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AMPX-77: A Modular Code System for Generating Coupled Multigroup Neutron-Gamma Cross-Section Libraries from ENDF/B-IV and/or ENDF/B-V

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AMPX-77: A MODULAR CODE SYSTEM FOR GENERATING COUPLED MULTIGROUP NEUTRON-GAMMA CROSS-SECTION LIBRARIES FROM ENDF/B-IV AND/OR ENDF/B-V

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DEDICATION

Much of the work and many of the ideas that are contained in the codes described in this report are due to the efforts of a dear colleague, James L. Lucius, who died in October 1987. Although he does not show as the primary author on very many of the modules (his primary work assignments were in areas external to AMPX), he worked on a large fraction of the AMPX modules at one time or another.

Certainly Jim's largest contributions came in the form of the several codes he developed in the 1960s, which served to prove the ideas that were later incorporated, either virtually intact, or in spirit, in the final AMPX codes. We sincerely miss his input in providing advice on ways to solve problems, but, more than this, we miss his daily camaraderie.

It is for these reasons that we dedicate this document in memory of our very dear friend.

PREFACE

There is perhaps a plethora of documents to be located that lay claim to the intention of serving as a "living document," inherently implying an association with an effort that is expected to exist over a long period of time or even in perpetuity.

AMPX is an example of an effort of this type, though neither of the previous two documents that described the codes in the system were anything like living, and were constructed in such a manner as to make even simple updates and corrections very awkward. It is probably because of the lack of preplanning on the structure of the document that led to this situation, where only the "master copies" of the principal authors are anything like up-to-date, and these are certainly not maintained in a formal structure, but are loose-leaf collections of notes, both typed and handwritten.

There have been at least two or three aborted and abandoned efforts to produce a new user's guide for AMPX that would update the previous issue and contain current information, but in each of these cases the "living effort" ran away from the documentation.

The same situation still exists. At least two or three quite useful modules have been written since this document was frozen, and there are at least 10 to 15 older codes that exist in varying levels of completion, but that should (and probably will) be included in a later version of this user's guide.

In order to allow for an expandable document that will accommodate the aforementioned needs, we have "invented" a new page-numbering scheme that is certainly unconventional, but that we hope our users will find acceptable. We have adopted the practice of starting the information for a major section on an odd (right-hand) page, with the numbers in a section ranging from 1 to whatever number of pages is required for the section. In addition, each right-hand page will contain a one- or two-word title at the lower outside margin of the page, which we hope will alleviate the need for tabs or other artifices to make locating a particular section easier.

Since the primary information is users' information for almost 50 separate modules arranged in alphabetical order by code name, this should make locating information on a particular code quite easy. This arrangement will make adding a new code trivial, because it can be issued and merely inserted in its proper alphabetical location. Renumbering of any other section will not be required. Other changes will be limited to the Table of Contents and whatever part of the Introduction that might be affected. Furthermore, if a new sample problem is required to demonstrate the new module, it can be added at the end of that section without requiring much, if any change to other parts of the section.

In the event pages from a section, or a whole section, require modification, a reissue will list the date of the current issue under the module name at the bottom of the page.

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ACKNOWLEDGMENTS

Many individuals have contributed to the AMPX system. Authors of the individual modules are identified at the front of Sect. 3.INSTRUCTIONS of this document.

This, the third, complete release of the system has been especially frustrating and difficult because of the lack of adequate funding and personnel support to prepare the requisite programs, distribution files, and documentation in a timely fashion. Perhaps the most frustrating part was the wait for a satisfactory copy of this user's guide, which was drafted in 1988. In this regard, the authors are sincerely appreciative of Lindy Norris, who took the collection of very rough output from attempts to generate a useable draft and produced this document. Her stamina, fortitude, accuracy, and attitude are all highly commendable.

And, finally, the authors are grateful for the several projects that provided the support necessary to complete this task.

ABSTRACT

AMPX-77 is a modular system of computer programs that pertain to nuclear analyses, with a primary emphasis on tasks associated with the production and use of multigroup cross sections. All basic cross-section data are to be input in the formats used by the Evaluated Nuclear Data Files (ENDF/B), and output can be obtained in a variety of formats, including its own internal and very general formats, along with a variety of other useful formats used by major transport, diffusion theory, and Monte Carlo codes. Processing is provided for both neutron and gamma-ray data.

The present release contains codes all written in the FORTRAN-77 dialect of FORTRAN and will process ENDF/B-V and earlier evaluations, though major modules are being upgraded in order to process ENDF/B-VI and will be released when a complete collection of usable routines is available.

1. INTRODUCTION

The AMPX system has been in continuous development at the Oak Ridge National Laboratory (ORNL) since the early 1970s. It is a collection of computer programs in a modular arrangement for generating multigroup or pointwise cross-section libraries. Starting with ENDF/B-IV- or ENDF/B-V-formatted nuclear data files,[1–8]* or with previously generated, pseudo-problem-independent fine-group, problem-dependent fine- or broad-group, or pointwise cross-section libraries,† the system includes a full range of features needed to: (1) produce multigroup neutron, gamma-ray production, and/or gamma-ray interaction cross-section data; (2) resonance self-shield; (3) spectrally collapse; (4) convert cross-section libraries from one format to another format; (5) execute a one-dimensional (1-D) discrete-ordinates calculation; and (6) perform miscellaneous cross-section operations (list, punch, plot, check, etc.). AMPX-produced cross sections can be used with radiation transport codes and systems, such as ANISN,[10] DOT,[11] FORSS,[12] KENO IV,[13] MORSE,[14] SCALE,[15] SWANLAKE,[16] XSDRN,[17] and VENTURE.[18–19]

The AMPX system was initially issued by the Radiation Shielding Information Center (RSIC) in October 1973 as the PSR-63/AMPX package.[20] The package included sample problems and an AMPX user's guide.[21] To incorporate modifications to the original AMPX modules and to add new modules, a second generation of the AMPX system (the "IBM standard version") was packaged and issued by RSIC in late 1978 as PSR-63/AMPX-II.[22]

Again, to incorporate literally hundreds of modifications to AMPX modules (including modifications to process ENDF/B-V data, to delete obsolete modules, and to add new modules) the third generation of the IBM version of the AMPX system was packaged and issued by RSIC as PSR-63/AMPX-77. This "User's Guide" is the documentation for AMPX-77. The designation "77" was chosen because all modules in this release are in FORTRAN-77, thereby making it easier to use AMPX on different computers.

A list of the modules included in the AMPX system and a brief statement of the purpose of each module are given in Table 1. In addition to the modules, AMPX-77 consists of subroutine libraries, sample problems, data libraries, etc. An overview of the AMPX system is given in Sect. 2.OVERVIEW. Input instructions for the AMPX modules are given in Sect. 3.INSTRUCTIONS. A catch-all sec-

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*ENDF/B-IV and ENDF/B-V data are distributed by the National Nuclear Data Center, Brookhaven National Laboratory, Upton, N.Y. ENDF/B-formatted LENDL,[5,6] DNA,[7] and HPICE[8] data are distributed by the Radiation Shielding Information Center (RSIC), Oak Ridge National Laboratory, Oak Ridge, Tennessee.

†Many previously generated cross-section libraries that can be used with the AMPX-III system are distributed by RSIC. A capsule review of the RSIC data library collection is given in ref. 9.

tion that contains detailed descriptions of various AMPX-77 features is given in Sect. 4.MISCELLANEOUS.

Selected AMPX-77 modules were used in a series of sample problems that were designed to illustrate how to execute the modules. AMPX becomes a system when the DRIVER program, the modules, the subroutine libraries, the data libraries, and the JCL for scratch and interface devices are incorporated into a procedure. An installation guide for AMPX-77 is given in Sect. 5.INSTALLATION. Several sample problems are described in Sect. 6.SAMPLE PROBLEMS. Finally, the FIDO (ANISN) data input system, which is used throughout the AMPX system, is described in Sect. 7.FIDO.

Table 1. AMPX modules

Module	Purpose
AIM	Converts master cross-section libraries from binary coded decimal (BCD) to binary format (or vice-versa). The BCD format is a card-image format intended primarily for passing AMPX master libraries between different computing systems.
AJAX	Merges, collects, reorders, joins, and/or copies selected data sets from AMPX master interfaces. This module is used to collect data sets from multiple AMPX master libraries to a single AMPX master library.
ALE	Produces listings of data from AMPX master and working interfaces. This module is an upgrade to the DIAL module.
ALPO	Produces ANISN libraries from AMPX master libraries.
ARID	Obsolete. Use the COMAND module.
AVAL	Obsolete. Use the LAVA module.
BONAMI	Performs Bondarenko resonance self-shielding calculation.
BRUT	Obsolete. Use the PRUDE and TABU modules.
CASTROL	Creates a library of point cross sections in ENDF/B "TAB1" format. The cross sections are specified in a card-image format.
CHOX	Obsolete. Use the UNITAB module.
CHOXM	Obsolete.
CLAROL	Allows for replacing and correcting individual terms on an AMPX master library. For example, it will allow overriding group-averaged values, nuclide titles, resonance parameters, etc.
COLLINS	Sums the cross sections for multiple inelastic levels into a single process (MT) = 4 matrix and discards the level cross sections, thereby making the library more compact.
COMAND	Collapses ANISN cross-section libraries.
COMET	Allows one to force consistency between averaged cross sections and transfer matrices on AMPX master libraries.
CONTAC	Produces ANISN or CCCC ISOTXS libraries from AMPX working libraries.
CORECTOL	Converts from structure used for resonance background arrays associated with the Nordheim treatment to the structure used by NITAWL-2.
CREST	Collects "TAB1" records from an arbitrary number of sources.
DIAL	Obsolete. Use the ALE module.
DOSE	Obsolete. Use the JERGENS, CASTROL, and VEL modules.
FRESH	Normalizes thermal matrices to account for several situations.

Table 1. (continued)

Module	Purpose
GERITOL	Processes group-integrated fluxes into energy flux pairs using least-squares fitting techniques, and writes the function in a "TAB1" record format.
ICE	Mixes cross sections on an AMPX working library and produces a macroscopic AMPX working library, ANISN libraries, or group-independent ANISN cross-section libraries.
JERGENS	Performs arithmetic operations with "TAB1" records.
LAPHNGAS	Generates multigroup secondary gamma-ray production cross sections and/or multiplicities from ENDF/B point data. The output is an AMPX master library.
LAVA	Produces an AMPX working library from an ANISN cross-section library.
MAD	Modifies entries in the directory records which describe the cross sections for nuclides on an AMPX master library.
MALOCS	Collapses fine-group AMPX master libraries into broad-group AMPX master libraries.
NITAWL-II	Converts from the AMPX master library format to an AMPX working library. Optionally, it will perform a Nordheim integral treatment calculation for nuclides with resonance parameters.
NPTXS	Prepares point cross sections for the MT = 1, 2, 18, and 102 reactions for resonance materials on an ENDF/B library. The cross sections are written in "TAB1" format for use in other AMPX modules, such as JERGENS, VEL, VASELINE, etc.
OCTAGN	Obsolete.
PAL	Punches group-averaged values from either an AMPX master or an AMPX working library.
PERFUME	Adjusts the Legendre coefficients used to present group-to-group scattering terms on an AMPX master library so that they are physically reasonable values.
POLIDENT	Prepares a point library in "TAB1" format for nuclides on an ENDF/B library. Resonance nuclides are processed into energy cross-section pairs. All processes with MT values less than 150 are passed.
PRELL	Creates, copies, modifies, punches, or lists from a library of energy group structures.
PRUDE	Uses ENDF/B unresolved resonance data to produce a file used by the TABU module to create Bondarenko factors.
RADE	Used to perform checks on AMPX master, AMPX working, and ANISN libraries. Checks are made to ensure values are reasonable and sum properly, etc.

Table 1. (continued)

Module	Purpose
ROLAIDS	Performs an integral transport calculation for the energy-pointwise, slowing-down flux distribution in each zone of a 1-D, multiregion geometry to produce multigroup resonance-shielded constants to be folded into an existing AMPX master data set.
RUFFLES	Takes the scalar fluxes output by ANISN or XSDRN on a binary file and allows for summing and/or splitting them into another group structure to produce a second binary scalar flux file. This program is used primarily to quickly produce starting flux guesses for a transport calculation.
SALVAGE	Salvages readable portions of an AMPX master library tape that has gone bad.
SMILER	Produce AMPX master libraries from NJOY GENDF files.
SMUG	Generates a photon-interaction master library from ENDF/B data.
TABU	Produces an AMPX master cross-section file which contains Bondarenko factor data for the unresolved energy region. TABU requires an input file from the PRUDE module.
TIDE	Scans an AMPX master library and keeps track of attributes, such as maximum array length, etc., in order to rewrite the library with proper directory entries for each nuclide.
UNITAB	Combines data for a nuclide from more than one AMPX master library to create a new AMPX master library. For example, it serves (as CHOX did) to create a coupled neutron-gamma library containing the union of data taken from AMPX masters written by XLACS-77, LAPHNGAS, and SMUG.
VASELINE	Produces plots of cross sections from ENDF/B libraries or from AMPX master or working libraries.
VEL	Uses data from libraries written in ENDF/B "TAB1" format (both cross sections and weighting functions) to form group-averaged values that are written onto an AMPX master library.
WAX	Collects data from one or more AMPX working libraries to create a new working library. (It is equivalent to the AJAX module used for master libraries.)
WINE	Forces scattering matrices and 1-D cross sections to normalize properly.
WISK	Produces an AMPX working library that contains a separate set of data for each nuclear process for all nuclides on the library structured as is needed by a cross-section sensitivity analysis.
WORKER	Produce a working library from a master library. Provides a capability to interpolate between scattering matrices at different temperatures.

