LA-7584-M (ENDF-272)
Manual

The NJOY Nuclear Data Processing System:

User's Manual

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This work was supported by the US Department of Energy, Office of Military Applications, and Division of Reactor Research and Technology, and by the Electric Power Research Institute.

LA-7584-M
Manual
UC-34c and UC-79d (Base Technology)
Issued: December 1978

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by

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ABSTRACT

The NJOY nuclear data processing system is a comprehensive computer code package for producing cross sections for neutron and photon transport calculations from ENDF/B-IV and V evaluated nuclear data. This user's manual provides a concise description of the code, input instructions, sample problems, and installation instructions.

I. INTRODUCTION

The NJOY[1-3] nuclear data processing system is a comprehensive computer code package for producing pointwise and multigroup neutron and photon cross sections from ENDF/B-IV and V evaluated nuclear data.[4] This document provides a concise description of the code, operating instructions, code installation instructions, and sample problems. A report giving theory, methods, and programmer details will be issued at a later date.

II. CODE DESCRIPTION

The NJOY code consists of a set of modules, each performing a well-defined processing task. RECONR reconstructs pointwise cross sections from ENDF/B resonance parameters and interpolation schemes. BROADR Doppler broadens and thins pointwise cross sections. UNRESR computes effective pointwise self-shielded cross sections in the unresolved resonance region. HEATR generates pointwise heat production cross sections (KERMA factors). THERMR produces thermal coherent cross sections for hexagonal materials and incoherent energy-to-energy matrices for free or bound scatterers. GROUPR generates self-shielded multigroup cross sections, group-to-group neutron transfer matrices, and photon production matrices. GAMINR calculates multigroup photon interaction cross sections and group-to-group photon transfer matrices. ERRORR produces multigroup covariance matrices from ENDF/B uncertainties. DTFR formats multigroup data for transport codes (DTF-IV[5] and its descendants). CCCCR formats multigroup data

for the CCCC standard interface files[6] ISOTXS, BRKOXS, and DLAYXS. MATXSR formats multigroup data for the new MATXS comprehensive cross-section interface file. Finally, MODER converts BCD ENDF/B files into the special blocked binary format used by NJOY. NJOY incorporates and improves upon the features of its direct ancestor, MINX.[7] It also includes and extends the photon production capabilities of LAPHANO,[8] the photon interaction capabilities of GAMLEG,[9] the heating capabilities of MACK,[10] the covariance capabilities of PUFF,[11] and the thermal capabilities of FLANGE-II[12] and HEXSCAT.[13]

The methods used in these modules will be described in detail in the final report. The following brief account will make the general flow of the code clear. RECONR reads an ENDF/B tape and produces a single energy grid for all reactions (the union grid) such that all cross sections can be obtained to within a specified tolerance by linear interpolation. Resonance reconstruction uses the methods of RESEND.[14] Summation cross sections (i.e., total, inelastic) are reconstructed from their parts. The resulting pointwise cross sections are written onto a "point-ENDF" (PENDF) tape for future use. BROADR reads a PENDF tape and Doppler broadens it using the method of SIGMA1[15] modified for better behavior at high temperatures and low energies. The union grid allows all resonance reactions to be broadened simultaneously, resulting in great savings of processing time. The summation cross sections are reconstructed from their parts. The results are written out on a PENDF tape for future use. UNRESR uses the methods of ETOX[16] to produce effective pointwise unresolved cross sections. The results are added to the PENDF tape in a special format. HEATR computes heating cross sections by the energy balance method. First, the contribution to heating of all neutron reactions is computed on the union grid as if no gamma rays were produced. If photon production files are available, the heating effect of the photons produced by each reaction is subtracted. The remainder is just the kinetic energy of recoil and charged secondaries, all of which lead to local heating. This approach helps ensure consistency in coupled neutron/photon problems since only photons explicitly produced can go on to cause heating through photon interactions. The results are added to the PENDF tape using the ENDF reaction numbers in the 300 series. THERMR produces cross sections in the thermal range. Bragg edges in coherent scattering are produced using the method of HEXSCAT[13] with an improved treatment at high energies. Energy-to-energy incoherent scattering matrices can be computed for free scattering or for bound scattering using a precomputed form factor $S(\alpha,\beta)$ in ENDF format. The secondary energy grid is determined adaptively so as to represent the function to a desired precision by linear interpolation. The results are added to the PENDF tape using a special format. GROUPR processes the pointwise cross sections produced by the modules described above into multigroup form using the Bondarenko flux weighting model.[17] As an option, a pointwise flux solution can be generated for a heavy absorber in a light moderator. Self-shielded cross sections, scattering matrices, and photon production matrices are all averaged in a unified way, the only difference being in the function which describes the "feed" into secondary group g' with Legendre order ℓ from initial energy E. The feed for two-body scattering is computed using a center-of-mass Gaussian integration scheme, which provides high accuracy even for small Legendre components of the scattering matrix. Special features are included for delayed neutrons and the coupled angle and energy dependence of the thermal scattering matrix. Self-shielding of matrices is allowed. The results are written in a special "groupwise-ENDF" format (GENDF) for use by the output modules. GAMINR uses a simplified version of GROUPR. Coherent and incoherent form factors[18] are processed in order to extend the useful range of the results to lower energies. Photon heat production cross

sections are also generated. The results are saved on a GENDF tape. ERRORR can either produce its own multigroup cross sections using the methods of GROUPR or start from a precomputed set. The cross sections and ENDF covariance data are combined in a way which includes the effects of deriving one cross section from several others. DTFR is a simple reformatting code which produces cross section tables acceptable to most discrete-ordinates codes. The user can define edit cross sections, which are any linear combination of the cross sections on the GENDF tape. This makes complex edits such as gas production possible. DTFR also contains system-dependent plotting routines for the cross sections and P_0 scattering and photon production matrices. CCCCR is also a straightforward reformatting code consistent with MINX libraries[19] and utility codes.[20,21] It should be noted that some of the cross sections producible with NJOY are not defined in the CCCC-III files. MATXSR also reformats GENDF data. This file will currently store all NJOY data types except delayed neutron and delayed photon spectra.

In the reference version of the code, each module is a separate overlay. The main overlay (NJOY) simply calls in each primary overlay (e.g., RECONR, GROUPR) as requested by the user's input commands. The NJOY level also contains utility routines used by all other modules (e.g., free-form input, storage allocation, and ENDF/B input/output). The code can easily be decomposed into 12 independent programs and a user library.

III. LINKING PROCESSING TASKS

The flow through the modules of NJOY is controlled by module names and input/output logical unit numbers. A module typically reads data from an input unit, modifies it, and writes the results on an output unit. Sometimes auxiliary inputs or multiple outputs are required. The output of one module can be the input for another.*

```
*RECONR*
  21  22
  .
  .  [input for RECONR]
  .
*BROADR*
  22  25
  .
  .  [input for BROADR]
  .
```

Since the files on most units are in ENDF/B format, the modules can be connected in many ways. The files can be saved at any point for later restart. Other combinations will be found in the examples.

NJOY provides for a special blocked binary mode for the ENDF/B files. Such files are indicated with negative unit numbers. The MODER module can be used to convert back and forth between BCD and binary modes. The user may assign units

*This example (and all others in this report) use NJOY free format. The stars indicate Hollerith input. See below for more details.

numbers from 20 to 26 for linking modules. Many modules also accept 0, which means do not use the input or output at all.

IV. NJOY INPUT INSTRUCTIONS

The input instructions for NJOY are included as comment cards at the start of each module (overlay); the current instructions have been printed out for this report as Appendix A. Some of the commands are described in more detail below. Others are made clear by the sample problems.

A. Free Form Input

For a card-input program, free-form input is convenient, but in a time-sharing environment, it is almost essential. Therefore, a subroutine FREE has been included among the NJOY utilities to provide a simple free-format input capability. This routine is machine dependent and may have to be adapted to local conditions.

Fields on the input cards are delimited by any character not used for another purpose (+,-,numeral,E,H,*,or/). For exponent fields, the E must be present, but spaces are allowed before the E. Decimal points are not required after numbers. Hollerith fields may use nHSTRING or *STRING*. The (/) terminates the input for one call to FREE (it may involve more than one card) leaving any unread variables unchanged. This feature is often used to default variables from the right.

Some input examples follow.

LEGAL	ILLEGAL
12 12. 1.2E1	1.2+1
U235 4HU235	4RU235

As an example of when the (/) is useful, in several NJOY routines a record of Hollerith information is constructed from user input. This is accomplished by calling FREE with NZA = 17 (the number of Hollerith words required to fill the 66 columns available for an ENDF/B "comment"). The array is preset to 17 blank words, so that the user need not blank-fill the line explicitly. Instead, he can write *MESSAGE*/ where the (/) terminates the process of replacing the default blanks with actual input ("MESSAGE" in this example).

The user should be cautioned that if the (/) is omitted from an input data block that is incomplete, as in Hollerith example above, FREE will go on reading successive input data cards until the expected NZA words are found, usually resulting in an error condition. For this reason, if the user is uncertain whether he has supplied enough input parameters to "satisfy" a particular call to FREE, it is good practice to use a (/) at the end of the input data for that data block.

The input examples for the NJOY test problems should answer any other questions about the syntax of free-form input.

B. RECONR Module

ERR... A reasonable value is 0.005 (½ %). For materials with many resonances such as ^{93}Nb and ^{238}U, it may be necessary to relax (increase) this somewhat in order to reduce the running time.

TEMP... Resonances can be constructed directly at an elevated temperature using the $\psi\chi$ resonance shapes (with some loss in accuracy and great savings in time). In general, it is recommended that resonance reconstruction be performed at zero Kelvin (TEMP=0); BROADR can then be used to Doppler broaden to the desired temperature with great accuracy.

NENDF... This is the unit containing an ENDF/B-IV or V tape.* It is recommended that binary mode be used whenever possible (i.e., use MODER).

C. BROADR Module

ERRTHN... Cross sections become smoother with Doppler broadening and can be thinned. It is recommended that ERRTHN $\leq$ ERR be used.

ISTRAP... "Bootstrap" refers to using the output of one broadening run as the input for a subsequent higher temperature run. If thinning was used, the second run can be much faster than the first. However, errors will accumulate.

ISTART... Since Doppler broadening is comparatively expensive, it is often useful to "restart" from previous data at a lower temperature. For example, in attempting to produce cross sections at 300, 900, and 2100 K, the job runs out of time while doing the last temperature. Set ISTART=1 and TEMP1=900, and continue the job using the output of the aborted run as input.

D. HEATR Module

NQA,MTA,QA... Because of lack of uniformity in evaluation practices, or because of the varying energy values of the separate isotopes in an element, it is sometimes necessary to override the evaluator's Q-values.

IPRINT=2... This option is provided mainly for evaluators. Computed KERMA factors are compared with limits obtained from kinematics. Note that the energy-balance method used in NJOY guarantees net energy conservation for "large" systems. However, if it is possible for a large fraction of photons to escape from the system, and if this option reveals many violations of kinematic limits, the results of both heating and gamma dose calculations must be held in doubt.

NP,MTK... Usually only the total KERMA is needed (NPK=0). Partials are useful in connection with IPRINT=2.

E. THERMR Module

NENDF... The thermal ENDF data (only MF=7 is used) is available on a special set of tapes (320 to 325).[22] No tape is required for free gas scattering.

MT201-250... Thermal data generated by this module are written onto the PENDF tape using the assigned MT numbers. These numbers are open to the user, except that MATXSR contains a certain list of names. The current values are given in Table I.

F. GROUPR Module

NTEMP,TEMP... The requested temperatures must occur on the input PENDF tape.

---

*ENDF/B tapes are available from the National Nuclear Data Center (NNDC) at Brookhaven National Laboratory, Upton, New York.

TABLE I

REACTION NUMBERS FOR THERMAL SCATTERING

MT	Contents
201	free gas
202	H in H_2O
203	H in polyethylene
204	D in D_2O
205	H in ZrH
209	graphite incoherent
210	graphite P_0 coherent
211	graphite P_1
⋮	
219	Be incoherent
220	Be P_0 coherent
⋮	
229	BeO incoherent
230	BeO P_0 coherent
⋮	

NSIGZ,SIGZ... One or more "background" cross sections must be specified in barns for the calculation of self-shielded group constants using the Bondarenko formalism. For infinite dilution, NSIGZ=1, and by convention, SIGZ=1.E10. If unresolved data have been added to the PENDF tape using UNRESR, the NSIGZ SIGZ values in GROUPR must agree with the first NSIGZ values used in UNRESR. In both codes, SIGZ is read in, in descending order, with $\sigma_0 = \infty$ first.

WGHT... If the user wishes to supply his own weight function, he must use a "TAB1" record. This is a particular ENDF/B data structure which, in the case where a single interpolation scheme INT is employed, has the following form.

```
card 1        0.    0.    0    0    1    N
card 2        N     INT
cards 3,4,...(E(I),WGHT(I),I=1,N)/
```

Here N is the number of energy-weight pairs, and INT specifies the functional form to be used to connect the points. For example, INT = 2 specifies that WGHT is a linear function of E between points, and INT = 5 specifies that the log (WGHT) varies linearly with log (E) between points. The (/) shown after the final weight is required. This is a departure from the normal NJOY convention, where (/) is needed only if the reading of a data block is to be terminated prematurely.

MFD,MTD,MTNAME... GROUPR requires that the user specify each reaction to be processed using its ENDF/B "MT-number". The MT-numbers used in a given evaluation can be obtained from the "dictionary" (MF1,MT451), a list of all the "files" (MF-numbers) and "sections" (MT-numbers) for this material (MAT-number). The user should first examine the sections of file 3, MF=3. Each section describes a different nuclear reaction, so from the list of MT-values, the user

can select the reactions he wishes to process. A list of ENDF/B reaction types[4] is reproduced here as Appendix B.

In order to process reaction "vectors" (as opposed to a group-to-group transfer matrices), one inputs data cards such as this one.

```
3    103    *(N,P)*/
3    105/
```

Here MFD=3 specifies a vector, MTD=103 is the section to be processed, and "(N,P)" is the user-supplied name for the reaction. This name is only used to label the listing and is optional as shown by the second line. There are several special MT-numbers recognized by NJOY while processing vectors.

MT	Meaning
252	$\bar{\mu}$ (average scattering cosine)
253	ξ (average log decrement)
259	mean reciprocal velocity
452	total fission yield
455	delayed fission yield
456	prompt fission yield

The first three are computed from fundamental definitions, not file 3. The last three are computed using MF1 yields and MF3 fission cross sections.

In order to process one matrix reaction (i.e., group-to-group scattering), use MFD=6 as in this example.

```
6    16    *(N,2N)*/
```

The reaction types with scattering data are most easily found under MF=4 in the dictionary (MF4, MT103-150 are charged particle angular distributions and should not be requested as matrices).

As a convenience feature, a consecutive sequence of MTDs can be specified as follows.

```
3    51    *FIRST INELASTIC LEVEL*/
3   -76    *HIGHER INELASTIC LEVELS*/
6    51    *FIRST INELASTIC LEVEL*/
6   -76    *HIGHER INELASTIC LEVELS*/
```

All values of MTD from 51 through 76 will be processed into both vectors and matrices.

Fissionable materials introduce some additional complexity. GROUPR produces a prompt fission group-to-group matrix which can be converted into the traditional $\nu\sigma_f$ and χ vectors by later modules (e.g., DTFR). For simple evaluations, it is only necessary to make this request.

```
3    18    *FISSION XSEC*/
6    18    *FISSION MATRIX*/
```

In several important evaluations, however, the evaluator has divided the fission process into parts: MT19, direct fission (n,f); MT20, second-chance fission (n,n')f; MT21, third-chance fission (n,2n)f; and MT38, fourth-chance fission (n,3n)f. The procedure makes possible a more accurate representation of the

high-energy portion of the fission spectrum when fission is induced by neutrons with energies above 5 or 6 MeV. For such evaluations (e.g., ^{235}U, ^{238}U, ^{239}Pu), the following input is recommended.

```
3    18    *TOTAL FISSION*/
3    19    *(N,F)*/
3    20    *(N,N)F*/
3    21    *(N,2N)F*/
3    38    *(N,3N)F*/
6    19    *(N,F)*/
6    20    *(N,N)F*/
6    21    *(N,2N)F*/
6    38    *(N,3N)F
```

Note that 6/18 is omitted. A subsequent code can add the partial matrices to obtain the total fission matrix.

A final complication of fission is the existence of delayed neutrons from fission. For those materials which contain delayed neutron data, the user should request these.

```
3    455    *DELAYED NUBAR*/
5    455    *DELAYED CHI*/
```

A later module, such as DTFR, can add the delayed data to the prompt matrix in order to obtain "steady-state" values for $\nu\sigma_f$ and χ.

If the evaluation includes photon production data, GROUPR will prepare a neutron-to-photon transfer matrix for each reaction requested. These reactions are identified in the material dictionary by the presence of MF=12 (photon production yields), MF13 (photon production cross sections), or both. For each reaction, input a data card with MFD=MF+4.

```
16    102    *CAPTURE GAMMA PRODUCTION*/
17      3    *NON-ELASTIC GAMMA PRODUCTION*/
```

Several examples of GROUPR input will be found in the sample problems.

G. GAMINR Module

MFD=-1... This option provides the user with a standard list of reaction types suitable for all elements: vectors for 501, 502, 504, 516, 602, and 621; matrices for 502, 504, and 516. Note that 621 is assigned specially for the photon heat production cross section.

H. ERRORR Module

NEK,EK,AKXY... ENDF/B-V will have a format for specifying derived cross sections in the file, so this is presently required only for ^{12}C (see example 4).

I. DTFR Module

IPTOTL,IPINGP,ITABL,NED... The standard transport table as used in many codes has the following structure for each group.

Position		Contents
1		response function edit
.		cross sections (missing
.		if IPTOTL = 3)
IPTOTL-2		σ_a
IPTOTL-1		$\nu\sigma_f$ "standard edits"
IPTOTL		σ_t
IPTOTL+1		upscatter (missing
.		if IPINGP = IPTOTL+1)
.		
IPINGP		in-group scattering
IPINGP+1		
.		downscatter
.		
ITABL		

If IEDIT = 1, the first NED positions are printed out as separate tables. If there is not enough room for all the downscatter between IPINGP and ITABL, the array is truncated in such a way as to preserve the scattering cross section; a similar procedure is used for upscatter.

NTHERM,MTI,MTC,NLC... These parameters control the addition of thermal upscatter to the transport table. In the lowest NTHERM groups, the static elastic scattering is replaced by MTI and the total is readjusted appropriately. If MTC, MTC+1, ...MTC+NLC, are requested, they are added to the in-group of the appropriate table and the total is increased by MTC.

JPOS,MT,MULT... This system allows the user to specify a response function which is any linear combination of the vector cross sections processed by GROUPR. Before reaction MT is added into JPOS, it is multiplied by MULT. For example, total helium production in ^{12}C is $(n,\alpha)+3\times(n,n')3\alpha$ and is formed by the cards

```
*N.HE4*/
 1 107 /
 1  91 3/
```

with NED = 2 and IPTOTL = 1 + 3 = 4.

Several special values of MT are recognized by DTFR.

MT	Meaning
300	P_0 flux
470	fission χ (steady-state)
471	delayed χ
455	delayed $\bar{\nu}$

J. CCCCR

NGGRUP,MAXUP,ICHIST... In the current version of the code, these parameters should all be zero (0). There is no coding for photon files, no provision for upscatter and no allowance for a set χ (chi).

ICHI... Only the values 0 and 1 are allowed. There is no provision for a χ-matrix.

K. MATXSR

NTYPE,NPART... A MATXS file can include any or all of four "types" of data; neutron cross sections and transfer matrices ("NSCAT"), gamma production matrices ("NGAMA"), photon interaction cross sections and transfer matrices ("GSCAT") and thermal neutron scattering ("NTHERM"). Depending on which data types are desired, group structures will be required for neutron ("NEUT") or photons ("GAMA") or both.

HTYPE,HPART,HMAT... Data types, particles, materials (and reactions) are identified by Hollerith names rather than integer flags as in the CCCC formats. Names are given in A6 format according to well defined conventions. Data type and particle names are left-justified.

```
*NSCAT *
*NEUT  *
```

Material names are divided into three fields. The first two characters contain the element abbreviation, left justified. The next three characters are for the right-justified isotope number. For elemental evaluations, the isotope number is replaced by the letters "NAT" (for "natural") in the "NSCAT" and "NGAMA" data types, and left blank for the "GSCAT" data type. The sixth position is used to distinguish among different evaluations of the same material. Some examples are given.

```
*H     1 *
*BE    9 *
*BE    9A*
*FENAT  *      for NSCAT and NGAMA
*FE     *      for GSCAT
*PU240  *
```

Some materials are not adaptable to these conventions and must be handled as individual cases.

```
*ZIRC2*
```

THE MATXSR user need not be concerned with conventions for naming reactions, as this is handled automatically.

In a typical MATXS run, the first several cards of input might be these.

```
-21   -22   23
  1     1   *T2LASL NJOY*/
  2     3    4
  * */
  *TYPICAL MATXS RUN WITH THREE DATA TYPES*/
  *BASIC DATA FROM ENDF/B-IV*/
  * */
  *NEUT *   *GAMA  */
 30    12
  *NSCAT*   *NGAMA*   *GSCAT   */
```

In this example, three data types are requested for a MATXS file on unit 23. Neutron interaction and gamma production data (in blocked binary) are input from unit 21 and photon interaction data (in blocked binary) are to be found

on unit 22. The code expects to find input data averaged over 30 neutron groups and 12 photon groups. Four cards of Hollerith identification are given.

Card input for the first data type ("NSCAT") is given next.

```
1    1    4    3
1
1
*H    1 *    1    1    1269
*FENAT *    5    2    1192
*PU240 *    1    1    1265
```

The code will search through unit 21 for MAT=1269, and output data for the first temperature and dilution factor under the name *H 1 *. The output for *FENAT * will include the first five temperatures and the first two dilution factors for MAT=1192. Particle one ("NEUT") is specified as both the incident (IINP) and outgoing (IOUTP) particles.

Input for the final two data types might be as follows.

```
1    1    4    3
1
2
*H    1 *    1    1    1269
*FENAT *    5    2    1192
*PU240 *    1    1    1265
1    1    4    3
2
2
*H     *    1    1       1
*FE    *    1    1      26
*PU    *    1    1      94
```

Note that for photon interaction data (GSCAT), all evaluations are elemental.

IFOPT,NSBLK... These parameters control the size of the matrix records on the MATXS file. If IFOPT=1 and NSBLK=1, then a single record contains all Legendre orders of the entire scattering matrix for a given reaction. The choice of IFOPT=2 separates each Legendre order into a separate record. The NSBLK parameter may be set equal to the number of groups (NOUTG) for the outgoing particle, and each group will be a separate record.

V. SAMPLE PROBLEMS

The sample problems are designed to demonstrate the major options of NJOY without using too much computer time. Long print options have been used to give the user many opportunities to check his installation of the NJOY code. The complete listing of the test problem output is included with this report on microfiche. For the user's convenience, parts of the listing are reproduced in Appendix C.

A. Example 1

This run tests group averaging and pointwise file generation for a light isotope (ENDF/B ^{12}C MAT1274). Linearization, Doppler broadening, thinning, heat

production, and thermal scattering are included. ENDF/B tapes 408 and 322 are required.

In RECONR, note that the code automatically adjusts the thresholds to agree with the given Q-values. The addition of 130 points by linearization and the removal of 25 points by thinning results in the final linear grid, which can be seen in MF3/MT1 on the PENDF tape. The HEATR output shows the neutron part of the heating for each reaction, then subtracts the energy carried off by photons to get the final results. The results check at all energies shown; however, an examination of 3/351 shows one negative KERMA factor at threshold.

In the GROUPR run, note that the LR-flag on MT91 was picked up; this reaction is actually $(n,n')3\alpha$. The LR flag was also used in HEATR. The thermal data shown here (MT201-203) is supplementary -- it is not included in MT=1. Subsequent codes such as DTFR must replace MT2 with MT201-203 in the thermal range (groups 1-4) and revise the total accordingly. Caution: GROUPR numbers groups in order of increasing energy.

