing.

14. For LO = 1 and LF = 1, the normalization should be tested. If $I_1 = \int g(E_\gamma \leftarrow E_i)dE_\gamma$, where $g(E_\gamma \leftarrow E_i)$ is the normalized photon energy distribution (i.e., probability density function), then the normalization is tested by insuring $|I_1 - 1| \leq 10^{-4}$. If not, flag the suspected normalization value and continue processing.

3.5. File 23 Checks

The proposed "physics" and consistency checks for File 23 are the following:

1. $\sigma_\gamma = \sigma_{pe} + \sigma + \sigma_c + \sigma_{pp}$, total photon cross section equals the sum of the individual cross sections for photoelectric effect, Rayleigh or coherent scattering, Compton scattering, and pair production. For practical purposes the effects of the following are neglected: Delbruck or potential scattering, Thomson scattering by the nucleus, photonuclear reactions, and crystal scattering. The sum should agree with σ_γ to within the fourth significant figure. If not, flag the suspected value and continue processing.

2. The Compton scattering cross section is checked by the Klein-Nishina formula

$$\sigma = \frac{2\pi e^4}{m_o{}^2 c^4}\left\{\frac{1+\alpha}{\alpha^2}\left[2\,\frac{(1+\alpha)}{1+2\alpha} - \frac{1}{\alpha}\ln(1+2\alpha)\right] + \frac{1}{2\alpha}\ln(1+2\alpha) - \frac{1+3\alpha}{(1+2\alpha)^2}\right\}$$

where $\alpha = h\nu/m_oc^2$ and e = an electron charge. The values should agree to within the second significant figure over most of the energies of practical interest. If not, flag the suspected value and continue processing.

3. For pair production $E_i > 1.02$ MeV. If not, flag the suspected value, ignore the corresponding cross section and continue processing.

4. For pair production, the total cross section should monotonically increase with photon energy. If not, flag the suspected values and continue processing.

5. The energy at which pair production contributes exactly one-half the total cross section is computed, printed and checked by the user against references.

6. The energy at which the photoelectric effect contributes exactly one-half the total cross section is computed, printed and checked by user against references.

7. The photoelectric effect for each shell has a threshold energy below which the reaction can not take place. Therefore,the lowest energy present in the file is found and printed for checking by the user against references (electron binding energies).

8. For the photoelectric effect, the K-edge and all other discontinuities are computed and printed for checking by the user against references.

9. For the photoelectric effect, the cross section decreases monotonically with photon energy at the edges. Any discrepancy would be picked up and flagged as an "edge."

3.6. File 24 Checks

The proposed "physics" and consistency checks for File 24 are the following:

1. LTT follows same checks as listed in File 14, Section 3.3.

2. LCT should be either 1 or 2. If not, flag the suspected value, set LCT = 1 and attempt to continue processing with the assumption that data are given in the LAB system. Where the secondary particle is a photon, the convention adopted[2] is that LCT = 1.

3. Normalization is tested by the following: $\int_{-1}^{1} d\mu\ p(\mu,E_i) = 1$. If the values do not agree to within the fourth significant figure, flag the suspected values and continue processing.

3.7. File 27 Checks

The proposed "physics" and consistency checks for File 27 are the following:

1. Incoherent form factors (sometimes called incoherent scattering functions) should monotonically increase and approach unity as photon energy increases. They should be within 3% of unity at 1 MeV.

2. Coherent form factors should decrease and approach zero as photon energy increases.

4. PHOX, A "Physics" Checking Code For Photon Data In The ENDF/B Data File

4.1. Introduction and Summary

Much work has been and is being done to place data in the ENDF/B Data File format. In the process of this work there are naturally many errors which occur and which might pass undetected in a visual review of these data. Therefore, a code called CHECKER[9] was written by BNL to check the mechanics (i.e., format syntax) of the data. However, no code existed which checked the physical aspects of the data, or otherwise determined whether the data were reasonable or even possible. Therefore, it is the purpose of this section to explain how several "physics" checks were incorporated into a computer code which does this to some degree for the photon data. The exact division between format syntax and "physics" types of checks is not well defined, so the pragmatic definition of "physics" checks is those checks not done by CHECKER.

There are several types of physical checks which are made by PHOX. They include checks such as testing that the values are within given ranges, that all energy points are above the theoretical threshold as determined from the Q value, that the total energy released by photons does not exceed the energy available as determined by the Q value and neutron energy, etc.

The PHOX code is designed in a manner similar to CHECKER in that it calls various subroutines which do the actual reading, checking and writing. It is written in FORTRAN IV and has been successfully run on the B5500 computer at the University of Virginia.

While the program is designed to attempt to process any section, even if an error in one of the control parameters is discovered, the code may terminate due to trying to read data in an alien format. When control parameters are out of the acceptable range, the code assumes a value within the acceptable range and attempts to proceed. Whenever an error is determined, a message is printed to that effect giving the necessary values, if needed.

4.2. PHOX Code and Subroutines

PHOX is a FORTRAN IV code designed to read an ENDF/B data tape and run certain checks on the data, flagging those it believes to be in error. It is designed primarily to read a BCD card image tape (mode 3) and, while not tested, it is also believed to be able to process a binary tape in standard arrangement for ENDF/B (i.e., mode 1). An INDEX'ed listing of PHOX, giving the statement numbers and variable names, is given in Appendix C.

The main program, PHOX, is essentially a calling routine which searches for the files to be checked and assigns the reading, checking, and writing tasks to the appropriate subroutines in the proper order. If the files of interest are not found on the data tape, messages to that effect are written, and the run is terminated. Several of the BNL retrieval subroutines[9] were used in PHOX. These include RREC, TERPI, ERROR, and WREC with its supplemental subroutines. A modification of the CHECKER subroutine TEST2B(MT)[9] was made and incorporated in PHOX. The purpose of this subroutine, called TEST2C(MT), is to check for the proper MT numbers in File 14.

4.2.1. CKHD(FILE)

CKHD is designed to check the HEAD records of Files 14 and 15. It checks the different fields (not including ZA and AWR) for range, and if discovered to be outside of the range, a "guess" is made and processing continues. When it is necessary to make a guess, a message to that effect is printed which informs the user as to the guessed value.

4.2.2. FIL3(AWR)

FIL3 is designed to calculate a theoretical threshold value for File 3, based on AWR and Q, and to test it against the first energy point given. If this energy point is found to be below the threshold value, a message to that effect is written, along with the theoretical value. FIL3 then stores Q (after checking it for reasonableness of sign and magnitude according to the reaction type) and the larger of either the theoretical threshold or the first energy point, for use in Files 14 and 15.

4.2.3. FILI4(N)

FILI4 is designed to test ES and EG for consistency and reasonableness of magnitude and sign. It also tests for a continuous spectrum and makes sure there is only one continuous spectrum. Using subroutine ESEGPR, FILI4 stores ES and EG for later use.

Each TABI record is tested for increasing order of incident neutron energy and for magnitude as compared with the threshold value stored in FIL3.

4.2.4. FILI5(N)

FILI5 is designed to check either option I or 2. In option I the subsection yields are totaled and checked against the total yields at the total yield energies. The total MeV released per interaction is calculated and compared against the sum of the Q value and kinetic energy, where appropriate. The incident neutron energies and the first energy in each array are checked against the threshold value stored in FIL3. The ES and EG pairs are also used in subroutine ESEGPR.

In option 2 the values of ES_i are checked for decreasing order, the TP_i for magnitude and total sum, and the GP_i for magnitude. The ES's are also checked against the magnitude of Q, as stored in FIL3, and that they correspond to previous state levels. Also the difference between each state level and the previous state levels are checked as ES and EG pairs by ESEGPR.

4.2.5. ESEGPR(N)

ESEGPR is designed to check that each ES-EG pair given in File I4 is used in File I5. In the case of option I in File I5 the comparison is direct, but for option 2 it is necessary to calculate the EG's by substracting the lower state levels from the present state level. After completion of File I5, ESEGPR is called and a final check of all the values,(ES-EG pairs), is made to insure that each has been accounted for. Any that are found to remain unaccounted for are listed on the output.

4.2.6. STATE(LG)

STATE is designed to check that each value of ES_i corresponds to a previous value of ES as read from previous inelastic scattering sections, MT = 5-14 and 51-80.

4.3. Input and Output Specifications

4.3.1. PHOX Input

The input consists of one ENDF/B data tape, designated unit NT, and two cards. The cards consist of

1) NT,MODE,MATW
   entered in (3I11) format, where NT is the input tape I/O unit number, MODE is the mode of the input tape, and MATW is the material number of the material to be checked.
2) LIST entered in (13A6,A2) format. This card is reproduced identically as the first line of output on the listing. This enables the user to place any information he desires on the output.

The card reader is designated as I/O unit number 5 while the line printer is designated as I/O unit number 6. The choice of the NT number is left to the user.

4.3.2. PHOX Output

The output consists of a listing of Files 3, 14 and 15 with any comments which PHOX might print. It should be pointed out that all comments are written after the ENDF/B record in which a possible error is detected and not necessarily immediately after the card on which it occurs.

4.4. Burroughs B5500 Computer Fortran IV Compiler Features

Only two minor characteristics of the B5500 Fortran IV dialect are known which might affect the running of PHOX on other computers. These are:

1) Upon entry into a subroutine, the B5500 automatically initializes to zero all variables not held in COMMON. It also initializes all storage points to zero upon entry into the main program.

2) The method used on the B5500 to determine the statement to proceed to upon reaching an End-of-File is:

READ (U,F,END=S) LIST

where U is the unit number,

F is the format number,

S is the number of the statement to go to if an End-of-File is reached and

LIST is the list of variables to be read.

APPENDIX A: Corrections and Alterations to the Data in UK Format

The following tabulation lists the card numbers, data changes and comments for all changes made to the data files in UK format since about July 1968. All changes made prior to that date were incorporated into the Cross Section Data Library at LASL, and were mostly to correct cards out of sequence, cards missing and other clerical errors. One alteration which was made after consultation with Drake was to change the RTN for the (n,n'p) reaction from 32 to 28, in agreement with the corresponding ENDF/B reaction type number, MT = 28.

Also found in this appendix, under the heading of A.1.2. are normalization values from File 14 and 15 of SODIUM for the photon secondary distributions as calculated by CHECKER. All materials were affected but only SODIUM is given here as an example. These are integrals found via the trapezoidal rule, as required by the interpolation scheme. They are only noted here; no renormalization was attempted in the UK Data File but corresponding data in ENDF/B were renormalized (cf. MF = 14).

CONTENTS OF APPENDIX A

A.1. UK Material Number (MIN) 205* SODIUM

A.1.1. Data File Changes

A.1.2. Normalization Value from CHECKER

A.2. UK Material Number (NIN) 206 * MAGNESIUM

A.2.1. Data File Changes

A.3. UK Material Number (NIN) 221 * CHLORINE

A.3.1. Data File Changes

A.4. UK Material Number (NIN) 227 * POTASSIUM

A.4.1. Data File Changes

A.5. UK Material Number (NIN) 231 * CALCIUM

A.5.1. Data File Changes

A.1. UK Material Number (NIN) 205 * SODIUM

A.1.1. Data File Changes

CARD(S) NUMBER: 00010
CHANGE: Field 3: From 113 to 105
COMMENTS: Correct card count.

CARD(S) NUMBER: 00012, 00013
CHANGE: Field 3: From 97 to 89
COMMENTS: Correct card count.

CARD(S) NUMBER: 00014
CHANGE: Field 3: From 89 to 81
COMMENTS: Correct card count.

CARD(S) NUMBER: 00019
CHANGE: Field 3: From 81 to 73
COMMENTS: Correct card count.

CARD(S) NUMBER: 00020
CHANGE: Field 3: From 57 to 49
COMMENTS: Correct card count.

CARD(S) NUMBER: 00022
CHANGE: Field 3: From 33 to 25
COMMENTS: Correct card count.

CARD(S) NUMBER:	03462
CHANGE:	Field 6 From 5.94301E-1 to 5.75982E-1
COMMENTS:	Error apparent from plot of data.
CARD(S) NUMBER:	03464
CHANGE:	Field 2: From 5.66787E-1 to 6.18222E-1
COMMENTS:	Error....
CARD(S) NUMBER:	03479
CHANGE:	Field 2: From 5.68798E-1 to 6.07534E-1
COMMENTS:	Error....
CARD(S) NUMBER:	03492
CHANGE:	Field 6: From 4.85219E-1 to 5.22592E-1
COMMENTS:	Error....
CARD(S) NUMBER:	03494
CHANGE:	Field 2: From 5.44224E-1 to 5.31727E-1
COMMENTS:	Error....
CARD(S) NUMBER:	03507
CHANGE:	Field 6: From 5.04533E-1 to 5.42012E-1
COMMENTS:	Error....
CARD(S) NUMBER:	03784
CHANGE:	Field 6: From 2.95058E-1 to 2.68496E-1
COMMENTS:	Error....
CARD(S) NUMBER:	03799
CHANGE:	Field 6: From 3.05212E-1 to 2.68238E-1
COMMENTS:	Error....
CARD(S) NUMBER:	03814
CHANGE:	Field 6: From 2.96422E-1 to 2.59656E-1
COMMENTS:	Error....

CARD(S) NUMBER: 03938
CHANGE: Field 6: From 1.70142E-1 to 3.61688E-1
COMMENTS: Error....

CARD(S) NUMBER: 03953
CHANGE: Field 6: From 1.7185E-1 to 3.62734E-1
COMMENTS: Error....

CARD(S) NUMBER: 03983
CHANGE: Field 6: From 4.54161E-1 to 3.39764E-1
COMMENTS: Error....

CARD(S) NUMBER: 03998
CHANGE: Field 6: From 4.81876E-1 to 3.29298E-1
COMMENTS: Error....

CARD(S) NUMBER: 03118
CHANGE: Field 6: From 3.44406E-1 to 2.95546E-1
COMMENTS: Error....

CARD(S) NUMBER: 03270 (second)
CHANGE: Field 2: From 3.91512E-1 to 3.21048E-1
COMMENTS: Error....

CARD(S) NUMBER: 08002
CHANGE: Field 5: From 69 to 68
COMMENTS: Clerical error in data pair count.

CARD(S) NUMBER: 10002
CHANGE: Field 5: From 63 to 61
COMMENTS: Clerical....

CARD(S) NUMBER: 12002
CHANGE: Field 5: From 57 to
COMMENTS: Clerical....

CARD(S) NUMBER: 14002
CHANGE: Field 5: From 57 to 55
COMMENTS: Clerical....

CARD(S) NUMBER: 17001

CHANGE: Field 2: From 14 to

COMMENTS: Correct card count.

CARD(S) NUMBER:
17010 to 17017
21010 to 21017
23010 to 23017
25010 to 25017
35010 to 35017
37010 to 37017
41010 to 41017

CHANGE: Delete these cards.

COMMENTS: Neutron angular distributions below the thresholds (or essentially at threshold for PCN = 51) for inelastic scattering to discrete levels. Data not meaningful.