Table 1. (continued)

Module	Purpose
WORM	Reads an AMPX working library and reformats it to write an AMPX master library, thereby making it possible to use various AMPX service modules (for example, CLAROL) with data from a working library.
XLACS-77	Uses ENDF/B data to produce multigroup neutron cross sections on an AMPX master library.
XSDRNPM	Performs a 1-D discrete-ordinates or diffusion theory calculation using cross sections on an AMPX working library. It can, on option, collapse its cross sections to produce a weighted library.
ZEST	Merges, collects, assembles, reorders, joins, and/or copies libraries written in the ENDF/B "TAB1" format. (As such, it performs the same service for the libraries as does AJAX for master libraries and WAX for working libraries.)

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2. OVERVIEW OF AMPX

In early 1971, an effort was initiated to build a system of computer programs capable of producing multigroup cross sections. This work was funded by the Defense Nuclear Agency (DNA), which had a particular interest in producing coupled neutron-gamma cross sections for use in weapons shielding and effects studies. The system was named AMPX, which is an acronym for Automation of MUG,[1] POPOP4,[2] and XLACS,[3] three codes which were then in use at ORNL to generate multigroup gamma-ray interaction, gamma-ray production, and neutron interaction cross sections, respectively.

The production of multigroup cross sections has always been a time-consuming and complicated process. It uses its own jargon (e.g., ENDF/B, self-shielding, $S_{\alpha,\beta}$, P_ℓ matrices, transport corrections, etc.). (A glossary of terms used to describe multigroup cross-section processing is given in Sect. 4.MISCELLANEOUS.7.) The selection of the most appropriate treatment from a wide variety of algorithms is a challenge even for the experienced cross-section producer.

Producing multigroup coupled neutron-gamma cross sections involves several time-consuming and expensive steps, many of which are not independent of each other and which must be performed in a certain order. An error in any step can mean a repetition of the entire sequence. It is clearly an area where stand-alone programs with all their awkward and labor-intensive data preparation procedures create an undesirable situation.

A better way of attacking the problem involves the use of a modular system that encompasses the complete collection of codes. In this system, one can set up the entire sequence, if necessary, thereby making it much easier to keep track of calculations or to repeat them.

In a well-defined modular system, there is little redundancy. Important functions are isolated into modules that are executed when needed. It is easier to maintain the system because programming for a function is only needed in one place. New modules are easier to write because they only have programming for new functions.

A key consideration for the modular system is that of communicating between the modules. It is absolutely imperative that major collections of data which must be transferred between modules be done in a manner that does not burden the user with large entries of data.

Considerations such as those cited above influenced the design of our AMPX system. Even though our present system does not totally satisfy all the goals, it is certainly much easier to use than was the previous situation.

Other considerations that went into the original system design are listed below. Even though some of these will seem either obvious or unnecessary in today's computing environment, they were made to be used with computing systems available in the early 1970s.

- All processing codes that need basic data use ENDF/B data.
- All codes use variable dimensioning, which means that the program assigns only the necessary space from a large container array for the problem being run. This was done both to conserve computer core and to keep from having to make "dimension"

changes in the programs. Although the amounts of storage easily obtained on today's virtual systems make it possible to allocate generous array dimensions and to let the system take care of shuttling data into core, the variable dimensioning techniques are still being used to good advantage, especially in situations where the computer cost algorithms take account of the amount of core requested.

- Codes write their multigroup cross-section data using a well-defined format capable of handling any and all kinds of cross sections used in the system. This format is constructed in a "self-defining" manner, whereby it can be read and understood without requiring external descriptive information to be supplied. This particular feature is extremely important to AMPX because these cross-section files form the bulk of the communication interfaces that one needs in a multigroup processing system. AMPX uses two types of these interfaces. The first is the more complicated and is called a master interface or library. It contains data at its lowest level. For example, it may contain resonance parameters or Bondarenko factors. It may contain averaged cross sections for an arbitrary number of neutron and gamma processes, as well as scattering matrices independently specified by process. It is the format that all of the basic processing codes produce. In this format the cross sections are not directly usable. Resonance calculations may be needed. Certainly data for many processes will have to be summed to make "total" values prior to using the cross sections in a calculation. The programs that deal with these "summed" values use a format called the AMPX working interface. As one would expect, it does not allow the detail of the master library, but is tailored for direct use in a transport calculation.
- Codes can be executed in any order (as long as all necessary input files to a module pre-exist or are produced in the execution sequence).
- Codes use a free-form input scheme for user data. The free-form scheme chosen for AMPX (described in Sect. 7.FIDO of this document) was developed for use in several large stand-alone programs and provides a wide variety of features, making it easier to instruct the codes on what to do.
- The system is planned to be comprehensive, thereby making provisions for most, or all, functions necessary to generate and process multigroup cross sections. To a large extent, this goal has been met. To the extent that it has not is one of the major strengths of the modular system. Whenever a new function (module) is required, it is written and combined with existing codes without requiring the reprogramming of existing modules.

2.OVERVIEW.1 AMPX CAPABILITIES

AMPX modules can be loosely categorized into the following areas:

- basic data processing
- resonance self-shielding
- spectral collapsing
- format conversion
- service functions

2.OVERVIEW.1.1 Basic Data Processing

AMPX has several modules that use ENDF/B data to produce multigroup libraries or to produce point data. XLACS-77 is a module that produces multigroup neutron cross sections. LAPHNGAS is a module that produces multigroup gamma-ray yield information (i.e., the data that allow one to determine the gamma sources produced by neutron interactions). SMUG is analogous to XLACS-77, except that it produces multigroup gamma-ray cross sections. NPTXS, POLIDENT, and PRUDE all process ENDF/B neutron resonance parameter data to produce various kinds of point neutron cross-section libraries.

2.OVERVIEW.1.2 Resonance Self-Shielding

The NITAWL-II module uses an improved version of the Nordheim Integral Treatment[4] for resonance self-shielding. Among improvements in the new version are (1) an ability to self-shield elastic scattering, (2) the ability to treat "multi-isotope" ENDF/B evaluations, and (3) the ability to treat $\ell > 0$ resonances. The BONAMI-S module provides for a Bondarenko (or shielding factor method) self-shielding treatment.[5] Indicative of this module's generality is the ability to perform the calculation over energy ranges that can vary for each nuclide. The ROLAIDS module provides a 1-D integral transport solution to a system with an arbitrary number of spatial zones, each of which contains an arbitrary mixture. The fluxes from this solution are used to produce self-shielded cross sections that include self-shielded elastic transfer matrices.

2.OVERVIEW.1.3 Spectral Collapsing

A large number of situations require starting with an existing multigroup library and reducing the number of energy groups by spectrally collapsing the library. If the weighting spectrum is known, the COMAND or MALOCS modules can be used for collapsing. COMAND is used to collapse ANISN libraries. MALOCS is a very important AMPX module that is used to collapse AMPX master cross-section interfaces (described later) while retaining all of the generality of these libraries. For the case where the weighting spectrum is not known (most prevalent situation) but where a 1-D calculation can be made to determine an appropriate one, the XSDRNPM module is provided. It can use cross sections in a discrete ordinates, diffusion theory, or B_n calculation whose fluxes are then used to collapse cross sections.

2.OVERVIEW.1.4 Format Conversion

Because of differences in their applications and heritages, the modules in AMPX and in other programs that use AMPX cross sections employ a variety of cross-section library formats. Several AMPX modules are provided to allow converting between these formats. In some cases, a simple rearrangement of the data is all that is required, while in other cases, considerable processing is necessary. The LAVA module converts ANISN[6]-formatted libraries to AMPX working libraries. The ALPO and CONTAC modules convert AMPX working libraries to ANISN libraries. The CONTAC module can also make a CCCC ISOTXS[7] library. A major function of the NITAWL module is to convert from an AMPX master library to an AMPX working library, while WORM converts from an AMPX working library to an AMPX master library. Several older AMPX modules (CONVERT, REVERT, and OCTAGN) which were for "format conversion" have been made obsolete because the codes they service are no longer in local use.

2.OVERVIEW.1.5 Service Functions

A myriad of operations is needed to maintain multigroup libraries. These operations include functions such as listing, plotting, checking, and modifying cross sections, combining sets of data, etc. As AMPX has evolved, most of these functions are provided in independent modules, in keeping with the modular approach. This feature is very desirable in that it makes new modules more compact and easier to maintain.

A very important function that could be needed at any stage of cross-section production is that of producing listings of group-averaged values. ALE serves this function for AMPX master and working libraries. It is an improved successor to the DIAL module.

For reasons of convenience and utility, it is often necessary to combine sets of cross sections from different libraries. The AJAX module provides this capability for AMPX master libraries. WAX serves the same purpose for working libraries, and ZEST does this for ENDF "TAB1" record-formatted libraries. These modules can merge, delete, update, reorder, etc., sets of data.

In several cases, AMPX modules only produce part of the data needed in a cross-section set. For example, XLACS-77 makes neutron cross sections, SMUG makes gamma cross sections, and LAPHNGAS makes the gamma-production cross sections. These modules all write their output in AMPX master library format. The UNITAB program is provided to allow collecting sets of information from multiple sources, such as just described, to create a final coupled set of data. In the case of neutrons, XLACS-77 makes all necessary data except the Bondarenko factors, which are made by TABU. UNITAB provides the necessary facility for combining data from all of these libraries. UNITAB also provides the capability for splitting a library back into its original multigroup constituent components, such that one could, for example, extract a neutron-only library from a coupled library.

It is often desirable to plot point cross sections, or group-averaged values, or both on the same graph. VASELINE provides a very powerful and flexible tool for making these plots.

If it is necessary to produce punched card output, the PAL module is provided.

One of the most important modules is named RADE. It performs numerous tests of the multigroup data on a master, working, or ANISN library in order to determine if the values are reasonable and consistent. When problems are noted, the COMET module can be used to force consistent values, or, if bad values are noted in some groups, the CLAROL module provides an easy method of introducing corrected values into the complicated formats. If a portion of a cross-section library becomes unreadable, the

SALVAGE module can be used to extract the usable data. If, because of numerical problems or whatever, the Legendre coefficients used to fit some of the group-to-group transfer matrices are found to be nonphysical, the PERFUME module is employed to both find and assign plausible values.

TIDE and MAD are modules that make corrections to the directories in AMPX master libraries which describe the data for each nuclide.

If it is necessary to pass cross-section libraries between sites using different computing hardware that cannot read the same binary-formatted tapes, the AIM module will convert an AMPX master library to a special BCD form which, when delivered to the second site, can be read by AIM to create the required binary library.

JERGENS is a very powerful module for dealing with ENDF/B "TAB1" records. If, for example, it is desired to generate a $1/E\Sigma_t$ weighting function where Σ_t is the macroscopic total cross section of a mixture containing an arbitrary number of nuclides, each with an arbitrary representation of its total cross section, JERGENS will generate the required energy, value pairs creating a new function to the accuracy specified by the user. It also contains many other useful options for generating and combining ENDF/B "TAB1" data records.

Many times a user will need to produce group-averaged values for a function that is not part of an ENDF/B library (e.g., a dose factor). With CASTROL, a function can be properly formatted for combination with a weighting function produced by JERGENS and weighted by the VEL module to produce a master library.

For reasons of convenience, the ICE module can mix multigroup cross sections to make a multigroup library of macroscopic mixture cross sections on an AMPX working library.

The COLLINS module might be used with a master library to combine the transfer matrices for inelastic levels to create a library that discards the level values in favor of a total inelastic transfer matrix to reduce the library size and make using the library more efficient to use input/output-wise.

In summary, the modular approach taken in this system has proven itself to be a very efficient and powerful means for developing a system of computer codes for producing multigroup cross sections.