On the PENDF tape, note that the dictionary and comments are correct. The format used for MF=6 is similar to ENDF/B except for the ordering of Legendre order and incident energy. The file uses a "TAB2" record to set up a loop over incident energy (49 points). At each energy (1.E-5,3.16-5,...), a "TAB1" record is given for each Legendre order (P_0 and P_1 in this case). Each "TAB1" record gives the normalized scattering probability versus secondary neutron energy.

B. Example 2

This run processes one isotope for a practical CCCC library. It tests resonance reconstruction, Doppler broadening to several temperatures, unresolved cross sections, self-shielded multigroup cross sections, and CCCC-III interface files (ISOTXS, BRKOXS, and DLAYXS). Tape 404 is required.

Note the message "POINTS REJECTED BY SIGNIFICANT FIGURES CHECK = 53". ENDF/B allows only 6 significant digits for energy on BCD tapes; this check ensures that no two points have the same energy value. In BROADR, note the extensive thinning achieved after Doppler broadening the resonances, and the speedup achieved using the "bootstrap" option.

In GROUPR, it was only necessary to request those reactions with appreciable temperature dependence at the higher temperatures. These normally include MT=1, 2, 18, 19, 102, 301, and 201-250. Also, MT259 is requested to get accurate group-averaged velocities for ISOTXS. In CCCCR, the option to block matrices by reaction was used. This is the best form for large-group structures. XSPO in BRKOXS is simply $4\pi a^2$ using the scattering length from MF2.

C. Example 3

The run demonstrates the generation of photon interaction cross sections with DTF and MATXS output. The photon interaction tape DLC7E is required.*

First, a RECONR run is used to linearize the cross sections. The GAMINR run uses the standard list of reactions. Note how the photon heat production is assembled from the partial reactions and written out as MT=621. In DTFR, the code automatically shifts over to photons when it sees MT501, so read "PHOTON" instead of "NEUTRON" on this listing. Note that one special edit is provided for heating in eV·barns, so the table length is set to 1+3+12=16, and the position of the total is 1+3=4. In these tables, the first 16 numbers are the positions for the first (highest energy) photon group, and so on for the other groups.

*Available from the Radiation Shielding Information Center at the Oak Ridge National Laboratory, Oak Ridge, Tennessee.

The matrices in the MATXS file are labelled by "position" rather than group. The group corresponding to each position is determined from the table of "LOWEST ENERGY GROUP". For example, GPAIR (pair production) has data for only 9 "positions". The table shows that the corresponding lowest energy source group is 9, so there is scattering into group 10 from the highest 9 groups.

D. Example 4

This run demonstrates NJOY's capability to produce cross-section covariances from ENDF/B data. Tape 408 is used.

The ERRORR module has been asked to produce its own cross sections using the 56-group union of the input 5-group structure and the energy points on the covariance file MF33. Some of these cross sections are to be derived from others.

```
MT2=MT1-MT51-MT91-MT102-MT107
MT3=MT51+MT91+MT102+MT107
MT4=MT51+MT91
```

The collapsed 5-group cross sections are printed out on the listing. The relationships of derived cross sections are also used to obtain the individual covariance matrices given. This input will not be required for ENDF/B-V.

VI. CODE INSTALLATION

The reference version of NJOY operates on CDC equipment at LASL. The code includes comment cards pointing out places where changes must be made to install the code on IBM equipment. This is an example.

```
      PROGRAM CCCCR
C IBM SUBROUTINE CCCCR
      :
      :
C IBM IMPLICIT REAL*8(H)
      :
      :
      MULT=1
C IBM MULT=2
```

The first line is to be "commented-out" with a C CDC ... and the C IBM is to be removed from the second card. The third line is an example where no CDC line is to be deleted. Some other routines are marked with alarms such as "machine-dependent CDC version". These IBM changes should prove to be a good starting point for conversion to other machines.

In order to simplify preparation of loader overlay instructions (if required), a CDC load map has been included as Appendix C. Caution: the same name is sometimes used for subroutines and common blocks in different overlays. Some systems use a non-ANSI "P-factor" -- in such cases, change every occurrence of 1P to 0P using a text editor.

Machine-dependent plotting logic has been left in DTFR as a guide to local implementation. All routines from PLOTED on can be deleted if desired. Also delete the plot calls at the end of DTFOUT.

NJOY is designed for use on an interactive time-sharing system, if desired. The main routine contains a unit number NSHORT, which should be equivalenced to the user's TTY (Tape 6 on 6600/NOS) for both input and output. NJOY will then prompt the user for all input and print a condensed account of the progress of the code and any error messages on the TTY. The regular long output will still be available on TAPE 7.

VII. TYPICAL MACHINE TIMES

Typical run times are difficult to quote for such a complex system. Tables II and III give CDC-7600 times for practical problems.

A few general principles may help the user to guess times for his jobs. The pointwise modules RECONR, BROADR, and HEATR require time proportional to the number of energy points in the cross sections, hence the number of resonances. UNRESR depends mostly on the number of energy points in MF2, MT151. In GROUPR, the time required for vectors depends on the number of energy points but not on the number of groups and only weakly on the number of σ_0 values requested. The matrix time does increase with the number of groups. Even more important is the energy range--discrete inelastic reactions require much more time if many groups above 10 MeV are requested, due to the extreme anisotropy found there.

This code is extremely "I/O bound". Run times can often be reduced by requesting larger input/output buffers from the system. Use binary mode when possible. Also, I/O time in BROADR can be reduced by allocating more storage if available (see /STORE/ and NAMAX in BROADR).

VIII. PROBLEM SIZE AND STORAGE ALLOCATION

NJOY uses variable dimensioning and dynamic storage allocation throughout. The STORAG system in the main overlay is provided for this purpose. Even with this flexible system, however, there is a set of complex tradeoffs on problem size and run time. The BROADR timing above is one example. These tradeoffs can sometimes be changed by altering the storage in /STORE/ in each overlay, and the sizes of certain other variables in each module. Violations will normally result in an error message. The practical problems in the timing tables give some idea of the range of problem size that NJOY can handle without modification.

ACKNOWLEDGMENTS

The IBM conversion was performed by R. Q. Wright and J. E. Lucius at Oak Ridge National Laboratory (ORNL). Thanks are also due to Odelli Ozer of the Electric Power Research Institute (EPRI) for help with the RESEND code and the design of the thermal processing capability; to D. E. Cullen of Lawrence Livermore Laboratory (LLL) and J. Hancock of LASL for their work on the Doppler broadening module; to P. G. Young for help with the heating calculation; to R. E. Seamon, P. D. Soran, W. B. Wilson, D. George, and L. Stewart (all of LASL) for help with testing and validation; and to R. J. LaBauve of LASL, D. R. Harris [LASL and Rensselaer Polytechnic Institute (RPI)], C. R. Weisbin of ORNL, and M. Becker of RPI for moral support, ideas, and constructive criticism.

The development of NJOY was jointly sponsored by the Military Applications and Reactor Research and Technology Divisions of the United States Department

TABLE II

CDC-7600 RUN TIMES FOR NUCLIDES FROM SEVERAL PRACTICAL LIBRARIES

Nuclide Name	Run Times (s)			
	30 x 12[a]	ENDF/B-IV-PENDF[b]	CPM (69-Group)[c]	185-Group[d]
H-1	87	785	-	-
He-4	55	92	76	511
Be-9	69	585	-	1200
C-12	56	698	560[e]	1665
O-16	146	220	127	1234
Na-23	397	328	171	959
Al-27	321	281	179	2130
K	159	94	220	-
Ti	46	-	-	-
Cr	452	576	351	3289
Fe	390	419	305	2963
Ni	400	470	213	3092
Nb-93	812	-	-	-
Mo	134	-	-	439
Ta-181	284	-	-	616
W-186	251	-	-	647
Pb	111	-	-	952
U-233	474	901	482	-
U-235	420	851	464	1470
U-238	3007	3078	1419	6021
Pu-238	105	264	270	-
Pu-240	1714	1705	1002	2357
Am-243	42	173	188	-
Cf-251	96	-	-	-

[a] A coupled neutron-photon-heating library with 30 neutron groups, 12 photon groups, P_4 matrices, T = 300 K, and $\sigma_0 = \infty$.

[b] A linearized, resonance-reconstructed, Doppler-broadened (five temperatures) library, with KERMA factors as well as bound and unbound thermal kernels in three Legendre orders. Basic data from ENDF/B-IV.

[c] Group-averaging (GROUPR) runs for P_3 thermal-reactor library using the EPRI-CPM 69-group structure, and including thermal matrices, self shielding factors for heavy isotopes, and P_1 matrices for light moderators.

[d] Group-averaging (GROUPR) runs for an extensive super-group library from preliminary ENDF/B-V with 185-neutron groups and 48 photon groups, and including thermal data, self-shielding, P_4 matrices, and photon production.

[e] ^{12}C and Graphite.

TABLE III

CDC-7600 RUN TIMES FOR SEVERAL
SPECIAL PROCESSING TASKS

Task	Time (s)
12 group P_3 photon interaction (per element)	73
48 group P_3 photon interaction (per element)	89
MATXSR run for complete 30 x 12 MATXS1 library including 74 nuclides of neutron data and 41 elements for photons	329

of Energy. Additional support was provided by the Electric Power Research Institute.

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APPENDIX A

INPUT INSTRUCTIONS AND MODULE ABSTRACTS COPIED FROM COMMENT CARDS IN NJOY

```
**********************************************************************
*                                                                    *
* NJOY NUCLEAR CROSS SECTION PROCESSING SYSTEM                       *
*                                                                    *
**********************************************************************
*                                                                    *
* NJOY IS A SYSTEM OF PROCESSING MODULES INTENDED TO CONVERT         *
* ENDF/B VERS. IV OR V CROSS SECTION DATA INTO FORMS USEFUL          *
* FOR PRACTICAL APPLICATIONS.                                        *
*                                                                    *
* RECONR...RECONSTRUCT POINTWISE CROSS SECTIONS FROM ENDF/B          *
*      RESONANCE PARAMETERS AND INTERPOLATION SCHEMES.               *
*                                                                    *
* BROADR...DOPPLER BROADEN AND THIN POINTWISE CROSS SECTIONS.        *
*                                                                    *
* UNRESR...COMPUTE EFFECTIVE POINTWISE SELF-SHIELDED CROSS           *
*      SECTIONS IN THE UNRESOLVED ENERGY RANGE.                      *
*                                                                    *
* HEATR...COMPUTE HEAT PRODUCTION CROSS SECTIONS (KERMA).            *
*                                                                    *
* THERMR...GENERATE NEUTRON SCATTERING CROSS SECTIONS AND            *
*      POINT-TO-POINT SCATTERING KERNALS IN THE THERMAL RANGE        *
*      FOR FREE OR BOUND ATOMS.                                      *
*                                                                    *
* GROUPR...GENERATE SELF-SHIELDED MULTIGROUP CROSS SECTIONS AND      *
*      GROUP-TO-GROUP SCATTERING AND PHOTON PRODUCTION MATRICES.     *
*                                                                    *
* GAMINR...COMPUTE MULTIGROUP PHOTON INTERACTION CROSS SECTIONS,     *
*      SCATTERING MATRICES, AND HEAT PRODUCTION.                     *
*                                                                    *
* ERRORR...CONSTRUCT MULTIGROUP COVARIANCE MATRICES.                 *
*                                                                    *
* MODER...CONVERT BETWEEN ENDF/B STANDARD BCD MODE AND THE           *
*      NJOY BLOCKED BINARY MODE.                                     *
```

```
*                                                                     *
* DTFR...OUTPUT AND PLOT MULTIGROUP DATA FOR DISCRETE ORDINATES       *
*     TRANSPORT CODES.                                                *
*                                                                     *
* CCCCR...FORMAT MULTIGROUP DATA INTO THE CCCC VERS. 3                *
*     INTERFACE FILES ISOTXS, BRKOXS, AND DLAYXS.                     *
*                                                                     *
* MATXSR...CONVERT MULTIGROUP DATA INTO THE COMPREHENSIVE MATXS       *
*     CROSS SECTION INTERFACE FORMAT.                                 *
*                                                                     *
* EACH MODULE IS A SEPARATE OVERLAY.  THE MAIN PROGRAM CONTROLS       *
* THE ORDER IN WHICH MODULES ARE USED AND CONTAINS UTILITY            *
* SUBROUTINES USED BY ALL MODULES.                                    *
*                                                                     *
*---INPUT SPECIFICATIONS-----------------------------------------------*
*                                                                     *
* CARD1          INPUT OPTION                                         *
*    IOPT        0 FOR CARD INPUT AND FULL OUTPUT,                    *
*                1 FOR TERMINAL INPUT WITH SHORT OUTPUT ON TERMINAL   *
* CARD2                                                               *
*    IVERF       ENDF/B VERSION NUMBER (4 OR 5 ONLY)                  *
* CARD 3                                                              *
*    MOPT        SIX CHARACTER MODULE NAME (ONLY FIRST FOUR           *
*                CHARACTERS ARE USED).  REPEAT FOR EACH MODULE        *
*                DESIRED.  USE STOP TO TERMINATE PROGRAM.             *
*                                                                     *
* SEE THE COMMENTS AT THE START OF EACH MODULE FOR                    *
* ITS SPECIFIC INPUT INSTRUCTIONS.                                    *
*                                                                     *
***********************************************************************

PROGRAM RECONR
***********************************************************************
*                                                                     *
* RECONSTRUCT POINTWISE CROSS SECTIONS                                *
*                                                                     *
* THIS PROGRAM GENERATES AN ENERGY GRID WHICH IS THE UNION OF         *
* AN INPUT GRID (IF ANY), THE RESONANCE ENERGIES (IF ANY), AND        *
* THE ENERGIES OF CROSS SECTIONS IN MF3 AND MF13 (OR MF23).           *
* THE POINTWISE CROSS SECTIONS ARE THEN COMPUTED ON THIS GRID         *
* AND POINTS ARE ADDED SO THAT THE RESONANCE CROSS SECTIONS AND       *
* ANY CROSS SECTIONS REPRESENTED BY NON-LINEAR INTERPOLATION          *
* ARE REPRODUCED WITHIN A SPECIFIED TOLERANCE BY LINEAR INTER-        *
* POLATION.  PSI-CHI RECONSTRUCTION CAN BE USED IF DESIRED.           *
* SECTIONS WHICH ARE NOT CROSS SECTIONS (MU,NU) AND PHOTON            *
* MULTIPLICITIES (MF12) ARE NOT PROCESSED.  REDUNDANT REACTIONS       *
* ARE RECONSTRUCTED TO BE THE SUM OF THEIR PARTS.  THE PENDF          *
* TAPE CONTAINS POINT CROSS SECTIONS IN MF3 AND MF13 (OR MF25)        *
* AND A DESCRIPTION OF THE PROCESSING IN MF1.  THE MF1 DICTION-       *
* ARY IS UPDATED.  THE C1 AND C2 FIELDS OF THE SECOND CARD IN         *
* MF1 CONTAIN THE TEMPERATURE AND RECONSTRUCTION TOLERANCE            *
* RESPECTIVELY.  AN MF2 APPROPRIATE TO NO RESONANCE PARAMETERS        *
* IS CONSTRUCTED WITH THE POTENTIAL SCATTERING LENGTH ADDED.          *
```

```
*                                                                     *
* THIS PROGRAM IS A PART OF THE NJOY NUCLEAR DATA PROCESSING          *
* SYSTEM.  THE RESONANCE RECONSTRUCTION USES THE METHODS OF           *
* RESEND WITH APPROPRIATE MODIFICATIONS.                              *
*                                                                     *
*---INPUT DATA CARDS---------------------------------------------------*
*                                                                     *
* CARD 1                                                              *
*    NENDF     UNIT FOR ENDF/B TAPE                                   *
*    NPEND     UNIT FOR PENDF TAPE                                    *
* CARD 2                                                              *
*    LABEL     66 CHARACTER LABEL FOR NEW PENDF TAPE                  *
* CARD 3                                                              *
*    MAT       MATERIAL TO BE RECONSTRUCTED                           *
*              MAT=0 TERMINATES EXECUTION OF RECONR.                  *
*    NCARDS    NUMBER OF CARDS OF DESCRIPTIVE DATA FOR NEW MF1        *
*    NGRID     NUMBER OF USER ENERGY GRID POINTS TO BE ADDED.         *
* CARD 4                                                              *
*    ERR       FRACTIONAL RECONSTRUCTION TOLERANCE                    *
*    TEMPR     RECONSTRUCTION TEMPERATURE (DEG KELVIN)                *
* CARD 5                                                              *
*    CARDS     NCARDS OF DESCRIPTIVE COMMENTS FOR MT451               *
* CARD 6                                                              *
*    ENODE     USERS ENERGY GRID POINTS                               *
*                                                                     *
***********************************************************************


PROGRAM BROADR
***********************************************************************
*                                                                     *
* DOPPLER BROADEN AND THIN NEUTRON POINT CROSS SECTIONS               *
*                                                                     *
* A MODIFIED VERSION OF THE KERNAL BROADENING METHOD DEVELOPED        *
* FOR SIGMA1 (D.E.CULLEN, LLL) IS USED.  CROSS SECTIONS               *
* FOR LOW THRESHOLD REACTIONS ARE UNIONIZED ON THE GRID OF THE        *
* TOTAL CROSS SECTION, THEN BROADENED AND THINNED IN PARALLEL.        *
* HIGH THRESHOLD REACTIONS ARE NOT BROADENED.  THE RESULTS ARE        *
* WRITTEN OUT IN PENDF FORMAT WITH EACH TEMPERATURE REPRESENTED       *
* AS A DIFFERENT MAT.  DICTIONARIES ARE CORRECTED TO REFLECT          *
* UNIONIZATION AND THINNING.  FOR HIGH TEMPERATURES AND LOW           *
* ENERGIES WHERE THE METHOD OF SIGMA1 BREAKS DOWN, A NEW DIRECT       *
* EXPANSION OF THE DOPPLER INTEGRAL IS USED.                          *
*                                                                     *
*---INPUT DATA CARDS---------------------------------------------------*
*                                                                     *
* CARD 1                                                              *
*    NIN       INPUT PENDF TAPE                                       *
*    NOUT      OUTPUT PENDF TAPE                                      *
* CARD 2                                                              *
*    MAT1      MATERIAL TO BE PROCESSED                               *
*    NTEMP2    NUMBER OF FINAL TEMPERATURES                           *
*    ISTART    RESTART (0 NO, 1 YES)                                  *
*    ISTRAP    BOOTSTRAP (0 NO, 1 YES)                                *
```

```
*     TEMP1     STARTING TEMPERATURE FROM NIN                          *
*     ERRTHN    FRACTIONAL TOLERANCE FOR THINNING                      *
* CARD 3                                                               *
*     TEMP2     FINAL TEMPERATURES (DEG KELVIN)                        *
* CARD 4                                                               *
*     MAT1      NEXT MAT NUMBER TO BE PROCESSED WITH THESE             *
*               PARAMETERS.  TERMINATE WITH MAT1=0.                    *
*                                                                      *
*---INPUT OPTIONS-----------------------------------------------------*
*                                                                      *
* THE OUTPUT TAPE WILL CONTAIN THE NTEMP2 FINAL TEMPERATURES           *
* SPECIFIED.  IT IS NECESSARY TO HAVE TEMP1.LE.TEMP2(1).               *
* IF TEMP2.EQ.TEMP1, THE DATA WILL BE THINNED ONLY.                    *
*                                                                      *
* RESTART     CONTINUE BROADENING AN EXISTING PENDF TAPE.  ALL         *
*             TEMPERATURES ARE COPIED THROUGH TEMP1.  ADDITIONAL       *
*             FINAL TEMPERATURES ARE ADDED BY STARTING WITH THE        *
*             DATA AT TEMP1.                                           *
*                                                                      *
* BOOTSTRAP   IF BOOTSTRAP IS NOT REQUESTED, EACH FINAL TEMPERA-       *
*             TURE IS GENERATED BY BROADENING DIRECTLY FROM            *
*             TEMP1 TO TEMP2.  IF BOOTSTRAP IS REQUESTED, EACH         *
*             FINAL TEMPERATURE IS BROADENED FROM THE PRECEDING        *
*             TEMPERATURE.  THIS OPTION IS FASTER DUE TO THE           *
*             THINNING IN THE PREVIOUS STEP.  HOWEVER, ERRORS          *
*             ACCUMULATE.                                              *
*                                                                      *
************************************************************************

PROGRAM UNRESR
************************************************************************
*                                                                      *
* COMPUTE UNRESOLVED RESONANCE CROSS-SECTIONS                          *
*                                                                      *
************************************************************************
*                                                                      *
* THE METHOD OF ETOX IS USED TO COMPUTE SELF-SHIELDED                  *
* UNRESOLVED RESONANCE CROSS-SECTIONS ON THE ENERGY GRID OF            *
* THE UNRESOLVED PARAMETERS.  SUBSEQUENT INTERPOLATION IS              *
* TO BE ON THE CROSS-SECTIONS AND NOT ON THE PARAMETERS.               *
* ADDITIONAL ENERGY GRID POINTS ARE ADDED AT QUARTER LETHARGY          *
* INTERVALS IF ONLY THREE OR FEWER GRID POINTS ARE FOUND.              *
* THE ACCURATE HWANG QUADRATURE SET IS USED FOR THE INTEGRALS.         *
*                                                                      *
*---INPUT DATA CARDS--------------------------------------------------*
*                                                                      *
* CARD 1                                                               *
*   NENDF    UNIT FOR ENDF/B TAPE                                      *
*   NIN      UNIT FOR INPUT PENDF TAPE                                 *
*   NOUT     UNIT FOR OUTPUT PENDF TAPE                                *
* CARD 2                                                               *
*   MATD     MATERIAL TO BE PROCESSED                                  *
```

```
*            MATD=0 TERMINATES UNRESR                                  *
*    NTEMP   NO. OF TEMPERATURES                                       *
*    NSIGZ   NO. OF SIGMA ZEROES                                       *
*    IPRINT  PRINT OPTION (0=MIN, 1=MAX)                               *
*  CARD 3                                                              *
*    TEMP    TEMPERATURES IN KELVIN (INCLUDING ZERO)                   *
*  CARD 4                                                              *
*    SIGZ    SIGMA ZERO VALUES (INCLUDING INFINITY)                    *
*                                                                      *
************************************************************************


PROGRAM HEATR
************************************************************************
*                                                                      *
* COMPUTE HEATING KERMA (KINETIC ENERGY RELEASE IN MATERIAL)           *
*                                                                      *
* THE PROMPT KERMA IS COMPUTED POINTWISE ON THE GRID OF THE            *
* TOTAL CROSS SECTION FROM THE INPUT PENDF TAPE AND WRITTEN            *
* ONTO THE OUTPUT PENDF TAPE AT INFINITE DILUTION USING THE            *
* 300 SERIES OF MT NUMBERS.  ALL TEMPERATURES ON THE INPUT PENDF       *
* TAPE FOR THE DESIRED MATERIAL ARE PROCESSED.  THE DICTIONARY         *
* IS REVISED.  REACTION Q VALUES ARE OBTAINED FROM THE ENDF/B          *
* TAPE UNLESS THE USER ENTERS HIS OWN VALUE.  PARTIAL KERMAS           *
* CAN BE REQUESTED FOR SELF-SHIELDING CALCULATIONS OR OTHER            *
* PURPOSES.  THE CODE USES THE ENERGY BALANCE METHOD WHERE             *
* PHOTON FILES ARE AVAILABLE AND DEPOSITS ALL PHOTON ENERGY            *
* LOCALLY WHEN FILES ARE NOT AVAILABLE.  THIS ASSURES                  *
* CONSISTENCY BETWEEN NEUTRON HEATING AND ENERGY DEPOSITON BY          *
* SUBSEQUENT PHOTON INTERACTIONS.                                      *
*                                                                      *
* IF DESIRED, THE ENERGY-BALANCE KERMA FACTORS CAN BE COMPARED         *
* WITH CONSERVATIVE KINEMATIC LIMITS (SET IPRINT=2).                   *
*                                                                      *
*---INPUT DATA CARDS---------------------------------------------------*
*                                                                      *
* CARD 1                                                               *
*    NENDF     UNIT FOR ENDF/B TAPE                                    *
*    NIN       UNIT FOR INPUT PENDF TAPE                               *
*    NOUT      UNIT FOR OUTPUT PENDF TAPE                              *
* CARD 2                                                               *
*    MATD      MATERIAL TO BE PROCESSED                                *
*    NPK       NUMBER OF PARTIAL KERMAS DESIRED                        *
*    NQA       NUMBER OF USER SPECIFIED Q VALUES TO BE ENTERED         *
*    IPRINT    PRINT OPTION (0 MAX, 1 MIN, 2 CHECK)                    *
* CARD 3                                                               *
*    MTK       MT NUMBERS FOR PARTIAL KERMAS DESIRED                   *
*              TOTAL (MT301) WILL BE PROVIDED AUTOMATICALLY            *
* CARD 4                                                               *
*    MTA       MT NUMBERS FOR USERS Q VALUES                           *
* CARD 5                                                               *
*    QA        USER SPECIFIED Q VALUES (EV)                            *
```