CARD(S) NUMBER: 21001

CHANGE: Field 2: From 12 to 11

COMMENTS: Correct card count.

CARD(S) NUMBER: 23001

CHANGE: Field 2: From 12 to 11

COMMENTS: Correct card count.

CARD(S) NUMBER: 25001

CHANGE: Field 2: From 11 to 10

COMMENTS: Correct card count.

CARD(S) NUMBER: 35001

CHANGE: Field 2: From 10 to 9

COMMENTS: Correct card count.

CARD(S) NUMBER: 37001

CHANGE: Field 2: From 7 to 6

COMMENTS: Correct card count.

CARD(S) NUMBER: 41001

CHANGE: Field 2: From 4 to 3

COMMENTS: Correct card count.

CARD(S) NUMBER: 65003

CHANGE: Field 2: From 9.0 to 9.05

COMMENTS: Clerical error.

A.1.2. Normalization Value from CHECKER (for Files 14 and 15)

MF = 14 * MT = 5

Energy (MeV)	Normalization Factor	Energy (MeV)	Normalization Factor
0.4580	0.99986	5.0000	0.99984
0.5000	1.0003	5.5000	0.99985
1.0000	0.99981	6.0000	0.99986
1.5000	0.99987	6.5000	0.99987
2.0000	0.99986	7.0000	0.99987
2.5000	0.99986	7.5000	0.99987
3.0000	0.99985	8.0000	0.99987
3.5000	0.99984	8.5000	0.99987
4.0000	0.99983	9.0000	0.99986
4.5000	0.99983		

MT = 6

2.1700	0.99920	2.1700	0.99920
2.5000	0.99946	2.5000	0.99946
3.0000	0.99969	3.0000	0.99969
3.5000	0.99987	3.5000	0.99987
4.5000	1.00010	4.5000	1.00010
5.0000	1.00020	5.0000	1.00020
5.5000	0.99960	5.5000	0.99960
6.0000	0.99960	6.0000	0.99960
6.5000	0.99961	6.5000	0.99961
7.0000	0.99962	7.0000	0.99962
7.5000	0.99963	7.5000	0.99963
8.0000	0.99966	8.0000	0.99966
8.5000	0.99968	8.5000	0.99968
9.0000	0.99972	9.0000	0.99972

MT = 9

Energy (MeV)	Normalization Factor	Energy (MeV)	Normalization Factor
2.8230	1.00050	2.8230	1.00210
3.0000	1.00130	3.0000	1.00130
3.5000	1.00060	3.5000	1.00060
4.0000	1.00010	4.0000	1.00010
4.5000	0.99982	4.5000	0.99982
5.0000	0.99970	5.0000	0.99970
5.5000	1.00030	5.5000	1.00030
6.0000	1.00030	6.0000	1.00030
6.5000	1.00030	6.5000	1.00030
7.0000	1.00030	7.0000	1.00030
7.5000	1.00030	7.5000	1.00030
8.0000	1.00040	8.0000	1.00040
8.5000	1.00040	8.5000	1.00040
9.0000	1.00050	9.0000	1.00050

MT = 10

8.5000	0.99987	8.5000	0.99987
9.0000	0.99982	9.0000	0.99982

MT = 12

4.0170	0.99966	4.0170	0.99966
4.5000	0.99962	4.5000	0.99962
5.0000	0.99973	5.0000	0.99973
5.5000	0.99981	5.5000	0.99981
6.0000	0.99955	6.0000	0.99955
6.5000	0.99915	6.5000	0.99915
7.0000	0.99896	7.0000	0.99896
7.5000	0.99892	7.5000	0.99892
8.0000	0.99904	8.0000	0.99904
8.5000	0.99931	8.5000	0.99931
9.0000	0.99974	9.0000	0.99974

MT = 13

Energy (MeV)	Normalization Factor	Energy (MeV)	Normalization Factor
4.0850	0.99972	4.0850	0.99972
4.5000	0.99981	4.5000	0.99981
5.0000	0.99987	5.0000	0.99987
5.5000	0.99975	5.5000	0.99975
6.0000	0.99974	6.0000	0.99974
6.5000	0.99975	6.5000	0.99975
7.0000	0.99963	7.0000	0.99963
7.5000	0.99960	7.5000	0.99960
8.0000	0.99960	8.0000	0.99960
8.5000	0.99965	8.5000	0.99965
9.0000	0.99974	9.0000	0.99974

MT = 51

4.9860	0.99961	7.5000	0.99965
5.5000	0.99968	8.0000	0.99986
6.0000	0.99971	8.5000	1.00030
6.5000	0.99972	9.0000	1.00090
7.0000	0.99972	4.9860	0.99961
7.5000	0.99965	5.5000	0.99968
8.0000	0.99986	6.0000	0.99971
8.5000	1.00030	6.5000	0.99972
9.0000	1.00090	7.0000	0.99972
4.9860	0.99961	7.5000	0.99965
5.5000	0.99968	8.0000	0.99986
6.0000	0.99971	8.5000	1.00030
6.5000	0.99972	9.0000	1.00090
7.0000	0.99972	4.9860	0.99961
7.5000	0.99965	5.5000	0.99968
8.0000	0.99986	6.0000	0.99971
8.5000	1.00030	6.5000	0.99972
9.0000	1.00090	7.0000	0.99972
4.9860	0.99961	7.5000	0.99965
5.5000	0.99968	8.0000	0.99986
6.0000	0.99971	8.5000	1.00030
6.5000	0.99972	9.0000	1.00090
7.0000	0.99972		

MT = 53

Energy (MeV)	Normalization Factor	Energy (MeV)	Normalization Factor
8.5000	0.99978	8.5000	0.99978
9.0000	0.99964	9.0000	0.99964
8.5000	0.99978	8.5000	0.99978
9.0000	0.99964	9.0000	0.99964

MF = 15 * MT = 15

9.0500	1.01220
12.0000	1.00040
16.0000	-------

A.2. UK Material Number (NIN) 206 * MAGNESIUM

A.2.1. Data File Changes

CARD(S) NUMBER:	00001
CHANGE:	Field 2: From 71650 to 7165
COMMENTS:	Card count changed - clerical error.
CARD(S) NUMBER:	03100
CHANGE:	Field 4: From 2.99689E-1 to 2.45057E-1
COMMENTS:	Error apparent from plot of data.
CARD(S) NUMBER:	03148
CHANGE:	Field 3: From -0.1 to -0.55 Field 4: From 0.0 to 0.50028
COMMENTS:	Appears to be an error. Values were interpolated between adjacent pairs in table to get an estimate of the correct value. Zero value in field 4 also occurs in the appendix of NDL-TR-89, Vol. II.
CARD(S) NUMBER:	03159 (second time)
CHANGE:	Field 2: From 4.77321E-1 to 4.32770E-1
COMMENTS:	Error....
CARD(S) NUMBER:	03200
CHANGE:	Field 4: From 1.38293 to 1.25720
COMMENTS:	Error....
CARD(S) NUMBER:	03281 (second time)
CHANGE:	Field 2: From 3.09070E-1 to 2.45343E-1
COMMENTS:	Error....
CARD(S) NUMBER:	03429
CHANGE:	Field 1: From -0.0 to -0.1
COMMENTS:	Clerical error.
CARD(S) NUMBER:	03455 (second time)
CHANGE:	Field 4: From 1.67767 to 1.46018
COMMENTS:	Error....

CARD(S) NUMBER: 15004

CHANGE: Field 2: From 4.32157E-1 to 5.08099E-1

COMMENTS: Error....

CARD(S) NUMBER: 27098

CHANGE: Field 2: From 4.75 to 4.25

COMMENTS: Clerical error.

CARD(S) NUMBER: 27125

CHANGE: Field 2: From 5.5 to 5.0

COMMENTS: Clerical error.

CARD(S) NUMBER:

29003	29011	29019	29027	29035	29043	29052
29061	29070	29079	29088	29097	29107	29117
29127	29137	29147	29157	29168	29179	29190
29201	29212	29223	29235	29247		
31003	31013	31023	31033	31044	31055	31066
31077	31088	31099	31111	31123		
33003	33013	33023	33033	33043	33053	33063
33074	33085	33096	33107	33118	33129	33141
33153						

CHANGE: Field 2: From 1.00000-02 to 1.00010-02

COMMENTS: Change to avoid double values at 1.00000-02.

CARD(S) NUMBER: 48001

CHANGE: "P" removed from margin.

COMMENTS: Clerical or machine error.

CARD(S) NUMBER: 57018

CHANGE: Field 4: From 5.84000-01 to 1.96200+00

COMMENTS: Clerical error in photon energy.

A.3. UK Material Number (NIN) 221 * CHLORINE

A.3.1. Data File Changes

CARD(S) NUMBER: 00002
CHANGE: Field 5: From 2002 to 1002
COMMENTS: Clerical error in RTN number in the "index".

CARD(S) NUMBER: 09077
CHANGE: Field 4: From 3.11891-01 to 4.85646-01
COMMENTS: Consistency between Q values in File 3, photon energies in File 14, and level energies in File 15.

CARD(S) NUMBER: 09079
CHANGE: Field 4: From 3.11891-01 to 4.85646-01
COMMENTS: Consistency....

CARD(S) NUMBER: 09085
CHANGE: Field 4: From 9.88596-01 to 3.86887-01
COMMENTS: Consistency....

CARD(S) NUMBER: 09087
CHANGE: Field 4: From 9.88596-01 to 3.86887-01
COMMENTS: Consistency....

CARD(S) NUMBER: 09093
CHANGE: Field 4: From 2.16940+00 to 2.17700-01
COMMENTS: Consistency....

CARD(S) NUMBER: 09095
CHANGE: Field 4: From 2.16940+00 to 2.17700-01
COMMENTS: Consistency....

CARD(S) NUMBER: 19002
CHANGE: Field 1: From 74.175 to 4.175
COMMENTS: Energy level in error. A clerical error.

CARD(S) NUMBER 28001
CHANGE: Field 3: From -1.6630+01 to -1.2650+01
COMMENTS: Clerical error in Q value.

CARD(S) NUMBER: 35020

CHANGE: Field 2: From 5.06532-01 to 5.06896-01

COMMENTS: Consistency....

CARD(S) NUMBER: 35024

CHANGE: Field 6: From 5.06532-01 to 5.06896-01

COMMENTS: Consistency....

CARD(S) NUMBER: 35028

CHANGE: Field 2: From 5.10364-01 to 5.10953-01

COMMENTS: Consistency....

CARD(S) NUMBER: 35032

CHANGE: Field 6: From 5.10364-01 to 5.10953-01

COMMENTS: Consistency....

A.4. UK Material Number (NIN) 227 * POTASSIUM

A.4.1. Data File Changes

CARD(S) NUMBER:	03354
CHANGE:	Field 6: From 9.70312-02 to 9.48761-02
COMMENTS:	Error apparent from plot of data.
CARD(S) NUMBER:	03744
CHANGE:	Field 6: From 1.01442-01 to 1.003238-01
COMMENTS:	Error....
CARD(S) NUMBER:	03774
CHANGE:	Field 4: From 3.24552+00 to 8.58534-02
COMMENTS:	Error....
CARD(S) NUMBER:	03789
CHANGE:	Field 4: From 8.45403+00 to 2.71933-02
COMMENTS:	Error....
CARD(S) NUMBER:	03804
CHANGE:	Field 4: From 6.38497+00 to 6.53297-02
COMMENTS:	Error....
CARD(S) NUMBER:	03808
CHANGE:	Field 6: From 5.10289-02 to 1.16280-01
COMMENTS:	Error....
CARD(S) NUMBER:	03823
CHANGE:	Field 6: From 1.15560-01 to 2.91788-01
COMMENTS:	Error....
CARD(S) NUMBER:	03838
CHANGE:	Field 6: From 1.96689-01 to 3.15894-01
COMMENTS:	Error....
CARDS:	17010
CHANGE:	Field 6: From Blank to 21
COMMENTS:	Clerical error - the number of data pairs in the subsection.

CARD(S) NUMBER: 27001

CHANGE: Field 2: From 60 to 6

COMMENTS: Clerical error.

CARD(S) NUMBER: 33001

CHANGE: Field 2: From blank to 1

COMMENTS: Clerical error.

A.5. UK Material Number (NIN) 231 * CALCIUM

A.5.1. Data File Changes

CARD(S) NUMBER: 00001

CHANGE: (a) Field 2: From 5683 to 5695

(b) Field 3: From 38 to 39

(c) Field 6: From 74 to 75

COMMENTS: (a) Change of total number of cards to represent this nuclide including the cards in Section 0.

(b) Number of card in this index, including this card.

(c) The number of RTN sections in this material.

CARD(S) NUMBER: 00035

CHANGE: Field 3: From 95 to 71

COMMENTS: Number of cards in Section 13015.

CARD(S) NUMBER: 00036

CHANGE: Field 5: From 13066 to 13060

COMMENTS: Clerical Error.

CARD(S) NUMBER: 00039

CHANGE: ADD card for new section

Field 1 = 75
Field 2 = 13103 RTN
Field 3 34 number of cards
Field 4)
Field 5) - blank
Field 6)
Field 7 = 23100039 Material number and sequence number.

CARD(S) NUMBER: 21010

CHANGE: Field 1 Energy: From 6.0 to 6.2

COMMENTS: Second neutron energy tabulated is less than the first one in this section. A clerical error.

CARD(S) NUMBER: 26003

CHANGE: Field 3: From 9.001 (MeV) to 9.00010 (MeV)

Field 4: From 1.0 -20 to .2387

COMMENTS: To eliminate repetition of a zero (i.e., 10^{-20}) cross section.

CARD(S) NUMBER: 39010

CHANGE: Field 1: Energy: From 8.0 to 8.2

COMMENTS: Second energy less than first.

CARD(S) NUMBER: 43010

CHANGE: Field 1: Energy: From 8.5 to 8.7

COMMENTS: Second neutron energy less than the first. A clerical error.

CARD(S) NUMBER: 66001

CHANGE: Field 6: Energy: Changed to 6.56

COMMENTS: Energy level corrected.

CARD(S) NUMBER: 67002

CHANGE: (a) Field 1: From 6.0 to 9.00010(MeV)

(b) Field 3: From 94 to 70

COMMENTS: (a) Lower limit of incident neutron energy range (MeV) changed to correspond with RTN 1015, where lowest energy is 9.0 MeV.

(b) Number of cards used to represent this incident neutron energy range, including this card.

CARD(S) NUMBER: 67003 thru 67026

CHANGE: Deleted section of data.

COMMENTS: These were tabulated energy and cross section data for reactions occurring below threshold. (ref. change on control card numbered 67002) Data can now be found under Reaction Type number 13103. Lower energy limit 9.00010 MeV to avoid duplicate photon specification at 9.0 MeV.

CARD(S) NUMBER: 67027

CHANGE: (a) Field 2: From 10 to 7

(b) Field 3: From 9.0 to 9.00010 (MeV)

COMMENTS: (a) Number of sub-sections in the section for this PCN.