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OVERVIEW

3. INPUT INSTRUCTIONS FOR AMPX-77 MODULES

Input instructions for an AMPX-77 module consist, in general, of subsections that give a discussion of the module, the input data it requires, the input/output assignments, and references. Instructions for the modules are arranged in the following order:

Subsection

- 3.AIM
- 3.AJAX
- 3.ALE
- 3.ALPO
- 3.BONAMI
- 3.CASTROL
- 3.CLAROL
- 3.COLLINS
- 3.COMAND
- 3.COMET
- 3.CONTAC
- 3.CORECTOL
- 3.CREST
- 3.FRESH
- 3.GERITOL
- 3.ICE
- 3.JERGENS
- 3.LAPHNGAS
- 3.LAVA
- 3.MAD
- 3.MALOCS
- 3.NITAWL-II
- 3.NPTXS
- 3.PAL

Subsection

- 3.PERFUME
- 3.POLIDENT
- 3.PRELL
- 3.PRUDE
- 3.RADE
- 3.ROLAIDS
- 3.RUFFLES
- 3.SALVAGE
- 3.SMILER
- 3.SMUG
- 3.TABU
- 3.TIDE
- 3.UNITAB
- 3.VASELINE
- 3.VEL
- 3.WAX
- 3.WINE
- 3.WISK
- 3.WORKER
- 3.WORM
- 3.XLACS-77
- 3.XSDRNPM
- 3.ZEST

Other than title cards, the FIDO input method is used to enter data into the AMPX modules. The FIDO system is described in Sect. 7.FIDO.

Many individuals other than the authors of this document either wrote or made major contributions to the modules in AMPX-77. The following chart identifies the primary authors of these modules:

Module	Responsible person(s)
AIM	N. M. Greene
AJAX	N. M. Greene
ALE	N. M. Greene
ALPO	N. M. Greene
BONAMI	N. M. Greene
CASTROL	N. M. Greene
CLAROL	N. M. Greene
COLLINS	N. M. Greene
COMAND	N. M. Greene
COMET	N. M. Greene
CONTAC	L. M. Petrie
CORECTOL	L. M. Petrie
CREST	N. M. Greene
FRESH	N. M. Greene
GERITOL	M. A. Bjerke
ICE	S. K. Fraley
JERGENS	N. M. Greene
LAPHNGAS	W. E. Ford, III, and J. L. Lucius
LAVA	N. M. Greene
MAD	N. M. Greene
MALOCS	N. M. Greene
NITAWL-II	L. M. Petrie and N. M. Greene
NPTXS	R. Q. Wright
PAL	N. M. Greene
PERFUME	L. M. Petrie
POLIDENT	N. M. Greene and L. M. Petrie
PRELL	L. M. Petrie
PRUDE	N. M. Greene
RADE	N. M. Greene
ROLAIDS	R. M. Westfall
RUFFLES	L. M. Petrie
SALVAGE	N. M. Greene
SMILER	N. M. Greene
SMUG	J. L. Lucius
TABU	N. M. Greene
TIDE	L. M. Petrie
UNITAB	L. M. Petrie and N. M. Greene
VASELINE	N. M. Greene
VEL	N. M. Greene
WAX	N. M. Greene
WINE	N. M. Greene
WISK	N. M. Greene

INSTRUCTIONS

Module	Responsible person(s)
WORKER	L. M. Petrie
WORM	N. M. Greene
XLACS-77	N. M. Greene
XSDRNPM	L. M. Petrie and N. M. Greene
ZEST	N. M. Greene

3.AIM — MODULE TO CONVERT MASTER CROSS-SECTION LIBRARIES FROM BCD TO BINARY FORMAT (OR VICE VERSA)

AIM (AMPX Interchangeable Masters) is a module whose primary purpose is to be able to pass AMPX master cross-section libraries between different computer hardware.

All AMPX cross-section files are written in binary formats, which are not movable between machines of different manufacturers. AIM has the capability to either read a binary-formatted master library and to "unload" it to the card-image (BCD) format or to read a file written in this same card-image format and create a binary master library. Because all machines can read card-image files, this file serves to transmit data between different computers. Alternatively, it is possible, though not necessarily efficient, to use AIM to create a master library using card-image input, because a user can independently create data in the special card-image format.

In the following descriptions, the term 1-D refers to group-averaged cross sections; 2-D refers to group-averaged scattering matrices.

3.AIM.1 AIM Input Data

Block 1.

0$ Logical Unit Assignments [2]*

1. MBIN - Binary master (1)†
2. MBCD - BCD master (18)

1$ Option Selection Trigger [1]

1. IOPT
   0 - Binary to BCD conversion
   1 - BCD to binary conversion

2$ Data Edit Triggers [4]

1. IP1D (0)
   0 - No 1-D edit
   1 - Edit 1-D cross sections
2. IP2D (−1)
   −1 - No 2-D edit
   L - Edit through P_L of 2-D arrays
3. IPRES (0)
   0 - FIDAS print master library data as processed
   1 - FIDAS print suppressed [WARNING—the FIDAS output from converting a BCD file to a binary file can be a very voluminous amount of information for even a modest cross-section library. The user may want to consider suppressing this information.]

---

*The number of entries in the array is given in square brackets.

†Default values are given in parentheses.

4. IPBOND – Not used, enter zero (0)

T Terminate Block 1.

If, and only if, the BCD data are to be read from cards, continue with the following input; otherwise, the input to AIM is complete. Note that the following input corresponds closely to the AMPX master interface described in Sect. 4.MISCELLANEOUS.1 of this document.

Block M1.

2$ Tape Identification [10]

1. IID – Library identification number
2. NNUC – Number of nuclides in this library
3. IGM – Number of neutron energy groups
4. IFTG – First thermal group
5. MSN – Nordheim treatment revision level required for this library
6. IPM – Number of gamma-ray energy groups
7. I7 – Zero
8. I8 – Zero
9. I9 – Zero
10. I10 – Zero

T Terminate Block M1.

Five title cards, each in (20A4) format. The five cards of Hollerith information are used to describe the library.

Block M2.

Repeat Block M2 NNUC times.

Title card in (18A4) format. This information is the title for the nuclide.

3.$ ID(19–50) Refer to the following table for a description of the ID(19), ID(20), . . . , ID(50) entries. Note that floating-point entries can be entered using the 3* designation, whereas the integers are input in a 3$ array. Input both 3$ and 3* arrays and use the "skip" or "address" options to make the input to the proper place in the array when it is necessary to specify both integer and floating-point values.

Word(s)	Item
1–18	18 words of text describing the set
19	Identifier of the set
20	Number of 6-parameter sets of resolved resonance data
21	Zero
22	Number of 1-D neutron processes (temperature-independent)
23	Number of 2-D neutron processes
24	Zero
25	Number of 1-D gamma processes
26	Number of 2-D gamma processes
27	Number of 2-D neutron-to-gamma processes
28	(Maximum order of scattering) 32768* + (total number of separate 2-D arrays for this set)
29	A – neutron equivalent mass number
30	ZA - 1000*Z + A
31	Zero
32	Zero
33	Zero
34	Power per fission in watt-s/fission
35	Energy release per capture in watt-s/capture
36	Maximum length of any 2-D record in the set
37	Number of sets of Bondarenko data
38	Number of σ_0's in Bondarenko data
39	Number of T's in Bondarenko data
40	Maximum number of groups in Bondarenko data
41	Zero
42	Zero
43	σ_p – potential scattering cross section
44	Zero
45	ENDF MAT for fast neutron data
46	ENDF MAT for thermal neutron data
47	ENDF MAT for gamma data
48	ENDF MAT for gamma production data
49	Nuclide symbol (text)
50	Number of records in this set

T Terminate Block M2.

*32768 is 2^{32}, which makes this entry easy to split into its two constituents if one is examining an IBM "hex" dump, because the first two hex characters will be the maximum order of scattering, and the last two, the total number of 2-D arrays.

Block M3.

7* Neutron Energy Group Boundaries [IGM+1]

The group boundaries are input high to low in eV. This array can be ignored if a "standard" AMPX group structure is being used.

8* Gamma-Ray Group Boundaries [IPM+1]

The group boundaries are input high to low in eV. This array can be ignored if a "standard" AMPX group structure is being used.

T Terminate Block M3.

Follow with NNUC sets of Blocks M4–M15 data, as described below:

Block M4.

Title card in (18A4) format. Use the same title card entered in data block M2 above for the nuclide title.

3.$ ID(19–50) Enter the same data for the appropriate nuclide as described in block M2 above.

T Terminate Block M4.

Blocks M5 and M6. Bondarenko data

If ID(37) > 0, enter the Bondarenko data.

In the following arrays, the array dimensions are taken from the ID values (3$ array).

ID(37) ≡ NBOND, number of Bondarenko processes
ID(38) ≡ NSIG0, number of σ_0 values
ID(39) ≡ NTEMP, number of temperatures

Block M5.

9* Bondarenko Table Ordinates [NTEMP+NSIG0+2]

Include NSIG0 σ_0 values (high to low), followed by NTEMP temperatures in K (low to high), followed by ELO and EHI, the lower and upper limits of the energy range for which Bondarenko factors apply.

10$ Bondarenko Table Directory [6*NBOND]

The directory array consists of six strings of numbers, arranged one after the other. The first NBOND numbers are the process identifiers (MT numbers) (e.g., 2 for elastic scattering, 18 for fission, etc.). The second string of numbers are the first energy groups for which Bondarenko factors are given for each of the processes. The third string of numbers are the last energy group for which the factors are given. The fourth string will contain all zeroes, except for the case of self-shielding transfer matrices, in which case it contains the order of scattering for the process (i.e., 0 for P_0 terms, 1 for P_1, etc.). The fifth string will contain all zeroes except for transfer matrix shielding, in which case it contains the position of the term to be shielded, relative to the "magic word" (see Block M9) in the transfer matrix array (e.g., for the case of only downscatter, a 1 would normally point to the within-group term, a 2 to the first downscatter term, etc.). The sixth string contains zeroes.

T Terminate Block M5.

Block M6.

This data block will be repeated NBOND times. It consists of two arrays: the infinite dilution values for the process and the corresponding Bondarenko factors. NF is the first group for which Bondarenko data are given, and NL is the last group. (These items are taken from the second and third strings in the directory array discussed earlier.)

11* Infinite Dilution Cross Sections [NL-NF+1]
(σ_{ID}(i), i = NF,NL)

12* Bondarenko Factors [NSIG0*NTEMP*(NL−NF+1)]
(((BF(i,j,k),i=1,NSIG0),j=1,NTEMP),k=NF,NL)

T Terminate Block M6.

Block M7. Resonance Parameter and Other Neutron Cross-Section Data

In this block, the following definitions are used:

NRES ≡ ID(20) = number of resolved resonances
N1D ≡ ID(22) = number of temperature-independent averaged neutron cross sections
N2D ≡ ID(23) = number of neutron-neutron scattering processes

13* Resonance Data Array; enter if NRES is nonzero
[6*NRES+9]

The first nine words contain parameters used in both the resolved and unresolved resonance calculations:

1. A, the mass ratio for the isotope or mixture of isotopes
2. σ_p, the potential scattering cross section
3. g, the average statistical factor in the unresolved region
4. NRES, the number of six-parameter resonance sets
5. s, a factor used in the Nordheim calculation to determine the range over which the calculation will be made
6. Zero
7. Zero
8. Zero
9. Zero

The next 6*NRES words consist of six-word sets of data used in the Nordheim calculation. The first six-word sets are

1. Zero

2. NBLK, the number of blocks of resolved data
3. Zero
4. Zero
5. TREF, the reference temperature in Kelvin at which the infinite dilution arrays on this library were calculated
6. Zero

Following these six-word sets are NBLK six-word groups that are used to specify information concerning blocks of resonance data that apply to, for example, different isotopes, different energy regions, different kinds of data (s-wave or p-wave resonances), etc. These are stacked as follows:

1. AWRI, the mass ratio associated with the block of data
2. ABUN, the abundance for the block of data
3. NRE, the number of resonances in the block
4. ℓ, the value of spin for the resonances in the block
5. EL, the low-energy cutoff in eV for resonances in the block
6. EH, the upper-energy cutoff in eV for resonances in the block

.
.
.

After these NBLK six-word groups, the six-word sets of resonance parameters are arranged as follows:

1. E_0, the resonance energy
2. Γ_n, the neutron width of the resonance
3. Γ_γ, the gamma width of the resonance
4. Γ_f, the fission width of the resonance
5. r, a factor used in the Nordheim treatment for determining the range of calculation
6. g_J, the statistical factor for the resonance

The following chart schematically illustrates the structure just described:

	1	2	3	4	5	6
	0	NBLK	0	0	TREF	0
	$AWRI_1$	$ABUN_1$	NRE_1	ℓ_1	EL_1	EH_1
	$AWRI_2$	$ABUN_2$	NRE_2	ℓ_2	EL_2	EH_2
	.					
	.					
	.					
	$AWRI_{NBLK}$	$ABUN_{NBLK}$	NRE_{NBLK}	ℓ_{NBLK}	EL_{NBLK}	EH_{NBLK}
	E_0	Γ_n	Γ_γ	Γ_f	r	g_J
first block	.	.	.	.	.	.
	.	.	.	.	.	.
	.	.	.	.	.	.