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


PROGRAM THERMR
************************************************************************
*                                                                      *
*  ADD POINTWISE SCATTERING CROSS SECTIONS AND SCATTERING              *
*  MATRICES TO AN EXISTING PENDF TAPE.  INCOHERENT CROSS               *
*  SECTIONS ARE ADDED TO MF3 AND INCOHERENT MATRICES ARE               *
*  WRITTEN IN MF6 (USING A MODIFIED FORMAT), BOTH USING MTREF.         *
*  COHERENT SCATTERING CROSS SECTIONS ARE WRITTEN IN MF3 ONLY          *
*  USING MTREF+1 FOR L=0, MTREF+2 FOR L=1, ETC.                        *
*  MULTIPLE SCATTERING TYPES (IE. H FREE AND H IN H2O) CAN BE          *
*  WRITTEN ON ONE PENDF TAPE BY USING DIFFERENT VALUES OF MTREF        *
*  FOR EACH THERMR RUN.  IF DATA FOR ONE MTREF IS ALREADY ON           *
*  THE TAPE, IT WILL BE REPLACED WITH THE NEW CROSS SECTIONS.          *
*  THE ENERGY GRID FOR COHERENT SCATTERING IS DETERMINED               *
*  ADAPTIVELY SO AS TO REPRESENT THE SHARP BRAGG EDGES TO              *
*  A SPECIFIED TOLERANCE USING LINEAR INTERPOLATION.  THE              *
*  SECONDARY ENERGY GRID FOR INCOHERENT SCATTERING IS ALSO             *
*  DETERMINED ADAPTIVELY.  THE INITIAL ENERGY GRID IS WIRED IN         *
*  (SEE EGRID IN CALCEM).  A SPECIAL PROJECTION INTERPOLATION          *
*  SCHEME IS USED IN GROUPR TO INTEGRATE THIS RELATIVELY               *
*  COARSE GRID.                                                        *
*  CURRENT CAPABILITIES...                                             *
*     1.)  COMPUTE FREE-GAS SCATTERING MATRICES AND NORMALIZE          *
*          TO THE ELASTIC CROSS SECTION ON THE OLD PENDF TAPE.         *
*     2.)  FORMAT TRIANGULAR MATRICES PRODUCED BY OTHER CODES.         *
*     3.)  COMPUTE INCOHERENT MATRICES FROM READ-IN                    *
*          S(ALPHA,BETA) DATA.                                         *
*     4.)  COMPUTE COHERENT SCATTERING FROM HEXAGONAL LATTICES.        *
*  FUTURE CAPABILITIES...                                              *
*     1.)  GENERATE S(ALPHA,BETA) FROM BASIC PHYSICS DATA.             *
*                                                                      *
*---USER INPUT----------------------------------------------------------*
*                                                                      *
*  CARD 1                                                              *
*     NENDF       ENDF/B TAPE FOR MF7 DATA                             *
*     NIN         OLD PENDF TAPE                                       *
*     NOUT        NEW PENDF TAPE                                       *
*  CARD 2                                                              *
*     MATDE       MATERIAL DESIRED ON ENDF TAPE                        *
*     MATDP       MATERIAL DESIRED ON PENDF TAPE                       *
*     LORD        MAXIMUM LEGENDRE ORDER                               *
*     NTEMP       NUMBER OF TEMPERATURES                               *
*     IINC        INCOHERENT OPTIONS                                   *
*                    0      NONE                                       *
*                    1      COMPUTE AS FREE GAS                        *
*                    2      READ TRIANGULAR MATRICES                   *
*                    3      COMPUTE S(A,B) AND MATRIX                  *
*                    4      READ S(A,B) AND COMPUTE MATRIX             *
*     ICOH        COHERENT OPTION (0=NO, 1=GRAPHITE)                   *
```

```
*                    0      NONE                                          *
*                    1      GRAPHITE                                      *
*                    2      BERYLLIUM                                     *
*                    3      BERYLLIUM OXIDE                               *
*      NATOM       NUMBER OF PRINCIPAL ATOMS                              *
*      MTREF       MT FOR INCOHERENT MATRIX (201-250 ONLY)                *
*                  COHERENT P0 WILL BE IN MTREF+1, ETC.                   *
*      IPRINT      PRINT OPTION (0=MAXIMUM, 1=MINIMUM)                    *
*   CARD 3                                                                *
*      TEMPR       TEMPERATURES (KELVIN)                                  *
*   CARD 4                                                                *
*      TOL         TOLERANCE                                              *
*      EMAX        MAXIMUM ENERGY FOR THERMAL TREATMENT                   *
*                                                                         *
*---FOR IINC=2 ONLY-------------------------------------------------------*

*   CARD 5                                                                *
*      IVDV        0=USE DEFAULT VELOCITY AND DELTA-VELOCITY              *
*                  ARRAYS FOR NGD=35, 1=READ IN VELOCITY AND              *
*                  DELTA-VELOCITY ARRAYS                                  *
*      NREAD       UNIT FOR INPUT TAPE FROM FLANGE.                       *
*                  0=INPUT IS ON CARDS                                    *
*   CARD 6 FOR IVDV=1                                                     *
*      VELOCITY                                                           *
*   CARD 7                                                                *
*      DELTA-VELOCITY                                                     *
*   CARD 8 FOR NREAD=0                                                    *
*      SCATTERING MATRIX FOR 1 L ORDER                                    *
*                                                                         *
***************************************************************************


PROGRAM GROUPR
***************************************************************************
*                                                                         *
*  COMPUTE SELF-SHIELDED GROUP-AVERAGED CROSS-SECTIONS                    *
*                                                                         *
* PRODUCES SELF-SHIELDED CROSS SECTIONS, NEUTRON SCATTERING               *
* MATRICES, AND PHOTON PRODUCTION MATRICES.  SCATTERING AND               *
* PHOTON MATRICES MAY BE SELF-SHIELDED IF DESIRED (SEE INIT).             *
* BONDARENKO WEIGHTING IS NORMALLY USED.  OPTIONALLY, THE FLUX            *
* CAN BE COMPUTED FOR AN INFINITE MIXTURE OF HEAVY ABSORBER               *
* AND LIGHT MODERATOR.  DELAYED NEUTRON DATA AND THERMAL                  *
* SCATTERING MATRICES ARE HANDLED SPECIALLY.                              *
*                                                                         *
* THE INTEGRATION OVER INITIAL ENERGY IS HANDLED IN THE SAME              *
* WAY FOR ALL REACTION TYPES BY USING THE INTEGRAND                       *
*                    FEED*XSEC*FLUX                                       *
* FEED IS THE SOURCE INTO FINAL ENERGY GROUP GPRIME AND                   *
* LEGENDRE ORDER L FROM INITIAL ENERGY E (SEE GETFF).  FOR                *
* VECTORS, THE FEED IS 1, OR A YIELD (NUMBAR, MUBAR).  FOR TWO            *
* BODY SCATTERING, A CENTER-OF-MASS GAUSSIAN INTEGRATION IS USED          *
* TO OBTAIN ACCURATE RESULTS EVEN FOR SMALL LEGENDRE COMPONENTS           *
```

```
* OF THE GROUP-TO-GROUP SCATTERING.  ADDITIONAL INITIAL ENERGY   *
* QUADRATURE POINTS ARE ADDED TO INTEGRATE THE KNOWN POLYNOMIAL  *
* ORDER OF THIS FEED FUNCTION.  FEED FOR TABULATED CONTINUUM     *
* REACTIONS IS COMPUTED EXACTLY ON THE ENDF/B GRID POINTS AND    *
* THEN INTERPOLATED AT E.  A SPECIAL PROJECTION INTERPOLATION    *
* SCHEME IS USED FOR THERMAL MATRICES (SEE GETAED).  THE FEED    *
* FOR ANALYTIC CONTINUUM REACTIONS IS EXACT.                     *
*                                                                *
*---INPUT DATA CARDS-----------------------------------------------*
*                                                                *
* CARD1                                                          *
*    NENDF    UNIT FOR ENDF/B TAPE                               *
*    NPEND    UNIT FOR PENDF TAPE                                *
*    NGOUT1   UNIT FOR INPUT GOUT TAPE                           *
*    NGOUT2   UNIT FOR OUTPUT GOUT TAPE                          *
* CARD2                                                          *
*    MATB     MATERIAL TO BE PROCESSED                           *
*    IGN      NEUTRON GROUP STRUCTURE OPTION                     *
*    IGG      GAMMA GROUP STRUCTURE OPTION                       *
*    IWT      WEIGHT FUNCTION OPTION                             *
*    LORD     LEGENDRE ORDER                                     *
*    NTEMP    NUMBER OF TEMPERATURES                             *
*    NSIGZ    NUMBER OF SIGMA ZEROES                             *
*    IPRINT   LONG PRINT OPTION (0=YES, 1=NO)                    *
* CARD3                                                          *
*    TITLE                                                       *
* CARD4                                                          *
*    TEMP     TEMPERATURES IN KELVIN                             *
* CARD5                                                          *
*    SIGZ     SIGMA ZERO VALUES (INCLUDING INFINITY)             *
* CARD6                                                          *
*             IF IGN=1, READ NEUTRON GROUP STRUCTURE             *
*    NGN      NUMBER OF GROUPS                                   *
* CARD 6A                                                        *
*    EGN      NGN+1 GROUP BREAKS (EV)                            *
* CARD7                                                          *
*             IF IGG=1, READ GAMMA GROUP STRUCURE                *
*    NGG      NUMBER OF GROUPS                                   *
* CARD 7A                                                        *
*    EGG      NGG+1 GROUP BREAKS (EV)                            *
* CARD 8A                                                        *
*             IF IWT.LT.0, READ FLUX CALCULATOR PARAMETERS       *
*    EHI      BREAK BETWEEN COMPUTED FLUX AND BONDARENKO FLUX    *
*                (MUST BE IN RESOLVED RANGE)                     *
*    SIGPOT   ESTIMATE OF POTENTIAL SCATTERING CROSS SECTION     *
*    NFLMAX   MAXIMUM NUMBER OF COMPUTED FLUX POINTS             *
* CARDS 8B                                                       *
*    WGHT     IF IWT=1 OR =-1, READ WEIGHT FUNCTION AS TAB1 RECORD *
* CARD 8C                                                        *
*             IF IWT=5 OR =-5, READ THE ANALYTIC FLUX PARAMETERS *
*    EB       THERMAL BREAK (EV)                                 *
*    TB       THERMAL TEMPERATURE (EV)                           *
*    EC       FISSION BREAK (EV)                                 *
```

```
*     TC        FISSION TEMPERATURE (EV)                                  *
* CARD9                                                                   *
*     MFD       FILE TO BE PROCESSED                                      *
*     MTD       SECTION TO BE PROCESSED                                   *
*     MTNAME    DESCRIPTION OF SECTION TO BE PROCESSED                    *
*               REPEAT FOR ALL REACTIONS DESIRED                          *
*               MFD=0 TERMINATES THIS TEMPERATURE/MATERIAL                *
* CARD10                                                                  *
*     MATD      NEXT MAT NUMBER TO BE PROCESSED                           *
*               TERMINATE GROUPR RUN WITH MATD=0.                         *
*                                                                         *
*---OPTIONS FOR INPUT VARIABLES-------------------------------------------*
*                                                                         *
*      IGN            MEANING                                           *
*      ---            -------                                           *
*       1             ARBITRARY STRUCTURE (READ IN)                     *
*       2             CSEWG 239 GROUP STRUCTURE                         *
*       3             LASL 30 GROUP STRUCTURE                           *
*       4             ANL 27 GROUP STRUCTURE                            *
*       5             RRD 50 GROUP STRUCTURE                            *
*       6             GAM-I 68 GROUP STRUCTURE                          *
*       7             GAM-II 100 GROUP STRUCTURE                        *
*       8             LASER-THERMOS 35 GROUP STRUCTURE                  *
*       9             EPRI-CPM 69 GROUP STRUCTURE                       *
*      10             LASL 185-GROUP STRUCTURE                          *
*                                                                         *
*      IGG            MEANING                                           *
*      ---            -------                                           *
*       0             NONE                                              *
*       1             ARBITRARY STRUCTURE (LIST RECORD)                 *
*       2             CSEWG 94 GROUP STRUCTURE                          *
*       3             LASL 12 GROUP STRUCTURE                           *
*       4             STEINER 21 GROUP GAMMA-RAY STRUCTURE              *
*                           (ORNL-TM-2564)                              *
*       5             STRAKER 22 GROUP STRUCTURE                        *
*       6             LASL 48-GROUP STRUCTURE                           *
*                                                                         *
*      IWT            MEANING                                           *
*      ---            -------                                           *
*       1             READ IN                                           *
*       2             CONSTANT                                          *
*       3             1/E                                               *
*       4             1/E + FISSION SPECTRUM + THERMAL MAXWELLIAN       *
*       5             EPRI-CELL LWR                                      *
*       6             (THERMAL) -- (1/E) -- (FISSION + FUSION)          *
*      -N             COMPUTE FLUX WITH WEIGHT N                        *
*                                                                         *
*      MFD            MEANING                                           *
*      ---            -------                                           *
*       3             CROSS SECTION OR YIELD VECTOR                     *
*       5             FISSION CHI BY SHORT-CUT METHOD                   *
*       6             NEUTRON-NEUTRON MATRIX                            *
*      16             NEUTRON-GAMMA MATRIX (PHOTON YIELDS GIVEN)        *
```

```
*      17              NEUTRON-GAMMA MATRIX (PHOTON XSECS GIVEN)      *
*                                                                     *
*      MTD             MEANING                                        *
*      ---             -------                                        *
*      -N              PROCESS ALL MT NUMBERS FROM THE PREVIOUS       *
*                              ENTRY TO N INCLUSIVE                   *
*      201-250         RESERVED FOR THERMAL SCATTERING                *
*                                                                     *
***********************************************************************
PROGRAM GAMINR
***********************************************************************
*                                                                     *
* PRODUCE MULTIGROUP PHOTON INTERACTION CROSS SECTIONS                *
* AND HEATING KERMA FACTORS USING ENDF/B-IV CROSS SECTIONS            *
* AND COHERENT AND INCOHERENT FOR FACTORS.  INITIAL ENERGY            *
* QUADRATURE TECHIQUES ARE IDENTICAL TO THOSE USED IN GROUPR.         *
* SECONDARY ENERGY-ANGLE QUADRATURE IS PERFORMED USING GAUSSIAN       *
* INTEGRATION.                                                        *
*                                                                     *
*---INPUT DATA CARDS-----------------------------------------------   *
*                                                                     *
* CARD1                                                               *
*    NENDF    UNIT FOR ENDF/B TAPE                                    *
*    NPEND    UNIT FOR PENDF TAPE                                     *
*    NGAM1    UNIT FOR INPUT NGAM TAPE                                *
*    NGAM2    UNIT FOR OUTPUT NGAM TAPE                               *
* CARD2                                                               *
*    MATB     MATERIAL TO BE PROCESSED                                *
*             INPUT MATERIALS IN ASCENDING ORDER                      *
*    IGG      GAMMA GROUP STRUCTURE OPTION                            *
*    IWT      WEIGHT FUNCTION OPTION                                  *
*    LORD     LEGENDRE ORDER                                          *
*    IPRINT   PRINT OPTION 0/1=MAXIMUM/MINIMUM                        *
* CARD3                                                               *
*    TITLE                                                           *
* CARD4                                                               *
*             IF IGG=1, READ GROUP STRUCTURE HERE                     *
*    NGG      NUMBER OF GROUPS                                        *
*    EGG      NGG+1 GROUP BOUNDS (EV)                                 *
* CARD5                                                               *
*             IF IWT=1, READ WEIGHT FUNCTION HERE                     *
*    WGHT     WEIGHT FUNCTION AS TAB1 RECORD                          *
* CARD6                                                               *
*    MFD      FILE TO BE PROCESSED                                    *
*    MTD      SECTION TO BE PROCESSED                                 *
*    MTNAME   DESCRIPTION OF SECTION TO BE PROCESSED                  *
*             REPEAT FOR ALL REACTIONS DESIRED                        *
*             MFD=0 TERMINATES THIS MATERIAL                          *
* CARD7                                                               *
*    MATD     NEXT MAT NUMBER TO BE PROCESSED                         *
*             TERMINATE GAMINR RUN WITH MATD=0.                       *
*                                                                     *
***********************************************************************
```

```
PROGRAM ERRORR
*****************************************************************
*                                                               *
* PRODUCE CROSS SECTION COVARIANCES                             *
* FROM ERROR FILES IN ENDF/B FORMAT.                            *
*                                                               *
* FIRST, THE UNION ENERGY GRID OF THE USERS GROUP STRUCTURE     *
* AND THE ENDF COVEARIANCE ENERGIES  IS DETERMINED.  THE ARRAY  *
* OF COEFFICIENTS FOR DERIVED CROSS SECTIONS IS ALSO CONSTRUCTED.*
* THEN MULTIGROUP CROSS SECTIONS ARE COMPUTED ON THIS FINE GRID *
* (SEE GRPAV) OR READ FROM A MASTER CROSS SECTION LIBRARY.  THE *
* METHODS OF GROUPR ARE USED FOR CROSS SECTION AVERAGING.  ENDF *
* COVARIANCES AND GROUP CROSS SECTIONS ANE THEN COMBINED TO     *
* GET THE BASIC COVARIANCE MATRICES (SEE COVCAL).  FINALLY,     *
* THE BASIC MATRICES ARE COMBINED TO GET COVARIANCES FOR        *
* DERIVED REACTIONS. THE MATRICES ARE COLLAPSED FOR THE UNION   *
* GROUP STRUCTURE, AND THE RESULTS ARE PRINTED AND/OR WRITTEN   *
* ONTO AN OUTPUT GENDF TAPE FOR LATER USE (SEE COVOUT).         *
*                                                               *
*---INPUT DATA---------------------------------------------------*
*                                                               *
*  CARD 1                                                       *
*    NENDF    UNIT FOR ENDF/B TAPE                             *
*    NPEND    UNIT FOR PENDF TAPE                              *
*    NGOUT    UNIT FOR GOUT TAPE                               *
*             (IF ZERO, GROUP XSECS WILL BE CALCULATED)        *
*    NOUT     UNIT FOR OUTPUT TAPE                             *
*  CARD 2                                                       *
*    MATD     MATERIAL TO BE PROCESSED                         *
*    IGN      NEUTRON GROUP OPTION                             *
*    IPRINT   PRINT OPTION (0=MINIMUM, 1=MAXIMUM)              *
*    IRELCO   RELATIVE COVARIANCE OPTION (0=ABS, 1=REL)        *
*  CARD 3     (OMIT IF NGOUT.GT.0)                             *
*    IWT      WEIGHT FUNCTION OPTION                           *
*    MPRINT   PRINT OPTION FOR GROUP AVERAGING (0=MIN., 1=MAX.)*
*                                                               *
*---FOR ENDF/B VERSION 4 (IVERF=4) ONLY--------------------------*
*                                                               *
*  CARD 4                                                       *
*    NEK      NUMBER OF DERIVED XSEC ENERGY RANGES             *
*             (IF ZERO, ALL XSECS ARE INDEPENDENT)             *
*  CARD 5     (OMIT IF NEK=0)                                  *
*    EK       NEK+1 DERIVED XSEC ENERGY BOUNDS                 *
*  CARD 6     (OMIT IF NEK=0)                                  *
*    AKXY     DERIVED CROSS SECTION COEFFICIENTS               *
*                                                               *
*---------------------------------------------------------------*
*                                                               *
*  CARD 7 (IF IGN.GT.1 ONLY)                                    *
*    NGN      NUMBER OF GROUPS                                 *
*  CARD 7A                                                      *
*    EGN      NGN+1 GROUP BOUNDS (EV)                          *
```

```
*  CARD 8 (IF IWT.GT.1 ONLY)                                          *
*    WGHT    WEIGHT FUNCTION AS A TAB1 RECORD                         *
*                                                                     *
***********************************************************************

PROGRAM MODER
***********************************************************************
*                                                                     *
*  CHANGE THE MODE OF AN ENDF/B TAPE.                                 *
*                                                                     *
*---INPUT-------------------------------------------------------------*
* CARD 1        UNIT NUMBERS                                          *
*      NIN      INPUT UNIT                                            *
*      NOUT     OUTPUT UNIT                                           *
*                                                                     *
*  A POSITIVE UNIT IS BCD (MODE 3).                                   *
*  A NEGATIVE UNIT IS BLOCKED BINARY (NJOY MODE).                     *
*                                                                     *
***********************************************************************

PROGRAM DTFR
***********************************************************************
*
* CONVERT OUTPUT OF GROUPR TO DTF FORMAT
*
* PROCESSES NEUTRON AND GAMMA PRODUCTION CROSS SECTIONS AND           *
* MATRICES.  THE NEUTRON TABLES CAN HAVE REDUCED TABLE LENGTH.        *
* UP-SCATTER IS ALLOWED.  THE ABSORPTION REACTION IS COMPUTED         *
* FROM THE TOTAL CROSS SECTION AND TOTAL SCATTERING.  ANY EDITS       *
* CAN BE PRODUCED WHICH ARE EITHER GIVEN IN THE ENDF/B FILE           *
* OR ARE LINEAR COMBINATIONS OF ENDF/B CROSS SECTIONS.  THE           *
* FISSION NU*SIGF AND CHI ARE COMPUTED FROM THE FISSION MATRICES      *
* FOR ALL PARTIAL FISSION REACTIONS.  CHI INCLUDES SOURCE             *
* WEIGHTING.  THE PL TABLES FOR L.GT.0 CONTAIN THE PL WEIGHTED        *
* TOTAL IN THE TOTAL POSITION AND THE PL TRANSPORT CROSS SECTION      *
* IN THE ABSORPTION POSITION.  THE GAMMA TABLES HAVE GAMMA GROUP      *
* 1 IN POSITION 1, 2 IN POSITION 2, ETC, WITH A TABLE LENGTH          *
* EQUAL TO THE NUMBER OF GAMMA GROUPS.                                *
*                                                                     *
* WARNING... THIS PROGRAM IS EXTREMELY MACHINE DEPENDENT              *
* BECAUSE OF ITS PLOTTING CAPABILITY.  THE CODING IS LEFT             *
* AS A GUIDE FOR CONVERSION TO OTHER SYSTEMS.                         *
*                                                                     *
*---INPUT DATA CARDS--------------------------------------------------*
*                                                                     *
* CARD 1        UNITS                                                 *
*    NIN        INPUT UNIT WITH DATA FROM GROUPR (BINARY).            *
*    NOUT       OUTPUT UNIT CONTAINING DTF TABLES (BCD).              *
*    NPEND      INPUT UNIT WITH PENDF TAPE FOR POINT PLOTS.           *
* CARD 2        OPTIONS                                               *
*    IPRINT     PRINT CONTROL (0 MAX, 1 MIN)                          *
```