(b) First energy at which photon production cross sections are specified.

CARD(S) NUMBER: 67036, 67045, 67055, 67065, 67075, 67085

CHANGE: Field 2: From 10 to 7

COMMENTS: Number of sub-sections in the section for this PCN.

CARD(S) NUMBER: 75001 thru 75035

CHANGE: New section for RTN 13103: (n,p) reaction.

COMMENTS: Data were derived from the original cards 67003 thru 67026 with a change only in the sub-section count parameter.

APPENDIX B: Alterations to the Data in Transforming to ENDF/B

As discussed in Section 2.3., several revisions were made to the data for compatibility with the ENDF/B system. These are documented in detail in this Appendix.

CONTENTS OF APPENDIX B

B.1. ENDF/B Material Number (MAT) 5001 * SODIUM

B.1.1. Data File Changes

B.2. ENDF/B Material Number (MAT) 5002 * MAGNESIUM

B.2.1. Data File Changes

B.3. ENDF/B Mateial Number (MAT) 5004 * CHLORINE

B.3.1. Data File Changes

B.4. ENDF/B Material Number (MAT) 5005 * POTASSIUM

B.4.1. Data File Changes

B.5. ENDF/B Material Number (MAT) 5006 * CALCIUM

B.5.1. Data File Changes

B.1. ENDF/B Material Number (MAT) 5001 * SODIUM

B.1.1. Data File Changes

CARD(S) NUMBER: 695
CHANGE: Field 1: From 2.1710E+06 to 2.1713E+06
COMMENTS: Threshold altered to make consistent with Q value.

CARD(S) NUMBER: 814
CHANGE: Field 1: From 3.8390E+06 to 3.8395E+06
COMMENTS: Threshold....

CARD(S) NUMBER: 869
CHANGE: Field 1: From 4.6250E+06 to 4.6255E+06
COMMENTS: Threshold...

CARD(S) NUMBER: 913
CHANGE: Field 1: From 1.0950E+07 to 1.0959E+07
COMMENTS: Threshold...

CARD(S) NUMBER: 955
CHANGE: Field 2: From -0.620E+7 to -0.627E+7
COMMENTS: Consistency between Q values in File 3, photon energies in File 14, and level energies in File 15.

CARD(S) NUMBER: 966
CHANGE: Field 1: From 7.4220E+06 to 7.4221E+06
COMMENTS: Threshold...

CARD(S) NUMBER: 977
CHANGE: Field 2: From 0.0 to +6.959E+6
COMMENTS: Enter Q value for (n,γ) reaction in MF = 3, MT = 102. (Na is monoisotropic-- ^{23}Na).

CARD(S) NUMBER: 5370
CHANGE: Field 2: From 2.1700E+06 to 2.1713E+06
COMMENTS: Threshold...

CARD(S) NUMBER: 5505

CHANGE: Field 2: From 1.6400E+6 to 1.6408E+6

COMMENTS: Consistency between Q values in File 3, photon energies in File 14, and level energies in File 15.

CARD(S) NUMBER: 5507

CHANGE: Field 2: From 2.1700E+06 to 2.1713E+06

COMMENTS: Threshold....

CARD(S) NUMBER: 5650, 5778

CHANGE: Field 2: From 2.8230E+06 to 2.8240E+06

COMMENTS: Threshold...

CARD(S) NUMBER: 5908, 6027

CHANGE: Field 2: From 3.1140E+06 to 3.1150E+06

COMMENTS: Threshold...

CARD(S) NUMBER: 6148, 6258, 6368, 6478

CHANGE: Field 2: From 3.8380E+06 to 3.8395E+06

COMMENTS: Threshold...

CARD(S) NUMBER: 6590, 6691

CHANGE: Field 2: From 4.0170E+06 to 4.0190E+06

COMMENTS: Threshold...

CARD(S) NUMBER: 6794, 6895, 7249, 7332

CHANGE: Field 2: From 4.0850E+06 to 4.0870E+06

COMMENTS: Threshold...

CARD(S) NUMBER: 7000, 7083, 7166

CHANGE: Field 2: From 4.9860E+06 to 4.9880E+06

COMMENTS: Threshold...

CARD(S) NUMBER: 7419, 7457, 7495, 7533

CHANGE: Field 2: From 7.4220E+06 to 7.4221E+06

COMMENTS: Threshold...

CARD(S) NUMBER:	7579
CHANGE:	Field 2: From 0.23 to 0.33
COMMENTS:	To correct error in Fig. I of Volume 2, (NDL-TR-89, Part II, GA-7829); transition probability array, 3rd level, as referenced in Fig. I.
CARD(S) NUMBER:	7625
CHANGE:	Field I: From 9.00E+6 to 9.05E+6
COMMENTS:	To agree with MF = 3, MT = 15 where cross section is essentially zero until 9.05 MeV.
CARD(S) NUMBER:	7839
CHANGE:	Field 2: From 1.6400E+6 to 1.6408E+6
COMMENTS:	Consistency....
CARD(S) NUMBER:	7851
CHANGE:	Field 2: From 1.9520E+6 to 1.9518E+6
COMMENTS:	Consistency....
CARD(S) NUMBER:	7863
CHANGE:	Field 2: From 2.2660E+6 to 2.2658E+6
COMMENTS:	Consistency....
CARD(S) NUMBER:	7881
CHANGE:	Field 2: From 2.5450E+6 to 2.5448E+6
COMMENTS:	Consistency....
CARD(S) NUMBER:	7893
CHANGE:	Field 2: From 3.2390E+6 to 3.2388E+6
COMMENTS:	Consistency....
CARD(S) NUMBER:	7929
CHANGE:	Field 2: From 3.4760E+6 to 3.4758E+6
COMMENTS:	Consistency....
CARD(S) NUMBER:	7947
CHANGE:	Field 2: From 4.3390E+6 to 4.3388E+6
COMMENTS:	Consistency....

CARD(S) NUMBER: 797i

CHANGE: Field 2: From 3.8800E+6 to 3.8790E+6

COMMENTS: Consistency....

B.2. ENDF/B Material Number (MAT) 5002 * MAGNESIUM

B.2.1. Data File Changes

CARD(S) NUMBER:	888, 1046
CHANGE:	Field 1: From 6.0760E+05 to 6.0823E+05
COMMENTS:	Threshold altered to make consistent with Q value.
CARD(S) NUMBER:	1099
CHANGE:	Field 1: From 1.0150E+06 to 1.0165E+06
COMMENTS:	Consistency between level energies (or Q values) in Files 3, 14, and 15.
CARD(S) NUMBER:	1144
CHANGE:	Field 2: From -1.3678E+06 to -1.3680E+06
COMMENTS:	Threshold....
CARD(S) NUMBER:	1229
CHANGE:	Field 1: From 1.6760E+6 to 1.6779E+6
COMMENTS:	Threshold....
CARD(S) NUMBER:	1265
CHANGE:	Field 1: From 1.8800E+6 to 1.8851E+6
COMMENTS:	Threshold....
CARD(S) NUMBER:	1297
CHANGE:	Field 1: From 2.0400E+6 to 2.0434E+6
COMMENTS:	Threshold....
CARD(S) NUMBER:	1326
CHANGE:	Field 1: From 2.6690E+6 to 2.6715E+6
COMMENTS:	Threshold....
CARD(S) NUMBER:	1345
CHANGE:	Field 1: From 2.8470E+6 to 2.8496E+6
COMMENTS:	Threshold....
CARD(S) NUMBER:	1361
CHANGE:	Field 1: From 2.9160E+6 to 2.9193E+6
COMMENTS:	Threshold....

CARD(S) NUMBER: 1376
CHANGE: Field 1: From 3.0530E+6 to 3.0620E+6
COMMENTS: Threshold....

CARD(S) NUMBER: 1450
CHANGE: Field 1: From 7.6200E+6 to 7.6279E+6
COMMENTS: Threshold....

CARD(S) NUMBER: 1518
CHANGE: Field 2: From -4.23E+06 to -4.232E+06
COMMENTS: Consistency....

CARD(S) NUMBER: 1564
CHANGE: Field 2: From -5.22E+06 to -5.224E+06
COMMENTS: Consistency....

CARD(S) NUMBER: 1566
CHANGE: Field 1: From 5.4400E+6 to 5.4408E+6
COMMENTS: Threshold....

CARD(S) NUMBER: 6686
CHANGE: Field 2: From 1.0150E+6 to 1.0165E+6
COMMENTS: Threshold....

CARD(S) NUMBER: 6991
CHANGE: Field 2: From 1.6760E+6 to 1.6779E+6
COMMENTS: Threshold....

CARD(S) NUMBER: 7058
CHANGE: Field 2: From 1.8800E+6 to 1.8851E+6
COMMENTS: Threshold....

CARD(S) NUMBER: 7116
CHANGE: Field 2: From 2.0400E+6 to 2.0434E+6
COMMENTS: Threshold....

CARD(S) NUMBER: 7165
CHANGE: Field 2: From 3.0530E+6 to 3.0620E+6
COMMENTS: Threshold....

CARD(S) NUMBER: 7194
CHANGE: Field 2: From 3.0530E+6 to 3.0620E+6
COMMENTS: Threshold....

CARD(S) NUMBER: 7223
CHANGE: Field 2: From 2.735E+06 to 2.752E+06
COMMENTS: Consistency....

CARD(S) NUMBER: 7292
CHANGE: Field 2: From 4.4080E+6 to 4.410E+6
COMMENTS: Threshold....

CARD(S) NUMBER: 7357
CHANGE: Field 2: From 4.4080E+6 to 4.410E+6
COMMENTS: Threshold....

CARD(S) NUMBER: 7424
CHANGE: Field 2: From 5.44000+6 to 5.4408E+6
COMMENTS: Threshold....

CARD(S) NUMBER: 7471
CHANGE: Field 2: From 4.6370E+06 to 4.6320E+06
COMMENTS: Consistency....

CARD(S) NUMBER: 7513
CHANGE: Field 1: From 1.3676E+07 to 1.3680E+06
COMMENTS: Consistency....

CARD(S) NUMBER: 7530, 7534, 7538
CHANGE: Field 2: From 1.0 to 0.0
COMMENTS: cf. Section 2.3.2. of text.

CARD(S) NUMBER: 7617
CHANGE: Field 1: From 4.1203E+06 to 4.1260E+6
COMMENTS: Consistency....

CARD(S) NUMBER: 7618
CHANGE: Field 1: From 1.3676E+06 to 1.3680E+6
COMMENTS: Consistency....

CARD(S) NUMBER: 7621

CHANGE: Field 1: From 4.2300E+06 to 4.2320E+06

COMMENTS: Consistency....

CARD(S) NUMBER: 7622

CHANGE: Field 1: From 1.3676E+06 to 1.3680E+06

COMMENTS: Consistency....

CARD(S) NUMBER: 7625

CHANGE: Field 1: From 5.2200E+06 to 5.2240E+06

COMMENTS: Consistency....

CARD(S) NUMBER: 7626

CHANGE: Field 1: From 1.3676E+06 to 1.3680E+06

COMMENTS: Consistency....

CARD(S) NUMBER: 7630

CHANGE: Field 1: From 4.2306E+06 to 4.2320E+6
Field 3: From 4.1203E+06 to 4.1200E+6
Field 5: From 1.3676E+06 to 1.3680E+6

COMMENTS: Consistency....

CARD(S) NUMBER: 7634

CHANGE: Field 1: From 4.2300E+06 to 4.2320E+06
Field 2: From 1.3676E+06 to 1.3680E+06

COMMENTS: Consistency....

CARD(S) NUMBER: 7778

CHANGE: Field 2: From 2.7350E+06 to 2.7520E+06

COMMENTS: Consistency....

CARD(S) NUMBER: 7806

CHANGE: Field 2: From 4.6370E+06 to 4.6320E+06

COMMENTS: Consistency....

CARD(S) NUMBER: 7813

CHANGE: Field 2: From 2.2100E+06 to 2.2080E+06

COMMENTS: Consistency....

CARD(S) NUMBER:	7818
CHANGE:	Field 2: From 5.0700E+06 to 5.0720E+06
COMMENTS:	Consistency....

B.3. ENDF/B Material Number (MAT) 5004 * CHLORINE

B.3.1. Data File Changes

CARD(S) NUMBER:	1278
CHANGE:	Field 2: From -1.6630E+07 to -0.1265E+08
COMMENTS:	Threshold altered to make consistent with Q Value.
CARD(S) NUMBER:	1302
CHANGE:	Field 1: From 6.5500E+06 to 6.5512E+06
COMMENTS:	Threshold...
CARD(S) NUMBER:	1329
CHANGE:	Field 1: From 6.2720E+06 to -6.2736E+06
COMMENTS:	Threshold...
CARD(S) NUMBER:	6451, 6452, 6453, 6454, 6455
CHANGE:	Deleted.
COMMENTS:	MF = 14, MT = 52, 53, 54 Combined and changed to MF = 14, MT = 110.
CARD(S) NUMBER:	6488
CHANGE:	Field 1: From 0.0 to 1.22E+06
COMMENTS:	Clerical Error.
CARD(S) NUMBER:	Sections created using UK Data from RTN numbers 13052, 13053, 13054
COMMENTS:	Excitation of first 3 levels of ^{37}Cl were entered in MT = 110 as photon production cross sections starting at E = 0.0. Other levels (MT = 5-14, 51) are for ^{35}Cl. (Cf. Sec. 2.2.1).

B.4. ENDF/B Material Number (MAT) 5005 * POTASSIUM

B.4.1. Data File Changes

CARD(S) NUMBER: 956

CHANGE: Field 1: From 2.5910E+06 to 2.5912E+06

COMMENTS: Threshold altered to be consistent with Q value

CARD(S) NUMBER: 1201

CHANGE: Field 1: From 6.3700E+06 to 6.3702E+06

COMMENTS: Threshold....

CARD(S) NUMBER: 5570

CHANGE: Field 2: From 3.0990E+06 to 3.1000E+06

COMMENTS: Threshold....

B.5. ENDF/B Material Number (MAT) 5006 * CALCIUM

B.5.1. Data File Changes

CARD(S) NUMBER: 1054
CHANGE: Field 1: From 1.18700E+06 to 1.1872E+06
COMMENTS: Threshold altered to make consistent with Q value.

CARD(S) NUMBER: 1134
CHANGE: Field 1: From 1.1870E+06 to 1.1872E+06
COMMENTS: Threshold....

CARD(S) NUMBER: 1162
CHANGE: Field 1: From 3.4300E+06 to 3.4344E+06
COMMENTS: Threshold....

CARD(S) NUMBER: 1236
CHANGE: Field 1: From 4.5900E+06 to 4.5928E+06
COMMENTS: Threshold....

CARD(S) NUMBER: 1250
CHANGE: Field 1: From 5.4000E+06 to 5.4027E+06
COMMENTS: Threshold...