14* Temperature-Independent Averaged Neutron Cross Sections [N1D*(IGM+1)]

Enter process identifier for first process followed by averaged cross sections for all groups (highest energy group to lowest). Enter second process identifier followed by its cross sections, etc.

16$ Directory for Neutron-Neutron Scattering Data [N2D*4]

Enter the process identifiers for all processes, followed by the corresponding length of the "magic-word" (see Block M9) compressed arrays, followed by the order of the Legendre fit to each process, followed by the number of temperatures at which the cross sections for each process are given:

(MT_i, i=1, N2D)
(L_i, i=1, N2D)
(NL_i, i=1, N2D)
(NT_i, i=1, N2D)

T Terminate Block M7.

Blocks M8 and M9. Neutron-Neutron Scattering Matrices

Each scattering process has an M8 and M9 block. Processes where NL is greater than zero have NL+1 repeats. When NT > 1, the number of repeats is NT*(NL+1). Data for all arrays for the first temperature are given first, etc.

Block M8. Parameters and Temperatures

17* Temperatures in units of eV at which the cross sections are given [NT]

18$ Parameters [2]

1. NMW – number of magic words required in the transfer matrix
2. LPL – length of the compressed scattering matrix (including space for the magic words)

T Terminate Block M8.

Block M9. Scattering Matrix

19$ Magic Words [NMW]

Specify the magic words that are included in the transfer matrix.

20* Scattering Matrix [LPL]

Specify the transfer matrix as in the master library format described below. Include zeroes in the positions that will contain magic words.

T Terminate Block M9.

3.AIM.2 Scattering Matrix Structure

This record type is used to store scattering matrix data (sometimes called 2-D data). As will be illustrated, it has provisions for truncating zero and/or impossible elements from the array. It exists in two forms: (1) a self-defining form used for gamma production data on a master library, and (2) a form that is not self-defining. The only difference is that the self-defining form has the array length as the first word in the record, while the other does not, that is,

L, (X(I), I=1, L)

or

(X(I), I=1, L) .

The structure of the X-array is as follows:

magic word for a group
terms for scattering to the group
magic word for the next group
terms for scattering to this group
etc., etc.

A negative or zero magic word can also be used to specify the end of data in the record in the event that the array is shorter than the length specified. This situation occurs, for example, when the lengths of the matrices of Legendre coefficients for the scattering terms vary.

A magic word contains the following terms:

1. the sink group number, III
2. the first group number, JJJ, which scatters to group III
3. the last group number, KKK, which scatters to group III

The magic word is defined as

MW = 1000000*JJJ + 1000*KKK + III

such that it is composed of three 3-digit integers:

MW : JJJKKKIII

The scattering terms below a magic word are in reverse ordering (following typical practice for transport theory programs) (i.e., the scattering term for scattering from the last group is first, etc.).

$$\begin{array}{c} \text{MW for group III} \\ \sigma(KKK \to III) \\ \sigma(KKK-1 \to III) \\ \cdot \\ \cdot \\ \cdot \\ \sigma(JJJ \to III) \end{array}$$

The scattering matrix record will contain one P_ℓ matrix for a process.

Consider an elastic-scattering matrix for hydrogen where all groups can scatter to any lower-energy group and assume three energy groups. The scattering matrix will look as follows:

$$\begin{gathered}1001001\\ \sigma(1\rightarrow 1)\\ 1002002\\ \sigma(2\rightarrow 2)\\ \sigma(1\rightarrow 2)\\ 1003003\\ \sigma(3\rightarrow 3)\\ \sigma(2\rightarrow 3)\\ \sigma(1\rightarrow 3)\end{gathered}$$

Note that the record contains a mixture of integer and floating-point terms.

Blocks M10, M11, and M12. Gamma Production Data

These blocks are required only when N2DY[≡ID(27)] is greater than zero, where N2DY is the number of processes requiring gamma-production data.

Block M10. Gamma Production Data Directory

21$ Enter the gamma production process identifiers, followed by the maximum length of the scattering matrices for a process, followed by the order of scattering for the processes, followed by a trigger (0/1–yields/cross sections) that specifies whether the gamma-production matrices are in cross-section or yield units.

(MTY_i, i=1, N2DY)
(LY_i, i=1, N2DY)
(NLY_i, i=1, N2DY)
(NTY_i, i=1, N2DY)

T Terminate Block M10.

Blocks M11 and M12. Gamma Production Data

These blocks are repeated NLY+1 times for each gamma production (N2DY) process. (Note that NLY is a function of the process.)

Block M11. Parameters

22$ Gamma Production Matrix Parameters [2]

1. NMWY – Number of magic words in the scattering matrix
2. LPLY – Length of the scattering matrix

T Terminate Block M11.

Block M12. Scattering Matrix

23$ Magic Words [NMWY]

Specify the magic words that will be part of the scattering matrix.

24* Scattering Matrix [LPLY]

Specify the scattering matrix. Use zeroes in the positions that will contain magic words.

T Terminate Block M12.

Blocks M13, M14, and M15. Gamma-Ray Cross Sections

These blocks will only be used if either of the following two parameters is nonzero.

N1DZ $\equiv$ ID(25) = number of gamma-ray averaged cross sections

N2DZ $\equiv$ ID(26) = number of gamma-gamma scattering processes

Block M13. Gamma Cross Sections and Directories

25* Gamma-Ray Averaged Cross Sections [N1DZ*(IPM+1)]

Specify the identifier for the first process, followed by its cross sections, followed by the second process identifier and its cross sections, etc.

26* Directory for Gamma-Ray Scattering Data [N2DZ*4]

Specify the identifiers of all scattering processes, followed by the lengths of the scattering matrices for the corresponding processes, followed by the orders of scattering for the processes, followed by a zero for each process.

(MTZ_i, i=1, N2DZ)
(LZ_i, i=1, N2DZ)
(NLZ_i, i=1, N2DZ)
(NTZ_i, i=1, N2DZ)

T Terminate Block M13.

Blocks M14 and M15. Gamma-Scattering Matrices

These blocks are repeated NLZ+1 times for each of the gamma-ray-scattering processes.

Block M14. Gamma Parameters

27$ Gamma-Gamma Matrix Size and Order

1. NMW2 - Number of magic words in the scattering matrix
2. LPL2 - Length of scattering matrix

T Terminate Block M14.

Block M15. Gamma-Scattering Matrix

28$ Magic Words [NMW2]

Specify the magic words from the scattering matrix.

29* Scattering Matrix [LPL2]

Specify the scattering matrix with zeroes in the magic word positions.

T Terminate Block M15.

3.AIM.3 AIM Input/Output Specifications

The following devices are typically needed to execute AIM:

Logical No.	Purpose
5	Standard input
6	Standard output
7	Standard punch
17	Scratch device
47	Built-in group structure library (not required for binary-to-BCD conversion)
MBIN(1)	Binary master
MBCD(18)	BCD master

3.AJAX — MODULE TO MERGE, COLLECT, ASSEMBLE, REORDER, JOIN, AND/OR COPY SELECTED DATA SETS FROM AMPX MASTER INTERFACES

AJAX (Automatic Joining of AMPX X-Sections) is a module to combine data from AMPX master interfaces. Options are provided to allow merging from any number of files in a manner as to allow the user to determine the final nuclide ordering. Any form of master interface (neutron, gamma-ray, or neutron-gamma) can be accessed. (AJAX always copies all the data for each nuclide selected, whereas UNITAB can be used to copy specific pieces.)

3.AJAX.1 AJAX Input Data

Block 1.

−1$ Core Size [1]

1. LENG – Number of words to allocate to AJAX (100000)

0$ Logical Unit Assignments [2]

1. MMT – Logical number of new library (default = 1)
2. NMAX – Not used

1$ Number of Files [1]

1. NFILE – Number of files to be used in constructing the new library (When "reordering" operations are performed which required the same file to be accessed several times, each access is counted in determining the value of NFILE.)

T Terminate Block 1.

Blocks 2 and 3 are stacked, one after the other, NFILE times.

Block 2.

2$ File and Option Selection [2]

1. NF – Logical unit number of file considered
2. IOPT – Nuclide selection option
   - -N Delete N nuclides from those on logical NF and add the remainder to the new file
   - 0 Add all nuclides on logical NF to the new file
   - +N Add N nuclides from logical NF to the new file

T Terminate Block 2.

Block 3. {Enter only when IOPT≠0}

3$ Nuclides Selected [|IOPT|]

Identifiers of nuclides which are to be added or deleted from NF.

4$ New Identifiers [|IOPT|] {Enter only if an identifier is to be changed}

This array allows changing the identifier given in the 3$ array for the set of data on the new library.

T Terminate Block 3.

Note that AJAX operates in a sequential manner to construct the new library. Once an identifier is selected for a nuclide on the new file, the occurrence of a set of data with that identifier will be ignored. Normally, the identifiers will remain the same as those used on the libraries from which the data are selected. The 4$ array provides a way to override these identifiers.

3.AJAX.2 AJAX Input/Output Specifications

The following devices are normally needed to execute AJAX:

Logical No.	Purpose
5	Card input
6	Standard output
15	Scratch device
16	Scratch device
18	Scratch device
19	Scratch device
MMT(1)	Master file to be created
NF	File(s) to be merged onto MMT

3.ALE — MODULE TO LIST INFORMATION FROM MASTER OR WORKING LIBRARIES

ALE (AMPX Library Editor) is a module that will produce listings of information contained in an AMPX master or working library. It offers all the capabilities of the DIAL module, which it replaces, in addition to considerable improvement in the manner in which data for a particular nuclide can be selected. It also has provisions for controlling the spacing of the output by allowing the user to specify carriage control characters. In the following description, 1-D refers to group-averaged cross sections, and 2-D refers to scattering matrices.

3.ALE.1 ALE Input Data

Block 1.

-1$ Core Allocation [1]

1. ICORE – Number of words allocated to ALE (default = 100000)

0$ Logical Assignments [2]

1. MMT – Master library (default = 1)
2. MWT – Working library (default = 0)

1$ Selection Option [1]

1. NEDIT – Number of nuclides for which listings are to be produced (a zero selects all nuclides on a library)

2$ Block Edit Option [10]

(A nonzero value selects editing the data.)

1. N1DN – 1-D neutron arrays
2. N1DG – 1-D gamma arrays
3. NRES – Resonance data (Use this option to select both resonance parameter and Bondarenko factor edits.)
4. IOPT4 – Not used
5. IOPT5 – Not used
6. IOPT6 – Not used
7. IOPT7 – Not used
8. IOPT8 – Not used
9. IOPT9 – Not used
10. ICORE – Not used

3$ Block Carriage Control Characters [25]

The entries have the following effect on how the header lines for particular kinds of data are printed – all values are 0, by default, which says to skip a line before printing the data block. A 1 is used to start the block on a new page.

1. Nuclide directory information
2. 1-D cross sections (absorption, fission, etc.)
3. 2-D cross sections (scattering matrices)

4. Bondarenko data
5. Unassigned
6. Unassigned
7. Unassigned
8. Unassigned
9. Unassigned
10. Unassigned
11. Unassigned
12. Unassigned
13. Unassigned
14. Unassigned
15. Unassigned
16. Unassigned
17. Unassigned
18. Unassigned
19. Unassigned
20. Unassigned
21. Unassigned
22. Unassigned
23. Unassigned
24. Unassigned
25. Unassigned

4$ Scattering Matrices to be Edited [100]

Enter the process identifiers for which edits are desired.

5$ Order of Scattering Matrices to be Edited [100]

The 4$ and 5$ arrays are entered in one-to-one correspondence. The entries in the 5$ array give the maximum order of Legendre coefficient to be listed (e.g., a value of 2 would cause the P_0-, P_1-, and P_2-scattering matrices to be listed).

T Terminate Block 1.

Block 2. {Enter only if NEDIT > 0}

11$ Nuclide Identifiers [NEDIT]

These are the identifiers for the nuclides for which listings are to be made.

T Terminate Block 2.

3.ALE.2 ALE Input/Output Specifications

ALE requires the following input/output devices:

Logical No.	Purpose
5	Standard input
6	Standard output
MMT	Master library
MWT	Working library

3.ALPO — MODULE FOR PRODUCING ANISN LIBRARIES FROM AMPX WORKING LIBRARIES

ALPO (ANISN Library Production Option) is a module for producing ANISN libraries from AMPX working libraries. Several working libraries can be accessed in a given run. The ANISN library can be produced in either binary or BCD format.

3.ALPO.1 ALPO Input Data

Block 1.

−1$ Process Identifiers by Position in the ANISN Library [100]

This array can be used to override the normal arrangement of cross-section types in ANISN libraries or can be used to produce special cross-section sets (e.g., dose factor sets). The identifier for the process to be placed in row 1 of the ANISN tables is input first, etc. Note that nuclides that do not contain the processes noted in this table will revert to the normal ANISN ordering (viz., σ_T in position IHT, $\overline{\nu\sigma_f}$ in position IHT-1, etc.).