```
*     IFILM      FILM CONTROL (0 YES, 1 NO)                              *
*     IEDIT      EDIT CONTROL (0 IN TABLE, 1 SEPARATE)                   *
*  CARD 3        NEUTRON TABLES                                          *
*     NLMAX      NUMBER OF NEUTRON TABLES DESIRED.                       *
*     NG         NUMBER OF NEUTRON GROUPS                                *
*     IPTOTL     POSITION OF TOTAL CROSS SECTION                         *
*     IPINGP     POSITION OF IN-GROUP SCATTERING CROSS SECTION.          *
*     ITABL      NEUTRON TABLE LENGTH DESIRED.                           *
*     NED        NUMBER OF ENTRIES IN EDIT TABLE BELOW.                  *
*     NTHERM     NUMBER OF THERMAL GROUPS                                *
*  CARD 3A       THERMAL INCOHERENT AND COHERENT MTS                     *
*     MTI        MT FOR THERMAL INCOHERENT DATA                          *
*     MTC        MT FOR THERMAL COHERENT DATA                            *
*     NLC        NO. COHERENT LEGENDRE ORDERS                            *
*  CARD 4        EDIT NAMES (IF ANY)                                     *
*        SIX CHARACTER HOLLERITH NAMES FOR EDITS FOR AS MANY            *
*        CARDS AS NEEDED.  THERE WILL BE IPTOTL-3 NAMES READ.           *
*  CARD 5        EDIT SPECIFICATIONS (IF ANY)                            *
*        NED TRIPLETS OF NUMBERS ON AS MANY CARDS AS NEEDED.            *
*        POSITIONS CAN APPEAR MORE THAN ONCE.                           *
*        REACTION TYPES CAN APPEAR MORE THAN ONCE.                      *
*     JPOS       POSITION OF EDIT QUANTITY.                              *
*     MT         ENDF/B REACTION NUMBER.                                 *
*     MULT       MULTIPLICITY TO BE USED WHEN ADDING THIS MT.            *
*  CARD 6        GAMMA RAY TABLES                                        *
*     NPTABL     NUMBER OF GAMMA TABLES DESIRED.                         *
*     NGP        NUMBER OF GAMMA GROUPS.                                 *
*  CARD 7        MATERIAL DESCRIPTION                                    *
*        ONE CARD FOR EACH TABLE SET DESIRED.                           *
*        MAT=0 TERMINATES EXECUTION OF DTFR.                            *
*     HISNAM     HOLLERITH ISOTOPE NAME                                  *
*     MAT        MATERIAL NUMBER AS IN ENDF/B                            *
*     JSIGZ      INDEX NUMBER OF SIGMA-ZERO DESIRED.                     *
*     DTEMP      TEMPERATURE DESIRED.                                    *
*                                                                        *
**************************************************************************

PROGRAM CCCCR
**************************************************************************
*                                                                        *
*  CCCC POST PROCESSOR PROGRAM                                           *
*  PRODUCE CCCC-III FILES FROM NJOY                                      *
*  INTERMEDIATE CROSS-SECTION LIBRARY.                                   *
*                                                                        *
*      WORKING FROMA A GROUPR OUTPUT TAPE, THIS MODULE PRODUCES          *
*  THE FOLLOWING THREE STANDARD INTERFACE FILES.                         *
*                                                                        *
*           ISOTXS       BRKOXS       DLAYXS,                          *
*                                                                        *
*  AS SPECIFIED BY THE COMMITTEE FOR COMPUTER CODE COORDINATION          *
*  (CCCC), TO FACILITATE THE EXCHANGE OF NUCLEAR DATA FOR REACTOR        *
*  CALCULATIONS (REFERENCE 1).                                           *
```

```
*       IN A GIVEN RUN, ALL THREE FILES CAN BE PRODUCED USING THE *
*  SAME USER-SPECIFIED LIST OF ISOTOPES.  THE CODE WILL IGNORE    *
*  ISOTOPES WHICH ARE NOT PRESENT ON THE GROUPR TAPE (AND IN THE *
*  CASE OF DLAYXS, ISOTOPES WITHOUT DELAYED NEUTRON DATA).       *
*       THE ISOTXS CODING ALLOWS FOR NSBLK EQUAL TO ONE OR NGROUP.*
*  IN ADDITION, FILES WITH HIGHER ORDER MATRICES CAN BE PRODUCED *
*  WITH A SEPARATE BLOCK FOR EACH L-ORDER (IFOPT=2) OR WITH ALL  *
*  ORDERS IN ONE BLOCK (IFOPT=1).  THIS FLEXIBILITY ACCOMMODATES *
*  LARGE GROUP STRUCTURES.  THE ONLY OPTION AVAILABLE FOR CHI IS *
*  THE FISSION MATRIX USING THE MODEL FLUX.                      *
*       IN BRKOXS, THE POTENTIAL SCATTERING CROSS SECTION FOR ALL *
*  ENERGY GROUPS IS EQUAL TO THE USER-INPUT VALUE (XSPO).        *
*                                                                *
*  1. B M CARMICHAEL, STANDARD INTERFACE FILES AND PROCEDURES FOR*
*       REACTOR PHYSICS CODES, LASL REPORT LA-5486-MS (FEB 1974) *
*                                                                *
*                                                                *
*---INPUT DATA CARDS-----------------------------------------------*
*                                                                *
*-CCCCR-                                                         *
* CARD 1 UNITS                                                   *
*    NIN       INPUT UNIT FOR DATA FROM GROUPR                   *
*    NISOT     OUTPUT UNIT FOR ISOTXS (0 IF ISOTXS NOT WANTED)   *
*    NBRKS     OUTPUT UNIT FOR BRKOXS (0 IF BRKOXS NOT WANTED)   *
*    NDLAY     OUTPUT UNIT FOR DLAYXS (0 IF DLAYXS NOT WANTED)   *
* CARD 2 IDENTIFICATION                                          *
*    LPRINT    PRINT FLAG (1/0 MEANS OUTPUT PRINTED/NOT PRINTED) *
*    IVERS     FILE VERSION NUMBER                               *
*    HUSE      USER IDENTIFICATION (12 CHARACTERS)               *
* CARD 3                                                         *
*    HSETID    HOLLERITH IDENTIFICATION OF SET (12 CHARACTERS)   *
* CARD 4 FILE CONTROL                                            *
*    NGROUP    NUMBER OF NEUTRON ENERGY GROUPS                   *
*    NGGRUP    NUMBER OF GAMMA ENERGY GROUPS                     *
*    NISO      NUMBER OF ISOTOPES DESIRE                         *
*    MAXORD    MAXIMUM LEGENDRE ORDER                            *
*    IFOPT     MATRIX BLOCKING OPTION (1/2=BLOCKING BY           *
*                                      REACTION/LEGENDRE ORDER)  *
* CARD 5 ISOTOPE PARAMETERS (ONE CARD PER ISOTOPE)               *
*    HISNM     HOLLERITH ISOTOPE LABEL                           *
*    HABSID    HOLLERITH ABSOLUTE ISOTOPE LABEL                  *
*    HIDENT    IDENTIFIER OF DATA SOURCE LIBRARY (ENDF/B)        *
*    HMAT      ISOTOPE IDENTIFICATION                            *
*    IMAT      NUMERICAL ISOTOPE IDENTIFIER (ENDF/B MAT NUMBER)  *
*    XSPO      AVERAGE POTENTIAL SCATTERING CROSS SECT. (BRKOXS) *
*                                                                *
*-CISTXS- (ONLY IF NISOT.GT.0)                                   *
* CARD 1 (4I6) FILE CONTROL                                      *
*    NSBLOK    SUBBLOCKING OPTION FOR SCATTERING MATRIX          *
*    MAXUP     MAXIMUM NUMBER OF UPSCATTER GROUPS (ALWAYS ZERO)  *
*    MAXDN     MAXIMUM NUMBER OF DOWNSCATTER GROUPS              *
*    ICHIST    SET FISSION SPECTRUM FLAG                         *
* CARD 2 ISOTOPE CONTROL (ONE CARD PER ISOTOPE)                  *
```

```
*     ICHI        ISOTOPE FISSION SPECTRUM FLAG                          *
*     KBR         ISOTOPE CLASSIFICATION                                 *
*     AMASS       GRAM ATOMIC WEIGHT                                     *
*     EFISS       TOTAL THERMAL ENERGY/FISSION                           *
*     ECAPT       TOTAL THERMAL ENERGY/CAPTURE                           *
*     TEMP        ISOTOPE TEMPERATURE                                    *
*     SIGPI       AVERAGE EFFECTIVE POTENTIAL SCATTERING                 *
*     ADENS       DENSITY OF ISOTOPE IN MIXTURE                          *
*                                                                        *
*--CBRKXS-- (ONLY IF NBRKS.GT.0)                                        *
* CARD 1 (2I6) FILE DATA                                                *
*     NTI         NUMBER OF TEMPERATURES DESIRED                         *
*                 (-N MEANS ACCEPT FIRST N TEMPERATURES)                 *
*     NZI         NUMBER OF SIGPO VALUES DESIRE                          *
*                 (-N MEANS ACCEPT FIRST N DILUTION FACTORS)             *
* CARD 2 (NOT NEEDED IF NTI.LT.0)                                       *
*     ATEM(NTI) VALUES OF DESIRED TEMPERATURES                          *
* CARD 3 (NOT NEEDED IF NZI.LT.0)                                       *
*     ASIG(NZI) VALUES OF DESIRED SIGPO                                 *
*                                                                        *
*--CDLAYX-- NO INPUT REQUIRED                                           *
*                                                                        *
**************************************************************************


PROGRAM MATXSR
**************************************************************************
*                                                                        *
*  POST PROCESSOR PROGRAM                                                *
*  PRODUCES MATXS INTERFACE FILE FROM NJOY                               *
*  INTERMEDIATE CROSS SECTION LIBRARY                                    *
*                                                                        *
*      THE MATXS FILE IS A GENERALIZED, FLEXIBLE FORMAT SIMILAR          *
*  TO THE CCCC-ISOTXS FORMAT.  WORKING FROM A GROUPR AND/OR              *
*  GAMINR OUTPUT TAPE, THIS MODULE CAN PROCESS NEUTRON CROSS             *
*  SECTIONS, GAMMA PRODUCTION DATA AND GAMMA INTERACTION CROSS           *
*  SECTIONS ONTO A SINGLE OUTPUT FILE.  IN ITS PRESENT FORM THIS         *
*  MODULE WILL ACCEPT ALL RELEVANT REACTIONS PRESENT ON THE INPUT        *
*  TAPE(S) AND PRODUCE AN ARCHIVAL OUTPUT FILE WHICH CAN BE              *
*  MANIPULATED BY A SEPARATE CODE CALLED *TRANSX*.                       *
*      A MATXS FILE SPECIFICATION MAY BE FOUND FOLLOWING THE             *
*  INPUT INSTRUCTIONS.                                                   *
*                                                                        *
*                                                                        *
*---INPUT DATA CARDS-----------------------------------------------------*
*                                                                        *
* CARD 1 UNITS                                                          *
*   NGEN1      INPUT UNIT FOR DATA FROM GROUPR                          *
*   NGEN2      INPUT UNIT FOR DATA FROM GAMINR                          *
*   NMATX      OUTPUT UNIT FOR MATXS                                    *
* CARD 2 USER IDENTIFICATION                                            *
*   LPRINT     0/1 MEANS NO PRINT/PRINT                                 *
*   IVERS      FILE VERSION NUMBER                                      *
```

```
*    HUSE       USER ID (12 CHARACTERS)                                  *
* CARD 3 FILE-CONTROL                                                    *
*    NPART      NUMBER OF PARTICLES FOR WHICH GROUP                      *
*                  STRUCTURES ARE GIVEN                                  *
*    NTYPE      NUMBER OF DATA TYPES IN SET                              *
*    NHOLL      NUMBER OF CARDS TO BE READ FOR HOLLERITH                 *
*               IDENTIFICATION RECORD.  TERMINATE CARDS WITH /.          *
* CARD 4 SET HOLLERITH IDENTIFICATION                                    *
*    HSETID     HOLLERITH IDENTIFICATION OF SET (A6)                     *
*                  (TO BE EDITED OUT 72 CHARACTERS PER LINE)             *
* CARD 5 PARTICLE IDENTIFIERS                                            *
*    HPART      HOLLERITH IDENTIFIERS FOR PARTICLES                      *
* CARD 6 ENERGY GROUPS                                                   *
*    NGRP       NUMBER OF GROUPS FOR EACH PARTICLE                       *
* CARD 7 DATA TYPE IDENTIFIERS                                           *
*    HTYPE      HOLLERITH IDENTIFIERS FOR DATA TYPES                     *
*                                                                        *
* THE FOLLOWING SEQUENCE OF CARDS IS REPEATED FOR EACH DATA TYPE         *
*                                                                        *
* CARD 11 DATA TYPE CONTROL                                              *
*    IFOPT      BLOCKING OPTION FOR MATRICES (1/2 MEANS                  *
*                  MATRICES NOT BLOCKED/BLOCKED BY L-ORDER)              *
*    NSBLK      SUB-BLOCKING PARAMETER (1/NING MEANS THAT A RECORD       *
*                  CONTAINS ALL INPUT GROUPS/ONE INPUT GROUP)            *
*    MAXORD     MAXIMUM LEGENDRE ORDER                                   *
*    NMATN      NUMBER OF MAT NAMES TO BE READ                           *
* CARD 12 INPUT PARTICLES                                                *
*    IINP       PARTICLE NUMBERS OF ALL INCIDENT PARTICLES               *
* CARD 13 OUTPUT PARTICLES                                               *
*    IOUTP      PARTICLE NUMBERS OF ALL OUTGOING PARTICLES               *
* CARD 14 MATERIAL DATA (ONE CARD PER MATERIAL)                          *
*    HMAT       HOLLERITH MATERIAL IDENTIFIER                            *
*    NTEMP      MAX NUMBER OF TEMPERATURES                               *
*    NSIGZ      MAX NUMBER OF SIGMA ZERO VALUES                          *
*    IMAT       INTEGER MATERIAL IDENTIFIER                              *
*                                                                        *
**************************************************************************
```

APPENDIX B

DEFINITION OF ENDF/B REACTION NUMBERS USED BY NJOY

MT	Description
1	Total cross section (redundant, equal to the sum of all partial cross sections)
2	Elastic scattering cross section
3	Nonelastic cross section (redundant, equal to the sum of all partial cross sections except elastic scattering)
4	Total inelastic cross section (redundant, equal to the sum of MT = 51, 52, 53, ..., 90, 91)
6	(n,2n) cross section for first excited state (describes first neutron)
7	(n,2n) cross section for second excited state (describes first neutron)
8	(n,2n) cross section for third excited state (describes first neutron)
9	(n,2n) cross section for fourth excited state (describes first neutron)
16	direct (n,2n) cross section [total (n,2n) cross section is sum of MT = 6, 7, 8, 9 and 16]
17	(n,3n) cross section
18	Total fission cross section (sum of MT = 19, 20, 21, 38)
19	(n,f) cross section (first chance fission)
20	(n,n'f) cross section (second chance fission)
21	(n,2nf) cross section (third chance fission)
22	(n,n´α) cross section
23	(n,n´3α) cross section
24	(n,2nα) cross section
25	(n,3nα) cross section
26	(n,2n) isomeric state cross section

28	(n,n´p) cross section
29	(n,n´2α) cross section
30	(n,2n2α) cross section
32	(n,n´d) cross section
33	(n,n´t) cross section
34	(n,n´^{3}He)
35	(n,n´d2α) cross section
36	(n,n´t2α) cross section
37	(n,4n) cross section
38	(n,3nf) cross section (fourth chance fission)
46	cross section for describing the second neutron from (n,2n) reaction for first excited state
47	cross section for describing the second neutron from (n,2n) reaction for second excited state
48	cross section for describing the second neutron from (n,2n) reaction for third excited state
49	cross section for describing the second neutron from (n,2n) reaction for fourth excited state (Note: MT = 46, 47, 48 and 49 should not be included in the sum for the total (n,2n) cross section)
50	(to be assigned)
51	(n,n') to the first excited state
52	(n,n') to the second excited state
.	
.	
.	
90	(n,n') to the 40th excited state
91	(n,n´) to the continuum
102	(n,γ) radiative capture cross section
103	(n,p) cross section
104	(n,d) cross section

105	(n,t) cross section
106	(n,^{3}He) cross section
107	(n,α) cross section
108	(n,2α) cross section
109	(n,3α) cross section
110	(to be assigned)
111	(n,2p) cross section
112	(n,pα) cross section
113	(n,t2α) cross section
114	(n,d2α) cross section
203	Total hydrogen production
204	Total deuterium production
205	Total tritium production
206	Total ^{3}He production
207	Total ^{4}He production
251	$\bar{\mu}_L$, the average cosine of the scattering angle (laboratory system) for elastic scattering
252	ξ, the average logarithmic energy decrement for elastic scattering
253	γ, the average of the square of the logarithmic energy decrement for elastic scattering, divided by twice the average logarithmic decrement for elastic scattering
301-450	Energy release rate parameters, $\overline{E^*\sigma}$, for total and partial cross sections. Subtract 300 from this number to obtain the specific reaction type identification. For example, MT = 302 = (300 + 2) denotes elastic scattering
451	Heading or title information (given only in File 1)
452	$\bar{\nu}$, average total (prompt plus delayed) number of neutrons released per fission event
455	Delayed neutrons from fission
456	Prompt neutrons from fission

501	Total photon interaction cross section
502	Photon coherent scattering
503	(to be assigned)
504	Photon incoherent scattering
516	Pair production, nuclear and electron field (i.e., pair plus triple production)
602	Photoelectric
700	(n,p_0) cross section (cross section for leaving the residual nucleus in the ground state)
701	(n,p_1) cross section for 1st excited state
702	(n,p_2) cross section for 2nd excited state
703	(n,p_3) cross section for 3rd excited state
704	(n,p_4) cross section for 4th excited state
.	
.	
.	
718	(n,p_c) cross section for continuum excited state
719	(n,p_c') cross section for continuum specifically not included in σ total (redundant, used for describing outgoing proton)
720	(n,d_0) cross section for ground state
721	(n,d_1) cross section for 1st excited state
722	(n,d_2) cross section for 2nd excited state
.	
.	
.	
738	(n,d_c) cross section for continuum excited state
739	(n,d_c') cross section for continuum specifically not included in σ total (redundant, used for describing outgoing deuteron)
740	(n,t_0) cross section for ground state
741	(n,t_1) cross section for 1st excited state
742	(n,t_2) cross section for 2nd excited state

.
.
.

750 (n,t_c) cross section for continuum excited state

759 (n,t_c') cross section for continuum specifically not included in σ total (redundant, used for describing outgoing triton)

760 ($n,^3He_0$) cross section for ground state

761 ($n,^3He_1$) cross section for 1st excited state

.
.
.

778 ($n,^3He_c$) cross section for continuum

779 ($n,^3He_c$) cross section for continuum specifically not included in σ total (redundant, used for describing outgoing ^{3}He)

780 (n,α_0) cross section for ground state

781 (n,α_1) cross section for 1st excited state

.
.
.

798 (n,α_c) cross section for continuum

799 (n,α_c') cross section for continuum specifically not included in σ_T (redundant, used to describe outgoing α)

The above MT numbers can also be used as "LR flags" to indicate the mode of decay of the residual nucleus. For instance, MT68/LR22 denotes a discrete (n,n') scattering event which leaves the residual nucleus in the 18th excited level; the residual nucleus then decays by α emission. The following MT numbers are used only as LR flags:

LR	Description
31	Indicates that γ-emission is the mode of decay of the residual nucleus formed in the primary reaction.
39	Indicates that internal conversion is the mode of decay of the residual nucleus formed in the primary reaction.
40	Indicates that electron-positron pair formation is the mode of decay of the residual nucleus formed in the primary reaction.

APPENDIX C

NJOY SAMPLE PROBLEMS

I. EXAMPLE 1, POINTWISE PROCESSING

```
MOJNT ENDF/B-IV TAPE 408 ON UNIT 20.
MOJNT ENDF/B-III THERMAL TAPE 322 ON UNIT 26.

 0
 4
 *MODER*
 20  -21
 *RECONR*
 -21  -22
 *PENDF TAPE FOR C-12 FROM ENDF/B TAPE 408*/
 1274  3  0
 .005  0.
 *6-C-12 FROM TAPE 408*/
 *PROCESSED BY THE NJOY NUCLEAR DATA PROCESSING SYSTEM*/
 *SEE ORIGINAL ENDF/B-IV TAPE FOR DETAILS OF EVALUATION*/
 0/
 *BROADR*
 -22  -23
 1274  1  0  1
 0.  .005
 300.
 0/
 *HEATR*
 -21  -23  -22
 1274  3  0  2
 302  351  402
 *THERMR*
 26  -22  -23
 1065  1274  1  1  4  1  1  201  0
 300.
 .05  1.3
 *GROUPR*
 -21  -23  0  -24
 1274  3  3  3  3  1  1  0
 *CARBON-12 IN GRAPHITE*/
 300.
 1E10
 3  1  *TOTAL*/
 3  2  *ELASTIC*/
 3  4  *INELASTIC*/
 3  51  *DISCRETE INELASTIC*/
 3  91  *CONT. INELASTIC*/
 3  102  *CAPTURE*/
 3  107  *(N,A)*/
 3  201  *THERMAL INCOHERENT*/
 3  202  *P0 THERMAL COHERENT*/
 3  203  *P1 THERMAL COHERENT*/
 3  301  *TOTAL HEAT PRODUCTION*/
 6  2  *ELASTIC*/
 6  51  *DISCRETE INELASTIC*/
 6  91  *CONT. INELASTIC*/
 6  201  *THERMAL INCOHERENT*/
```

```
   17  51 *INELASTIC GAMMA PRODUCTION*/
   16  102  *CAPTURE GAMMA PRODUCTION*/
   0/
   0/
   *MODER*
   -23  25
   *STOP*
```

```
**************************************************************************
*                                                *                       *
*    $$   $$        $$   $$$$$   $$    $$      *                       *
*    $$$  $$        $$  $$$$$$$   $$  $$       *  NUCLEAR              *  VERS.1-9/77  *
*    $$$$ $$        $$  $$   $$    $$$$        *  CROSS SECTION        *  RAN AT LASL  *
*    $$ $$$$  $$   $$  $$   $$     $$         *  PROCESSING           *  ON 09/21/77  *
*    $$  $$$  $$$$$$$  $$$$$$$     $$         *  SYSTEM               *  AT 00.08.53  *
*    $$   $$   $$$$$    $$$$$      $$         *                       *               *
*                                               *                       *
**************************************************************************
```

```
MODER...CHANGE THE MODE OF AN ENDF/B TAPE                          68.962S

INPUT UNIT (+ FOR BCD, - FOR BB) .....   20
OUTPUT UNIT (+ FOR BCD, - FOR BB) ....  -21

TAPE LABEL
----------------------------------------
  ENDF/B-IV TAPE 408 (REV. 3)                    1-SEPT-76
                                                                   79.564S
**************************************************************************

RECONR...RECONSTRUCT POINTWISE CROSS SECTIONS IN PENDF FORMAT      79.893S

UNIT FOR ENDF/B TAPE ..................  -21
UNIT FOR PENDF TAPE ...................  -22

LABEL FOR PENDF TAPE
----------------------------------------
 PENDF TAPE FOR C-15 FROM ENDF/B TAPE 408

TAPE LABEL
----------------------------------------
  ENDF/B-IV TAPE 408 (REV. 3)                    1-SEPT-76

                                                  STORAGE  15/25000
                                                  ID ENOD   1/ 1000
                                                  ID CARD   2/ 1051

MATERIAL TO BE PROCESSED ..............  1274
RECONSTRUCTION TOLERANCE ..............  .005
RECONSTRUCTION TEMPERATURE ............    0K

DESCRIPTIVE CARDS FOR PENDF TAPE
----------------------------------------
  6-C-12 FROM TAPE 408
  PROCESSED BY THE NJOY NUCLEAR DATA PROCESSING SYSTEM
  SEE ORIGINAL ENDF/B-IV TAPE FOR DETAILS OF EVALUATION

                                                  ID SCR    3/ 1407
```

```
PROCESSING MAT   1274
------------------------------------
   6- C- 12 ORNL       EVAL-DEC73 F.G.PEREY AND C.Y.FU

                                                                ID DICT    4/ 1581
                                                                XX DICT         0
                                                                ID MFS     4/ 1423
                                                                ID MTS     5/ 1439
                                                                ID NCS     6/ 1455
                                                                ID RES     7/24948

MAT HAS NO RESONANCE PARAMETERS

                                                                XX RES          0
                                                                ID BUFO    7/ 2455
                                                                ID BUFN    8/ 3455
                                                                ID X       9/ 3475
                                                                ID Y      10/ 3495

CHANGED THRESHOLD FROM 4.80000E+06 TO 4.80362E+06 FOR MT 51

POINTS IN INITIAL UNIONIZED GRID =  389
POINTS ADDED BY LINEARIZATION = 130
                                                                          80.720S
                                                                XX BUFO        -1
                                                                XX ENOD         1
                                                                ID BUFO    7/ 1456
                                                                ID BUFN    8/ 2456
                                                                ID BUFG    9/ 3456
                                                                ID BUFR   10/ 7456
                                                                XX BUFO        -1
                                                                ID BUFO    7/ 1456
                                                                ID BUFN    8/ 2456
                                                                XX ENOD        -1
                                                                ID ENOD    1/ 1000
                                                                          81.084S
**********************************************************************************

BROADR...DOPPLER BROADENING OF ENDF/B DATA                                81.288S

UNIT FOR INPUT RENDF TAPE ..........      -22
UNIT FOR OUTPUT RENDF TAPE .........      -23
MATERIAL TO BE PROCESSED ...........     1274
STARTING MATERIAL TEMPERATURE ......       0K
THINNING TOLERANCE .................     .005
NUMBER OF FINAL TEMPERATURES .......        1
RESTART (0 NO, 1 YES) ..............        0
BOOTSTRAP (0 NO, 1 YES) ............        1
FINAL TEMPERATURES .................
        300

                                                                STORAGE  10/30000
                                                                ID BUFO    1/ 1000
                                                                ID BUFN    2/ 2000
                                                                ID SCR     3/ 2356
                                                                XX SCR          0
                                                                ID E       3/ 8417
                                                                ID S       4/21251
                                                                ID EB      5/23817
                                                                ID SB      6/28949
                                                                ID SCR     7/29949
                                                                          81.519S
```

```
BROADENED MAT1274 FROM  0.          TO  3.0000E+02 K
        POINTS IN=   519  POINTS OUT=   494
        MT   2 102
                                                                  XX SCR          356
                                                                  ID B        8/29661
                                                                  XX SCR           -1
                                                                               82.252S
********************************************************************************

HEATR...PROMPT KERMA                                                           82.379S

ENDF/B UNIT ..............................      -21
INPUT PENDF UNIT .........................      -23
OUTPUT PENDF UNIT ........................      -22
MAT DESIRED ..............................     1274
PARTIAL KERMA MT=S DESIRED ...............      302
                                                351
                                                402

                                                  STORAGE   15/12000
                                                  ID BUFO    1/ 1000
                                                  ID BUFN    2/ 2000
                                                  ID SCR     3/ 2356
                                                  XX SCR           0
                                                  ID SCR     3/ 2356

PROCESSING AT TEMPERATURE= 3.0000E+02

                                                  ID B       4/ 2712
                                                  ID D       5/ 5212
                                                  ID A       6/11948

NEUTRON HEATING FOR MT  2   00 =  0.
            E              EBAR              XSEC          HEATING
    1.0000E-05     8.5696E-06     7.8778E+01     1.1269E-04
    1.0936E-04     9.3719E-05     2.4182E+01     3.7832E-04
    1.1933E-03     1.0200E-03     8.4593E+00     1.4404E-03
      .
      .
      .