CARD(S) NUMBER: 1262
CHANGE: Field 1: From 5.7600E+06 to 5.7615E+06
COMMENTS: Threshold...

CARD(S) NUMBER: 1292
CHANGE: Field 1: From 6.7200E+06 to 6.7251E+06
COMMENTS: Threshold...

CARD(S) NUMBER: 1313
CHANGE: Field 1: From 1.028E+07 to 1.0283E+07
COMMENTS: Threshold...

CARD(S) NUMBER: 1374
CHANGE: Field 1: From 8.2900E+06 to 8.2936E+06
COMMENTS: Threshold...

CARD(S) NUMBER: 1382
CHANGE: Field 1: From 8.5800E+06 to 8.5807E+06
COMMENTS: Threshold....

CARD(S) NUMBER: 5120
CHANGE: Field 2: From 3.8240E+06 to 3.8300E+06
COMMENTS: Threshold...

CARD(S) NUMBER: 5521
CHANGE: Field 2: From 5.4000E+06 to 5.4027E+06
COMMENTS: Threshold...

CARD(S) NUMBER: 5604
CHANGE: Field 2: From 5.4000E+06 to 5.4027E+06
COMMENTS: Threshold...

CARD(S) NUMBER: 5689
CHANGE: Field 2: From 5.7600E+06 to 5.7615E+06
COMMENTS: Threshold...

CARD(S) NUMBER: 5763
CHANGE: Field 6: From 8 to 7
COMMENTS: Clerical error

CARD(S) NUMBER: 5764
CHANGE: Field 1: From 8 to 7
COMMENTS: Clerical error.

CARD(S) NUMBER: 5973
CHANGE: Field 2: From 6.7200E+06 to 6.7251E+06
COMMENTS: Threshold . . . .

CARD(S) NUMBER: 6029
CHANGE: Field 2: From 6.7200E+06 to 6.7251E+06
COMMENTS: Threshold...

CARD(S) NUMBER: MF = 14 MT = 15
CHANGE: Added section
COMMENTS: Add isotropic distribution for photons, both discrete and continuum, from (n,p) reactions. Continuum photons from RTN 13015 (cf. section 2.2.3).

APPENDIX C: INDEX'ed Listing of PHOX

The following INDEX'ed listing of PHOX contains only the portions of the code which were written at the University of Virginia and does not include the standard ENDF/B retrieval subroutines distributed by the NNCSC. The INDEX'ed listing includes both the statement numbers and variable names.

```
 ****************************************************************
C*********************************************************************
C*                                                                   *
C*       PHOX-A FORTRAN CODE TO CHECK PHOTON DATA IN ENDF/B DATA FILE *
C*            FORMAT                                                 *
C*                                                                   *
C*       WRITTEN BY                                                  *
C*                                                                   *
C*       JASON M. COOK                                               *
C*       DEPARTMENT OF NUCLEAR ENGINEERING                           *
C*       UNIVERSITY OF VIRGINIA                                      *
C*       THORNTON HALL                                               *
C*       CHARLOTTESVILLE, VA. 22901                                  *
C*            TELEPHONE 703-924-7136                                 *
C*                                                                   *
C*********************************************************************
C
C
C-----THE DATA, IN EITHER STANDARD BINARY ARRANGEMENT(MODE 1) OR BCD
C     CARD IMAGE FORM(MODE 3), IS ON INPUT TAPE NT(I/O UNIT NUMBER).
C
C-----INPUT DATA, 2 CARDS
C
C          CARD 1--NT,MODE,MATW          ENTERED IN (3I11) FORMAT
C               NT-I/O UNIT NUMBER
C               MODE-MODE ARRANGEMENT OF TAPE(EITHER 1 OR 3)
C               MATW-ENDF/B MATERIAL NUMBER OF MATERIAL BEING USED
C
C          CARD--2(ALL ALPHA FIELD)      ENTERED IN (13A6,A2) FORMAT
C               THIS ALLOWS THE USER TO PLACE ANY HEADING HE DESIRES
C               ON THE OUTPUT LISTING.
C
C-----ALL ERROR MESSAGES ARE PRINTED AFTER THE RECORD IN WHICH THE
C     ERROR IS DETECTED.
C
C-----IN ORDER TO FACILITATE THE EASE OF READING THE RETRIVAL SUBROU-
C     TINES AND TO HELP UNDERSTAND THE LOGIC BEHIND THE PROGRAM, THE
C     FOLLOWING VARIABLES, ENDF/B RECORDS, HAVE BEEN DECLARED TO BE
1         INTEGER        BCD,CONT,FEND,HEAD,HOL,SEND,TAB1,TAB2,TEND,TPID
C                        LIST,MEND
C     AND HAVE BEEN ASSIGNED THE VALUES OF
2         BCD  = 3
3         CONT = 1
4         FEND = 1
5         HEAD = 1
6         HOL  = 5
7         LIST = 2
8         MEND = 1
9         SEND = 1
10        TAB1 = 3
11        TAB2 = 4
```

```
      ****************************************************************

      TEND = 1                                                          PHX  51
      TPID = 6                                                          PHX  52
C                                                                       PHX  53
C                                                                       PHX  54
      DIMENSION A(14)                                                   PHX  55
      COMMON/COUN/LG,NC,ND,NE,NI,NK,NP,NTAB,NS1                         PHX  56
      COMMON/RECS/MAT,MF,MT,C1,C2,L1,L2,N1,N2,NBT(100),JNT(100),X(2000),PHX  57
     1               Y(2000),B(2000),N1X,N2X,NS                         PHX  58
      N1X = 100                                                         PHX  59
      N2X = 2000                                                        PHX  60
C                                                                       PHX  61
C-----READ INPUT.                                                       PHX  62
C                                                                       PHX  63
      READ (5,601,END=18) NT,MODE,MATW                                  PHX  64
      READ (5,602,END=18) (A(I),I=1,14)                                 PHX  65
      WRITE (6,603) (A(I),I=1,14)                                       PHX  66
C                                                                       PHX  67
C-----SEARCH FOR FILE 3.                                                PHX  68
C                                                                       PHX  69
      CALL SEARCH(NT,MODE,MATW,3,0,LNT)                                 PHX  70
      BACKSPACE NT                                                      PHX  71
      READ (NT,604) NS                                                  PHX  72
      IF (LNT .EQ. 0) GO TO 2                                           PHX  73
      GO TO 19                                                          PHX  74
C                                                                       PHX  75
C-----PROCESS FILE 3.                                                   PHX  76
C                                                                       PHX  77
    1 CALL RREC(HEAD,NT,MODE,-1.0)                                      PHX  78
    2 CALL WREC(HEAD,6,BCD)                                             PHX  79
      IF (MF .EQ. 0) GO TO 3                                            PHX  80
      AWR = C2                                                          PHX  81
      CALL RREC(TAB1,NT,MODE,-1.0)                                      PHX  82
      CALL WREC(TAB1,6,BCD)                                             PHX  83
      CALL FIL3(AWR)                                                    PHX  84
      CALL RREC(SEND,NT,MODE,-1.0)                                      PHX  85
      CALL WREC(SEND,6,BCD)                                             PHX  86
      GO TO 1                                                           PHX  87
C                                                                       PHX  88
C-----SEARCH FOR FILE 14.                                               PHX  89
C                                                                       PHX  90
    3 CALL SEARCH(NT,MODE,MATW,14,0,LNT)                                PHX  91
      BACKSPACE NT                                                      PHX  92
      READ (NT,604) NS                                                  PHX  93
      IF (LNT .EQ. 0) GO TO 5                                           PHX  94
      GO TO 20                                                          PHX  95
C                                                                       PHX  96
C-----PROCESS FILE 14.                                                  PHX  97
C                                                                       PHX  98
    4 CALL RREC(HEAD,NT,MODE,-1.0)                                      PHX  99
    5 CALL WREC(HEAD,6,BCD)                                             PHX 100
```

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           **********************************************************************

      IF (MF .EQ. 0) GO TO 12                                        PHX 101
      CALL CKHD(MF)                                                  PHX 102
      CALL TEST2C(MT)                                                PHX 103
      IF (L1 .EQ. 1) GO TO 8                                         PHX 104
      IF (L2 .EQ. 1) GO TO 9                                         PHX 105
C                                                                    PHX 106
C     TABULATED FORM                                                 PHX 107
C                                                                    PHX 108
      NTA = ND + NC                                                  PHX 109
      DO 7  J = 1, NTA                                               PHX 110
      CALL RREC(TAB2,NT,MODE,-1,0)                                   PHX 111
      CALL WREC(TAB2,6,BCD)                                          PHX 112
      CALL FIL14(1)                                                  PHX 113
      DO 6  I = 1, NE                                                PHX 114
      CALL RREC(TAB1,NT,MODE,-1,0)                                   PHX 115
      CALL WREC(TAB1,6,BCD)                                          PHX 116
    6 CALL FIL14(2)                                                  PHX 117
    7 CALL FIL14(3)                                                  PHX 118
    8 CALL RREC(SEND,NT,MODE,-1,0)                                   PHX 119
      CALL WREC(SEND,6,BCD)                                          PHX 120
      GO TO 4                                                        PHX 121
C                                                                    PHX 122
C     LEGENDRE POLYNOMIAL FORM                                       PHX 123
C                                                                    PHX 124
    9 NTA = ND + NC                                                  PHX 125
      DO 11  J = 1, NTA                                              PHX 126
      CALL RREC(TAB2,NT,MODE,-1,0)                                   PHX 127
      CALL WREC(TAB2,6,BCD)                                          PHX 128
      CALL FIL14(4)                                                  PHX 129
      DO 10  I = 1, NE                                               PHX 130
      CALL RREC(LIST,NT,MODE,-1,0)                                   PHX 131
      CALL WREC(LIST,6,BCD)                                          PHX 132
   10 CALL FIL14(5)                                                  PHX 133
   11 CALL FIL14(6)                                                  PHX 134
      CALL RREC(SEND,NT,MODE,-1,0)                                   PHX 135
      CALL WREC(SEND,6,BCD)                                          PHX 136
      GO TO 4                                                        PHX 137
C                                                                    PHX 138
C-----PROCESS FILE 15.                                               PHX 139
C                                                                    PHX 140
   12 CALL RREC(HEAD,NT,MODE,-1,0)                                   PHX 141
      CALL WREC(HEAD,6,BCD)                                          PHX 142
      IF (MF .EQ. 0) GO TO 17                                        PHX 143
      CALL CKHD(MF)                                                  PHX 144
      IF (L1 .EQ. 2) GO TO 16                                        PHX 145
C                                                                    PHX 146
C     OPTION 1                                                       PHX 147
C                                                                    PHX 148
      CALL RREC(TAB1,NT,MODE,-1,0)                                   PHX 149
      CALL WREC(TAB1,6,BCD)                                          PHX 150
```

```
      ***********************************************************************
      CALL FIL15(1)                                                     PHX 151
      DO 15  J = 1, NK                                                  PHX 152
      CALL RREC(TAB1,NT,MODE,-1,0)                                      PHX 153
      CALL WREC(TAB1,6,BCD)                                             PHX 154
      IF (L2 .EQ. 2) GO TO 14                                           PHX 155
C                                                                       PHX 156
C     ARBITRARY TABULATED FUNCTION                                      PHX 157
C                                                                       PHX 158
      CALL FIL15(2)                                                     PHX 159
      CALL RREC(TAB2,NT,MODE,-1,0)                                      PHX 160
      CALL WREC(TAB2,6,BCD)                                             PHX 161
      CALL FIL15(3)                                                     PHX 162
      DO 13  I = 1, NE                                                  PHX 163
      CALL RREC(TAB1,NT,MODE,-1,0)                                      PHX 164
      CALL WREC(TAB1,6,BCD)                                             PHX 165
   13 CALL FIL15(4)                                                     PHX 166
      CALL FIL15(5)                                                     PHX 167
      GO TO 15                                                          PHX 168
C                                                                       PHX 169
C     DISCRETE FINAL ENERGY                                             PHX 170
C                                                                       PHX 171
   14 CALL FIL15(6)                                                     PHX 172
   15 CONTINUE                                                          PHX 173
      CALL FIL15(7)                                                     PHX 174
      CALL RREC(SEND,NT,MODE,-1,0)                                      PHX 175
      CALL WREC(SEND,6,BCD)                                             PHX 176
      GO TO 12                                                          PHX 177
C                                                                       PHX 178
C     OPTION 2                                                          PHX 179
C                                                                       PHX 180
   16 CALL RREC(LIST,NT,MODE,-1,0)                                      PHX 181
      CALL WREC(LIST,6,BCD)                                             PHX 182
      CALL FIL15(8)                                                     PHX 183
      CALL RREC(SEND,NT,MODE,-1,0)                                      PHX 184
      CALL WREC(SEND,6,BCD)                                             PHX 185
      GO TO 12                                                          PHX 186
   17 CALL ESEGPR(5)                                                    PHX 187
      STOP                                                              PHX 188
   18 WRITE (6,605)                                                     PHX 189
      STOP                                                              PHX 190
   19 WRITE (6,606) NT,MODE,MATW                                        PHX 191
      STOP                                                              PHX 192
   20 WRITE (6,607)                                                     PHX 193
      STOP                                                              PHX 194
  601 FORMAT (3I11)                                                     PHX 195
  602 FORMAT (13A6,A2)                                                  PHX 196
  603 FORMAT (1X,13A6,A2//)                                             PHX 197
  604 FORMAT (75X,I5)                                                   PHX 198
  605 FORMAT (15(1H*),16H NO CARD INPUT. ,79(1H*))                      PHX 199
  606 FORMAT (15(1H*),19H FILE 3 NOT FOUND. ,6H NT = ,I2,8H MODE = ,I1,7PHX 200
```

```
     ************************************************************************
          1H MAT = ,I4,51(1H*))                                         PHX 201
      607 FORMAT (1H1,14(1H*),20H FILE 14 NOT FOUND. ,75(1H*))          PHX 202
          END                                                           PHX 203-
```

```
I N D E X                                                                                      PAGE    6
          ****************************************************************************

SYMBOL     = = = = = = = = = = = = = = =    REFERENCES    = = = = = = = = = = = = = = =

1        -   27*     36
2        -   25      28*
3        -   29      37*
4        -   42*     61      74
5        -   40      43*
6        -   54      57*
7        -   50      58*
8        -   47      59*
9        -   48      62*
10       -   67      70*
11       -   63      71*
12       -   44      75*     102     108
13       -   91      94*
14       -   66      97*
15       -   83      96      98*
16       -   79      103*
17       -   77      109*
18       -  111*
19       -   26      113*
20       -   41      115*
601      -   19RD    117*
602      -   20RD    118*
603      -   21WR    119*
604      -   24RD    39RD    120*
605      -  111WR    121*
606      -  113WR    122*
607      -  115WR    123*
A        -   14DI    20RD    21WR
AWR      -   30=     33AG
B        -   16CO
BCD      -    1IN     2=     28AG    32AG    35AG    43AG    52AG    56AG    60AG    65AG
             69AG    73AG    76AG    81AG    85AG    89AG    93AG   101AG   104AG   107AG
C1       -   16CO
C2       -   16CO    30
CKHD     -   45      78
CONT     -    1IN     3=
COUN     -   15CO
END      -   19RD    20RD
ESEGPR   -  109
FEND     -    1IN     4=
FIL14    -   53      57      58      66      70      71
FIL15    -   62      87      90      94      95      97      99      105
FIL3     -   33
HEAD     -    1IN     5=     27AG    28AG    42AG    43AG    75AG    76AG
HOL      -    1IN     6=
I        -   20RD    21WR    54      67      91
J        -   50      63      83
JNT      -   16CO
```