0$ Logical Assignments [2]

1. MAN – Logical unit for the ANISN library (use a 7 when a punched card output is desired) (default = 20)
2. MAX – Logical unit of one of the working libraries which will be accessed (4).

1$ Primary Options [9]

1. NFILE – Number of working libraries to be accessed
2. IHT – Position of the total cross section in the ANISN tables (3)
3. IHS – Position of the within-group cross section in the ANISN tables, IHT + IGM − IFTG + 1, where IGM is the number of neutron energy groups; IFTG is the first thermal group
4. ITL – Table length of the ANISN tables, IHS + IGM + IPM − 1, where IPM is the number of gamma-ray groups
5. MAXPL – The maximum order of scattering to be written on the ANISN library (20)
6. IOPT1D – Option to print label with each block of ANISN cross sections (0) A "1" selects printing; a "0" selects no printing
7. IOPT2D – Option to print scattering matrices (0) A "1" selects printing
8. ITRANS – Transport correction option (0)
   - −N, truncate P_N and above matrices and correct all lower ordered within-group terms by subtracting $(2\ell+1)^*\sigma_N(g\rightarrow g')2/(2N+1)$
   - 0, no transport correction
   - 1, replace σ_t with $\sigma_{tr} = \sigma_a + (1-\mu)\sigma_s$ where μ is calculated by summing the P_1 matrix and dividing by the P_0 sum, or by 2/(3*A), when P_1 is not given. The within-group term is also adjusted.
9. ICORE – Number of words to allocate to ALPO (50000)

T Terminate Block 1.

Data Blocks 2 and 3 are repeated NFILE times.

Block 2.

2$ File Selection Options [2]

1. NF – Logical number of the working library
2. IOPT – Nuclide selection

   −N, accept all nuclides from the working library except the N designated in the 3$ array below

   0, accept all nuclides from the working library

   +N, accept all nuclides that are designated in the 3$ array below

T Terminate Block 2.

Block 3. {IOPT $\neq$ 0}

3$ Nuclides to be Selected or Ignored [|IOPT|]

T Terminate Block 3.

3.ALPO.2 ALPO Input/Output Specifications

The following devices are normally needed to execute ALPO:

Logical No.	Purpose
5	Card input
6	Standard output
7	Punched card output
14	Scratch device
MAN(20)	ANISN binary library
MAX(4)	AMPX working library

3.BONAMI — MODULE TO PERFORM BONDARENKO RESONANCE SELF-SHIELDING

BONAMI (BONdarenko AMPX Interpolator) is an upgraded version of the BONAMI module. It uses Bondarenko factor data in a self-shielding calculation. The output is a master library that contains the self-shielded cross sections produced in the calculation.

The Bondarenko[1] method is basically an "infinite medium" method that parameterizes cross sections for a nuclide as a function of temperature, T, and the "background" cross section, σ_0, of all the other nuclides mixed with the nuclide. Simplistically, given the temperature and background cross-section values, one determines self-shielded cross sections by interpolating in tables. Since self-shielding causes the "background" values that a nuclide sees to change, an iterative procedure involving all nuclides is used.

To account for two region systems, the σ_0 value is augmented by an escape cross section, σ_e. This escape cross-section value is a function of the total cross-section value in the medium and its geometry. Even though many implementations of this approach use the Wigner rational approximation or a modified form, BONAMI uses exact values of escape probabilities, developed for slabs, cylinders and spheres, by Case, de Hoffman, and Placzek.[2] These "exact" values are also approximations, because they are based on assuming that the flux in the fuel is spatially flat and that the scattering is isotropic.

Multizone situations, such as reactor lattices, are accounted for by the use of Dancoff factors, which, in effect, modify the escape probability and, hence, the value of σ_e.

Certainly, several of the approximations used in the Bondarenko method break down in some situations. At low energies, many nuclides have resonances that are wide when compared with the scattering ranges for the mixtures in a particular configuration. If the Bondarenko factors used in the calculation are based on the narrow resonance approximation, this can produce cross-section values that are too high. Systems with nuclides whose resonances overlap also cause inaccuracies.

In AMPX, the treatment is used primarily for the unresolved energy region where the resonances are so narrow that they cannot be (have not been) resolved into sets of resonance parameters, etc. The Bondarenko method contains approximations, such as the flat flux and isotropic scattering assumptions, for determining escape probabilities that may have an effect on calculated results. However, there is probably more potential error in the final group-averaged values due to the procedures used to generate the original Bondarenko factor tables, which may or may not have included resonance resonance overlap terms, etc. In short, it is felt that the treatment is very good for the "unresolved" region.

BONAMI is an improvement over earlier versions in several respects, including:

- Several code errors have been corrected.
- It handles any number of Bondarenko processes for a nuclide.
- It can self-shield transfer arrays (e.g., elastic removal effects can be explicitly treated).

- It will edit Bondarenko factors and/or self-shielded cross sections as a function of nuclide and process.
- It has more options for treating lattice effects.
- It has an improved scheme[3] for interpolating within the Bondarenko factors which guarantees monotonicity and avoids other problems encountered with Lagrangian schemes widely used for this process.
- It uses a correction scheme developed by John Otter[4] to use with the Wigner rational approximation that effectively determines exact escape probabilities for slabs, spheres, and cylinders.
- It allows the user to select temperatures by nuclide (i.e., all nuclides in the same zone need not have the same temperature).
- It uses a reciprocity relationship to determine an effective "escape cross section" for moderator regions and uses this in the determination of a σ_0 for these regions.

BONAMI requires a mockup of the problem geometry in either 1-D slab, cylindrical, or spherical geometry or in a homogeneous representation. The mockup can include an arbitrary number of spatial regions, though all of the Dancoff options assume either a two- or a three-region system. To accomplish this, the code allows the user to "mark" the regions as to their type (fuel, moderator, or cladding) and will take care of collecting and adjusting parameters to fit the option.

For the homogeneous case, the user can mock a multiregion case and have an arbitrary number of independent homogeneous calculations performed in the same run.

BONAMI produces a separate set of cross sections for every zone in which a nuclide occurs. The identifier of the individual sets can be specified by the user or, by default, the code assigns one of the form: original ID−0−zone number. For example, if a nuclide with identifier 1111 occurred in zones 1 and 3 of a problem, two sets would be produced with identifiers 111101 and 111103, respectively.

A unique, and sometimes confusing, feature of BONAMI is that it copies every set of data on the input master library, including nuclides that are not required in the problem. The user who desires only those nuclides in the problem to be output should first run a service module, such as AJAX, and select the nuclides to be used.

BONAMI can be triggered to make either an iterative or noniterative calculation. In the iterative case, values for the macroscopic total cross sections (including heterogeneity effects) are iterated to convergence. From these values, nuclide values for σ_0 by group can be determined and used to interpolate in Bondarenko factor tables. In the noniterative case, macroscopic cross sections are determined based on the potential scattering cross sections for the nuclides, and only one pass is made through the data. The interpolation in the Bondarenko data is analogous to the iterative case. The basis for the argument against iteration is that most resonances of most nuclides may not really overlap; hence, what any one resonance of a nuclide typically sees is the potential cross section of another nuclide and not an averaged value that contains added contributions from resonances that fall within a group.

The Dancoff options in BONAMI were largely taken from options given in the SPHINX code and include:

Option (ISSOPT)	Situation
0	Homogeneous infinite medium
1	Sauer's approximation for cylindrical cell in a hexagonal lattice
2	Sauer's approximation for cylindrical cell in a square lattice
3	Symmetric slab cell
4	Asymmetric slab cell
5	Isolated rod
6	Bell approximation for cylindrical cell
7	Bell approximation for symmetric slab cell
8	Sauer's approximation for a cylindrical cell with cladding included in a hexagonal lattice
9	Sauer's approximation for a cylindrical cell with cladding included in a square lattice

Provisions are made to allow the user to input an "extra" escape cross section that will be used to augment the escape cross sections that are determined by the schemes mentioned above. In this case, the input values by zone are directly added to those determined by the Dancoff option. A typical use of this option is to mock up a homogeneous problem (ISSOPT=0) and to use an escape cross section determined by some external means or select cross sections for a particular value of σ_0.

3.BONAMI.1 BONAMI Input Data

Block 1.

0$ Logical Unit Assignments [4]

1. MMT – Input master library (default = 23)
2. MWT – Scratch for Bondarenko factors (default = 24)
3. MSC – Scratch device (default = 18)
4. NEW – Output master library (default = 22)

1$ Case Description [6]

1. IGR – Geometry $\left\{\begin{array}{ll} 0 & \text{homogeneous} \\ 1 & \text{slab} \\ 2 & \text{cylinder} \\ 3 & \text{sphere} \end{array}\right.$
2. IZM – Number of zones or material regions
3. MS – Mixing table length. This is the total number of entries needed to describe the concentrations of all constituents in all mixtures in the problem.
4. IBL – Cross-section edit option (0/1 – no/yes)

5. IBR – Bondarenko factor edit option (0/1 – no/yes)
6. ISSOPT – Dancoff factor

ISSOPT	Option
0 or 1000	Homogeneous $\sigma_e = 0.0$
1 or 1001	Cylindrical cell (Sauer's method) hex lattice
2 or 1002	Cylindrical cell (Sauer's method) square lattice
3 or 1003	Symmetric slab cell
4 or 1004	Asymmetric slab cell
5 or 1005	Isolated lump (Dancoff = 0.0)
6 or 1006	Cylindrical cell (Bell approximation)
7 or 1007	Symmetric slab (Bell approximation)
8 or 1008	Cylindrical cell (Sauer's method) hex lattice w/clad
9 or 1009	Cylindrical cell (Sauer's method) square lattice w/clad

Note that when ISSOPT $\geq$ 1000, the code will use potential scattering values in place of total cross section in determining σ_0 values and will not iterate.

2* Floating-Point Constants [2]

1. EPS – Convergence criteria for the Bondarenko iteration (default = 0.001)
2. A – Geometrical escape probability adjustment factor. See notes below on this parameter. (default = 0.0)

T Terminate Block 1.

Block 2.

3$ Mixture Number in the Mixing Table [MS]

4$ Component (Nuclide) Identifiers in the Mixing Table [MS]

5* Concentrations (atoms/barn-cm) in the Mixing Table [MS]

6$ Mixtures by Zone [IZM]

7* Outer Radii (cm) by Zone [IZM]

8* Temperature (K) by Zone [IZM]

9* Extra Cross Section (cm^{-1}) by Zone [IZM]

10$ New Identifiers for Components in the Mixing Table [MS]

11$ Zone Type Identifiers
0 — fuel zone
1 — moderator zone
2 — cladding zone

12* Temperature (K) of the Nuclide in a One-to-One Correspondence With the Mixing Table Arrays

T Terminate Block 2.

This concludes the input data required by BONAMI.

3.BONAMI.1.1 Notes on input

In the 1$ array, IGR specifies the geometry. This notation is used in conjunction with the 7* array to calculate the volumes of each zone.

IZM, the number of zones, may or may not mock a real situation. It may, for example, be used to specify IZM independent infinite media when IGR, ISSOPT, and the entries in the 11$ array are properly selected. It can also be used to perform a cell calculation in parallel with one or more infinite medium calculations, if properly directed. In this case, the entries in the 11$ array for the infinite medium zones can be anything other than 0, 1, or 2.

In the 2* array, EPS is used to specify the convergence expected on all macroscopic total values by zone, that is, each $\Sigma_t\ (g,j)$ in group g and zone j is converged such that

$$\frac{|\Sigma_t^i(g,j) - \Sigma_t^{i-1}(g,j)|}{\Sigma_t^i(g,j)} \leq \text{EPS},$$

where i is the iteration number.

The "A" factor in the 2* array is the parameter used to adjust the Wigner rational approximation to give a more correct value for the escape probability. It has been suggested that if one wishes to use one constant value, A should be 1.0 for slabs and 1.35, otherwise. In the ordinary case, BONAMI defaults A to zero and uses a prescription[4] developed by Otter to determine a cross-section geometry-dependent value of A which makes the escape probability "exact." The user who wishes the constant value can, however, use it by inputting a value other than zero.

The 3$, 4$, and 5* arrays are used to specify the concentrations of the constituents of all mixtures in the problem as follows:

Entry	3$ (Mixture Number)	4$ (Nuclide ID)	5* (Concentrations)
1	1	92235	0.040
2	1	8016	0.035
.			
.			
.			
.			
MS	10	92238	0.025

The entries in these three arrays are in a one-to-one correspondence among themselves and also with the 10$ and 12* arrays. The 10$ array provides a means of changing the identifier of any nuclide used in the problem. In the event that the number of zones, IZM, is more than one and when an entry in the 10$ array is zero, BONAMI will automatically form a new identifier that is

original ID – 0 – zone number.

For example, a nuclide in zone 5 identified by 1111 would become 111105 on the output master library.

Because of the manner in which BONAMI references the nuclides in a calculation, each nuclide in the problem must have a unique entry in the mixing table. This says that one cannot specify a mixture and subsequently load it into more than one zone, such as can be the case with many modules requiring this type of data.