PHOTON ENERGY (FROM XSECS) MF13, MT 51
            E              EBAR              XSEC          HEATING
    1   4.4330E+06 FV GAMMA
    5.1800E+06     4.4330E+06     4.5000E-02    -1.9948E+05
    6.4900E+06     4.4330E+06     2.6089E-01    -1.1565E+06
    8.1200E+06     4.4330E+06     4.7424E-01    -2.1023E+06
    1.0170E+07     4.4330E+06     3.5609E-01    -1.5786E+06
    1.2900E+07     4.4330E+06     2.8107E-01    -1.2460E+06
    1.7500E+07     4.4330E+06     1.5800E-01    -7.0041E+05

    2.0000E+07     4.4330E+06     1.5800E-01    -7.0041E+05
                                                  XX B             -1

FINAL KERMA FACTORS
            E              301            302            351            402

          MIN    -1.2966E+03     1.1269E-04     0.          -1.2966E+03
    1.0000E-05     2.1893E+02     1.1269E-04     0.           2.1893E+02
          MAX     1.5914E+03     1.1270E-04     0.           1.5914E+03
```

```
          MIN    -4.4370E+02    3.7832E-04    0.          -4.4370E+02
1.0936E-04        7.4915E+01    3.7832E-04    0.           7.4915E+01
          MAX     5.4458E+02    3.7832E-04    0.           5.4458E+02

          MIN    -1.3848E+02    1.4403E-03    0.          -1.3848E+02
1.1903E-03        2.3382E+01    1.4404E-03    0.           2.3381E+01
          MAX     1.6996E+02    1.4404E-03    0.           1.6996E+02
   .
   .
   .

          MIN     1.8631E+06    9.8140E+05    2.8585E+05    0.
1.7500E+07        4.5899E+06    9.8141E+05    2.8592E+05    0.
          MAX     4.5900E+06    9.8142E+05    2.8599E+05    0.

          MIN     2.1285E+06    1.1216E+06    3.3298E+05    0.
2.0000E+07        5.7024E+06    1.1216E+06    3.3305E+05    0.
          MAX     5.7025E+06    1.1216E+06    3.3312E+05    0.
                                                            ID B       4/ 2712
                                                            XX SCR        -1

                                                                      83.941S
*******************************************************************************

THERMR...COMPUTE THERMAL SCATTERING CROSS SECTIONS AND MATRICES       84.142S

UNIT FOR ENDF/B TAPE ..................          26
UNIT FOR INPUT PENDF TAPE .............         -22
UNIT FOR OUTPUT PENDF TAPE ............         -23
MATERIAL TO BE PROCESSED (ENDF) .......        1065
MATERIAL TO BE PROCESSED (PENDF) ......        1274
MAXIMUM LEGENDRE ORDER ................           1
NUMBER OF TEMPERATURES ................           1
INCOHERENT OPTION .....................           4
COHERENT OPTION .......................           1
NUMBER OF PRINCIPAL ATOMS .............           1
REFERENCE MT ..........................         201
PRINT OPTION ..........................           0
TEMPERATURES (KELVIN) .................  3.00E+02
TOLERANCE .............................  5.00E-02
EMAX ..................................  1.30E+00

                                                            STORAGE   10/20000
                                                            ID SCR     1/ 2050
                                                            ID BUFO    2/ 3050
                                                            ID BUFN    3/ 4050
                                                            ID STK     4/ 4110
                                                            ID FL      5/19963
                                                            XX FL           406
                                                            XX STK         -1
                                                            ID F       4/ 4095
                                                            ID XSEC    5/ 4140
                                                            ID ALPH    6/ 4180
                                                            ID BETA    7/ 4260
                                                            ID SAB     8/ 7460

DIFFERENCE BETWEEN TEMPERATURES DESIRED AND FOUND IS  4.00E+00
                                                            XX ALPH        -1
                                                            ID DICO    6/ 4224
                                                            ID DICN    7/ 4332
                                                            XX DICO        -1
```

```
WROTE THERMAL DATA FOR TEMP= 3.00E+02                                    111.742S
                                                                         111.745S
**************************************************************************************

GROUPR...COMPUTE SELF-SHIELDED GROUP-AVERAGED CROSS-SECTIONS             111.919S

UNIT FOR ENDF/B TAPE ..................      -21
UNIT FOR PENDF TAPE ...................      -23
UNIT FOR INPUT GOUT TAPE ..............        0
UNIT FOR OUTPUT GOUT TAPE .............      -24
MAT TO BE PROCESSED ...................     1274
NEUTRON GROUP STRUCTURE OPTION ........        3
GAMMA GROUP OPTION ....................        3
WEIGHT FUNCTION OPTION ................        3
LEGENDRE ORDER ........................        3
PRINT OPTION ..........................        0

RUN TITLE
-------------------------------------
     CARBON-12 IN GRAPHITE

TEMPERATURES (KELVIN) ................. 3.00E+02
SIGMA ZEROES ........................... INFINITY

NEUTRON GROUP STRUCTURE.....LASL 30 GROUP
    1    1.3900E-04 -   1.5200E-01
    2    1.5200E-01 -   4.1400E-01
    3    4.1400E-01 -   1.1300E+00
    4    1.1300E+00 -   3.0600E+00
    5    3.0600E+00 -   8.3200E+00
    6    8.3200E+00 -   2.2600E+01
    7    2.2600E+01 -   6.1400E+01
    8    6.1400E+01 -   1.6700E+02
    9    1.6700E+02 -   4.5400E+02
   10    4.5400E+02 -   1.2350E+03
   11    1.2350E+03 -   3.3500E+03
   12    3.3500E+03 -   9.1200E+03
   13    9.1200E+03 -   2.4800E+04
   14    2.4800E+04 -   6.7600E+04
   15    6.7600E+04 -   1.8400E+05
   16    1.8400E+05 -   3.0300E+05
   17    3.0300E+05 -   5.0000E+05
   18    5.0000E+05 -   8.2300E+05
   19    8.2300E+05 -   1.3530E+06
   20    1.3530E+06 -   1.7380E+06
   21    1.7380E+06 -   2.2320E+06
   22    2.2320E+06 -   2.8650E+06
   23    2.8650E+06 -   3.6800E+06
   24    3.6800E+06 -   6.0700E+06
   25    6.0700E+06 -   7.7900E+06
   26    7.7900E+06 -   1.0000E+07
   27    1.0000E+07 -   1.2000E+07
   28    1.2000E+07 -   1.3500E+07
   29    1.3500E+07 -   1.5000E+07
   30    1.5000E+07 -   1.7000E+07

GAMMA GROUP STRUCTURE.....LASL 12 GROUP
    1    1.0000E+04 -   1.0000E+05
    2    1.0000E+05 -   5.0000E+05
    3    5.0000E+05 -   1.0000E+06
    4    1.0000E+06 -   2.0000E+06
    5    2.0000E+06 -   3.0000E+06
    6    3.0000E+06 -   4.0000E+06
    7    4.0000E+06 -   5.0000E+06
```

```
    8     5.0000E+06 -    6.0000E+06
    9     6.0000E+06 -    7.0000E+06
   10     7.0000E+06 -    8.0000E+06
   11     8.0000E+06 -    9.0000E+06
   12     9.0000E+06 -    2.0000E+07

WEIGHT FUNCTION.....1/E FOR ALL L
```

```
STORAGE   20/18000
ID SCR     1/  356
```

```
PROCESSING MAT   1274
-----------------------------------------
 6-C-12 FROM TAPE 4##8
```

```
ID UNR     2/17933
XX UNR           1
ID BUF     3/ 1357
ID SCR1    4/ 1713
XX SCR1         -1
ID SIG     4/ 1713
ID ANS     5/ 1715
ID FF      6/ 1717
```

```
GROUP CONSTANTS AT T=3.000E+02 DEG K                    113.0628
FOR MF 3 AND MT   1 TOTAL

ENRGY  GROUP CONSTANTS AT
GROUP  INFINITE DILUTION

  1     8.099E+00
  2     4.752E+00
  3     4.738E+00
  4     4.732E+00
  5     4.730E+00
  6     4.730E+00
  .
  .
  .

GROUP CONSTANTS AT T=3.000E+02 DEG K                    113.4278
FOR MF 3 AND MT  51 DISCRETE INELASTIC

ENRGY  GROUP CONSTANTS AT
GROUP  INFINITE DILUTION

 24     5.170E-02
 25     2.465E-01
 26     3.119E-01
 27     3.609E-01
 28     2.899E-01
 29     2.092E-01
 30     1.580E-01
```

```
XX SIG          -1
ID SIG     4/ 1713
ID ANS     5/ 1715
ID FF      6/ 1717
```

```
GROUP CONSTANTS AT T=3.000E+02 DEG K                    113.5268
FOR MF 3 AND MT  91 CONT. INELASTIC
             LR 23 PARTICLE EMISSION
```

```
ENRGY  GROUP CONSTANTS AT
GROUP  INFINITE DILUTION

 26    1.110E-02
 27    8.096E-02
 28    1.750E-01
  .
  .
  .

GROUP CONSTANTS AT T=3.000E+02 DEG K                          113.765S
FOR MF 3 AND MT201 THERMAL INCOHERENT

ENRGY  GROUP CONSTANTS AT
GROUP  INFINITE DILUTION

  1    6.035E-01
  2    2.501E+00
  3    3.734E+00

                                              XX SIG          -1
                                              ID SIG    4/ 1713
                                              ID ANS    5/ 1715
                                              ID FF     6/ 1717

GROUP CONSTANTS AT T=3.000E+02 DEG K                          113.932S
FOR MF 3 AND MT202 P0 THERMAL COHERENT

ENRGY  GROUP CONSTANTS AT
GROUP  INFINITE DILUTION

  1    2.703E+00
  2    2.175E+00
  3    9.165E-01

                                              XX SIG          -1
                                              ID SIG    4/ 1713
                                              ID ANS    5/ 1715
                                              ID FF     6/ 1717

GROUP CONSTANTS AT T=3.000E+02 DEG K                          114.100S
FOR MF 3 AND MT203 P1 THERMAL COHERENT

ENRGY  GROUP CONSTANTS AT
GROUP  INFINITE DILUTION

  1    5.656E-02
  2    7.137E-01
  3    5.920E-01

                                              XX SIG          -1
                                              ID SIG    4/ 1713
                                              ID ANS    5/ 1715
                                              ID FF     6/ 1717

GROUP CONSTANTS AT T=3.000E+02 DEG K                          114.263S
FOR MF 3 AND MT301 TOTAL HEAT PRODUCTION
```

ENRGY GROUP	CONSTANTS AT INFINITE DILUTION
1	1.892E+01
2	1.823E+00
3	1.478E+00
4	1.910E+00
5	3.909E+00

.
.
.

GROUP CONSTANTS AT T=3.000E+02 DEG K 127.005$
FOR MF 6 AND MT201 THERMAL INCOHERENT

INITL GROUP	FINAL GROUP	GROUP CONSTANTS VS LEGENDRE ORDER 0	1
1	1	5.889F-01	-9.150E-02
1	2	1.438F-02	-3.130E-03
1	3	9.057F-07	-1.066E-06
2	1	4.244F-01	-1.183E-01
2	2	2.042F+00	-3.572E-01
2	3	3.481F-02	-3.773E-03
3	1	1.028F-02	-4.047E-03
3	2	6.058F-01	-1.652E-01
3	3	3.108F+00	-1.134E-01
3	4	1.006F-02	5.310E-03

XX SIG		-1
ID SIG	4/	1713
ID YL	5/	17933
XX YL		1
ID GYL	6/	1715
ID EYL	7/	1716
ID FLG	8/	17933
XX FLG		2700
ID GFL	9/	4420
ID ANS	10/	4472
ID FF	11/	4524

GROUP CONSTANTS AT T=3.000E+02 DEG K 135.968$
FOR MF17 AND MT 51 INELASTIC GAMMA PRODUCTION

INITL GROUP	FINAL GROUP	GROUP CONSTANTS VS LEGENDRE ORDER 0	1	2	3
24	7	5.171F-02	0.	5.832E-03	0.
25	7	2.465F-01	0.	7.786E-03	0.
26	7	3.119F-01	0.	2.796E-02	0.
27	7	3.609F-01	0.	9.153E-02	0.
28	7	2.899F-01	0.	7.997E-02	0.
29	7	2.092F-01	0.	4.611E-02	0.
30	7	1.580F-01	0.	2.749E-02	0.

.
.
.

10	4	6.430F-06	0.	6.430E-06	1.366E-05
11	4	3.483F-06	0.	3.483E-06	7.401E-06
12	4	1.146F-07	0.	1.146E-07	2.436E-07

```
                                                                XX SIG          -1
                                                                XX UNR          -1
                                                                            137.755$
*****************************************************************************

MODER...CHANGE THE MODE OF AN ENDF/B TAPE                                   137.763$

INPUT UNIT (+ FOR BCD, - FOR BB) .....  -23
OUTPUT UNIT (+ FOR BCD, - FOR BB) ....   25

TAPE LABEL
----------------------------------
 PENDF TAPE FOR C-12 FROM ENDF/B TAPE 408
                                                                            141.093$
*****************************************************************************


 COPYSF      1 FILES FROM


PENDF TAPE FOR C-12 FROM ENDF/B TAPE 408                                 1 0  0     0
 6.01200+ 3 1.18969+ 1          0           0           0          181274 1451     1
 3.00000+ 2 5.00000- 3          0           0           3           01274 1451     2
6-C-12 FROM TAPE 408                                                  1274 1451     3
PROCESSED BY THE NJOY NUCLEAR DATA PROCESSING SYSTEM                  1274 1451     4
SEE ORIGINAL ENDF/B-IV TAPE FOR DETAILS OF EVALUATION                 1274 1451     5
                                    1         451          17          01274 1451     6
                                    2         151           4          01274 1451     7
                                    3           1         168          01274 1451     8
                                    3           2         168          01274 1451     9
                                    3           4          88          01274 1451    10
                                    3          51          88          01274 1451    11
                                    3          91          39          01274 1451    12
                                    3         102         168          01274 1451    13
                                    3         107          65          01274 1451    14
                                    3         201         153          01274 1451    15
                                    3         202         153          01274 1451    16
                                    3         203         153          01274 1451    17
                                    3         301          15          01274 1451    18
                                    3         302          15          01274 1451    19
                                    3         351          37          01274 1451    20
                                    3         402          15          01274 1451    21
                                    6         201        1532          01274 1451    22
                                   13          51          89          01274 1451    23
                                                                        1274 1  0     24
                                                                        1274 0  0     25
 6.01200+ 3 1.18969+ 1          0           0           1          01274 2151    26
 6.01200+ 3 0.00000+ 0          0           0           1          01274 2151    27
 1.00000- 5 2.00000+ 7          0           0           0          01274 2151    28
 0.00000+ 0 6.13500- 1          0           0           0          01274 2151    29
                                                                        1274 2  0     30
                                                                        1274 0  0     31
 6.01200+ 3 1.18969+ 1          0          99           0           01274 3  1     32
 3.00000+ 2 0.00000+ 0          0           0           1         4941274 3  1     33
       494          2                                                 1274 3  1     34
 1.00000- 5 7.89241+ 1 1.17450- 5 7.28467+ 1 1.36822- 5 6.75147+ 11274 3  1     35
  .
  .
  .
```

```
1.15241+ 0 4.23483- 1 1.15243+ 0 4.23477- 1 1.15596+ 0 4.22492- 11274 3203 1277
1.15598+ 0 4.22486- 1 1.15692+ 0 4.22224- 1 1.15695+ 0 4.22214- 11274 3203 1278
1.18487+ 0 4.14579- 1 1.18489+ 0 4.14568- 1 1.24485+ 0 3.99000- 11274 3203 1279
1.24488+ 0 3.98994- 1 1.24525+ 0 3.98902- 1 1.24527+ 0 3.98895- 11274 3203 1280
1.24769+ 0 3.98291- 1 1.24771+ 0 3.98285- 1 1.24985+ 0 3.97750- 11274 3203 1281
1.24988+ 0 3.97742- 1 1.27962+ 0 3.90455- 1 1.27965+ 0 3.90448- 11274 3203 1282
1.29999+ 0 3.85607- 1 1.30001+ 0 0.00000+ 0 2.00000+ 7 0.00000+ 01274 3203 1283
                                                                  1274 3  0 1284
6.01200+ 3 1.18969+ 1           0           0           0           01274 3301 1285
3.00000+ 2 0.00000+ 0           0           0           1         4941274 3301 1286
       494         2                                                1274 3301 1287
1.00001- 5 2.18926+ 2 1.17450- 5 2.04986+ 2 1.36822- 5 1.92340+ 21274 3301 1288
1.58216- 5 1.80849+ 2 1.81733- 5 1.70386+ 2 2.07490- 5 1.60833+ 21274 3301 1289
2.35572- 5 1.52098+ 2 2.66083- 5 1.44091+ 2 2.99121- 5 1.36735+ 21274 3301 1290
3.73447- 5 1.23672+ 2 4.59170- 5 1.12507+ 2 5.57130- 5 1.02885+ 21274 3301 1291
6.68119- 5 9.45313+ 1 7.94626- 5 8.71422+ 1 9.36174- 5 8.06517+ 11274 3301 1292
1.09363- 4 7.49154+ 1 1.26782- 4 6.98184+ 1 1.45976- 4 6.52614+ 11274 3301 1293
1.67016- 4 6.11746+ 1 1.89988- 4 5.74917+ 1 2.14975- 4 5.41598+ 11274 3301 1294
2.43759- 4 5.10324+ 1 2.73489- 4 4.81914+ 1 3.41766- 4 4.32336+ 11274 3301 1295
4.20582- 4 3.90623+ 1 5.10674- 4 3.55151+ 1 6.12990- 4 3.24640+ 11274 3301 1296
7.28138- 4 2.98226+ 1 8.56893- 4 2.75174+ 1 1.00000- 3 2.54921+ 11274 3301 1297
 .
 .
 .
6.01200+ 3 1.18969+ 1           0           0           0           01274 3351 1623
3.00000+ 2 0.00000+ 0           0           0           1         2551274 3351 1624
       255         2                                                1274 3351 1625
4.80562+ 6-3.98615+ 3 4.85000+ 6 2.79971+ 3 4.89990+ 6 7.84157+ 31274 3351 1626
4.90000+ 6 7.85187+ 3 4.91940+ 6 1.00034+ 4 4.92000+ 6 1.00705+ 41274 3351 1627
4.93000+ 6 1.15531+ 4 4.93450+ 6 1.20611+ 4 4.93550+ 6 1.21742+ 41274 3351 1628
4.93670+ 6 1.23100+ 4 4.93850+ 6 1.25140+ 4 4.93950+ 6 1.26274+ 41274 3351 1629
4.94000+ 6 1.26842+ 4 4.94320+ 6 1.29318+ 4 4.94810+ 6 1.33119+ 41274 3351 1630
4.95000+ 6 1.34597+ 4 4.95460+ 6 1.40417+ 4 4.95840+ 6 1.45240+ 41274 3351 1631
 .
 .
 .
6.01200+ 3 1.18969+ 1           0           3           0           01274 6201 1882
3.00000+ 2 0.00000+ 0           0           0           1          451274 6201 1883
       45          2                                                1274 6201 1884
3.00000+ 2 1.00000- 5           0           0           1           01274 6201 1885
0.00000+ 0 0.00000+ 0           0           0           1          391274 6201 1886
       39          2                                                1274 6201 1887
2.00000+ 0 0.00000+ 0 1.00000- 5 3.74648- 3 1.61390- 2 2.57839+ 11274 6201 1888
3.22680- 2 1.36631+ 1 6.45260- 2 5.75426+ 0 6.85582- 2 4.62433+ 01274 6201 1889
7.25905- 2 4.19899+ 0 7.66227- 2 4.20955+ 0 8.06550- 2 3.23580+ 01274 6201 1890
8.87195- 2 2.07925+ 0 9.27517- 2 1.73760+ 0 9.67840- 2 1.64874+ 01274 6201 1891
1.04848- 1 1.50598+ 0 1.08881- 1 1.52221+ 0 1.12913- 1 1.21134+ 01274 6201 1892
1.16945- 1 9.41831- 1 1.20977- 1 8.13265- 1 1.29042- 1 6.09363- 11274 6201 1893
1.37106- 1 5.22262- 1 1.41139- 1 3.42183- 1 1.45171- 1 2.96997- 11274 6201 1894
1.53235- 1 2.43739- 1 1.61300- 1 1.51043- 1 1.77429- 1 1.39621- 11274 6201 1895
1.93558- 1 6.18836- 2 2.01622- 1 4.22893- 2 2.05655- 1 2.32305- 21274 6201 1896
2.09687- 1 1.28564- 2 2.13719- 1 7.21654- 3 2.17751- 1 5.69094- 31274 6201 1897
2.25816- 1 3.61977- 3 2.33880- 1 2.35313- 3 2.41945- 1 1.54310- 31274 6201 1898
2.58074- 1 8.39635- 4 2.90332- 1 2.32014- 4 3.22590- 1 8.22118- 51274 6201 1899
3.87106- 1 5.41923- 6 5.16138- 1 0.00000+ 0 1.03227+ 0 0.00000+ 01274 6201 1900
0.00000+ 0 0.00000+ 0           0           1           1         321274 6201 1901
       32          2                                                1274 6201 1902
0.00000+ 0 0.00000+ 0 1.00000- 5-1.09071- 3 1.01806- 3-5.22825- 21274 6201 1903
2.02612- 3-9.02805- 2 4.04225- 3-1.52924- 1 8.07450- 3-2.51247- 11274 6201 1904
1.21067- 2-3.20549- 1 1.61390- 2-3.48596- 1 2.42035- 2-2.21681- 11274 6201 1905
3.22680- 2-1.42526- 1 4.03325- 2-1.03466- 1 4.83970- 2-8.36527- 21274 6201 1906
```