```
        ********************************************************************

L1      -    16CD    47      79
L2      -    16CD    48      86
LG      -    15CD
LIST    -     7=     68AG    69AG    103AG   104AG
LNT     -    25      40
MAT     -    16CD
MATW    -    19RD    22AG    37AG    113WR
MEND    -     8=
MF      -    16CD    29      44      45AG    77      78AG
MODE    -    19RD    22AG    27AG    31AG    34AG    37AG    42AG    51AG    55AG    59AG
             64AG    68AG    72AG    75AG    80AG    84AG    88AG    92AG    100AG   103AG
             106AG   113WR
MT      -    16CD    46AG
N1      -    16CD
N1X     -    16CD    17=
N2      -    16CD
N2X     -    16CD    18=
NBT     -    16CD
NC      -    15CD    49      62
ND      -    15CD    49      62
NE      -    15CD    54      67      91
NI      -    15CD
NK      -    15CD    83
NP      -    15CD
NS      -    16CD    24RD    39RD
NS1     -    15CD
NT      -    19RD    22AG    23      24RD    27AG    31AG    34AG    37AG    38      39RD
             42AG    51AG    55AG    59AG    64AG    68AG    72AG    75AG    80AG    84AG
             88AG    92AG    100AG   103AG   106AG   113WR
NTA     -    49=     50      62=     63
NTAB    -    15CD
RECS    -    16CD
RREC    -    27      31      34      42      51      55      59      64      68      72
             75      80      84      88      92      100     103     106
SEARCH  -    22      37
SEND    -     1IN     9=     34AG    35AG    59AG    60AG    72AG    73AG    100AG   101AG
             106AG   107AG
STOP    -    110     112     114     116
TAB1    -     1IN    10=     31AG    32AG    55AG    56AG    80AG    81AG    84AG    85AG
             92AG    93AG
TAB2    -     1IN    11=     51AG    52AG    64AG    65AG    88AG    89AG
TEND    -     1IN    12=
TEST2C  -    46
TPID    -     1IN    13=
WREC    -    28      32      35      43      52      56      60      65      69      73
             76      81      85      89      93      101     104     107
X       -    16CD
Y       -    16CD

-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
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```
  1           SUBROUTINE CKHD(FILE)
  2           COMMON/COUN/LG,NC,ND,ME,NI,NK,NP,NTAB,NS1
  3           COMMON/RECS/MAT,MF,MT,C1,C2,L1,L2,N1,N2,NBT(100),JNT(100),X(2000),
             1            Y(2000),B(2000),N1X,N2X,NS
  4           IF (FILE .NE. 14) GO TO 4
        C
        C-----CHECK FILE 14 HEAD CARD.
        C     CHECK LI.
        C
  5           IF (L1.EQ.0 .OR. L1.EQ.1) GO TO 1
  6           WRITE (6,601)
  7           L1 = 0
        C
        C     CHECK LTT.
        C
  8         1 IF (L2.EQ.1 .OR. L2.EQ.2) GO TO 2
  9           WRITE (6,602)
 10           L2 = 2
        C
        C     CHECK ND.
        C
 11         2 IF (N1 .GT. (MT-4)) WRITE (6,603)
        C
        C     CHECK NC.
        C
 12           IF (N2.EQ.0 .OR. N2.EQ.1) GO TO 3
 13           WRITE (6,604)
 14           N2 = 1
 15         3 ND = N1
 16           NC = N2
 17           RETURN
 18         4 IF (FILE .NE. 15) GO TO 10
        C
        C-----CHECK FILE 15 HEAD CARD.
        C     CHECK LO.
        C
 19           IF (L1 .EQ. 2) GO TO 7
 20           IF (L1 .EQ. 1) GO TO 5
 21           WRITE (6,605)
 22           L1 = 1
 23         5 IF (L2 .NE. 0) WRITE (6,606)
        C
        C     CHECK ND.
        C
 24           IF (N1 .GT. (MT-4)) WRITE (6,603)
        C
        C     CHECK NK.
        C
 25           IF (N2 .GE. N1) GO TO 6
 26           WRITE (6,607)
```

```
 27          N2 = N1                                                     CHD  51
 28        6 ND = N1                                                     CHD  52
 29          NK = N2                                                     CHD  53
 30          RETURN                                                      CHD  54
       C                                                                 CHD  55
       C     CHECK LG.                                                   CHD  56
       C                                                                 CHD  57
 31        7 IF (L2.EQ.1 .OR. L2.EQ.2) GO TO 8                           CHD  58
 32          WRITE (6,608)                                               CHD  59
 33          L2 = 3                                                      CHD  60
       C                                                                 CHD  61
       C     CHECK NS.                                                   CHD  62
       C                                                                 CHD  63
 34        8 IF (N1 .LE. (MT-4)) GO TO 9                                 CHD  64
 35          WRITE (6,609)                                               CHD  65
 36          NS1 = MT -4                                                 CHD  66
 37        9 IF (N2 .NE. 0) WRITE (6,610)                                CHD  67
 38          LG = L2                                                     CHD  68
 39          RETURN                                                      CHD  69
 40       10 WRITE (6,611)                                               CHD  70
 41          RETURN                                                      CHD  71
 42      601 FORMAT (15(1H*), 46H LI NOT IN DEFINED RANGE.  LI SET EQUAL TO 0. CHD  72
            1, 49(1H*))                                                  CHD  73
 43      602 FORMAT (15(1H*), 48H LTT NOT IN DEFINED RANGE.  LTT SET EQUAL TO 2CHD  74
            1. , 47(1H*))                                                CHD  75
 44      603 FORMAT (15(1H*), 84H ND LARGER THAN STATE LEVEL WILL ALLOW.  WILL CHD  76
            1CONTINUE PROCESSING WITH ND AS GIVEN. , 11(1H*))            CHD  77
 45      604 FORMAT (15(1H*), 46H NC NOT IN DEFINED RANGE.  NC SET EQUAL TO 1. CHD  78
            1, 49(1H*))                                                  CHD  79
 46      605 FORMAT (15(1H*), 46H LO NOT IN DEFINED RANGE.  LO SET EQUAL TO 1. CHD  80
            1, 49(1H*))                                                  CHD  81
 47      606 FORMAT (15(1H*), 27H FOURTH FIELD SHOULD BE 0. , 68(1H*))   CHD  82
 48      607 FORMAT (15(1H*), 42H ND GREATER THAN NK.  NK SET EQUAL TO ND. , 64CHD  83
            1(1H*))                                                      CHD  84
 49      608 FORMAT (15(1H*),73H LG NOT IN DEFINED RANGE.  PROCESSING OF THIS SCHD  85
            1ECTION WILL BE ATTAMPTED. ,22(1H*))                         CHD  86
 50      609 FORMAT (15(1H*), 70H NS LARGER THAN STATE LEVEL WILL ALLOW.  NS SECHD  87
            1T EQUAL TO STATE LEVEL. , 25(1H*))                          CHD  88
 51      610 FORMAT (15(1H*), 26H SIXTH FIELD SHOULD BE 0. , 69(1H*))    CHD  89
 52      611 FORMAT (15(1H*),36H HEAD CARD NOT PROCESSED DUE TO MF. ,59(1H*))  CHD  90
 53          END                                                         CHD  91-
```

SUBROUTINE CKHD(FILE)

SYMBOL		= = = = = = = = = = = = = = =			REFERENCES		= = = = = = = = = = = = = = =
1	-	5	8*						
2	-	8	11*						
3	-	12	15*						
4	-	4	18*						
5	-	20	23*						
6	-	25	28*						
7	-	19	31*						
8	-	31	34*						
9	-	34	37*						
10	-	18	40*						
601	-	6WR	42*						
602	-	9WR	43*						
603	-	11WR	24WR	44*					
604	-	13WR	45*						
605	-	21WR	46*						
606	-	23WR	47*						
607	-	26WR	48*						
608	-	32WR	49*						
609	-	35WR	50*						
610	-	37WR	51*						
611	-	40WR	52*						
B	-	3CO							
C1	-	3CO							
C2	-	3CO							
CKHD	-	1							
COUN	-	2CO							
FILE	-	1AG	4	18					
JNT	-	3CO							
L1	-	3CO	5	7=	19	20	22=		
L2	-	3CO	8	10=	23	31	33=	38	
LG	-	2CO	38=						
MAT	-	3CO							
MF	-	3CO							
MT	-	3CO	11	24	34	36			
N1	-	3CO	11	15	24	25	27	28	34
N1X	-	3CO							
N2	-	3CO	12	14=	16	25	27=	29	37
N2X	-	3CO							
NBT	-	3CO							
NC	-	2CO	16=						
ND	-	2CO	15=	28=					
NE	-	2CO							
NI	-	2CO							
NK	-	2CO	29=						
NP	-	2CO							
NS	-	3CO							
NS1	-	2CO	36=						
NTAB	-	2CO							

SUBROUTINE CKHD(FILE)

```
RECS     -      300
RETURN   -      17       30       39       41
X        -      300
Y        -      300
```

-+

SUBROUTINE FIL3(AWR)

```
      SUBROUTINE FIL3(AWR)
      COMMON/RECS/MAT,MF,MT,C1,C2,L1,L2,N1,N2,NBT(100),JNT(100),X(2000),
     1              Y(2000),B(2000),N1X,N2X,NS
      COMMON/SAVE/ETH(300),Q(300),ETAB(2000),YTAB(2000),YKTAB(2000),
     1              YCAL(2000),YTIL(2000),EK(2000),YK(2000),ES(40)
C
C-----TEST Q.
C
      IF (MT.LE.4 .OR. (MT.GE.15 .AND. MT.LE.50) .OR. MT.GE.81) GO TO 1
      IF (C2 .GE. 0.0) WRITE (6,601)
      IF (ABS(C2).LT.1.0*10**4 .OR. ABS(C2).GT.2.0*10**7) WRITE (6,602)
    1 IF (MT.NE.15 .AND. MT.NE.110) GO TO 2
      IF (C2 .EQ. 0.0) GO TO 2
      WRITE (6,603)
      C2 = 0.0
    2 IF (MT .NE. 102) GO TO 3
      IF (C2 .LT. 0.0) WRITE (6,604)
      IF (C2.NE.0 .AND. (C2.LT.1.7*10**6 .OR. C2.GT.1.2*10**7)) WRITE (6
     1,605)
C
C-----CALCULATE AND TEST THRESHOLD.
C
    3 ETHEO = (AWR+1)*ABS(C2)/AWR
      IF (C2 .GT. 0.0) ETHEO = 0.0
      IF (ETHEO.GT.X(1) .AND. C2.LT.0.0) WRITE (6,606) ETHEO
C
C-----STORE Q AND THRESHOLD.
C
      Q(MT)=C2
      ETH(MT) = X(1)
      IF (ETHEO .GT. X(1)) ETH(MT) = ETHEO
C
C-----CALCULATE 2200 M/SEC CROSS SECTION, MT = 102.
C
      IF (MT .NE. 102) GO TO 8
      K = 0
      IF (X(1) .GT. 0.0253) GO TO 9
      DO 4  I = 1, N2
      K = K + 1
      IF (X(I) .EQ. 0.0253) GO TO 5
    4 IF (X(I).LT.0.0253 .AND. X(I+1).GT.0.0253) GO TO 6
    5 WRITE (6,607) Y(K)
      GO TO 8
    6 DO 7  I = 1, N1
    7 IF (K .LE. NBT(I)) INT = JNT(I)
      ENG = 0.0253
      CALL TERP1(X(K),Y(K),X(K+1),Y(K+1),ENG,SIGMA,INT)
      WRITE (6,607) SIGMA
    8 RETURN
    9 WRITE (6,608)
```

```
 36           RETURN                                                           F 3  51
 37       601 FORMAT (15(1H*),28H Q SHOULD BE LESS THAN 0.0, ,67(1H*))         F 3  52
 38       602 FORMAT(15(1H*),46H Q SHOULD BE IN THE RANGE 1.0E+04 TO 2.0E+07. ,4F 3  53
             19(1H*))                                                          F 3  54
 39       603 FORMAT (15(1H*),76H Q SHOULD BE EQUAL TO 0.0.  Q SET EQUAL TO 0.0 F 3  55
             1FOR REMAINDER OF PROCESSING. ,19(1H*))                           F 3  56
 40       604 FORMAT (15(1H*),43H Q SHOULD BE GREATER THAN OR EQUAL TO 0.0. ,52(F 3  57
             11H*))                                                            F 3  58
 41       605 FORMAT (15(1H*),74H WHEN Q IS NOT EQUAL TO 0.0, Q SHOULD BE IN THEF 3  59
             1 RANGE 1.7E+06 TO 1.2E+07. ,21(1H*))                             F 3  60
 42       606 FORMAT (15(1H*),65H EFFECTIVE THRESHOLD VALUE BELOW THEORETICAL ALF 3  61
             1LOWED BY Q VALUE. ,30(1H*)/15(1H*),15H THEORETICAL = ,1PE12.5,38X,F 3  62
             230(1H*))                                                         F 3  63
 43       607 FORMAT (81(1H*),15H SIGMA(2200) = ,1PE12.5,2H B)                 F 3  64
 44       608 FORMAT (81(1H*),29H SIGMA(2200) = DATA NOT GIVEN)                F 3  65
 45           END                                                              F 3  66-
```

SUBROUTINE FIL3(AWR)

SYMBOL		REFERENCES									
1	-	4	7*								
2	-	7	8	11*							
3	-	11	14*								
4	-	23	26*								
5	-	25	27*								
6	-	26	29*								
7	-	29	30*								
8	-	20	28	34*							
9	-	22	35*								
601	-	5WR	37*								
602	-	6WR	38*								
603	-	9WR	39*								
604	-	12WR	40*								
605	-	13WR	41*								
606	-	16WR	42*								
607	-	27WR	33WR	43*							
608	-	35WR	44*								
ABS	-	6	14								
AWR	-	1AG	14								
B	-	2CO									
C1	-	2CO									
C2	-	2CO	5	6	8	10=	12	13	14	15	16
		17									
EK	-	3CO									
ENG	-	31=	32AG								
ES	-	3CO									
ETAB	-	3CO									
ETH	-	3CO	18=	19=							
ETHEO	-	14=	15=	16	19						
FIL3	-	1									
I	-	23	25	26	29	30					
INT	-	30=	32AG								
JNT	-	2CO	30								
K	-	21=	24=	27WR	30	32AG					
L1	-	2CO									
L2	-	2CO									
MAT	-	2CO									
MF	-	2CO									
MT	-	2CO	4	7	11	17	18	19	20		
N1	-	2CO	29								
N1X	-	2CO									
N2	-	2CO	23								
N2X	-	2CO									
NBT	-	2CO	30								
NS	-	2CO									
Q	-	3CO	17=								
RECS	-	2CO									
RETURN	-	34	36								

SUBROUTINE FIL3(AWR)

SAVE	-	3CO							
SIGMA	-	32AG	33WR						
TERP1	-	32							
X	-	2CO	16	18	19	22	25	26	32AG
Y	-	2CO	27WR	32AG					
YCAL	-	3CO							
YK	-	3CO							
YKTAB	-	3CO							
YTAB	-	3CO							
YTIL	-	3CO							

-+

SUBROUTINE FIL14(N)