The 12* array is used to allow varying the temperatures by nuclide within a zone. In the event this array is omitted, the 12* array entries will default to the temperatures of the zone containing the nuclide.

The mixture numbers in each zone are specified in the 6$ array. Mixture numbers are arbitrary and need only match up with those used in the 3$ array.

The radii in the 7* array are referenced to a zero value at the left boundary of the system.

In the event that the temperatures in the 8* array are outside the temperature values in the Bondarenko tables, BONAMI will select the "bound" closest to the value. For example, a request for 273 K for a nuclide with Bondarenko sets at 300, 900, and 2100 K would use the 300 K values. No attempt will be made to extrapolate.

The extra cross sections in the 9* array allow an extra value to be specified by zone. (This array can usually be ignored.) It is used in the calculation of σ_0 as follows:

$$\sigma_0 = \frac{\sum_{n \neq i} N_n \sigma_t^n + \mathrm{SIGH} + \sigma_{\mathbf{extra}}}{N_i} .$$

In the event one wishes to select cross sections at a fixed σ_0, a mixture with one nuclide with a number density of unity and

$$\sigma_{\mathbf{extra}} = \text{desired } \sigma_0$$

will accomplish the request.

The zone-type identifiers in the 11$ array are used in conjunction with the Dancoff option (ISSOPT) to determine which zones should be combined, etc., in determining a Dancoff factor.

3.BONAMI.2 BONAMI Input/Output Specifications

BONAMI requires the following input/output assignments during a normal calculation:

Logical No.	Purpose
5	Card input
6	Standard output
8	Scratch file
9	Scratch file
17	Scratch file
18	Scratch file
19	Scratch file
MMT(23)	Input master cross-section library
NEW(22)	Shielded master cross-section library

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3. N. M. Greene, "A Simple Monotonic Interpolation Scheme," *Trans. Am. Nucl. Soc.* **34**, 299 (June 1980).
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5. W. J. Davis, M. B. Yarbrough, and A. B. Bortz, *SPHINX—A One Dimensional Diffusion and Transport Nuclear Cross Section Processing Code*, WARD-XS-3045-17, Westinghouse Electric Corp., August 1977.

3.CASTROL — MODULE TO WRITE "TAB1" RECORDS WITH CROSS SECTIONS INPUT FROM CARDS

CASTROL (Create A STRing Ordered Library) allows one to specify a function on cards and have it written out in "TAB1" format, so that it can be used in the JERGENS, VEL, VASELINE, CREST, ZEST, or other AMPX modules where a "point" cross-section library is required.

3.CASTROL.1 CASTROL Input Data

Block 1.

0$ Logical Unit Assignment [1]

1. LOG – Unit onto which the cross sections are to be written (31)

1$ Problem Size [2]

1. NS – Number of functions to be written
2. ICORE – Number of words to allocate to CASTROL (25000)

T Terminate Block 1.

Data Blocks 2 and 3 are repeated NS times.

Block 2.

2$ Function Description [9]

1. MAT – The material number to be assigned to the function
2. MF – The file number to be used
3. MT – The process identifier
4. C1 – Constant associated with the function
5. C2 – Second constant associated with the function
6. L1 – First special flag associated with the function
7. L2 – Second special flag associated with the function
8. N1 – Number of interpolation regions
9. N2 – Number of points (energy-value pairs)

T Terminate Block 2.

Block 3.

3$ Interpolation Table [2*N1]

(NBT_i, JNT_i, $i = 1, N1$)
NBT is the point up through which the corresponding interpolation type, JNT, is to be used.

Allowed interpolation types are

JNT	Type
1	Histogram
2	Linear E, linear σ
3	Log E, linear σ
4	Linear E, log σ
5	Log E, log σ

4* Function [2*N2]

(E_i, σ_i, $i = 1$, N2), where E is the energy in eV, with σ being the cross section (or flux, etc.) value.

T Terminate Block 3.

3.CASTROL.2 CASTROL Input/Output Specifications

CASTROL uses the following input/output assignments:

Logical No.	Purpose
5	Card input
6	Printed output
LOG(31)	"TAB1" library

3.CLAROL — A MODULE TO REPLACE CROSS SECTIONS ON AN AMPX MASTER INTERFACE

Only AMPX Knows for Sure

CLAROL (Correct Libraries And Replace Old Labels) is a module that replaces or adds data in an AMPX master library at the lowest level (e.g., it can replace individual elements in either 1-D or transfer arrays). It also has provisions for modifying entries in the "Table of Contents" on a master library and for overriding the title cards that are associated with each data set on a master library.

Because this module operates at such a detailed level, it is recommended that the user be familiar with the idiosyncracies of the AMPX master interface format (Sect. 4.MISCELLANEOUS.1) before attempting to use CLAROL.

Another capability of CLAROL is to merge ROLAIDS-produced "superzone" weighted cross sections* (logical NIN) and data on an existing AMPX master library (logical NLD) to create an updated resonance-shielded AMPX master library (logical NEW). Although the CLAROL input for this operation is straightforward, care must be taken to ensure that data sets in the existing AMPX master library have identifiers that are compatible with the data sets in the ROLAIDS library.

CLAROL input data and input/output logical unit assignments are given in Sects. 3.CLAROL.1 and 3.CLAROL.2, respectively. Hints for executing special CLAROL cases are given in Sect. 3.CLAROL.3.

3.CLAROL.1 CLAROL Input Data

Block 1.

−1$ Special Vector Operations [100]

See Sect. 3.CLAROL.3, "Special CLAROL Cases," Items 4 and 5

0$ Logical Unit Assignments [3]

1. NEW – New master library (1)
2. NLD – Old master library (28)
3. NIN – This parameter is both a trigger and a logical unit assignment. (0) NIN's function depends on its values as follows:
   - 0 CLAROL is to replace or add data—blocks 2 and 3 are read in the standard input stream (no ROLAIDS-produced data are to be used).
   - N Blocks 2 and 3 are read from the ROLAIDS-produced "CLAROL data file" mounted on logical N.

6$ Direct-Access Parameters for Logical Unit 8 [2]

The data from block(s) 3 are placed on logical unit 8. Efficient utilization of the direct-access device *may* require changes in the following parameters:

---

*The ROLAIDS-produced library of "superzone" weighted cross sections is also called a "CLAROL data file."

1. NBK – Number of physical records on logical unit 8[*] (200)
2. NWB – Number of words/block on logical unit 8[†] (880)

7$ Print Suppression Trigger [3]

1. NOUT – Logical unit for printing CLAROL data set instructions. Assign a dummy unit to suppress printing. (6)
2. NOP – Logical unit for input data from ROLAIDS-produced CLAROL data file. Assign a dummy unit to suppress print. (6)
3. NCM – Logical unit for "status statements" that monitor progress of CLAROL calculations. Assign a dummy unit to suppress printing. (6)

8$ Core Allocation [1]

1. NWORD – Number of words allocated to CLAROL (100000)

T Terminate Block 1.

If NIN = 0, blocks 2 and 3 are repeated until a set with an identifier II = 0 is specified. If NIN $\neq$ 0, the input to CLAROL is complete.

Block 2.

1$ Data Set Identifier on the Output Master Library [1]

1. IDOUT – The identifier of the set of data which CLAROL will create on the output master library. If IDOUT = 0, CLAROL will use II from the 2$ array. If less than 100, CLAROL will form an identifier of II – 0 – IDOUT. (Note that this parameter can be used to create multiple copies of the set identified by II.)

2$ Set and Process Selection [4]

1. II – Data set identifier on the master library (on NLD)
2. MT – Process identifier (ENDF MT numbers are used)
3. NF – First group to be replaced or added
4. NL – Last group to be replaced or added

3$ Transfer Matrix Pointers [3]

1. NSINK – Sink group corresponding to transfer elements for groups NF to NL (default = 0)
2. L – Order of transfer matrix to be modified (default = 0)
3. NTEMP – Temperature number of the matrix to be modified (default = 1)

T Terminate Block 2.

---

[*] Each set of Block 3 data is placed on a separate record.

[†] The actual number of words/block is the number of entries in the Block 3 being written.

Block 3.

4* Cross-Section Values [NL − NF + 1]

If NSINK = 0, this is:

[σ (process MT, group i), i = NF, NL] for the Lth order transfer matrix given at the NTEMPth temperature number.

T Terminate Block 3.

3.CLAROL.2 CLAROL Input/Output Specifications:

CLAROL uses the following input/output devices:

Logical No.	Purpose
5	Card input
6	Standard output
16	Scratch device
18	Scratch device
NEW(1)	New master interface
NLD(28)	Old master interface
NIN	As explained in the input instruction for the 0$ array, NIN is both a trigger and a logical unit assignment. If NIN is input >0, it is the logical unit for the ROLAIDS-produced CLAROL data file.

3.CLAROL.3 Special CLAROL Cases

Several helpful observations for executing special CLAROL cases are given below.

3.CLAROL.3.1 Title card replacement

Enter IDOUT=0

Enter MT = 0, with NF and NL entered as the relative position of the first and last characters to be replaced in the title. To replace the entire title card, NF and NL should be 1 and 72, respectively. Block 3 is entered in the following manner:

4/1 N T	where N is the number of four-character words required to hold the characters being replaced. (The "T" is the T which is used to indicate the end of the block.)
(Title_i,i=1,N)	is written on a separate card in 18A4 format. Characters NF through NL of the 72-character title are replaced by the first NF - NL + 1 characters read in.

3.CLAROL.3.2 Resonance parameter replacement

Enter MT = 151 with NF = 1, NL = 6 and L specified as the resonance number to be replaced. The six parameters are then given in the 4* array.

3.CLAROL.3.3 Creating new cross-section arrays

New 1-D cross-section arrays can be placed on a master library. The MT number assigned to the new data must be different from any MT numbers in the original library. New 1-D arrays cannot be placed on a coupled neutron-gamma library with CLAROL. For a coupled master library, the UNITAB module should be used to split the coupled data into separate neutron and gamma-ray libraries, CLAROL should be run to add the new data to the libraries separately, and UNITAB should be run to recouple the modified libraries.

3.CLAROL.3.4 Special vector commands

These commands are provided to reduce the number of commands that must be specified to modify a library. For example, if one modifies the neutron-gamma (MT = 102) cross section, changes are also required to the capture (MT = 101), absorption (MT = 27), and total (MT = 1) cross sections. These changes can, of course, be specified singly, but a "vector" command can be given which says to modify the latter three values (which are already consistent with the old neutron-gamma values) by the changes to the neutron-gamma values.

The −1$ array can contain up to 100 entries which are arranged in strings as follows:

Primary MT—one-or-more secondary MTs—zero

A string says to change the values of the primary process every time a change is made to any one of the secondary processes. Up to 20 primary processes (strings) can be specified, and the strings are any length which fit into the 100 words. Zeroes are used as string delimiters. As an example, if one specifies new values for MT = 102 values, the MT = 1, 27, 101 values will be modified if the following three strings are input:

```
1    102    0    27    102    0    101    102    0 .
```

Whenever NIN is input greater than zero (0$ array), the following vector string is automatically inserted:

```
  1     2    18   102    0
 27    18   102     0
101   102     0
```

which says to modify the total values when the elastic or fission or neutron-gamma values change, modify the absorption values when the fission or neutron-gamma values change, and modify the capture values when the neutron-gamma values change.

3.CLAROL.3.5 Replacement of entries in the master library directories

Included in the AMPX master library is a set of records that is repeated for each data set in the library. The first record in the set, record R1, is called the data set "directory." To change any of the 50 words in a directory, enter MT = -1 and denote the number of the first and last words to be changed with NF and NL, respectively. Using block 3, enter the new [NL – NF + 1] integers in a 4$ array; or if floating-point values are to be changed, use a 4* array.

3.CLAROL.3.6 Replacement of values in the Bondarenko reference cross sections

Enter the nuclide identifier in II, 10000 + MT in MT (this is the flag that Bondarenko data are being replaced), the first group in NF and the last group in NL. The cross-section values are entered in the 4* array. For the case where values of scattering matrices are being modified, the particular set is designated by entering (100 + NOFF + ℓ), where NOFF is the "offset" and ℓ is the order in the L value in the 3$ array.

3.CLAROL.3.7 Replacement of Bondarenko factor values

Enter the nuclide identifier in II, 10000 + MT in MT, the first group in NF, and the last group in NL. Enter the relative position of the σ_0 value in NSINK and the relative position of the temperature set in NTEMP. The factor values are entered in the 4* array. For the case of factors for scattering matrices, the particular set is designated by entering (100 × NOFF + ℓ) in the L value of the 3$ array, where NOFF is the "offset" and ℓ is the scattering order.