```
5.24292- 2-8.72858- 2 5.64615- 2-8.09605- 2 6.04937- 2-5.95902- 21274 6201 1907
6.45260- 2-4.43431- 2 8.06550- 2-1.66984- 2 8.87195- 2-1.16180- 21274 6201 1908
9.27517- 2-1.00456- 2 9.67840- 2-9.56456- 3 1.12913- 1-7.31369- 31274 6201 1909
1.20977- 1-5.24072- 3 1.29042- 1-4.08827- 3 1.37106- 1-3.51600- 31274 6201 1910
1.45171- 1-2.21418- 3 1.53235- 1-1.13074- 3 1.61300- 1-7.31317- 41274 6201 1911
1.93558- 1-2.95102- 4 2.25816- 1-4.05589- 5 2.58074- 1-6.87675- 61274 6201 1912
5.16138- 1 0.00000+ 0 1.03227+ 0 0.00000+ 0                      1274 6201 1913
0.00000+ 0 3.16000- 5           0           0           1       01274 6201 1914
0.00000+ 0 0.00000+ 0           0           0           1     381274 6201 1915
        38          2                                            1274 6201 1916
0.00000+ 0 0.00000+ 0 3.16000- 5 1.71036- 2 1.61606- 2 2.58054+ 11274 6201 1917
3.22896- 2 1.36576+ 1 6.45476- 2 5.74790+ 0 6.85798- 2 4.61909+ 01274 6201 1918
7.26121- 2 4.19405+ 0 7.66443- 2 4.19948+ 0 8.06766- 2 3.23165+ 01274 6201 1919
8.87411- 2 2.07661+ 0 9.27733- 2 1.73541+ 0 9.68056- 2 1.64664+ 01274 6201 1920
1.04870- 1 1.50404+ 0 1.08902- 1 1.52022+ 0 1.12935- 1 1.20977+ 01274 6201 1921
1.16967- 1 9.40627- 1 1.20999- 1 8.12229- 1 1.29064- 1 6.08592- 11274 6201 1922
1.37128- 1 5.21594- 1 1.41160- 1 3.41766- 1 1.45193- 1 2.96634- 11274 6201 1923
1.53257- 1 2.43029- 1 1.61322- 1 1.50819- 1 1.77451- 1 1.39405- 11274 6201 1924
1.93580- 1 6.17892- 2 2.01644- 1 4.22248- 2 2.05676- 1 2.31982- 21274 6201 1925
2.09709- 1 1.28407- 2 2.13741- 1 7.20902- 3 2.17773- 1 5.68530- 31274 6201 1926
2.25838- 1 3.63935- 3 2.41967- 1 1.54118- 3 2.58096- 1 8.38553- 41274 6201 1927
2.90354- 1 2.31705- 4 3.22612- 1 8.20821- 5 3.87128- 1 5.41016- 61274 6201 1928
5.16160- 1 0.00000+ 0 1.03229+ 0 0.00000+ 0                      1274 6201 1929
0.00000+ 0 0.00000+ 0           0           1           1     321274 6201 1930
        32          2                                            1274 6201 1931
0.00000+ 0 0.00000+ 0 3.16000- 5-4.97934- 3 1.03966- 3-9.41947- 21274 6201 1932
2.24772- 3-1.61425- 1 4.06385- 3-2.72384- 1 8.09610- 3-4.46647- 11274 6201 1933
1.21283- 2-5.69476- 1 1.61606- 2-6.19104- 1 2.42251- 2-3.93997- 11274 6201 1934
3.22896- 2-2.53022- 1 4.03541- 2-1.83661- 1 4.84186- 2-1.48479- 11274 6201 1935
5.24508- 2-1.54921- 1 5.64831- 2-1.43690- 1 6.05153- 2-1.05761- 11274 6201 1936
6.45476- 2-7.87002- 2 8.06766- 2-2.96478- 2 8.87411- 2-2.06276- 21274 6201 1937
9.27733- 2-1.78359- 2 9.68056- 2-1.69814- 2 1.12935- 1-1.29846- 21274 6201 1938
1.20999- 1-9.39438- 3 1.29064- 1-7.25831- 3 1.37128- 1-6.24219- 31274 6201 1939
1.45193- 1-3.93114- 3 1.53257- 1-2.20337- 3 1.61322- 1-1.29810- 31274 6201 1940
1.93580- 1-5.23785- 4 2.25838- 1-6.77412- 5 2.58096- 1-1.22079- 51274 6201 1941
5.16160- 1 0.00000+ 0 1.03229+ 0 0.00000+ 0                      1274 6201 1942
0.00000+ 0 1.00000- 4           0           0           1       01274 6201 1943
0.00000+ 0 0.00000+ 0           0           0           1     381274 6201 1944
        38          2                                            1274 6201 1945
0.00000+ 0 0.00000+ 0 1.00000- 4 7.79018- 2 1.62290- 2 2.58690+ 11274 6201 1946
3.23580- 2 1.36383+ 1 6.46160- 2 5.72700+ 0 6.86482- 2 4.60185+ 01274 6201 1947
7.26805- 2 4.17390+ 0 7.67127- 2 4.17334+ 0 8.07450- 2 3.21779+ 01274 6201 1948
8.88095- 2 2.06797+ 0 9.28417- 2 1.72823+ 0 9.68740- 2 1.63977+ 01274 6201 1949
1.04938- 1 1.49768+ 0 1.08971- 1 1.51371+ 0 1.13003- 1 1.20465+ 01274 6201 1950
1.17035- 1 9.36692- 1 1.21067- 1 8.08841- 1 1.29132- 1 6.06070- 11274 6201 1951
1.37196- 1 5.19409- 1 1.41229- 1 3.40398- 1 1.45261- 1 2.95381- 11274 6201 1952
  .
  .
  .
```

II. EXAMPLE 2, CCCC CROSS-SECTION LIBRARY

```
MOUNT ENDF/B-IV TAPE 404 ON UNIT 20.

 0
 4/
 *MODER*
 20 -21
 *RECONR*
 -21 -22
 *PENDF TAPE FOR PU-238 FROM ENDF/B-IV TAPE 404*/
```

```
1050 3 0
.005  0.
*94-PU-238 FROM TAPE 404*/
*PROCESSED BY THE NJOY NUCLEAR DATA SYSTEM*/
*SEE ORIGINAL ENDF/B-IV TAPE FOR DETAILS OF THE EVALUATION*/
0/
*BROADR*
-22 -23
1050  3  0  1  0.0  0.002
300.  900.  2100.
0/
*UNRESR*
-21 -23 -22
1050  3  7  1
300.  900.  2100.
1.E10  1.E5  1.E4  1.E3  100.  10.  1.
0/
*GROUPR*
-21 -22 0 -25
1050  5  0  4  3  7  7  0
*94-PU-238*/
300.  900.  2100.
1.E10  1.E5  1.E4  1.E3  100.  10.  1.
0.1  0.025  0.8208F06  1.4E06
3  1  *TOTAL*/
3  2  *ELASTIC*/
3  16  *N2N*/
3  18  *FISSION*/
3  102  *CAPTURE*/
3  251  *MUBAR*/
3  252  * XI */
3  259  *1/V*/
6  2  *ELASTIC*/
6  16  *N,2N*/
6  17  *N,3N*/
6  18  *FISSION*/
6  51  *DISCRETE INELASTIC*/
6  -59  *CONTINUED*/
6  91  *CONTINUUM INELASTIC*/
0/
3  1  *TOTAL*/
3  2  *ELASTIC*/
3  18  *FISSION*/
3  102  *CAPTURE*/
6  2  *ELASTIC*/
0/
3  1  *TOTAL*/
3  2  *ELASTIC*/
3  18  *FISSION*/
3  102  *CAPTURE*/
6  2  *ELASTIC*/
0/
0/
*CCCCR*
-25  21  22  0
1  1  *T2LASL NJOY* /
*CCCCR TEST8 JULY-AUG 1977*/
50  0  1  4  1
*PU238 *  *PU238 *  *ENDFB4*  * 1050 *  1050  10.89
1  0  50  0
1  0  2.3821E02  3.3003E-11  1.7461E-12  0.0  1.0E10  0.0
3  6
300.  900.  2100.
1.E5  1.E4  1.E3  100.  10.  1.
*STOP*
```

```
**************************************************************************************
*                                                *                   *                *
*    $$   $$        $$   $$$$$   $$    $$   *                   *                *
*    $$$  $$        $$  $$$$$$$  $$  $$    *  NUCLEAR          *  VERS.1-8/78   *
*    $$$$ $$        $$  $$   $$    $$$$     *  CROSS SECTION    *  RAN AT LASL   *
*    $$ $$$$  $$   $$  $$   $$     $$      *  PROCESSING       *  ON 10/11/78   *
*    $$  $$$  $$$$$$$  $$$$$$$     $$      *  SYSTEM           *  AT 12.13.24   *
*    $$   $$   $$$$$    $$$$$      $$      *                   *                *
*                                           *                   *                *
**************************************************************************************

MODER...CHANGE THE MODE OF AN ENDF/B TAPE                                  46.7538


INPUT UNIT (+ FOR BCD, - FOR BB) .....   20
OUTPUT UNIT (+ FOR BCD, - FOR BB) ....  -21

TAPE LABEL
----------
  ENDF/B-IV TAPE 404 (REV. 3)                          1-SEPT-76
                                                                           56.6758
**************************************************************************************

RECONR...RECONSTRUCT POINTWISE CROSS SECTIONS IN PENDF FORMAT              57.3638

UNIT FOR ENDF/B TAPE ..................  -21
UNIT FOR PENDF TAPE ...................  -22

LABEL FOR PENDF TAPE
--------------------
 PENDF TAPE FOR PU-238 FROM ENDF/B-IV TAPE 404

TAPE LABEL
----------
  ENDF/B-IV TAPE 404 (REV. 3)                          1-SEPT-76

                                                       STORAGE  15/25000
                                                       ID ENDD   1/ 1000
                                                       ID CARD   2/ 1051

MATERIAL TO BE PROCESSED ............. 1050
RECONSTRUCTION TOLERANCE ............. .005
RECONSTRUCTION TEMPERATURE ...........    0K

DESCRIPTIVE CARDS FOR PENDF TAPE
--------------------------------
  94-PU-238 FROM TAPE 404
  PROCESSED BY THE NJOY NUCLEAR DATA SYSTEM
  SEE ORIGINAL ENDF/B-IV TAPE FOR DETAILS OF THE EVALUATION

                                                       ID SCR    3/ 1407

PROCESSING MAT   1050
---------------------
  94-PU-238 AI         EVAL-MAY67 ALTER AND DUNFORD

                                                       ID DICT   4/ 1665
                                                       XX DICT      0
                                                       ID MFS    4/ 1431
                                                       ID MTS    5/ 1455
                                                       ID NCS    6/ 1479
                                                       ID RES    7/24948
                                                       XX RES       223
                                                       ID BUFO   8/ 2702
```

```
                                                                ID BUFN    9/ 3702
                                                                ID X      10/ 3752
                                                                ID Y      11/ 3802

CHANGED THRESHOLD FROM 7.58000E+05 TO 7.58197E+05 FOR MT 55.

CHANGED THRESHOLD FROM 9.89000E+05 TO 9.89171E+05 FOR MT 57.

CHANGED THRESHOLD FROM 1.20000E+06 TO 1.20006E+06 FOR MT 91.

POINTS IN INITIAL UNIONIZED GRID =  110
POINTS ADDED BY LINEARIZATION = 337                                      58.403S
                                                                XX BUFO       -1
                                                                XX ENOD        1
                                                                ID BUFR    8/ 4703
                                                                ID BUFG    9/ 5703
                                                                ID X      10/ 5723
                                                                ID Y      11/ 5743
                                                                ID SIGS   12/ 5803

POINTS ADDED BY RESONANCE RECONSTRUCTION =  2832
TOTAL NUMBER OF RESONANCE POINTS =  2851                                 61.320S
POINTS REJECTED BY SIGNIFICANT FIGURES CHECK =    50
                                                                XX BUFR       -1
                                                                XX RES         0
                                                                ID BUFO    7/ 1480
                                                                ID BUFN    8/ 2480
                                                                ID BUFG    9/ 3480
                                                                ID BUFR   10/ 7480
                                                                XX BUFO       -1
                                                                ID BUFO    7/ 1480
                                                                ID BUFN    8/ 2480
                                                                XX ENOD       -1
                                                                ID ENOD    1/ 1000
                                                                         65.724S
**************************************************************************************

BROADR...DOPPLER BROADENING OF ENDF/B DATA                               65.900S

UNIT FOR INPUT PENDF TAPE ..........      -22
UNIT FOR OUTPUT PENDF TAPE .........      -23
MATERIAL TO BE PROCESSED ...........     1050
STARTING MATERIAL TEMPERATURE ......        0K
THINNING TOLERANCE .................     .002
NUMBER OF FINAL TEMPERATURES .......        3
RESTART (0 NO, 1 YES) ..............        0
BOOTSTRAP (0 NO, 1 YES) ............        1
FINAL TEMPERATURES .................
         300         900        2100

                                                                STORAGE   10/30000
                                                                ID BUFO    1/ 1000
                                                                ID BUFN    2/ 2000
                                                                ID SCR     3/ 2356
                                                                XX SCR          0
                                                                ID E       3/ 6812
                                                                ID S       4/21248
                                                                ID EB      5/23172
                                                                ID SB      6/28944
                                                                ID SCR     7/29944
                                                                         68.556S
```

```
BROADENED MAT1050 FROM  0.          TO  3.0000E+02 K
        POINTS IN=  3232  POINTS OUT=  2342
        MT   2  18 102
                                                                XX SCR        356
                                                                ID B       8/29656
                                                                XX SCR         -1
                                                                ID SCR     7/29944
                                                                           94.611S
BROADENED MAT1050 FROM  3.0000E+02 TO  9.0000E+02 K
        POINTS IN=  2342  POINTS OUT=  2076
        MT   2  18 102
                                                                XX SCR        356
                                                                ID B       8/29656
                                                                XX SCR         -1
                                                                ID SCR     7/29944
                                                                          104.431S
BROADENED MAT1050 FROM  9.0000E+02 TO  2.1000E+03 K
        POINTS IN=  2076  POINTS OUT=  1827
        MT   2  18 102
                                                                XX SCR        356
                                                                ID B       8/29656
                                                                XX SCR         -1
                                                                          112.741S
**************************************************************************************

UNRESR...CALCULATION OF UNRESOLVED RESONANCE CROSS SECTIONS                113.605S

                                                                STORAGE    8/20000
                                                                ID SCR     1/ 1000
UNIT FOR INPUT ENDF/B TAPE ..... -21
UNIT FOR INPUT PENDF TAPE ..... -23
UNIT FOR OUTPUT PENDF TAPE ..... -22
TEMPERATURES ...........................
   3.00E+02   9.00E+02   2.10E+03
SIGMA ZERO VALUES ......................
   1.00E+10   1.00E+05   1.00E+04   1.00E+03   1.00E+02   1.00E+01   1.00E+00
PRINT OPTION ...........................  1

MAT = 1050    TEMP =  3.00E+02                                             114.202S
                                                                ID EUNR    2/ 1150
                                                                ID ARRY    3/19969
                                                                XX ARRY         41
                                                                ID SB      4/ 1251
                                                                ID B       5/19969
ENERGY =  2.0000E+02
  6.538E+01  6.442E+01  5.780E+01  3.715E+01  2.018E+01  1.492E+01  1.402E+01
  4.493E+01  4.423E+01  3.946E+01  2.568E+01  1.578E+01  1.301E+01  1.255E+01
  3.582E+00  3.537E+00  3.211E+00  2.004E+00  7.677E-01  3.314E-01  2.553E-01
  1.687E+01  1.666E+01  1.513E+01  9.466E+00  3.633E+00  1.570E+00  1.211E+00
  6.538E+01  6.349E+01  5.185E+01  2.683E+01  1.520E+01  1.284E+01  1.248E+01
ENERGY =  5.0000E+02
  4.541E+01  4.516E+01  4.318E+01  3.351E+01  2.037E+01  1.506E+01  1.409E+01
  3.445E+01  3.425E+01  3.270E+01  2.544E+01  1.650E+01  1.328E+01  1.273E+01
  3.114E+00  3.099E+00  2.975E+00  2.285E+00  1.088E+00  4.963E-01  3.811E-01
  7.852E+00  7.815E+00  7.507E+00  5.789E+00  2.783E+00  1.282E+00  9.880E-01
  4.541E+01  4.492E+01  4.119E+01  2.713E+01  1.562E+01  1.284E+01  1.243E+01
    .
    .
    .
                                                                ID D       7/ 2044
                                                                XX D             0
                                                                XX C             0
```

```
GENERATED CROSS SECTIONS AT  15 POINTS                          145.286S
                                                          XX B          -1
                                                          XX EUNR        0

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

GROUPR...COMPUTE SELF-SHIELDED GROUP-AVERAGED CROSS-SECTIONS    145.555S

UNIT FOR ENDF/B TAPE ..................      -21
UNIT FOR PENDF TAPE ...................      -22
UNIT FOR INPUT GOUT TAPE ..............        0
UNIT FOR OUTPUT GOUT TAPE .............      -25
MAT TO BE PROCESSED ...................     1050
NEUTRON GROUP STRUCTURE OPTION ........        5
GAMMA GROUP OPTION ....................        0
WEIGHT FUNCTION OPTION ................        4
LEGENDRE ORDER ........................        3
PRINT OPTION ..........................        0

RUN TITLE
-------------------------------------
     94-PU-238

TEMPERATURES (KELVIN) ................. 3.00E+02
                                        9.00E+02
                                        2.10E+03
SIGMA ZEROES ........................... INFINITY
                                        1.00E+05
                                        1.00E+04
                                        1.00E+03
                                        1.00E+02
                                        1.00E+01
                                        1.00E+00

NEUTRON GROUP STRUCTURE.....RRD 50 GROUP
    1    1.0000E-05 -   6.8256E-01
    2    6.8256E-01 -   1.1254E+00
    3    1.1254E+00 -   1.8554E+00
    .
    .
    .
   48    3.6788E+06 -   6.0653E+06
   49    6.0653E+06 -   1.0000E+07
   50    1.0000E+07 -   1.9971E+07

WEIGHT FUNCTION.....THERMAL + 1/E + FISSION
THERMAL BREAKPOINT AND TEMPERATURE    1.0000E-01  2.5000E-02
FISSION BREAKPOINT AND TEMPERATURE    8.2080E+05  1.4000E+06

                                                  STORAGE  20/18000
                                                  ID SCR    1/  356
                                                  ID NU     2/17933
                                                  XX NU           0

PROCESSING MAT   1050
-------------------------------------
 94-PU-238 FROM TAPE 404

                                                  ID UNR    2/17933
                                                  XX UNR        976
                                                  ID BUF    3/ 2332
                                                  ID SCR1   4/ 2688
                                                  XX SCR1         -1
```

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                                                                ID SIG     4/ 2688
                                                                ID ANS     5/ 2716
                                                                ID FF      6/ 2720

GROUP CONSTANTS AT T=3.000E+02 DEG K                                          147.307S
FOR MF 3 AND MT  1 TOTAL

ENRGY  LGEND  GROUP CONSTANTS VS SIGMA ZERO
GROUP  ORDER  INFINITY   1.000E+05  1.000E+04  1.000E+03  1.000E+02  1.000E+01

  1       0   3.686F+02  3.676E+02  3.593E+02  3.124E+02  2.184E+02  1.663E+02
    FLUX  0   5.023F+00  5.004E+00  4.849E+00  3.827E+00  1.578E+00  2.850E-01
  1       1   3.686F+02  3.666E+02  3.505E+02  2.685E+02  1.317E+02  8.004E+01
    FLUX  1   5.023F+00  4.986E+00  4.684E+00  3.017E+00  6.808E-01  3.165E-02
  2       0   2.452F+01  2.450E+01  2.452E+01  2.445E+01  2.406E+01  2.258E+01
  .
  .
  .

    FLUX  1   5.001F-01  5.000E-01  4.991E-01  4.905E-01  4.150E-01  1.279E-01
                                                           ID FF      7/ 4670

GROUP CONSTANTS AT T=3.000E+02 DEG K                                          159.630S
FOR MF 6 AND MT  2 ELASTIC

INITL  FINAL  LGEND  GROUP CONSTANTS VS SIGMA ZERO
GROUP  GROUP  ORDER  INFINITY   1.000E+05  1.000E+04  1.000E+03  1.000E+02

  1      1      0   1.922E+01  1.921E+01  1.918E+01  1.893E+01  1.817E+01
  1      1      1   5.425E-02  5.423E-02  5.403E-02  5.266E-02  4.889E-02
  1      1      2   6.892E-05  6.887E-05  6.850E-05  6.597E-05  6.015E-05
  1      1      3   0.         0.         0.         0.         0.
  2      1      0   2.564E-01  2.564E-01  2.562E-01  2.542E-01  2.384E-01
  2      1      1  -8.494E-02 -8.493E-02 -8.479E-02 -8.349E-02 -7.329E-02
  2      1      2  -3.067E-04 -3.065E-04 -3.046E-04 -2.864E-04 -1.647E-04
  2      1      3  -2.407E-06 -2.400E-06 -2.333E-06 -1.724E-06  9.116E-07
  2      2      0   1.343E+01  1.343E+01  1.343E+01  1.342E+01  1.334E+01
  2      2      1   1.236E-01  1.236E-01  1.234E-01  1.221E-01  1.113E-01
  2      2      2   3.558E-04  3.556E-04  3.536E-04  3.353E-04  2.125E-04
  .
  .
  .

GROUP CONSTANTS AT T=3.000E+02 DEG K                                          167.028S
FOR MF 6 AND MT 17 N,3N

INITL  FINAL  ISOTROPIC MATRIX VS FINAL GROUP
GROUP  GROUP  +0         +1         +2         +3

 50     12    1.477F-09  4.012E-09  4.116E-09  6.783E-09  1.118E-08  1.842E-08
 50     18    3.034F-08  4.996E-08  8.226E-08  1.354E-07  2.227E-07  3.660E-07
 50     24    6.011F-07  9.862E-07  1.616E-06  2.642E-06  4.311E-06  7.012E-06
 50     30    1.136F-05  1.833E-05  2.929E-05  4.622E-05  7.289E-05  1.135E-04
 50     36    1.740F-04  2.613E-04  3.826E-04  5.416E-04  7.359E-04  9.490E-04
 50     42    1.145F-03  1.271E-03  2.387E-03  1.329E-03  3.300E-04  3.122E-05
 50     48    1.328F-06  6.269E-09

                                                                XX SIG       -1
                                                                ID SIG     4/ 2688
                                                                ID YLD     5/17933
```

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                                                                    XX YLD          8
                                                                    ID FLS     6/ 3046
                                                                    XX FLS          1
                                                                    ID SED     7/ 2747
                                                                    ID SC      8/17933
                                                                    XX SC          26
                                                                    ID ANS     9/ 2824
                                                                    ID FF     10/ 2875

GROUP CONSTANTS AT T=3.000E+02 DEG K                                          167.841S
FOR MF 6 AND MT 18 FISSION

INITL  FINAL  ISOTROPIC MATRIX VS FINAL GROUP
GROUP  GROUP  +0          +1          +2          +3

  1      1    9.531E-09   9.083E-09   1.878E-08   3.919E-08   8.223E-08   1.731E-07
  1      7    3.653E-07   7.718E-07   1.632E-06   3.452E-06   7.305E-06   1.546E-05
  1     13    3.272E-05   2.821E-05   4.104E-05   5.971E-05   8.686E-05   1.264E-04
  1     19    1.838E-04   2.674E-04   3.889E-04   5.657E-04   8.226E-04   1.196E-03
  1     25    1.739E-03   2.528E-03   3.673E-03   5.334E-03   7.744E-03   1.124E-02
  1     31    1.629E-02   2.359E-02   3.411E-02   4.925E-02   7.095E-02   1.019E-01
  1     37    1.459E-01   2.078E-01   2.943E-01   4.135E-01   5.754E-01   7.906E-01
  1     43    1.069E+00   3.239E+00   4.980E+00   6.250E+00   5.654E+00   3.042E+00
  1     49    7.275E-01   5.040E-02
  2      4    1.144E-09   2.400E-09   5.053E-09   1.066E-08   2.252E-08   4.763E-08
  2     10    1.007E-07   2.132E-07   4.512E-07   9.549E-07   8.233E-07   1.198E-06
  2     16    1.743E-06   2.535E-06   3.688E-06   5.365E-06   7.804E-06   1.135E-05
  2     22    1.651E-05   2.401E-05   3.491E-05   5.075E-05   7.377E-05   1.072E-04
  2     28    1.557E-04   2.260E-04   3.279E-04   4.754E-04   6.884E-04   9.956E-04
  2     34    1.437E-03   2.071E-03   2.974E-03   4.257E-03   6.065E-03   8.589E-03
  2     40    1.207E-02   1.679E-02   2.307E-02   3.119E-02   9.453E-02   1.453E-01
  2     46    1.824E-01   1.650E-01   8.878E-02   2.123E-02   1.471E-03
  3      8    2.044E-09   4.321E-09   9.142E-09   1.934E-08   4.094E-08   8.664E-08
  3     14    7.470E-08   1.087E-07   1.581E-07   2.300E-07   3.346E-07   4.868E-07
  3     20    7.081E-07   1.030E-06   1.498E-06   2.178E-06   3.168E-06   4.605E-06
  3     26    6.693E-06   9.726E-06   1.413E-05   2.051E-05   2.975E-05   4.313E-05
  3     32    6.246E-05   9.033E-05   1.304E-04   1.879E-04   2.699E-04   3.863E-04
  3     38    5.503E-04   7.793E-04   1.095E-03   1.524E-03   2.094E-03   2.830E-03
  3     44    8.577E-03   1.319E-02   1.655E-02   1.497E-02   8.055E-03   1.927E-03
  .
  .
  .