```
  1          SUBROUTINE FIL14(N)
  2          COMMON/COUN/LG,NC,ND,NE,NI,NK,NP,NTAB,NS1
  3          COMMON/RECS/MAT,MF,MT,C1,C2,L1,L2,N1,N2,NBT(100),JNT(100),X(2000),
            1         Y(2000),B(2000),N1X,N2X,NS
  4          COMMON/SAVE/ETH(300),Q(300),ETAB(2000),YTAB(2000),YKTAB(2000),
            1         YCAL(2000),YTIL(2000),EK(2000),YK(2000),ES(40)
  5          COMMON/SAV14/EG,EN,ESI,IL,IN
  6          GO TO (1,6,9,1,10,9), N
       C
       C-----TEST TAR2 RECORD.
       C
  7        1 NE = N2
  8          CALL ESEGPR(1)
  9          IF ((MT.GE.5 .AND. MT.LE.14) .OR. (MT.GE.51 .AND. MT.LE.80)) GO TO
            1 2
       C
       C     MT IN RANGE 1-4, 15-50, 81-UP
       C     TEST ES AND EGI.
       C
 10          IF (C2 .LT. 0.0) WRITE (6,601)
 11          IF (C1 .LT. 0.0) WRITE (6,602)
 12          IF (C1.NE.0.0 .AND. C2.GT.C1) WRITE (6,603)
       C
       C     TEST FOR CONTINUOUS SPECTRUM.
       C
 13          EG = 1.0
 14          IF (MT .EQ. 110) GO TO 5
 15          IF (C1.NE.0.0 .OR. C2.NE.0.0) GO TO 5
 16          IL = IL + 1
 17          IF (IL.EQ.1 .AND. NC.NE.1) WRITE (6,604)
 18          IF (IL .GT. 1) WRITE (6,605)
 19          GO TO 5
       C
       C     MT IN RANGE 5-14, 51-80
       C     TEST ES AND EGI.
       C
 20        2 IF (C2 .GE. 0.0) GO TO 3
 21          WRITE (6,601)
 22          IF (C1 .LT. 0.0) WRITE (6,602)
 23        3 IF (C1 .LT. C2) WRITE (6,603)
 24          IF (C1 .NE. ABS(Q(MT))) WRITE (6,606)
       C
       C     TEST ORDER OF ES AND EGI.
       C
 25          IN = IN + 1
 26          IF (IN .GT. 1) GO TO 4
 27          ESI = C1
 28          EG = C2
 29          GO TO 5
 30        4 IF (C1 .NE. ESI) WRITE (6,607)
```

```
      IF (C2 .GE. EG) WRITE (6,608)
      EG = C2
C
C     CHECK INTERPOLATION SCHEME
C
    5 IF (N2 .LE. N1) WRITE (6,609)
      IF (N1.NE.1 .OR. JNT(1).NE.2) WRITE (6,610)
      RETURN
C
C------TEST TAB1 RECORD.
C     TABULATED FORM
C
    6 IF (N1.NE.1 .OR. JNT(1).NE.2) WRITE (6,611)
      IF (ETH(MT) .GT. C2) WRITE (6,612) ETH(MT)
      IF (C2 .LE. EN) WRITE (6,613)
      EN = C2
      DO 7  I = 1, N2
    7 IF (Y(I).LT.0.499 .OR. Y(I).GT.0.501) GO TO 8
      IF (N2 .NE. 2) WRITE (6,614)
    8 RETURN
C
C------RE-INITIALIZE.
C
    9 IF (NC.EQ.1 .AND. IL.EQ.0) WRITE (6,615)
      IF (EG.EQ.0.0 .AND. IL.EQ.0) WRITE (6,616)
      IF (((MT.GE.5 .AND. MT.LE.14) .OR. (MT.GE.51 .AND. MT.LE.80)) .AND
     1. NC.EQ.1) WRITE (6,617)
      EG = 0.0
      EN = 0.0
      EGI = 0.0
      IL = 0
      IN = 0
      RETURN
C
C------TEST TAB1 RECORD.
C     LEGENDRE POLYNOMIAL FORM
C
   10 IF (ETH(MT) .GT. C2) WRITE (6,612) ETH(MT)
      IF (C2 .LE. EN) WRITE (6,613)
      EN = C2
      RETURN
  601 FORMAT (15(1H*),45H EGI SHOULD BE GREATER THAN OR EQUAL TO 0.0. ,5
     10(1H*))
  602 FORMAT (15(1H*),44H ES SHOULD BE GREATER THAN OR EQUAL TO 0.0. ,51
     1(1H*))
  603 FORMAT (15(1H*),44H ES SHOULD BE GREATER THAN OR EQUAL TO EGI. ,51
     1(1H*))
  604 FORMAT (15(1H*),45H FOR A CONTINUOUS SPECTRUM, NC MUST EQUAL 1. ,5
     10(1H*))
  605 FORMAT (15(1H*),49H ONLY 1 CONTINUOUS SPECTRUM PER SECTION ALLOWED
```

```
              1. ,46(1H*))                                                    F14 101
   62      606 FORMAT (15(1H*),48H ES SHOULD BE EQUAL TO THE ABSOLUTE VALUE OF Q.F14 102
              1 ,47(1H*))                                                     F14 103
   63      607 FORMAT (15(1H*),25H ALL ES SHOULD BE EQUAL. ,73(1H*))          F14 104
   64      608 FORMAT (15(1H*),33H EGI MUST BE IN DECENDING ORDER. ,62(1H*))  F14 105
   65      609 FORMAT (15(1H*),29H NP MUST BE GREATER THAN NR. ,65(1H*))      F14 106
   66      610 FORMAT (15(1H*),72H INTERPOLATION SCHEME IS REQUIRED TO BE LINEAR F14 107
              1THROUGHOUT ENTIRE RANGE. ,23(1H*))                             F14 108
   67      611 FORMAT (15(1H*),64H INTERPOLATION SCHEME SHOULD BE LINEAR THROUGHOF14 109
              1UT ENTIRE RANGE. ,31(1H*))                                     F14 110
   68      612 FORMAT (15(1H*),68H INCIDENT NEUTRON ENERGY LESS THAN EFFECTIVE THF14 111
              1RESHOLD IN FILE 3( = ,1PE12.5,3H). ,12(1H*))                   F14 112
   69      613 FORMAT (15(1H*),55H INCIDENT NEUTRON ENERGIES MUST BE IN ASCENDINGF14 113
              1 ORDER. ,40(1H*))                                              F14 114
   70      614 FORMAT (15(1H*),47H DISTRIBUTION SHOULD BE ENTERED ISOTROPICALLY. F14 115
              1,48(1H*))                                                      F14 116
   71      615 FORMAT (15(1H*),54H FOR NC EQUAL 1, THERE MUST BE A CONTINUOUS SPEF14 117
              1CTRUM. ,41(1H*))                                               F14 118
   72      616  FORMAT (15(1H*),37H FOR EGI EQUAL TO 0.0, NC MUST BE 1. ,58(1H*))F14 119
   73      617 FORMAT (15(1H*),54H THERE CAN BE NO CONTINUOUS SPECTRUM IN THIS SEF14 120
              1CTION. ,41(1H*))                                               F14 121
   74          END                                                            F14 122-
```

SUBROUTINE FIL14(N)

SYMBOL		REFERENCES									
1	-	6	7*								
2	-	9	20*								
3	-	20	23*								
4	-	26	30*								
5	-	14	15	19	29	33*					
6	-	6	36*								
7	-	40	41*								
8	-	41	43*								
9	-	6	44*								
10	-	6	53*								
601	-	10WR	21WR	57*							
602	-	11WR	22WR	58*							
603	-	12WR	23WR	59*							
604	-	17WR	60*								
605	-	18WR	61*								
606	-	24WR	62*								
607	-	30WR	63*								
608	-	31WR	64*								
609	-	33WR	65*								
610	-	34WR	66*								
611	-	36WR	67*								
612	-	37WR	53WR	68*							
613	-	38WR	54WR	69*							
614	-	42WR	70*								
615	-	44WR	71*								
616	-	45WR	72*								
617	-	46WR	73*								
ABS	-	24									
B	-	3C0									
C1	-	3C0	11	12	15	22	23	24	27	30	
C2	-	3C0	10	12	15	20	23	28	31	32	37
		38	39	53	54	55					
COUN	-	2C0									
EG	-	5C0	13=	28=	31	32=	45	47=			
EK	-	4C0									
EN	-	5C0	38	39=	48=	54	55=				
ES	-	4C0									
ESEGPR	-	8									
ESI	-	5C0	27=	30	49=						
ETAB	-	4C0									
ETH	-	4C0	37	53							
FIL14	-	1									
I	-	40	41								
IL	-	5C0	16=	17	18	44	45	50=			
IN	-	5C0	25=	26	51=						
JNT	-	3C0	34	36							
L1	-	3C0									
L2	-	3C0									

SUBROUTINE FIL14(N)

LG	-	2C0							
MAT	-	3C0							
MF	-	3C0							
MT	-	3C0	9	14	24	37	46	53	
N	-	1AG	6						
N1	-	3C0	33	34	36				
N1X	-	3C0							
N2	-	3C0	7	33	40	42			
N2X	-	3C0							
NBT	-	3C0							
NC	-	2C0	17	44	46				
ND	-	2C0							
NE	-	2C0	7=						
NI	-	2C0							
NK	-	2C0							
NP	-	2C0							
NS	-	3C0							
NS1	-	2C0							
NTAB	-	2C0							
Q	-	4C0	24						
RECS	-	3C0							
RETURN	-	35	43	52	56				
SAV14	-	5C0							
SAVE	-	4C0							
X	-	3C0							
Y	-	3C0	41						
YCAL	-	4C0							
YK	-	4C0							
YKTAB	-	4C0							
YTAB	-	4C0							
YTIL	-	4C0							

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SUBROUTINE FIL15(N)

```
      SUBROUTINE FIL15(N)                                               F15   1
      COMMON/COUN/LG,NC,ND,NE,NI,NK,NP,NTAB,NS1                         F15   2
      COMMON/RECS/MAT,MF,MT,C1,C2,L1,L2,N1,N2,NBT(100),JNT(100),X(2000),F15   3
     1            Y(2000),B(2000),N1X,N2X,NS                            F15   4
      COMMON/SAVE/ETH(300),Q(300),ETAB(2000),YTAB(2000),YKTAB(2000),    F15   5
     1            YCAL(2000),YTIL(2000),EK(2000),YK(2000),ES(40)        F15   6
      COMMON/SAV15/A(2000)                                              F15   7
      GO TO (1,3,10,11,13,19,26,29), N                                  F15   8
C                                                                       F15   9
C-----STORE TABULATED ENERGIES AND YIELDS.                              F15  10
C                                                                       F15  11
    1 DO 2 I = 1, N2                                                    F15  12
      ETAB(I) = X(I)                                                    F15  13
    2 YTAB(I) = Y(I)                                                    F15  14
      NTAB = N2                                                         F15  15
      IF (ETAB(1) .LT. ETH(MT)) WRITE (6,601) ETH(MT)                   F15  16
      RETURN                                                            F15  17
C                                                                       F15  18
C-----LF = 1                                                            F15  19
C     STORE SECTION ENERGIES AND YIELD.                                 F15  20
C                                                                       F15  21
    3 DO 4 I = 1, N2                                                    F15  22
      EK(I) = X(I)                                                      F15  23
    4 YK(I) = Y(I)                                                      F15  24
      NP = N2                                                           F15  25
C                                                                       F15  26
C     TEST ENERGIES.                                                    F15  27
C                                                                       F15  28
      IF (EK(1) .LT. ETH(MT)) WRITE (6,601) ETH(MT)                     F15  29
      IF (EK(1).LT.ETAB(1) .OR. EK(NP).GT.ETAB(NTAB)) WRITE (6,602)     F15  30
      CALL ESEGPR(2)                                                    F15  31
C                                                                       F15  32
C     CALCULATE SECTION YIELDS FOR TABULATED ENERGIES.                  F15  33
C                                                                       F15  34
      DO 9 I = 1, NTAB                                                  F15  35
      L = N2 - 1                                                        F15  36
      K = 0                                                             F15  37
      DO 5 J = 1, L                                                     F15  38
      K = K + 1                                                         F15  39
      IF (EK(J) .EQ. ETAB(I)) GO TO 6                                   F15  40
    5 IF (EK(J).LT.ETAB(I) .AND. EK(J+1).GT.ETAB(I)) GO TO 7            F15  41
      K = K + 1                                                         F15  42
      IF (EK(N2) .EQ. ETAB(I)) GO TO 6                                  F15  43
      GO TO 9                                                           F15  44
    6 YKTAB(I) = YK(K)                                                  F15  45
      GO TO 9                                                           F15  46
    7 DO 8 J = 1, N1                                                    F15  47
    8 IF (K .LE. NBT(J)) INT = JNT(J)                                   F15  48
      CALL TERP1(EK(K),YK(K),EK(K+1),YK(K+1),ETAB(I),YKTAB(I),INT)      F15  49
    9 YCAL(I) = YCAL(I) + YKTAB(I)                                      F15  50
```