3.COLLINS — MODULE TO COLLECT INELASTIC SCATTERING INTO A SINGLE MATRIX

COLLINS (<u>COLL</u>ect <u>IN</u>elastic <u>S</u>cattering) adds up the matrices for MT = 51 through MT = 91 into a single MT = 4 matrix and rewrites the master library. The matrices for MT = 51 through MT = 91 are not carried. Necessary adjustments are made to the directories on the master library. This module is very useful for compressing a master library, thereby reducing the input/output penalty for reading the detailed arrays for inelastic scattering transfer matrices.

3.COLLINS.1 COLLINS Input Data

Block 1.

0$ Logical Assignments [2]

1. MMT - Logical number of new library (default = 1)
2. NMAX - Logical number of file to be accessed in creating MMT buffer requirements (this is an input unit, not logical MMT)

1$ Number of files [2]

1. NFILE - Number of files which will have data selected from them
2. NWORD - Number of words of core to allocate to COLLINS (50000)

T Terminate Block 1.

Blocks 2 and 3 are stacked, one after the other, NFILE times.

Block 2.

0$ File and Option Selection [2]

1. NF - Logical number of file considered
2. IOPT* = −N Delete N nuclides from NF to create the new file on MMT
   0 Add all nuclides to the new file on MMT
   N Add N nuclides from NF to create the new file on MMT

T Terminate Block 2.

Block 3. {Enter only when IOPT≠0}

3$ Nuclides Selected [|IOPT|]

Identifiers of nuclides which are to be added or deleted from NF.

4$ New Identifiers [|IOPT|]

This array allows changing the identifier given in the 3$ array when it is selected for the new library.

---

*Sets with duplicate identifiers will not be entered on MMT. The first occurrence of an identifier selects that set for the new library.

T Terminate Block 3.

3.COLLINS.2 COLLINS Input/Output Specifications

The following devices are usually needed to execute COLLINS:

Logical No.	Purpose
5	Card input
6	Standard output
14	Scratch device
15	Scratch device
16	Scratch device
17	Scratch device
18	Scratch device
19	Scratch device
MMT(1)	Master file to be created
NF	
NF_2	Files to be merged onto MMT(1)
NF_3	
.	
.	
.	
NF_{NFILE}	

3.COMAND — MODULE TO COLLAPSE ANISN CROSS-SECTION LIBRARIES

COMAND (COllapse Multigroup ANISN Data) is a module for collapsing ANISN libraries. It accepts ANISN libraries in BCD or binary format, truncates upscatters and/or downscatters, combines the ANISN data from up to four libraries, and allows for stripping groups (neutrons or gammas) from the libraries. Several weighting spectra can be read in and used in the same computer run. COMAND collapses all sets of data on the input library.

3.COMAND.1. COMAND Input Data

Block 1.

1$ ANISN Library Parameters [8]

$$\left.\begin{array}{l}\text{1. IGM – Number of groups}\\ \text{2. IHT – Position of } \sigma_{\mathrm{T}}\\ \text{3. IHS – Position of } \sigma_{g\to g}\end{array}\right\}\text{ Input ANISN library}$$

$$\left.\begin{array}{l}\text{4. IHM – Table length}\\ \text{5. IGHF –Number of groups}\\ \text{6. IHTF –Position of } \sigma_{\mathrm{T}}\\ \text{7. IHSF –Position of } \sigma_{g\to g}\\ \text{8. IHM – Table length}\end{array}\right\}\text{ Output ANISN library}$$

2$ More Data [8]

1. IEDIT – 0, almost no edit (0)
   1, edit the output collapsed data
   2, edit the input fine-group and the output collapsed data
2. NCARDS – 0, no BCD-formatted input cross sections (0)
   N, use the Nth spectrum to weight BCD-formatted input cross sections
3. MODE – 0, BCD input is free-form FIDO
   1, BCD input is formatted FIDO
4. NPNCH – 0, no punch (0)
   1, punch collapsed cross sections
5. NSPEC – Number of weighting spectra that will be read in the 4* array (1)
6. NSCRTH – A collapsed ANISN library is written on this logical number (2)
7. NUNIT – BCD-formatted data are input on this logical unit (5)
8. NCHI – Position of fission spectrum (χ) in fine-group tables – if these data are included in the ANISN library
9. NWORD – Number of words to allocate to COMAND (50000)

3$ Logical Units of ANISN Binary Libraries and Weighting Spectra Selectors [8]

1. NT1 – Logical number of first ANISN binary library to be collapsed (0)
2. NT2 – Logical number of second ANISN binary library to be collapsed (0)
3. NT3 – Logical number of third ANISN binary library to be collapsed (0)
4. NT4 – Logical number of fourth ANISN binary library to be collapsed (0)
5. NS1 – Weighting spectrum to associate with NT1 (1)
6. NS2 – Weighting spectrum to associate with NT2 (1)
7. NS3 – Weighting spectrum to associate with NT3 (1)
8. NS4 – Weighting spectrum to associate with NT4 (1)

(Note that NT2 can equal NT1 and allow weighting the same cross sections over different spectra, etc.)

T Terminate Block 1.

Block 2.

4* Few-Group Weight Spectra [NSPEC*IGM]

Stack NSPEC sets of IGM numbers in this array. The value for the highest energy of the first spectrum is first.

5* Broad-Group Numbers by Few Group [IGM]

This group corresponds to the 28$ array in ANISN and 51$ array in XSDRNPM. A zero entry will delete a group. This feature allows stripping neutron or gamma-ray groups.

T Terminate Block 2.

3.COMAND.2 COMAND Input/Output Specifications

COMAND generally requires the following input/output devices to be available:

Logical No.	Purpose
5	Card input
6	Standard output
7	Punched output
NT1(0)	ANISN binary library input
NT2(0)	ANISN binary library input
NT3(0)	ANISN binary library input
NT4(0)	ANISN binary library input
NUNIT(5)	BCD ANISN library
NSCRTH(2)	Collapsed ANISN binary library

3.COMAND.3 COMAND Special Notes

A. To assume a flat (unity) weighting spectrum, enter ΔE_g in the 4* array, where ΔE_g is the energy width of group in eV's. To assume a 1/E weighting spectrum, enter the lethargy widths of the energy groups.

B. BCD-formatted cross sections, input either on cards or on tape, are read in subroutine COLANS with the following statements:

```
      DIMENSION    A(12),D(NA)
      .
      .
      .
  150 READ(NUNIT,10400)NOG,ITL,ICT,ID,A
      IF(ICT.EQ.7)GO TO 170
      .
      .
      .
      CALL READSG(D(LFINE),NOG*ITL,NUNIT,MODE)
      .
      .
      .
10400 FORMAT(4I6,12A4)
      .
      .
      .
      GO TO 150
      .
      .
      .
  170 CONTINUE
```

where

NA is the dimension of the D array,
NOG is the number of groups in the ANISN library on NUNIT,
ITL is the cross-section table length,
ICT is the trigger to signal the end of the library,
ID is the identification number of the ANISN-formatted data set,
A is the title card array (12A4 format), and
D is the array for the cross sections. Appropriate space is allocated in another subroutine.

READSG is an AMPX library routine. A "T" should not end the BCD-formatted cross sections [i.e., (NOG*ITL) cross sections are read in subroutine READSG]. Note that the final card of the BCD-formatted cross sections must be a "NOG, ITL, ICT, ID, A" card with ICT equal to seven. See statement 10400 above for the format.

C. COMAND does not retain the original identification numbers on the input ANISN library or libraries. It numbers the identifiers in the collapsed ANISN library (on NSCRTH) sequentially (i.e., 1, 2, ..., NT), where NT equals the total number of data sets on NT1, NT2, NT3, and NT4.

3.COMET — MODULE TO FORCE CONSISTENCY BETWEEN AVERAGED VALUES AND SCATTERING MATRICES ON AMPX MASTER LIBRARIES

COMET (<u>CO</u>rrect <u>M</u>aster <u>E</u>xcessive <u>T</u>olerance) is a module to correct selected portions of an AMPX master interface. A complete library can be easily corrected. Operations are provided to ensure that transfer matrices normalize to the proper 1-D values, or vice versa. Note that COMET copies the whole library, not just selected data sets. Although coupled neutron-gamma libraries can be read in, COMET only "operates" on the neutron data on a master library.

3.COMET.1 COMET Input Data

Block 1.

−1$ Special Vector Manipulations [200] (default = all zeroes)

These commands are used when it is desired that certain groupings of cross sections sum to a "total" value. For example, it is desirable that $\sigma_a = \sigma_c + \sigma_f$ or that all inelastic partial values sum to the total inelastic values. This array is made up of strings of MT numbers as follows:

Primary MT number—Secondary MT numbers—Zero

This string directs COMET to ensure that the use of the cross sections identified by the secondary MT numbers sums to the cross section identified by the primary identifier. Zeroes serve as "string delimiters." A positive primary identifier says to sum the secondaries and replace (or form) the primary values. A negative primary identifier says to normalize the secondaries such that they sum to the primary. Up to 20 strings can be specified. A negative secondary says to subtract this process so that one can form, for example, $\sigma_c = \sigma_a - \sigma_f$.

0$ Logical Unit Assignments [3]

1. MMTO – Old master library (28)
2. MMTN – New master library (1)
3. MSC – Scratch device (18)

1$ Options [2]

1. IOPT
   - −1 – Correct the "Table of Contents" of the master library on MMTO. (MMTN is not used.)
   - 0 – "Correct" the complete master library on MMTO, and write a new one on MMTN.
   - N – Correct N sets from MMTO and write on MMTN.
2. ICORE – Number of words to allocate to COMET (100000)

2$

MT – Numbers of processes to be corrected [200]

Place up to 200 MT numbers into the 2$ array. A negative MT number says to force the 1-D cross section to agree with the appropriate transfer matrix sums; a positive MT number forces the transfer matrix to be normalized to the 1-D value. After entering the MT numbers of interest, complete the arrays by filling with zeroes.

6$ Direct-Access File Characteristics [2]

1. NBLK - Number of blocks to use in the direct-access file on logical N9 (400)
2. LRECL - Number of words in each block on the direct-access file on logical N9 (788)

T Terminate Block 1.

Block 2. {Input if IOPT > 0}

3$ Identifiers for Master Data Sets to be corrected [IOPT]

T Terminate Block 2.

3.COMET.2 COMET Input/Output Specifications

COMET requires the following input/output devices:

Logical No.	Purpose
5	Card input
6	Standard output
9	Scratch device (random access)
17	Scratch device
MMTO(28)	Old master library
MMTN(1)	New master library
MSC(18)	Scratch device

3.CONTAC — MODULE TO PRODUCE ANISN OR CCCC ISOTXS LIBRARIES FROM AMPX WORKING LIBRARIES

CONTAC (CONvert To ANISN or CCCC format) is a module to make either an ANISN or a CCCC ISOTXS cross-section library from an AMPX working library. The complete working library is converted to either punched cards or a binary library if the ANISN format is selected. If a CCCC ISOTXS library is selected, the nuclides to be placed on the interface and their new names are specified in the input.

3.CONTAC.1 CONTAC Input Data

Block 1.

−1$ Core Allocation [1]

1. ICORE – Number of words to allocate to CONTAC (100000)

0$ Logical Unit Assignments [4]

1. NT3 – AMPX working or weighted library (3)
2. NT2 – ISOTXS or ANISN binary library (20)
3. NT7 – Scratch device (18)
4. NPU – ANISN punched output (7)

1$ Output Control Options [2]

1. ITP – 1 – Make a CCCC ISOTXS library (0)
   2 – Punch ANISN cards
   3 – Make ANISN binary library
2. IMP – Number of nuclides to be put on NT2 when an ISOTXS library is made (0)

2$ ANISN Output Control Parameters [6]

1. MSCM – Number of extra 1-D cross sections to be placed on ANISN output. (0) If the value of this parameter is input as −1 and a CCCC ISOTXS library is being made (ITP = 1), it signals that the fission spectrum to be written on that library will be specified in the 7* array and velocities will be specified in the 8* array below.
2. IHT – Position of total cross-section ANISN formats (0)
3. IDS – Position of within-group-scattering cross section in ANISN formats (0)
4. ITL – Table length for cross sections in ANISN formats (0)
5. IPRT – Print control for ANISN output (0)
   (ANISN arrays will be printed through order of scattering equal IPRT. A −1 will suppress the printing of all ANISN arrays.)
6. IOLD – 0 – A new ANISN library will be written (0)
   1 – Data will be added to an existing ANISN library

T Terminate Block 1.

Block 2.

3$ Nuclide Identifiers of Sets to be Placed on ISOTXS. [IMP]

4$ MT Number(s) of the Transport Cross Sections to be Placed on ISOTXS (filled with 1001) [IMP]

5/ Six-Character Hollerith Names to be Placed on ISOTXS

The names correspond to nuclides in the 3$ array. [2*IMP] (The / is followed by an integer identifying the first location to be filled and then an integer identifying the last location to be filled [i.e., (1 and 2*IMP)]. Starting on the next card, *the names are read with an 18A4 format, but the six-character Hollerith names should be considered as being read with a 9(A6,2X) format.*

6$ Extra Cross-Section MT Numbers [MSCM]

For neutron data, these are the ENDF MT numbers of the cross sections which are to be placed in the ANISN cross-section tables in the first MSCM positions. For photon-interaction data (SMUG-produced data), these are the AMPX MT identifiers minus 500 (e.g., 102 is the identifier for the photoelectric cross section, which has an AMPX identifier of 602).