                                                                    XX SIG         -1
                                                                    XX UNR         -1
                                                                                226.053S
********************************************************************************

                                                                    STORAGE  15/25000

CCCCR...PRODUCE CCCR FORMAT OUTPUT FILES                                      226.446S

GENDF UNIT ..........................  -25
ISOTXS UNIT .........................   21
BRKOXS UNIT .........................   22
DLAYXS UNIT..........................    0

***FILE ISOTXS -- VERSION  1 -- UNIT 21***
**USER IDENTIFICATION**T2LASL    NJOY
```

FILE CONTROL PARAMETERS

NGROUP	NUMBER OF ENERGY GROUPS IN SET	50
NISO	NUMBER OF ISOTOPES IN SET	1
MAXUP	MAXIMUM NUMBER OF UPSCATTER GROUPS	0
MAXDN	MAXIMUM NUMBER OF DOWNSCATTER GROUPS	50
MAXORD	MAXIMUM SCATTERING ORDER	4
ICHIST	SET FISSION SPECTRUM FLAG	0
	ICHIST=1 SET VECTOR =NGROUP, SET MATRIX	
NSCMAX	MAXIMUM NUMBER OF BLOCKS OF SCATTERING DATA	4
NSBLOK	BLOCKING CONTROL FOR SCATTERING DATA	1

CCCCR TESTS JULY-AUG 1977

ISOTOPE	NAME
1	PU238

GROUP	NEUTRON VELOCITY (CM/SEC)	UPPER ENERGY (EV)
1	4.673583E+09	1.997108E+07
2	3.712038E+09	1.000000E+07
3	2.947549E+09	6.065307E+06
.		
.		
.		
48	1.660799E+06	1.855391E+00
49	1.293510E+06	1.125352E+00
50	3.142003E+05	6.825603E-01
		1.000021E-05

NUMBER OF RECORDS TO BE SKIPPED

ISOTOPE	NUMBER
1	0

ISOTOPE 1

ISOTOPE CONTROL PARAMETERS

HABSID	ABSOLUTE ISOTOPE LABEL	PU238
HIDENT	LIBRARY IDENTIFIER	ENDFB4
HMAT	ISOTOPE IDENTIFICATION	1050
AMASS	GRAM ATOMIC WEIGHT	2.38210E+02
EFISS	THERMAL ENERGY/FISSION (W*SEC/FISS)	3.30030E-11
ECAPT	THERMAL ENERGY/CAPTURE (W*SEC/CAPT)	1.74610E-12
TEMP	ISOTOPE TEMPERATURE (DEG K)	0.
SIGPOT	AVE. POTENTIAL SCATTERING (BARNS/ATOM)	1.00000E+10
ADENS	REFERENCE ATOM DENSITY (A/B*CM)	0.
KBR	ISOTOPE CLASSIFICATION	0
ICHI	FISSION SPECTRUM FLAG (0/1/N=SET CHI/VECTOR/MATRIX)	1
IFIS	(N,F) X-SEC FLAG (0/1=NO/YES)	1
IALF	(N,A) X-SEC FLAG (0/1=NO/YES)	0
INP	(N,P) X-SEC FLAG (0/1=NO/YES)	0
IN2N	(N,2N) X-SEC FLAG (0/1=NO/YES)	1
IND	(N,D) X-SEC FLAG (0/1=NO/YES)	0
INT	(N,T) X-SEC FLAG (0/1=NO/YES)	0
LTOT	NUMBER OF TOTAL X-SEC MOMENTS	1

```
 LTRN    NUMBER OF TRANSPORT X-SEC MOMENTS                    1
 ISTRPD  NUMBER OF TRANSPORT X-SEC DIRECTIONS                 0

BLOCK     TYPE     IDENT   ORDERS


    1   INELAS      200        4
    2   ELASTC      100        4
    3      N2N      300        1
    4    TOTAL        0        4

SCATTERING BANDWIDTH AND IN-GROUP SCATTERING POSITION

GROUP/BLOCK        1    2    3    4    1    2    3    4
    1              1    1    1    1    1    1    1    1
    2              2    2    2    2    1    1    1    1
    .
    .
    .
   47              0    2    0    2    1    1    1    1
   48              0    2    0    2    1    1    1    1
   49              0    2    0    2    1    1    1    1
   50              0    2    0    2    1    1    1    1

PRINCIPAL CROSS-SECTIONS

GROUP     STRPL          STOTPL          SNGAM          SFIS          SNUTOT
  1   3.507193E+00   5.880666E+00   5.582499E-03   2.469372E+00   4.103454E+00
  2   3.838440E+00   6.592859E+00   7.338992E-03   2.605169E+00   3.604299E+00
  3   4.202539E+00   7.319474E+00   1.090618E-02   2.611247E+00   3.290535E+00
  4   4.279195E+00   7.144853E+00   1.817040E-02   2.399612E+00   3.088907E+00
  5   4.330708E+00   6.948723E+00   2.249072E-02   2.170158E+00   2.958458E+00
  6   4.722907E+00   7.204844E+00   4.046411E-02   2.057278E+00   2.877846E+00
  .
  .
  .
 47   8.293250E+01   8.295935E+01   7.109914E+01   2.346358E+00   2.749996E+00
 48   1.014921E+01   1.017623E+01   5.801815E-01   2.674259E-02   2.749996E+00
 49   2.446293E+01   2.450158E+01   1.051660E+01   2.947278E-01   2.749996E+00
 50   3.685953E+02   3.686496E+02   3.393321E+02   1.009861E+01   2.749996E+00

BLOCK  1  INELAS SCATTERING, ORDER  4
      GROUP   1
       POSN        ORDER  1      ORDER  2      ORDER  3      ORDER  4
         1      5.147142E-01   8.885546E-03   1.931176E-03  -1.237181E-03
      GROUP   2
       POSN        ORDER  1      ORDER  2      ORDER  3      ORDER  4
         1      6.841726E-01   1.106306E-02   8.156876E-05  -2.049436E-08
         2      4.981426E-02  -7.289216E-03  -1.929146E-03   1.237181E-03
  .
  .
  .

***FILE BRKOXS -- VERSION  1 -- UNIT 22***
**USER IDENTIFICATION**T2LASL     NJOY

FILE CONTROL PARAMETERS

 NGROUP     NUMBER OF ENERGY GROUPS IN SET                   50
 NISOSH     NUMBER OF ISOTOPES WITH SELF-
              SHIELDING FACTORS                               1
```

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 NSIGPT     TOTAL NUMBER OF VALUES OF VARIABLE X
              WHICH ARE GIVEN.  NSIGPT IS EQUAL TO
              THE SUM FROM 1 TO NISOSH OF NTABP(I)              6
 NTEMPT     TOTAL NUMBER OF VALUES OF VARIABLE TB
              WHICH ARE GIVEN.  NTEMPT IS EQUAL TO
              THE SUM FROM 1 TO NISOSH OF NTABT(I)              3

    ISOTOPE     NAME
       1        PU238

 LN(SIGP0)/LN(10) VALUES FOR ALL ISOTOPES
     ISOTOPE       1ST VALUE       2ND VALUE                . . .
        1     5.00000E+00     4.00000E+00     3.00000E+00     2.00000E+00

 TEMPERATURES (DEG C) FOR ALL ISOTOPES

 ISOTOPE       1ST VALUE       2ND VALUE                . . .
        1     2.68400E+01     6.26840E+02     1.82684E+03

 MAXIMUM ENERGY BOUND
   GROUP J
         1  1.99711E+07
         2  1.00000E+07
         3  6.06531E+06
         .
         .
         .
        48  1.85539E+00
        49  1.12535E+00
        50  6.82560E-01

 MINIMUM ENERGY BOUND OF SET

                 1.00002E-05

 F-FACTOR START AND STOP GROUPS
 AND NUMBER OF SIG0 AND TEMPERATURE VALUES

 ISOTOPE            JBFH            JBFL            NTABF            NTABT
       1               1              50                6                3

 TOTAL SELF-SHIELDING FACTORS          ISOTOPE  1
       GROUP      1
       SIG0       TEMP     1     TEMP     2     TEMP     3
          1       1.00000E+00  1.00000E+00  1.00000E+00
          2       1.00000E+00  1.00000E+00  1.00000E+00
          3       9.99999E-01  9.99999E-01  9.99999E-01
          4       9.99993E-01  9.99993E-01  9.99993E-01
          5       9.99956E-01  9.99956E-01  9.99956E-01
          .
          .
          .
 GROUP    23
 SIG0       TEMP     1     TEMP     2     TEMP     3
    1       9.99901E-01  9.99951E-01  9.99993E-01
    2       9.98931E-01  9.99345E-01  9.99601E-01
    3       9.90231E-01  9.93906E-01  9.96219E-01
    1       9.99782E-01  1.00271E+00  1.00850E+00
    2       9.99927E-01  1.00071E+00  1.00621E+00
    3       9.84848E-01  9.86990E-01  9.91255E-01
    4       9.45673E-01  9.46943E-01  9.49474E-01
```

```
          5       9.15636E-01   9.16549E-01   9.18349E-01
          6       9.00452E-01   9.10309E-01   9.11990E-01

GROUP          XSPO          XSIN          XSE           XSMU          XSED
    1 1.089000E+01 5.708530E-01 2.721172E+00 8.681754E-01 9.797313E-02
    2 1.089000E+01 8.422080E-01 3.117220E+00 8.822920E-01 1.390958E-02
    3 1.089000E+01 1.040582E+00 3.656773E+00 8.515447E-01 1.657478E-02
    .
    .
    .
   46 1.089000E+01 0.           9.977078E+00 2.822861E-03 1.823958E-01
   47 1.089000E+01 0.           9.513845E+00 2.822861E-03 1.603397E-01
   48 1.089000E+01 0.           9.569289E+00 2.822861E-03 1.623892E-01
   49 1.089000E+01 0.           1.369017E+01 2.822861E-03 2.563818E-01
   50 1.089000E+01 0.           1.921889E+01 2.822861E-03 0.
                                                                234.4335
*******************************************************************************
```

III. EXAMPLE 3, PHOTON INTERACTION PROCESSING

```
MOUNT FILE 23 PART OF DLC7E ON UNIT 20.
MOUNT FILE 27 PART OF DLC7E ON UNIT 22.

 0
 4
 *RECONR*
 20  21
 *PENDF TAPE FOR PHOTON INTERACTION CROSS SECTIONS FROM DLC7E.*/
 1  1  0
 .001  0.
 *1-HYDROGEN*/
 92  1  0
 .001  0.
 *92-URANIUM*/
 0/
 *GAMINR*
 22  21  0  23
 1  3  3  4  0
 *12 GROUP PHOTON INTERACTION LIBRARY*/
 -1  0/
 92
 -1  0/
 0/
 *DTFR*
 23  24  21
 0  0  0
 5  12  4  5  16  1  0
 *PHEAT*
 1  621  1
 0/
 *H*  1  1  0./
 *U*  92  1  0./
 0/
 *MATXSR*
 0  23  25
 1  1  *T2LASL NJOY*/
 1  1  1
 *12-GROUP PHOTON INTERACTION LIBRARY*/
 *GAMA*
 12
```

```
*GSCAT*
1  1  3  2
1
1
*H*  1  1  1
*U*  1  1  92
*STOP*
```

```
**************************************************************************************
*                                                *                   *                *
*    $$   $$        $$   $$$$$   $$    $$      *                   *                *
*    $$$  $$        $$  $$$$$$$  $$  $$       *  NUCLEAR          *  VERS.1-8/78   *
*    $$$$ $$        $$  $$   $$    $$$$        *  CROSS SECTION    *  RAN AT LASL   *
*    $$ $$$$  $$   $$  $$   $$     $$         *  PROCESSING       *  ON 10/14/78   *
*    $$  $$$  $$$$$$$  $$$$$$$     $$         *  SYSTEM           *  AT 17.07.58   *
*    $$   $$   $$$$$    $$$$$      $$         *                   *                *
*                                               *                   *                *
**************************************************************************************

RECONR...RECONSTRUCT POINTWISE CROSS SECTIONS IN PENDF FORMAT                  43.450S

UNIT FOR ENDF/B TAPE .....................   20
UNIT FOR PENDF TAPE ......................   21

LABEL FOR PENDF TAPE
--------------------------------------
 PENDF TAPE FOR PHOTON INTERACTION CROSS SECTIONS FROM DLC7E.

TAPE LABEL
--------------------------------------
 DLC-7E PHOTON INTERACTION LIBRARY IN ENDF FORMAT - DATAFOR FILE 23

                                                                STORAGE  15/25000
                                                                ID ENOD   1/ 1000
                                                                ID CARD   2/ 1017

MATERIAL TO BE PROCESSED ..............    1
RECONSTRUCTION TOLERANCE ..............  .001
RECONSTRUCTION TEMPERATURE ............    0K

DESCRIPTIVE CARDS FOR PENDF TAPE
--------------------------------------
  1-HYDROGEN

                                                                ID SCR    3/ 1373

PROCESSING MAT      1
--------------------------------------
         PHOTON INTERACTION DATA FOR    1 H

                                                                ID DICT   4/ 1409
                                                                XX DICT         0
                                                                ID MFS    4/ 1382
                                                                ID MTS    5/ 1391
                                                                ID NCS    6/ 1400
                                                                ID RES    7/24948

MAT HAS NO FILE 2.

MAT HAS NO RESONANCE PARAMETERS
                                                                XX RES          0
                                                                ID BUFO   7/ 2400
```

```
                                                    ID BUFN    8/ 3400
                                                    ID X       9/ 3450
                                                    ID Y      10/ 3500

 POINTS IN INITIAL UNIONIZED GRID =    39
 POINTS ADDED BY LINEARIZATION = 263
                                                              43.773S
                                                    XX BUFO         -1
                                                    XX ENOD          1
                                                    ID BUFO    7/ 1401
                                                    ID BUFN    8/ 2401
                                                    ID BUFG    9/ 3401
                                                    ID BUFR   10/ 7401
                                                    XX BUFO         -1
                                                    ID BUFO    7/ 1401
                                                    ID BUFN    8/ 2401
                                                    XX ENOD         -1
                                                    ID ENOD    1/ 1000
                                                    ID CARD    2/ 1017

MATERIAL TO BE PROCESSED ..............   92
RECONSTRUCTION TOLERANCE ..............  .001
RECONSTRUCTION TEMPERATURE ............   0K

DESCRIPTIVE CARDS FOR PENDF TAPE
********************************
  92-URANIUM

                                                    ID SCR     3/ 1373

PROCESSING MAT     92
**************************************
         PHOTON INTERACTION DATA FOR   92 U

                                                    ID DICT    4/ 1409
                                                    XX DICT          0
                                                    ID MFS     4/ 1382
                                                    ID MTS     5/ 1391
                                                    ID NCS     6/ 1400
                                                    ID RES     7/24948

MAT HAS NO FILE 2.

MAT HAS NO RESONANCE PARAMETERS
                                                    XX RES           0
                                                    ID BUFO    7/ 2400
                                                    ID BUFN    8/ 3400
                                                    ID X       9/ 3450
                                                    ID Y      10/ 3500

POINTS IN INITIAL UNIONIZED GRID =    59
POINTS ADDED BY LINEARIZATION = 493
                                                              47.855S
                                                    XX BUFO         -1
                                                    XX ENOD          1
                                                    ID BUFO    7/ 1401
                                                    ID BUFN    8/ 2401
                                                    ID BUFG    9/ 3401
                                                    ID BUFR   10/ 7401
                                                    XX BUFO         -1
                                                    ID BUFO    7/ 1401
                                                    ID BUFN    8/ 2401
```

```
                                                                XX ENOD          =1
                                                                ID ENOD     1/ 1000
                                                                           49.591S
*****************************************************************************

GAMINR...PRODUCE PHOTON INTERACTION CROSS SECTIONS                         49.658S


 UNIT FOR ENDF/B TAPE ..................          22
 UNIT FOR PENDF TAPE ...................          21
 UNIT FOR INPUT GAMOUT TAPE ............           0
 UNIT FOR OUTPUT GAMOUT TAPE ...........          23
 MAT TO BE PROCESSED ...................           1
 GAMMA GROUP OPTION ....................           3
 WEIGHT FUNCTION OPTION ................           3
 LEGENDRE ORDER ........................           4

 RUN TITLE
 *************************************
      12 GROUP PHOTON INTERACTION LIBRARY


 GAMMA GROUP STRUCTURE.....LASL 12 GROUP
     1     1.0000E+04 -    1.0000E+05
     2     1.0000E+05 -    5.0000E+05
     3     5.0000E+05 -    1.0000E+06
     4     1.0000E+06 -    2.0000E+06
     5     2.0000E+06 -    3.0000E+06
     6     3.0000E+06 -    4.0000E+06
     7     4.0000E+06 -    5.0000E+06
     8     5.0000E+06 -    6.0000E+06
     9     6.0000E+06 -    7.0000E+06
    10     7.0000E+06 -    8.0000E+06
    11     8.0000E+06 -    9.0000E+06
    12     9.0000E+06 -    2.0000E+07

 WEIGHT FUNCTION.....CONSTANT WITH ROLLOFFS

                                                    STORAGE    8/ 8000
                                                    ID SCR     1/  356
                                                    ID TOTH    2/  380


 PROCESSING MAT       1
 ***************************************
      1-HYDROGEN
                                                    ID SIG     3/  736
                                                    ID ANS     4/  738
                                                    ID FF      5/  740

                                                               49.698S
 GROUP CONSTANTS
 FOR MF23 AND MT501 TOTL

 GAMMA   SIGMA
 GROUP   (BARNS)
   1     5.256E-01
   2     3.648E-01
   3     2.448E-01
   4     1.748E-01
   5     1.296E-01
   6     1.058E-01
   7     9.046E-02
   8     7.962E-02
   9     7.158E-02
  10     6.524E-02
```

```
 11     6.026E-02
 12     4.986E-02
```

```
                                                                ID SIG     3/  736
                                                                ID ANS     4/  738
                                                                ID FF      5/  740
```

```
GROUP CONSTANTS                                                                  49.810S
FOR MF23 AND MT502 COHT

GAMMA   SIGMA
GROUP   (BARNS)
   1     1.235E-03
   2     9.291E-05
   3     9.275E-06
   4     2.318E-06
   5     7.716E-07
   6     3.864E-07
   7     2.316E-07
   8     1.543E-07
   9     1.104E-07
  10     8.281E-08
  11     6.432E-08
  12     3.652E-08
```

```
                                                                XX SIG          -1
                                                                ID SIG     3/  736
                                                                ID PFF     4/ 7969
                                                                XX PFF         101
                                                                ID ANS     5/  847
                                                                ID FF      6/  857
```

```
GROUP CONSTANTS                                                                  49.919S
FOR MF26 AND MT502 COHT

INITL   FINAL   CROSS SECTIONS Vs
GROUP   GROUP   LEGENDRE ORDER
   1       1    1.235E-03  1.220E-03  1.193E-03  1.158E-03  1.117E-03
   2       2    9.291E-05  9.286E-05  9.276E-05  9.260E-05  9.240E-05
   3       3    9.275E-06  9.274E-06  9.274E-06  9.273E-06  9.272E-06
   4       4    2.318E-06  2.318E-06  2.318E-06  2.318E-06  2.318E-06
   5       5    7.716E-07  7.716E-07  7.716E-07  7.716E-07  7.716E-07
   6       6    3.864E-07  3.864E-07  3.864E-07  3.864E-07  3.864E-07
   7       7    2.316E-07  2.316E-07  2.316E-07  2.316E-07  2.316E-07
   8       8    1.543E-07  1.543E-07  1.543E-07  1.543E-07  1.543E-07
   9       9    1.104E-07  1.104E-07  1.104E-07  1.104E-07  1.104E-07
  10      10    8.281E-08  8.281E-08  8.281E-08  8.281E-08  8.281E-08
   .
   .
   .
```

```
GROUP CONSTANTS                                                                  71.042S
FOR MF23 AND MT621 HEAT

GAMMA   HEATING
GROUP   (EV-BARNS)
   1     4.489E+03
   2     2.837E+04
   3     7.312E+04
   4     1.277E+05
   5     1.800E+05
   6     2.199E+05
   7     2.524E+05
   8     2.803E+05
   9     3.049E+05
```

```
 10     3.276E+05
 11     3.490E+05
 12     4.139E+05

PROCESSING MAT      92
*************************************
     92-URANIUM                                                    ID SIG     3/  736
                                                                   ID ANS     4/  738
                                                                   ID FF      5/  740

GROUP CONSTANTS                                                                71.075$
FOR MF23 AND MT501 TOTL

GAMMA   SIGMA
GROUP   (BARNS)
   1     2.769E+03
   2     3.776E+02
   3     4.634E+01
   4     2.278E+01
   5     1.775E+01
   6     1.718E+01
   7     1.736E+01
   8     1.767E+01
   9     1.800E+01
  10     1.850E+01
  11     1.909E+01
   .
   .
   .

GROUP CONSTANTS                                                                86.380$
FOR MF26 AND MT504 INCH

INITL  FINAL  CROSS SECTIONS Vs
GROUP  GROUP  LEGENDRE ORDER
   1      1    3.676E+01 -3.149E-02  2.240E+00 -8.225E-01 -6.794E-01
   1   XSEC    3.676E+01
   1   HEAT    3.561E+05
   2      1    2.304E+00 -9.141E-01  2.073E-01 -9.153E-02 -2.528E-03
   2      2    2.889E+01  6.635E+00  3.271E+00  6.284E-01 -2.008E-01
   2   XSEC    3.119E+01
   2   HEAT    2.555E+06
   3      2    1.428E+01  3.448E-01 -9.044E-01 -1.135E+00 -4.217E-01
   3      3    7.856E+00  6.694E+00  4.778E+00  2.729E+00  1.093E+00
   3   XSEC    2.214E+01
   3   HEAT    6.607E+06
   4      2    5.876E+00 -1.528E+00 -9.503E-01  7.707E-02  4.574E-01
   4      3    5.749E+00  3.798E+00  1.130E+00 -7.766E-01 -1.269E+00
   4      4    4.272E+00  3.948E+00  3.358E+00  2.604E+00  1.807E+00
   4   XSEC    1.590E+01
   4   HEAT    1.161E+07
   .
   .
   .
  11     1.337E+08
  12     2.221E+08
                                                                               136.381$
*********************************************************************************************
```

```
DTFR...PRODUCE DTF FORMAT FROM GROUPR OUTPUT                    136.603$

INPUT UNIT ..............................  23
OUTPUT UNIT .............................  24
PENDF UNIT ..............................  21
PRINT OPTION (0 MAX, 1 MIN) .............   0
FILM OPTION (0 YES, 1 NO) ...............   0
EDIT OPTION (SPECIAL FORMATS) ...........   0
NUMBER OF NEUTRON TABLES ................   5
NUMBER OF NEUTRON GROUPS ................  12
POSITION OF TOTAL .......................   4
POSITION OF IN-GROUP ....................   5
TABLE LENGTH ............................  16
EDIT CROSS SECTIONS .....................  NAME    POSITION REACTION MULTIPLICITY
                                           PHEAT      1       621          1
NUMBER OF PHOTON TABLES .................   0


MAT=   1  ISO=H        SIGZERO NO= 1  TEMP= 0.
IL= 1 TABLE 12 GP 16 POS, MAT=    1 IZ= 1 TEMP= 0.
  4.1391E+05 -3.7505E-03  0.          4.0857E-02  4.1578E-03  0.
  0.          0.          0.          0.          0.          0.
  0.          0.          0.          0.          3.4899E+05 -2.7088E-03
  0.          6.2264E-02  1.6493E-03  2.0886E-03  0.          0.
  0.          0.          0.          0.          0.          0.
  0.          0.          3.2760E+05 -2.3235E-03  0.          6.5243E-02
  2.1088E-03  3.5582E-03  2.1557E-03  0.          0.          0.
  0.          0.          0.          0.          0.          0.
  3.2488E+05 -1.9554E-03  0.          7.1500E-02  2.7893E-03  4.5764E-03
  3.6228E-03  2.2724E-03  0.          0.          0.          0.
  0.          0.          0.          0.          2.8026E+05 -1.6035E-03
  0.          7.9620E-02  3.8653E-03  6.1046E-03  4.6878E-03  3.7878E-03
  2.4665E-03  0.          0.          0.          0.          0.
  0.          0.          2.5241E+05 -1.2097E-03  0.          9.0462E-02
  5.7082E-03  8.5557E-03  6.3152E-03  4.9875E-03  4.1224E-03  2.7905E-03
  0.          0.          0.          0.          0.          0.
  2.1986E+05 -7.6340E-04  0.          1.0582E-01  9.2738E-03  1.2857E-02
  9.2099E-03  6.9264E-03  5.6433E-03  4.7766E-03  3.3590E-03  0.
  0.          0.          0.          0.          1.7998E+05 -3.4354E-04
  0.          1.2965E-01  1.7641E-02  2.1524E-02  1.4064E-02  1.0508E-02
  8.4492E-03  7.1060E-03  6.1540E-03  4.4796E-03  0.          0.
  0.          0.          1.2770E+05 -5.5753E-05  0.          1.7402E-01
  4.6321E-02  4.3859E-02  2.6338E-02  1.9302E-02  1.5439E-02  1.2952E-02
  1.1198E-02  9.8814E-03  7.3857E-03  0.          0.          0.
  7.3121E+04 -6.7471E-07  0.          2.4480E-01  8.7096E-02  6.3311E-02
  3.2297E-02  2.4047E-02  2.0158E-02  1.7905E-02  1.6479E-02  1.5637E-02
  1.5184E-02  1.4864E-02  0.          0.          2.8372E+04 -1.1390E-07
  0.          3.6485E-01  3.3763E-01  1.5770E-01  6.4447E-02  3.6192E-02
  2.5481E-02  1.9587E-02  1.5940E-02  1.3440E-02  1.1622E-02  1.0236E-02
  7.5874E-03  0.          4.4889E+03  5.8680E-05  0.          5.2556E-01
  5.2550E-01  2.7214E-02  0.          0.          0.          0.
  0.          0.          0.          0.          0.          0.
IL= 2 TABLE 12 GP 16 POS, MAT=    1 IZ= 1 TEMP= 0.
  0.          0.          0.          0.          4.1274E-03  0.
  0.          0.          0.          0.          0.          0.
  0.          0.          0.          0.          0.          0.
  0.          0.          1.6453E-03  2.0610E-03  0.          0.
  0.          0.          0.          0.          0.          0.
  0.          0.          0.          0.          0.          0.
  2.1023E-03  3.5300E-03  2.1095E-03  0.          0.          0.
  0.          0.          0.          0.          0.          0.
   .
   .
   .
```

```
                                                                        140.490S
*****************************************************************************

                                                          STORAGE  15/25000

MATXSR...PRODUCE A MATXS FORMAT OUTPUT FILE                              140.749S

NGEN1.....................................  0
NGEN2.....................................  23
   .
   .
   .


*****************************************
*** FILE  MATXS         ****************
*** VERS    1           ****************
*** USER  T2LASL NJOY   ****************
*****************************************

FILE CONTROL PARAMETERS

 NPART    NUMBER OF PARTICLES FOR WHICH GROUP                    1
          STRUCTURES ARE GIVEN
 NTYPE    NUMBER OF DATA TYPES PRESENT IN SET                    1
 NHOLL    NUMBER OF WORDS IN SET HOLLERITH                      12
          IDENTIFICATION RECORD

FILE DESCRIPTION

 12-GROUP PHOTON INTERACTION LIBRARY

FILE DATA

  PARTICLE      NAME      NGRP
  --------      ----      ----
       1        GAMA        12

  DATA TYPE     NAME      NMAT     NINP     NING     NOUTP     NOUTG      LOCT
  ---------     ----      ----     ----     ----     -----     -----      ----
       1        GSCAT        2        1       12         1        12         0

  GROUP STRUCTURES

  PARTICLE  1

  GROUP          MAXIMUM ENERGY
     1             2.000000E+07
     2             9.000000E+06
     3             8.000000E+06
     4             7.000000E+06
     5             6.000000E+06
     6             5.000000E+06
     7             4.000000E+06
     8             3.000000E+06
     9             2.000000E+06
    10             1.000000E+06
    11             5.000000E+05
    12             1.000000E+05

  EMIN             1.000000E+04
```

```
**********************************************
*** DATA TYPE   1 ****** GSCAT  ********
**********************************************

DATA TYPE CONTROL

 MATERIAL    HMATNM       TEMP         SIGZ         LOCA


 --------    ------      ----         -----        -----
     1       H           0.           1.00E+10         0
     2       J           0.           1.00E+10         7

  INCIDENT PARTICLES      1
  OUTGOING PARTICLES      1
  NSBLK                   1


*** GSCAT  *** MATERIAL    1 **********
**********************************************

MATERIAL CONTROL

    HMAT              H
    AMASS             0.992E-01
    TEMP              0.
    SIGZ              1.000E+10
    IMAC                      1
    N1DR                      7
    N1DB                      1
    N2DB                      3

VECTOR CONTROL

  REACTION     REACTION ID     BLOCK     FIRST GROUP     LAST GROUP
  --------     -----------     -----     -----------     ----------
     1           GWT0            1           1              12
     2           GTOT0           1           1              12
     3           GCOH            1           9              12
     4           GINCH           1           1              12
     5           GPAIR           1           1               9
     6           GABS            1          12              12
     7           GHEAT           1           1              12

VECTOR PARTIAL BLOCK    1

 GROUP    GWT0          GTOT0         GCOH          GINCH         GPAIR
 -----    ------        ------        ------        ------        ------
   1     3.801E+06     4.986E-02                   4.611E-02     3.751E-03
   2     1.300E+06     6.026E-02                   5.756E-02     2.709E-03
   3     1.000E+06     6.524E-02                   6.292E-02     2.323E-03
   4     1.000E+06     7.150E-02                   6.954E-02     1.955E-03
   5     1.000E+06     7.962E-02                   7.802E-02     1.604E-03
   6     1.000E+06     9.046E-02                   8.925E-02     1.210E-03
   7     1.000E+06     1.058E-01                   1.051E-01     7.633E-04
   8     1.000E+06     1.296E-01                   1.293E-01     3.435E-04
   9     1.000E+06     1.740E-01     2.318E-06     1.740E-01     5.597E-05
  10     5.000E+05     2.448E-01     9.275E-06     2.448E-01
  11     4.000E+05     3.648E-01     9.291E-05     3.648E-01
  12     3.331E+04     5.256E-01     1.235E-03     5.243E-01
```