```
36              RETURN
          C
          C-----TEST TAB2 RECORD.
          C
37           10 NE = N2
38              IF (NE .NE. NP) WRITE (6,603)
39              IF (N1.NE.1 .OR. JNT(1).NE.2) WRITE (6,604)
40              RETURN
          C
          C     CALCULATE TOTAL YIELD.
          C
41           11 NI = NI + 1
          C
          C     TEST ENERGIES.
          C
42              IF (C2 .LT. ETH(MT)) WRITE (6,605) ETH(MT)
43              IF (C2 .LT. EK(NI)) WRITE (6,606)
44              L = N2 - 1
          C
          C     INTEGRATE PHOTON YIELD PROBABILITIES.
          C
45              DO 12 I = 1, L
46              A1 = A1 + (X(I+1)-X(I))*(Y(I+1)+Y(I))/2.0
47           12 A2 = A2 + (X(I+1)-X(I))*(X(I+1)*Y(I+1)+X(I)*Y(I))/2.0
48              IF (ABS(A1-1.0000) .GT. 0.0001) WRITE (6,607) A1
49              A(NI) = A2/A1
50              A2 = 0.0
51              A1 = 0.0
52              RETURN
53           13 DO 18  I = 1, NTAB
54              L = N2 - 1
55              K = 0
56              DO 14  J = 1, L
57              K = K + 1
58              IF (EK(J) .EQ. ETAB(I)) GO TO 15
59           14 IF (EK(J).LT.ETAB(I) .AND. EK(J+1).GT.ETAB(I)) GO TO 16
60              K = K + 1
61              IF (EK(N2) .EQ. ETAB(I)) GO TO 15
62              GO TO 17
63           15 A3 = A(K)
64              GO TO 17
65           16 CALL TERP1(EK(K),A(K),EK(K+1),A(K+1),ETAB(I),A3,2)
66           17 YTIL(I) = YTIL(I) + YKTAB(I)*A3
67           18 A3 = 0.0
68              RETURN
          C
          C-----LF = 2
          C     TEST ENERGIES.
          C
69           19 IF (X(1) .LT. ETH(MT)) WRITE (6,601) ETH(MT)
```

```
      IF (X(1).LT.ETAB(1) .OR. X(N2).GT.ETAB(NTAB)) WRITE (6,602)
      CALL ESEGPR(2)
C
C     CALCULATE SECTION YEILDS FOR TABULATED ENERGIES.
C
      DO 25  I = 1, NTAB
      L = N2 - 1
      K = 0
      DO 20 J = 1, L
      K = K + 1
      IF (X(J) .EQ. ETAB(I)) GO TO 21
   20 IF (X(J).LT.ETAB(I) .AND. X(J+1).GT.ETAB(I)) GO TO 22
      K = K + 1
      IF (X(N2) .EQ. ETAB(I)) GO TO 21
      GO TO 24
   21 YKTAB(I) = Y(K)
      GO TO 24
   22 DO 23  J = 1, N1
   23 IF (K .LE. NBT(J)) INT = JNT(J)
      CALL TERP1(X(K),Y(K),X(K+1),Y(K+1),ETAB(I),YKTAB(I),INT)
C
C     CALCULATE TOTAL YIELD.
C
   24 YCAL(I) = YCAL(I) + YKTAB(I)
   25 YTIL(I) = YTIL(I) + YKTAB(I)*C2
      RETURN
C
C-----TEST TOTAL YIELD.
C
   26 DO 27  I = 1, NTAB
      YDIFF = (YTAB(I) - YCAL(I))/YCAL(I)
      IF (ABS(YDIFF) .GT. 0.0001) WRITE (6,608) YTAB(I),YCAL(I),ETAB(I)
      IF (((MT.GE.5 .AND. MT.LE.14) .OR. (MT.GE.51 .AND. MT.LE.80)) .AND
     1. YTIL(I).GT.ABS(Q(MT))) WRITE (6,609) YTIL(I),Q(MT),ETAB(I)
   27 IF ((MT.LE.4 .OR.(MT.GE.15 .AND. MT.LE.50) .OR. MT.GE.81) .AND. YT
     1IL(I).GT.(Q(MT)+ETAB(I))) WRITE (6,610) YTIL(I),ETAB(I)
C
C-----RE-INITIALIZE.
C
      DO 28  I = 1, 2000
      A(I) = 0.0
      ETAB(I) = 0.0
      EK(I) = 0.0
      YTAB(I) = 0.0
      YCAL(I) = 0.0
      YKTAB(I) = 0.0
      YK(I) = 0.0
   28 YTIL(I) = 0.0
      NI = 0
      RETURN
```

SUBROUTINE FIL15(N)

```
      C
      C-----TEST LG.
      C
         29 GO TO (30,34,39), LG
      C
      C-----OPTION 1
      C     CHECK 2NT = 2 * NT
      C
         30 IF (N1 .EQ. (2*N2)) GO TO 31
            WRITE (6,611)
            N1 = 2 * N2
      C
      C     TEST ENERGIES.
      C
         31 IF (B(1) .GE. C1) WRITE (6,612)
            IF (C1 .LT. ABS(Q(MT))) WRITE (6,613)
            DO 32  I = 3, N1, 2
         32 IF (B(I).GE.B(I-2) .AND. N1.NE.2) WRITE (6,614) B(I)
            CALL STATE(LG)
            CALL ESEGPR(3)
      C
      C     TEST TP ARRAYS.
      C
            DO 33  I = 2, N1, 2
            IF (B(I) .LE. 0.0) WRITE (6,615) B(I-1)
            IF (B(I) .GT. 1.0) WRITE (6,616) B(I-1)
         33 TP = TP + B(I)
            IF (TP .LE. 0.9999) WRITE (6,617) TP
            IF (TP .GT. 1.0001) WRITE (6,618) TP
            TP = 0.0
            RETURN
      C
      C-----OPTION 2
      C     CHECK 3NT = 3 * NT
      C
         34 IF (N1 .EQ. (3*N2)) GO TO 35
            WRITE (6,611)
            N1 = 3 * N2
      C
      C     TEST ENERGIES.
      C
         35 IF (B(1) .GE. C1) WRITE (6,612)
            IF (C1 .LT. ABS(Q(MT))) WRITE (6,613)
            DO 36  I = 4, N1, 3
         36 IF (B(I).GE.B(I-3) .AND. N1.NE.3) WRITE (6,614) B(I)
            CALL STATE(LG)
            CALL ESEGPR(4)
      C
      C     TEST TP ARRAYS.
      C
```

SUBROUTINE FIL15(N)

```
133          DO 37  I = 2, N1, 3                                                F15 201
134          IF (B(I) .LE. 0.0) WRITE (6,615) B(I-1)                            F15 202
135          IF (B(I) .GT. 1.0) WRITE (6,616) B(I-1)                            F15 203
136       37 TP = TP + B(I)                                                     F15 204
137          IF (TP .LE. 0.9999) WRITE (6,617) TP                               F15 205
138          IF (TP .GT. 1.0001) WRITE (6,618) TP                               F15 206
139          TP = 0.0                                                           F15 207
      C                                                                         F15 208
      C      TEST GP ARRAYS.                                                    F15 209
      C                                                                         F15 210
140          DO 38  I = 3, N1, 3                                                F15 211
141          IF (B(I) .LE. 0.0) WRITE (6,619) B(I-2)                            F15 212
142       38 IF (B(I) .GT. 1.0) WRITE (6,620) B(I-2)                            F15 213
143          RETURN                                                             F15 214
      C                                                                         F15 215
      C-----TRY TO DETERMINE LG, IF NOT 1 OR 2.                                 F15 216
      C                                                                         F15 217
144       39 RATIO = FLOAT(N1)/FLOAT(N2)                                        F15 218
145          IF (RATIO .GE. 2.5000) GO TO 34                                    F15 219
146          GO TO 30                                                           F15 220
147      601  FORMAT (15(1H*),57H FIRST ENERGY LESS THAN EFFECTIVE THRESHOLD INF15 221
            1 FILE 3( = ,1PE12.5,3H). ,23(1H*))                                 F15 222
148      602 FORMAT (15(1H*),87H SUB-SECTION YIELD ENERGY RANGE EXCEEDS (BELOW F15 223
            1AND/OR ABOVE) TOTAL YIELD ENERGY RANGE. ,8(1H*))                   F15 224
149      603 FORMAT (15(1H*),48H NE NOT EQUAL TO NP.  NE ASSUMED TO BE CORRECT.F15 225
            1,47(1H*))                                                          F15 226
150      604 FORMAT (15(1H*),64H INTERPOLATION SCHEME SHOULD BE LINEAR THROUGHOF15 227
            1UT ENTIRE RANGE. ,31(1H*))                                         F15 228
151      605 FORMAT (15(1H*),69H INCIDENT NEUTRON ENERGY LESS THAN EFFECTIVE THF15 229
            1RESHOLD IN FILE 3( = ,1PE12.5,3H). 11(1H*))                        F15 230
152      606 FORMAT (15(1H*),72H INCIDENT NEUTRON ENERGY NOT EQUAL TO CORRESPONF15 231
            1DING TOTAL YIELD ENERGY. ,18(1H*)/15(1H*),20H TOTAL YIELD ENERGY ,F15 232
            217HASSUMED CORRECT. , 40X,18(1H*))                                 F15 233
153      607 FORMAT (15(1H*),49H THE INTEGRAL OF THE PHOTON YIELD PROBABILITY (F15 234
            1= ,F11.7,18H) NOT NORMALIZED. ,17(1H*))                            F15 235
154      608 FORMAT (15(1H*),69H TABULATED TOTAL YIELD NOT EQUAL TO TOTAL OF THF15 236
            1E SUB-SECTION YIELDS. ,26(1H*)/15(1H*),25H TABULATED TOTAL YIELD =F15 237
            2 ,1PE11.4,33X,26(1H*)/15(1H*),26H CALCULATED TOTAL YIELD = ,1PE11.F15 238
            34,32X,26(1H*)/15(1H*),10H ENERGY = ,1PE11.4,48X,26(1H*))           F15 239
155      609 FORMAT (15(1H*),50H TOTAL MEV/INTERACTION EXCEEDS THAT ALLOWED BY F15 240
            1Q. ,45(1H*)/15(1H*), 19H MEV/INTERACTION = ,1PE11.4,20X,45(1H*)/15F15 241
            2(1H*),5H Q = ,1PE11.4,34X,45(1H*)/15(1H*),10H ENERGY = ,1PE11.4,29F15 242
            3X,45(1H*))                                                         F15 243
156      610 FORMAT (15(1H*),80H TOTAL MEV/INTERACTION EXCEEDS THAT ALLOWED BY F15 244
            1Q + E (INCIDENT NEUTRON ENERGY). ,15(1H*)/15(1H*),19H MEV/INTERACTF15 245
            2ION = ,1PE11.4,50X,15(1H*)/15(1H*),10H ENERGY = ,1PE11.4,59X,15(1HF15 246
            3*))                                                                F15 247
157      611 FORMAT (15(1H*),52H FIFTH AND SIXTH FIELDS OF FIRST CARD DO NOT AGF15 248
            1REE. ,43(1H*))                                                     F15 249
158      612 FORMAT (15(1H*),26H ES(1) NOT EQUAL TO ESNS. ,69(1H*))             F15 250
```

SUBROUTINE FIL15(N)

```
159        613 FORMAT (15(1H*),26H ES SHOULD BE EQUAL TO 0. ,69(1H*))             F15 251
160        614 FORMAT (15(1H*),27H ESI OUT OF ORDER AT ESI = ,1PE11.4,3H . ,54(1HF15 252
              1*))                                                                 F15 253
161        615 FORMAT (15(1H*),40H TPI LESS THAN OR EQUAL TO 0.0 AT ESI = ,1PE11.F15 254
              14,3H . ,41(1H*))                                                    F15 255
162        616 FORMAT (15(1H*),31H TPI GREATER THAN 1.0 AT ESI = ,1PE11.4,3H . ,5F15 256
              10(1H*))                                                             F15 257
163        617 FORMAT (15(1H*),28H TOTAL TP LESS THAN 0.9999. ,67(1H*)/15(1H*),6HF15 258
              1 TP = ,E12.5,10X,67(1H*))                                           F15 259
164        618 FORMAT (15(1H*),31H TOTAL TP GREATER THAN 1.0001. ,64(1H*)/15(1H*)F15 260
              1,6H TP = ,1PE12.5,13X,64(1H*))                                      F15 261
165        619 FORMAT (15(1H*),40H GPI LESS THAN OR EQUAL TO 0.0 AT ESI = ,1PE11.F15 262
              14,3H . ,41(1H*))                                                    F15 263
166        620 FORMAT (15(1H*),31H GPI GREATER THAN 1.0 AT ESI = ,1PE11.4,3H . ,5F15 264
              10(1H*))                                                             F15 265
167            END                                                                 F15 266-
```

SYMBOL		= = = = = = = = = = = = = = = REFERENCES	= = = = = = = = = = = = = = =		
1	-	6	7*		
2	-	7	9*		
3	-	6	13*		
4	-	13	15*		
5	-	23	26*		
6	-	25	28	30*	
7	-	26	32*		
8	-	32	33*		
9	-	20	29	31	35*
10	-	6	37*		
11	-	6	41*		
12	-	45	47*		
13	-	6	53*		
14	-	56	59*		
15	-	58	61	63*	
16	-	59	65*		
17	-	62	64	66*	
18	-	53	67*		
19	-	6	69*		
20	-	75	78*		
21	-	77	80	82*	
22	-	78	84*		
23	-	84	85*		
24	-	81	83	87*	
25	-	72	88*		
26	-	6	90*		
27	-	90	94*		
28	-	95	103*		
29	-	6	106*		
30	-	106	107*	146	
31	-	107	110*		
32	-	112	113*		
33	-	116	119*		
34	-	106	124*	145	
35	-	124	127*		
36	-	129	130*		
37	-	133	136*		
38	-	140	142*		
39	-	106	144*		
601	-	11WR	17WR	69WR	147*
602	-	18WR	70WR	148*	
603	-	38WR	149*		
604	-	39WR	150*		
605	-	42WR	151*		
606	-	43WR	152*		
607	-	48WR	153*		
608	-	92WR	154*		
609	-	93WR	155*		

SUBROUTINE FIL15(N)

610	-	94WR	156*								
611	-	108WR	125WR	157*							
612	-	110WR	127WR	158*							
613	-	111WR	128WR	159*							
614	-	113WR	130WR	160*							
615	-	117WR	134WR	161*							
616	-	118WR	135WR	162*							
617	-	120WR	137WR	163*							
618	-	121WR	138WR	164*							
619	-	141WR	165*								
620	-	142WR	166*								
A	-	5C0	49=	63	65AG	96=					
A1	-	46=	48	49	51=						
A2	-	47=	49	50=							
A3	-	63=	65AG	66	67=						
ABS	-	48	92	93	111	128					
B	-	3C0	110	113	117	118	119	127	130	134	135
		136	141	142							
C1	-	3C0	110	111	127	128					
C2	-	3C0	42	43	88						
COUN	-	2C0									
EK	-	4C0	14=	17	18	25	26	28	34AG	43	58
		59	61	65AG	98=						
ES	-	4C0									
ESEGPR	-	19	71	115	132						
ETAB	-	4C0	8=	11	18	25	26	28	34AG	58	59
		61	65AG	70	77	78	80	86AG	92WR	93WR	94
		97=									
ETH	-	4C0	11	17	42	69					
FIL15	-	1									
FLOAT	-	144									
I	-	7	8	9	13	14	15	20	25	26	28
		30	34AG	35	45	46	47	53	58	59	61
		65AG	66	72	77	78	80	82	86AG	87	88
		90	91	92WR	93	94	95	96	97	98	99
		100	101	102	103	112	113	116	117	118	119
		129	130	133	134	135	136	140	141	142	
INT	-	33=	34AG	85=	86AG						
J	-	23	25	26	32	33	56	58	59	75	77
		78	84	85							
JNT	-	3C0	33	39	85						
K	-	22=	24=	27=	30	33	34AG	55=	57=	60=	63
		65AG	74=	76=	79=	82	85	86AG			
L	-	21=	23	44=	45	54=	56	73=	75		
L1	-	3C0									
L2	-	3C0									
LG	-	2C0	106	114AG	131AG						
MAT	-	3C0									
MF	-	3C0									
MT	-	3C0	11	17	42	69	93	94	111	128	

SUBROUTINE FIL15(N)

N	-	1AG	6								
N1	-	3C0	32	39	84	107	109=	112	113	116	124
		126=	129	130	133	140	144				
N1X	-	3C0									
N2	-	3C0	7	10	13	16	21	28	37	44	54
		61	70	73	80	109	126	144			
N2X	-	3C0									
NBT	-	3C0	33	85							
NC	-	2C0									
ND	-	2C0									
NE	-	2C0	37=	38							
NI	-	2C0	41=	43	49	104=					
NK	-	2C0									
NP	-	2C0	16=	18	38						
NS	-	3C0									
NS1	-	2C0									
NTAB	-	2C0	10=	18	20	53	70	72	90		
Q	-	4C0	93	94	111	128					
RATIO	-	144=	145								
RECS	-	3C0									
RETURN	-	12	36	40	52	68	89	105	123	143	
SAV15	-	5C0									
SAVE	-	4C0									
STATE	-	114	131								
TERP1	-	34	65	86							
TP	-	119=	120	121	122=	136=	137	138	139=		
X	-	3C0	8	14	46	47	69	70	77	78	80
		86AG									
Y	-	3C0	9	15	46	47	82	86AG			
YCAL	-	4C0	35=	87=	91	92WR	100=				
YDIFF	-	91=	92								
YK	-	4C0	15=	30	34AG	102=					
YKTAB	-	4C0	30=	34AG	35	66	82=	86AG	87	88	101=
YTAB	-	4C0	9=	91	92WR	99=					
YTIL	-	4C0	66=	88=	93	94	103=				

-+

SUBROUTINE ESEGPR(N)