SCATTERING MATRIX CONTROL

BLOCK	IDENTIFIER	LOWEST ORDER	ORDER
1	GCOH	0	4
2	GINCH	0	4
3	GPAIR	0	1

BANDWIDTHS AND LOWEST ENERGY GROUPS

GROUP/BLOCK	1	2	3	1	2	3
1	0	1	0	0	1	0
2	0	2	0	0	2	0
3	0	3	0	0	3	0
4	0	4	0	0	4	0
5	0	5	0	0	5	0
6	0	6	0	0	6	0
7	0	7	0	0	7	0
8	0	8	0	0	8	0
9	1	9	0	9	9	0
10	1	10	9	10	10	9
11	1	11	0	11	11	0
12	1	2	0	12	12	0

SCATTERING MATRICES

BLOCK 1 ** GCOH **

FINAL GROUP	INITL POSN	XSEC VS LEGENDRE ORDER ORDER 1	ORDER 2	ORDER 3	ORDER 4
9	1	2.318E-06	2.318E-06	2.318E-06	2.318E-06
10	1	9.275E-06	9.274E-06	9.274E-06	9.273E-06
11	1	9.291E-05	9.286E-05	9.276E-05	9.260E-05
12	1	1.235E-03	1.220E-03	1.193E-03	1.158E-03

BLOCK 2 ** GINCH **

FINAL GROUP	INITL POSN	XSEC VS LEGENDRE ORDER ORDER 1	ORDER 2	ORDER 3	ORDER 4
1	1	4.158E-03	4.127E-03	4.067E-03	3.978E-03
2	1	1.649E-03	1.645E-03	1.637E-03	1.626E-03
	2	2.089E-03	2.061E-03	2.006E-03	1.927E-03
3	1	2.109E-03	2.102E-03	2.089E-03	2.070E-03
	2	3.558E-03	3.530E-03	3.474E-03	3.391E-03

.
.
.

INDEX OF MATXS FILE 142.517$

```
**************************************
*** FILE  MATXS          *************
*** USER  T2LASL NJOY    *************
*** VERS    1            *************
**************************************
```

```
FILE DESCRIPTION

 12-GROUP PHOTON INTERACTION LIBRARY

DATA TYPES ON FILE

            NAME       LOCT
            ----       ----
    1     GSCAT           0


****************************************
*** DATA TYPE  1 ****** GSCAT  ********
****************************************

MATERIALS ON FILE FOR THIS DATA TYPE

            NAME       TEMP       SIGZ     LOCA
            ----       ----       ----     ----
    1     H         0.          1.00E+10        0
    2     U         0.          1.00E+10        7

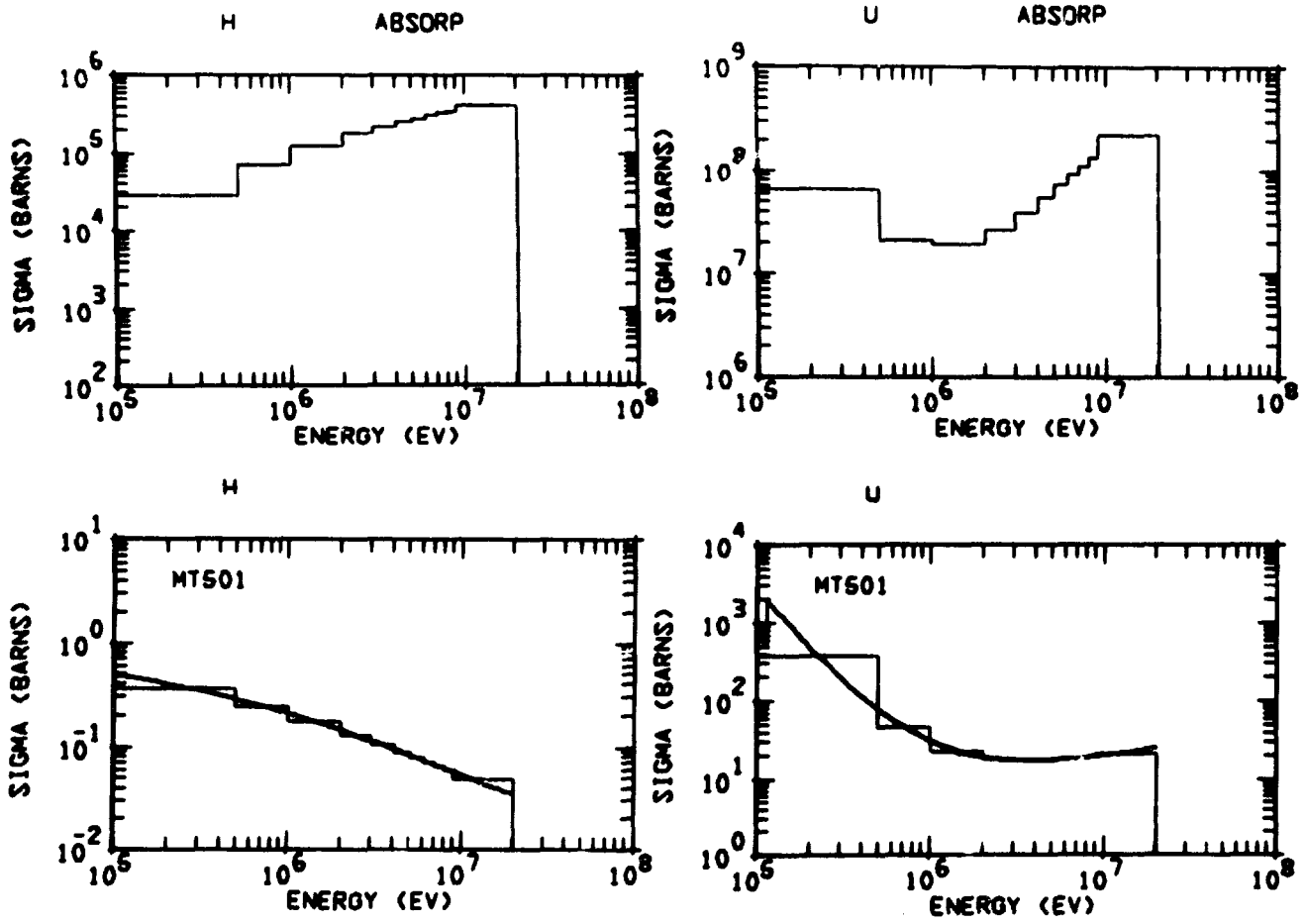
VECTOR REACTION TYPES ON FILE BY MATERIAL

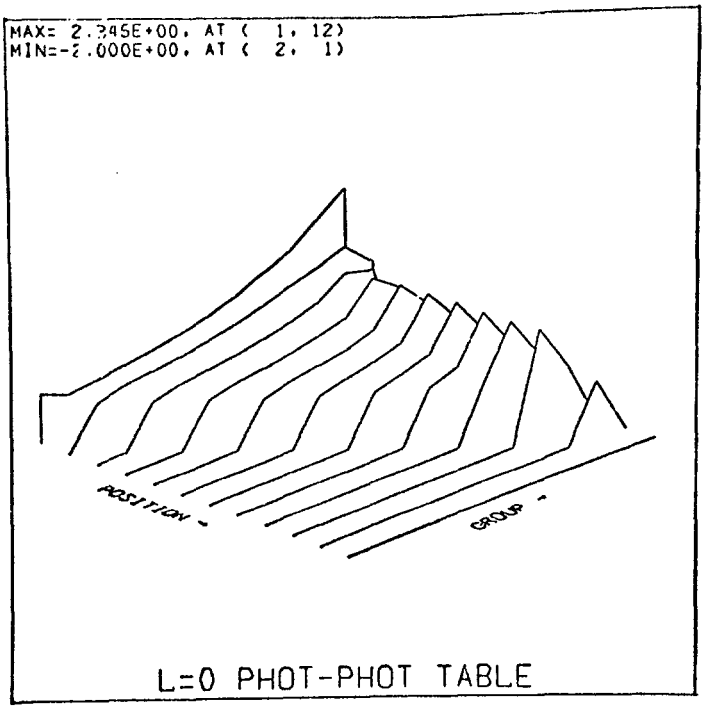
                1          2
            ------     ------
    1     GWT0       GWT0
    2     GTOT0      GTOT0
    3     GCOH       GCOH
    4     GINCH      GINCH
    5     GPAIR      GPAIR
    6     GABS       GABS
    7     GHEAT      GHEAT

MATRIX REACTION TYPES ON FILE BY MATERIAL

                1          2
            ------     ------
    1     GCOH       GCOH
    2     GINCH      GINCH
    3     GPAIR      GPAIR

INDEX COMPLETE                                                          142.534S
                                                                        142.535S
********************************************************************************
```





Sample photon interaction cross section and group-to-group matrix graphs from DTFR. Both pointwise and multigroup results are shown for the total (MT501). The isometric plot shows the log of the uranium scattering cross section; "position" 1 is the "in-group" cross section.

IV. EXAMPLE 4, TEST OF COVARIANCE PROCESSING

```
MOUNT ENDF/B-IV TAPE 408 ON UNIT 20.
INPUT DATA CARDS.

 0
 4
 *MODER*
 20  21
 *ERRORR*
 20  21  0  0
 1274  1  1  1
 3  0
 1
 1E-5  2E7
 1  0  0  0  0  0  0  0/
 1  0  0  0  -1  -1  -1  -1/
 0  0  0  0  1  1  1  1/
 0  0  0  0  1  1  0  0/
 0  0  0  0  1  0  0  0/
 0  0  0  0  0  1  0  0/
 0  0  0  0  0  0  1  0/
 0  0  0  0  0  0  0  1/
 5
 1.E-4  1  1E3  1E6  1E7  1.0E7/
   .
   .
   .
```

```
*****************************************************************************
*                                                 *                         *
*    $$    $$        $$    $$$$$    $$     $$    *                         *
*    $$$   $$        $$   $$$$$$$   $$   $$     *  NUCLEAR                *  VERS.1-8/78  *
*    $$$$  $$        $$   $$    $$    $$$$      *  CROSS SECTION          *  RAN AT LASL  *
*    $$ $$$$  $$     $$   $$    $$     $$       *  PROCESSING             *  ON 10/14/78  *
*    $$  $$$  $$$$$$$$   $$$$$$$$     $$       *  SYSTEM                 *  AT 17.16.41  *
*    $$   $$   $$$$$      $$$$$       $$       *                         *               *
*                                                 *                         *
*****************************************************************************

MODER...CHANGE THE MODE OF AN ENDF/B TAPE                          27.188S


INPUT UNIT (+ FOR BCD, - FOR BB) .....   20
OUTPUT UNIT (+ FOR BCD, - FOR BB) ....   21

TAPE LABEL
----------------------------------------
  ENDF/B-IV TAPE 408 (REV. 3)                    1-SEPT-76
                                                          50.593S
*****************************************************************************

ERRORR...PRODUCE CROSS SECTION COVARIANCES                         50.902S

                                                    STORAGE  20/20000

ENDF/B UNIT ..........................   20
PENDF UNIT ...........................   21
GOUT UNIT ............................    0
OUTPUT UNIT ..........................    0
DESIRED MATERIAL ..................... 1274
NEUTRON GROUP OPTION .................    1
```

```
PRINT OPTION ..........................    1
RELATIVE COVARIANCE OPTION ............    1
GROUP AV. WEIGHT OPTION ...............    3
GROUP AV. PRINT OPTION ................    0

NO. OF DERIVED XSEC ENERGY RANGES ....    1
```

```
ID E       1/ 1000

ID DICT    2/ 2000
XX DICT          0
ID KXY     2/ 1064
```

COEFFICIENTS FOR DERIVED CROSS SECTIONS

FOR 1.0000E-05 TO 2.0000E+07 EV

MT =	1	2	3	4	51	91	102	107
1 =	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 =	1.0	0.0	0.0	0.0	-1.0	-1.0	-1.0	-1.0
3 =	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0
4 =	0.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0
51 =	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
91 =	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
102 =	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0
107 =	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0

COMPUTING MULTIGROUP CROSS SECTIONS

```
51.154S
ID SCR     3/ 1420
```

```
NEJTRON GROUP STRUCTURE.....READ IN
    1       1.0000E-04 = 1.0000E+00
    2       1.0000E+00 = 1.0000E+03
    3       1.0000E+03 = 1.0000E+06
    4       1.0000E+06 = 1.0000E+07
    5       1.0000E+07 = 1.9000E+07
```

```
ID UN      4/19933
XX E             0
XX UN           55
```

```
UNION STRUCTURE HAS  54 GROUPS

    1       1.0000E-04 = 1.0000E+00
    2       1.0000E+00 = 1.0000E+03
    3       1.0000E+03 = 1.0000E+05
    4       1.0000E+05 = 5.0000E+05
    .
    .
    .
```

```
COVARIANCES CALCULATED FOR  8 REACTIONS AND  54 GROUPS
                                                    57.229S
XX SIG1          -1
ID SCR     7/ 1299
ID CFLX    8/ 1304
ID SUM     9/19933
```

TABLE OF MULTIGROUP CROSS SECTIONS

GROUP NO.	LOWER ENERGY	CROSS SECTION MT 1	MT 2	MT 3	MT 4	MT 51
1	1.0000E-04	4.7471E+00	4.7290E+00	1.1615E-02	0.	0.
2	1.0000E+00	4.7288E+00	4.7283E+00	1.5168E-04	0.	0.

```
   3  1.2000E+03  4.3304E+00  4.3304E+00  2.1014E-06  0.          0.
   4  1.0000E+06  1.7708E+00  1.6781E+00  9.2702E-02  7.2971E-02  7.1766E-02
   5  1.0000E+07  1.3346E+00  7.9547E-01  5.3918E-01  4.4949E-01  2.4824E-01

GROUP CROSS SECTION
 NO.   MT 91       MT102       MT107
-----  -----       -----       -----
   1   0.          1.1615E-02  0.
   2   0.          1.5168E-04  0.
   3   0.          2.1014E-06  0.
   4   1.2041E-03  0.          1.9731E-02
   5   2.0125E-01  0.          8.9684E-02

RELATIVE COVARIANCE ( MT  1 , IG , MT  1 , IGP )                    57.802S

 IG   IGP          +0          +1          +2
---   ---       ----        ----        ----
  1     1   8.900E-05   8.900E-05   6.400E-05   2.297E-05
  2     1   8.900E-05   8.900E-05   6.400E-05   2.297E-05
  3     1   6.400E-05   6.400E-05   7.811E-05   2.297E-05
  4     1   2.297E-05   2.297E-05   2.297E-05   6.821E-05   6.503E-05
  5     4   6.503E-05   1.637E-03

RELATIVE COVARIANCE ( MT  1 , IG , MT  2 , IGP )                    57.991S

 IG   IGP          +0          +1          +2
---   ---       ----        ----        ----
  1     1   8.934E-05   8.901E-05   6.400E-05   2.423E-05
  2     1   8.934E-05   8.901E-05   6.400E-05   2.423E-05
  3     1   6.425E-05   6.401E-05   7.811E-05   2.423E-05
  4     1   2.325E-05   2.297E-05   2.297E-05   7.198E-05   1.091E-04
  5     4   6.862E-05   2.746E-03

RELATIVE COVARIANCE ( MT  1 , IG , MT  3 , IGP )                    58.179S

ZERO
.
.
.

  2     1   3.600E-03   3.600E-03
  5     5   0.

RELATIVE COVARIANCE ( MT102 , IG , MT107 , IGP )                    64.175S

ZERO

RELATIVE COVARIANCE ( MT107 , IG , MT107 , IGP )                    64.362S

 IG   IGP          +0          +1          +2
---   ---       ----        ----        ----
  4     4   1.457E-02   2.453E-03
  5     4   2.453E-03   1.676E-02
                                                                    64.364S
*************************************************************************
```

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