```
      SUBROUTINE ESEGPR(N)
      COMMON/COUN/LG,NC,ND,NE,NI,NK,NP,NTAB,NS1
      COMMON/RECS/MAT,MF,MT,C1,C2,L1,L2,N1,N2,NBT(100),JNT(100),X(2000),
     1            Y(2000),B(2000),N1X,N2X,NS
      COMMON/ESEG/NPS,NESEGP(300),ESP(2000),EGP(2000),NPU(2000)
      GO TO (1,2,6,10,14), N
C
C-----STORE 1 ES-EG PAIR FROM FILE 14.
C
    1 NESEGP(MT) = NESEGP(MT) + 1
      NPS = NPS + 1
      ESP(NPS) = C1
      EGP(NPS) = C2
      RETURN
C
C-----CHECK ES-EG PAIR FROM FILE 15.
C     OPTION 1
C
    2 IF (NESEGP(MT) .EQ. 0) GO TO 5
      M = MT - 1
      DO 3  I = 1, M
    3 NTB = NTB + NESEGP(I)
      I1 = NTB + 1
      I2 = NTB + NESEGP(MT)
      DO 4  I = I1, I2
    4 IF (ESP(I).EQ.C1 .AND. EGP(I).EQ.C2) NPU(I) = 1
    5 RETURN
C
C     OPTION 2, LG = 1
C
    6 IF (NESEGP(MT) .EQ. 0) GO TO 9
      M = MT - 1
      DO 7  I = 1, M
    7 NTB = NTB + NESEGP(I)
      I1 = NTB + 1
      I2 = NTB + NESEGP(MT)
      DO 8  I = 1, N1, 2
      DO 8  J = I1, I2
      EG = C1 - B(I)
    8 IF (ESP(J).EQ.C1 .AND. EGP(J).EQ.EG) NPU(I) = 1
    9 RETURN
C
C     OPTION 2, LG = 2
C
   10 IF (NESEGP(MT) .EQ. 0) GO TO 13
      M = MT - 1
      DO 11  I = 1, M
   11 NTB = NTB + NESEGP(I)
      I1 = NTB + 1
      I2 = NTB + NESEGP(MT)
```

SUBROUTINE ESEGPR(N)

```
          DO 12  I = 1, N1, 3                                           ESG  51
          DO 12  J = I1, I2                                             ESG  52
          EG = C1 - B(I)                                                ESG  53
       12 IF (ESP(J).EQ.C1 .AND. EGP(J).EQ.EG) NPU(I) = 1               ESG  54
       13 RETURN                                                        ESG  55
C                                                                       ESG  56
C-----CHECK ALL ES-EG PAIRS USED.                                        ESG  57
C                                                                       ESG  58
       14 DO 17  I = 1, NPS                                             ESG  59
          IF (NPU(I) .EQ. 1) GO TO 17                                   ESG  60
          DO 15  J = 1, 300                                             ESG  61
          K = J                                                         ESG  62
          NTB = NTB + NESEGP(I)                                         ESG  63
       15 IF (NTB .GE. I) GO TO 16                                      ESG  64
       16 WRITE (6,601) K,ESP(I),EGP(I)                                 ESG  65
          NTB = 0                                                       ESG  66
       17 CONTINUE                                                      ESG  67
          RETURN                                                        ESG  68
      601 FORMAT (15(1H*),41H THE FOLLOWING ES-EG PAIR, GIVEN IN MT = ,I3,34ESG  69
         1H , WAS NOT REFERENCED IN FILE 15. ,17(1H*)/15(1H*),6H ES = ,1PE12ESG  70
         1.5,21X,6H EG = ,1PE12.5,21X,17(1H*))                          ESG  71
          END                                                           ESG  72-
```

SUBROUTINE ESEGPR(N)

```
SYMBOL        = = = = = = = = = = = = = = =    REFERENCES    = = = = = = = = = = = = = = =

1        -    5      6*
2        -    5     11*
3        -   13     14*
4        -   17     18*
5        -   11     19*
6        -    5     20*
7        -   22     23*
8        -   26     27      29*
9        -   20     30*
10       -    5     31*
11       -   33     34*
12       -   37     38      40*
13       -   31     41*
14       -    5     42*
15       -   44     47*
16       -   47     48*
17       -   42     43      50*
601      -   48WR   52*
B        -    3C0   28      39
C1       -    3C0    8      18      28      29      39      40
C2       -    3C0    9      18
COUN     -    2C0
EG       -   28=    29      39=     40
EGP      -    4C0    9=     18      29      40      48WR
ESEG     -    4C0
ESEGPR   -    1
ESP      -    4C0    8=     18      29      40      48WR
I        -   13     14      17      18      22      23      26      28      29      33
             34     37      39      40      42      43      46      47      48WR
I1       -   15=    17      24=     27      35=     38
I2       -   16=    17      25=     27      36=     38
J        -   27     29      38      40      44      45
JNT      -    3C0
K        -   45=    48WR
L1       -    3C0
L2       -    3C0
LG       -    2C0
M        -   12=    13      21=     22      32=     33
MAT      -    3C0
MF       -    3C0
MT       -    3C0    6      11      12      16      20      21      25      31      32
             36
N        -    1AG    5
N1       -    3C0   26      37
N1X      -    3C0
N2       -    3C0
N2X      -    3C0
NBT      -    3C0
```

NC	-	2C0									
ND	-	2C0									
NE	-	2C0									
NESEGP	-	4C0	6=	11	14	16	20	23	25	31	34
		36	46								
NI	-	2C0									
NK	-	2C0									
NP	-	2C0									
NPS	-	4C0	7=	8	9	42					
NPU	-	4C0	18=	29=	40=	43					
NS	-	3C0									
NS1	-	2C0									
NTAB	-	2C0									
NTB	-	14=	15	16	23=	24	25	34=	35	36	46=
		47	49=								
RECS	-	3C0									
RETURN	-	10	19	30	41	51					
X	-	3C0									
Y	-	3C0									

-+

SUBROUTINE STATE(LG)

```
 1            SUBROUTINE STATE(LG)
 2            COMMON/RECS/MAT,MF,MT,C1,C2,L1,L2,N1,N2,NBT(100),JNT(100),X(2000),
             1          Y(2000),B(2000),N1X,N2X,NS
 3            COMMON/SAVE/ETH(300),Q(300),ETAB(2000),YTAB(2000),YKTAB(2000),
             1          YCAL(2000),YTIL(2000),EK(2000),YK(2000),ES(40)
        C
        C-----STORE ES.
        C
 4            IF (MT.LE.4 .OR. (MT.GE.15 .AND. MT.LE.50) .OR. MT.GE.81) GO TO 3
 5            IF (MT.GE.5 .AND. MT.LE.14) NOST = MT - 4
 6            IF (MT.GE.51 .AND. MT.LE.80) NOST = MT - 40
 7            ES(NOST) = C1
        C
        C-----TEST ES.
        C     FOR LG = 1, N = 2.
        C     FOR LG = 2, N = 3.
        C
 8            N = LG + 1
 9            DO 2  I = 1, N1, N
10            DO 1  J = 1, NOST
11          1 IF (B(I) .EQ. ES(J)) GO TO 2
12            IF (B(I) .EQ. 0.0) GO TO 2
13            WRITE (6,601) B(I)
14          2 CONTINUE
15          3 RETURN
16        601 FORMAT (15(1H*),56H ESI MUST BE EQUAL TO ONE OF THE PREVIOUS STATE
             1 LEVELS. ,39(1H*)/15(1H*),23H THE ESI IN QUESTION = ,1PE11.4,22X,3
             19(1H*))
17            END
```

SUBROUTINE STATE(LG)

SYMBOL		REFERENCES			
1	-	10	11*		
2	-	9	11	12	14*
3	-	4	15*		
601	-	13WR	16*		
B	-	2C0	11	12	13WR
C1	-	2C0	7		
C2	-	2C0			
EK	-	3C0			
ES	-	3C0	7=	11	
ETAB	-	3C0			
ETH	-	3C0			
I	-	9	11	12	13WR
J	-	10	11		
JNT	-	2C0			
L1	-	2C0			
L2	-	2C0			
LG	-	1AG	8		
MAT	-	2C0			
MF	-	2C0			
MT	-	2C0	4	5	6
N	-	8=	9		
N1	-	2C0	9		
N1X	-	2C0			
N2	-	2C0			
N2X	-	2C0			
NBT	-	2C0			
NOST	-	5=	6=	7	10
NS	-	2C0			
Q	-	3C0			
RECS	-	2C0			
RETURN	-	15			
SAVE	-	3C0			
STATE	-	1			
X	-	2C0			
Y	-	2C0			
YCAL	-	3C0			
YK	-	3C0			
YKTAB	-	3C0			
YTAB	-	3C0			
YTIL	-	3C0			

SUBROUTINE TEST2C(MT)

```
  1           SUBROUTINE TEST2C(MT)                                             T2C    1
      C=====TEST REACTION TYPE, MT, FOR FILE 14================================T2C    2
      C     MT MUST BE IN THE RANGE 3-29, 51-80, 101-108, 110, 301-450          T2C    3
  2           COMMON/TST2C/NIN,NOUT,NPUN,NT,MAT,MF,MM,NSEQ,LRD,LFI,LDD,LFP,ZA,AWT2C    4
             1R,MATP,MFP,MTP,NSEQP,NOPT,NSEQP1                                  T2C    5
  3           NOUT = 6                                                          T2C    6
  4           NOPT = 0                                                          T2C    7
  5        10 IF(MT-3)150,20,20                                                 T2C    8
  6        20 IF(MT-29)170,170,30                                               T2C    9
  7        30 IF(MT-51)150,40,40                                                T2C   10
  8        40 IF(MT-80)170,170,50                                               T2C   11
  9        50 IF(MT-101)150,60,60                                               T2C   12
 10        60 IF(MT-108)170,170,70                                              T2C   13
 11        70 IF(MT-110)150,170,80                                              T2C   14
 12        80 IF(MT-301)150,90,90                                               T2C   15
 13        90 IF(MT-450)170,170,150                                             T2C   16
 14       150 IF(NOPT.EQ.0)GO TO 152                                            T2C   17
 15           WRITE(NOUT,151)MT,NSEQP                                           T2C   18
 16       151 FORMAT(37X,3HMT=I4,29H INCORRECT     SEQUENCE NUMBER,2X,I6)       T2C   19
 17           GO TO 170                                                         T2C   20
 18       152 WRITE(NOUT,153)MT                                                 T2C   21
 19       153 FORMAT(37X,3HMT=I4,10H INCORRECT)                                 T2C   22
 20       170 RETURN                                                            T2C   23
 21           END                                                               T2C   24-
```

```
                                   SUBROUTINE TEST2C(MT)

SYMBOL      = = = = = = = = = = = = = = = =    REFERENCES    = = = = = = = = = = = = = = = =

10        -     5*
20        -     5       6*
30        -     6       7*
40        -     7       8*
50        -     8       9*
60        -     9      10*
70        -    10      11*
80        -    11      12*
90        -    12      13*
150       -     5       7       9      11      12      13      14*
151       -    15WR    16*
152       -    14      18*
153       -    18WR    19*
170       -     6       8      10      11      13      17      20*
AWR       -     2C0
LDD       -     2C0
LFI       -     2C0
LFP       -     2C0
LRD       -     2C0
MAT       -     2C0
MATP      -     2C0
MF        -     2C0
MFP       -     2C0
MM        -     2C0
MT        -     1AG     5       6       7       8       9      10      11      12      13
               15WR    18WR
MTP       -     2C0
NIN       -     2C0
NOPT      -     2C0     4=     14
NOUT      -     2C0     3=     15WR    18WR
NPUN      -     2C0
NSEQ      -     2C0
NSEQP     -     2C0    15WR
NSEQP1    -     2C0
NT        -     2C0
RETURN    -    20
TEST2C    -     1
TST2C     -     2C0
ZA        -     2C0
=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+=+
```


I N D E X

END OF COMPUTATION.

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13. ABSTRACT

Evaluations of neutron interaction and photon production cross sections for sodium, magnesium, chlorine, potassium, and calcium have been translated from a modified-UK format into ENDF/B format. The data have been reviewed and revised to a minor extent, and can be used by the LAPH code to generate multigroup photon production cross section matrices. All data sets have been transmitted to the University of California, Los Alamos Scientific Laboratory, to the National Neutron Cross Section Center at BNL, and to the Radiation Shielding Information Center at ORNL. Several "physics" checks have been proposed for the photon data, and a FORTRAN IV code, PHOX, has been written to incorporate some of these checks.

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UNCLASSIFIED

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
neutron interaction cross sections						
photon production cross sections						
sodium						
magnesium						
chlorine						
potassium						
calcium						
photon data checking code						
ENDF/B format						

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