7* Fission Spectrum [IGM] {ITF=1 and MSCM=−1}

Input the group-integrated values for the fission spectrum – highest-energy group to the lowest. Use this array to provide a fission spectrum to be written on an ISOTXS file, when the input library is a working library (not a weighted library).

8* Velocities [IGM] {ITF=1 and MSCM=−1}

Input weighted velocities for each neutron group. Use this to supply velocities for an ISOTXS file when the input library is a working library.

9$ Maximum Order of Scatter by Nuclide [IMP]

Use this array to specify the maximum order of scatter, which will be written on the ISOTXS file.

T Terminate Block 2.

Note: If the 5/ array is the last array in Block 2, an "E T" is entered to end the data block.

3.CONTAC.2 CONTAC Input/Output Specifications

CONTAC requires the following input/output devices:

Logical No.	Purpose
5	Standard card input
6	Standard printed output
NPU(7)	Punched output
NT2(20)	ISOTXS or ANISN binary library
NT3(3)	Input AMPX working (or working/weighted) library
NT7(18)	Scratch device

3.CORECTOL — MODULE TO CONVERT PRE-AMPX-77 MASTER LIBRARIES TO THE AMPX-77 FORM

Prior to AMPX-77, the implementation of the Nordheim Integral Treatment in the NITAWL module assumed that the cross sections in the master library would be split into two cases:

1. cross sections for the bodies of the resonances (weighted over a reference flux); and
2. wing cross sections, which included correction values, values for $\ell = 1$, 2, etc., resonances (i.e., everything in the cross sections which the Nordheim calculation was not going to calculate)

This arrangement allowed one to simply add these pieces together if an infinite dilution set was desired, or to perform a resonance self-shielding calculation and add to the second set noted above to obtain self-shielded values.

This procedure required that the basic processing code, such as XLACS, be required to know exactly where the bodies of the resonances would be calculated, and, thereby, precluded the use of the Nordheim treatment with libraries not based on this knowledge.

It was recognized that a better way to implement the Nordheim treatment would be to reference the self-shielded values to infinite dilution values, that is, the Nordheim calculation would really be two calculations: (1) the regular calculation, just as before, and (2) a calculation where the cross-section values are simply weighted over a 1/E flux. The difference in the two values could then simply be added to the reference set to obtain shielded values. This method has several obvious advantages: (1) it allows the Nordheim calculation to be performed with any library that used 1/E weighting in the resonance range, a commonly used scheme; and (2) it allows one to always refine (or unrefine) a calculation by adding (for example, $\ell = 1$) or deleting resonance parameters. This method has other advantages from an accuracy viewpoint, which we will not discuss here.

Clearly, the base library needed by the two approaches is different. The task of taking the earlier AMPX master libraries and converting them to the new format by adding together the resonance body values and the wing values and discarding the wing values is the purpose of the CORECTOL (<u>COR</u>r<u>ECT</u> <u>O</u>ld <u>L</u>ibraries) module. It is a very simple module to use and requires essentially that the user define where the files are located. Obviously, CORECTOL has no counterpart module for converting newer libraries to the older form, because it is this complicated task that the newer procedures have been designed to eliminate.

In the event you do not know if your library is in the older or newer format, the ALE module can be run (the header information contains a parameter called the "Nordheim Processing Level," which will be "0" on older libraries and will be "2" on the new ones).

3.CORECTOL.1 CORECTOL Input Data

Block 1.

−1$ Core Assignment [1]

1. ICORE – Number of words of core to assign to this module (100000)

0$ Logical Assignments [4]

1. NT1 – Old AMPX master (1)
2. NT2 – New AMPX master (2)
3. NS – Scratch device (18)
4. NT – Scratch device (19)

T Terminate Block 1.

3.CORECTOL.2 CORECTOL Input/Output Specifications

CORECTOL uses the following input/output devices:

Logical No.	Purpose
5	Card input
6	Printed output
NT1(1)	Old AMPX master library
NT2(2)	New AMPX master library
NS(18)	Scratch device
NT(19)	Scratch device

3.CREST — A MODULE TO COLLECT INFORMATION FROM ENDF/B, MASTER, AND WORKING LIBRARIES

CREST (Collect and REname STrings) is a module that will scan ENDF/B and AMPX master and working libraries and collect information from them to write out in ENDF/B "TAB1" format (string format). The file, produced by CREST, can be used by a variety of modules, including JERGENS, VEL, and VASELINE.

The binary form of the "TAB1" format consists of three records per process:

Record 1 – MAT, MF, MT, NZ, NZ, NZ, NZ, NZ, NZ,
Record 2 – MAT, MF, MT, NZ, NZ, NZ, NZ, N1, N2,(NBT_i, JNJ_i, i=1, N1), (X_i, Y_i, i=1, N2),
Record 3 – MAT, MF, NZ, NZ, NZ, NZ, NZ, NZ, NZ,

where MAT is the MAT-number, MF is the file number (always 3 for CREST), MT is the process identifier, NZ is a zero, N1 is the number of interpolation regions, N2 is the number of energy value pairs, NBT,JNT are the interpolation table parameters, and X,Y define the function. Values taken from a master or working library specify that histogram interpolation is to be used with the group-averaged values.

3.CREST.1 CREST Input Data

Block 1.

1$ Case Description [2]

1. MP – Number of "commands" given in Block(s) 2
2. IP – This is the logical number of the file to be written (default = 31)

2$ Options [10]

1. IOPT1 – Not used
2. IOPT2 – Not used
3. IOPT3 – Not used
4. IOPT4 – Not used
5. IOPT5 – Not used
6. IOPT6 – Not used
7. IOPT7 – Not used
8. IOPT8 – Not used
9. IOPT9 – Not used
10. IOPT10 – Number of words allocated to CREST (50000)

T Terminate Block 1.

Block 2 is repeated MP times.

Block 2.

3$ Process Selection [5]

1. MATNO – New "MAT" number to be given the string of information
2. MT – Process identifier
3. IDM – Identifier of the nuclide on the master file
4. IDW – Identifier of the nuclide on the working file
5. IDE – MAT number for the nuclide on the ENDF file (only one of the parameters IDM, IDW, and IDE should be specified nonzero in a command)

4$ File Locations and Modes [5]

1. MMTN – Logical number of the master file (default = 1)
2. MWTN – Logical number of the working file (default = 4)
3. MENDF – Logical number of the ENDF library (default = 11)
4. MODE – "Mode" of the ENDF library (default = 1 for binary formatted libraries; a "2" should be used for BCD formatted libraries)
5. MFILE – ENDF "file" containing the data (default = 3)

T Terminate Block 4.

3.CREST.2 CREST Input/Output Specifications

CREST may require the following input/output devices:

Logical No.	Purpose
5	Card input
6	Standard output
IP(31)	Created file
MMTN	Master library
MWTN	Working library
MENDF	ENDF/B library

Note that several files may be required in a single execution of MMTN, MWTN, and MENDF.

3.FRESH — AMPX MODULE TO RENORMALIZE THERMAL SCATTERING MATRICES

FRESH (Fix RESonance Hangups) is a module that allows one to post-process the thermal-scattering matrices for many resonance nuclides produced by XLACS-77 in order to normalize them to user-specified values. Note that only resonance nuclides need this operation, and only those with strong resonance effects at thermal energies.

A problem arises from the procedure used in XLACS-77 to generate these data. This procedure generates $S_{\alpha,\beta}$ data consistent with a free-gas model that assumes the thermal-scattering cross section is a flat value at 0 K. This value is the so-called free-atom cross section. It is not part of the ENDF/B file and, therefore, must be acquired from somewhere else. At one point, XLACS used the value for elastic scattering in the first group above thermal. The present XLACS-77 scheme uses the scattering radius from File 2 on the ENDF library to calculate a scattering cross section. Neither of these schemes is very satisfactory, because they both generate a smooth variation in the thermal region, which does not reflect the true shape.

FRESH provides three options for dealing with nuclides:

Option 0 – do not adjust thermal matrices,
Option 1 – normalize the matrices to the averaged values produced by the resonance calculation in XLACS,
Option 2 – normalize the matrices such that the value in the first thermal group is equal to that in the first group above thermal.

Option 1 will probably ultimately be incorporated into XLACS-77, thereby precluding the need for this exercise. It certainly is the most reasonable approach. However, until this time, the FRESH module should be used. It is wise to keep in mind that the effect from this repair is negligible in most cases. Resonance nuclides are generally heavier nuclides, and, for this case, thermal-scattering kinematics do not greatly affect most analyses, because the result of a scattering is to shift the energy of the neutron only slightly.

3.FRESH.1 FRESH Input Data

Block 1.

-1$ Core Allocation [1]
  1. ICORE – Number of words to allocate to FRESH (100000)

0$ Logical Assignments [1]
  1. MMT – Output AMPX master library (1)

1$ Files to Process [1]
  1. NFILE – Number of master libraries that will be accessed

T Terminate Block 1.

Blocks 2 and 3 are repeated NFILE times.

Block 2.

2$ File Selection [12]

1. NF – Logical number of the file to process
2. IOPT – Number of nuclides to accept from the file on logical NF
3. I1
4. I2

.
.
.

12. I10

Reserved for special applications that should be of no interest to users

T Terminate Block 2.

Block 3.

3$ Nuclide Selection [IOPT]
Input the identifiers for the nuclides selected from logical NF.

4$ Nuclide Identifier Override [IOPT]
Input a nonzero new identifier value in the position corresponding to an identifier in the 3$ array to change the nuclides identified on the output file.

5$ Normalization Option [IOPT]
Enter 0 to bypass normalization, 1 to normalize to average to resonance values or 2 to normalize to the first scattering value above thermal. These values are given in one-to-one correspondence with the 3$ array.

6$ Combination of 3$ and 5$ array [2*IOPT]
This is a convenience array and recognizes that long lists in separate arrays, such as the 3$ and 5$ arrays, are sometimes difficult to keep value associations correct. If one chooses the alternative array, input the identifier followed by the option, etc., until IOPT pairs are specified. Do not input the 3$ or 5$ arrays. (The 4$ array still must be given in correspondence with the doublets. It was elected not to include it in the 6$ array in recognition that the need to override identifiers is not that common.)

T Terminate Block 3.

3.FRESH.2 FRESH Input/Output Specifications

FRESH uses the following input/output assignments:

Logical No.	Purpose
5	Card input
6	Standard output
15	Scratch file
16	Scratch file
18	Scratch file
19	Scratch file
MMT	Output master file
NF	Input master file (there will be NFILE of these)

3.GERITOL — AMPX MODULE TO PLACE GROUP CONSTANTS INTO A "STRING" LIBRARY

Given a set of group fluxes

$$\left(\phi_i \;=\; \int_{E_i+1}^{E_i} \phi(E) dE \right)$$

or group cross sections

$$\left(\sigma_i = \frac{1}{E_i - E_{i+1}} \int_{E_i+1}^{E_i} \sigma(E) dE \right) \quad ,$$

GERITOL (GEneRate InexacT Oscillating Lines) uses the interpolation allowed in ENDF and a least-squares fitting routine to generate a set of (E,F(E)) pairs to place the generated data into a set of ENDF HEAD, TAB1, and SEND records — a "string" library.

For each group in the input energy structure, GERITOL first calculates the value of $F(E) = \phi_i/(E_i - E_{i+1})$ for input fluxes or $F(E) = \sigma_i$ for input cross sections. Then, the module fits the $F(E)$'s to the following three forms: $F(E) = A + b \times \ln(E)$, $\ln[F(E)] = A + b \times E$, and $\ln[F(E)] = \ln[A + b \times E]$. (For those fitting functions linearly dependent on energy, the value of $F(E)$ is taken at the group midpoint energy. For those fitting functions dependent on the logarithm of energy, the value is taken at the lethargy midpoint.) The parameters A and b for each fitting function are then used to calculate the integral in the group, and the function yielding the integral with the smallest deviation from the known integral is assigned to that group.

If the integral calculated by the "best" function is not within an input fraction, DVMIN, of the true integral, this function is discarded and a linear-linear function is assumed. Likewise, if the integral computed by the linear-linear function is not within DVMIN of the true integral, or if the function at either group boundary is negative, this function is discarded, and a constant function is chosen to make the integral correct.

Once a best-fitting function is determined, the values of $F(E)$ at the group boundaries are computed and stored. When all groups have been processed, one has a TAB1 record, with the number of points equal to twice the number of groups. The number of points is then thinned by discarding the value of $F(E)$ at the lower boundary of a group if it is within an input fraction, EPS, of the value of $F(E)$ at the upper boundary of the previous group. Some thinning is also achieved by discarding points in successive regions whose parameters are equal within the same fraction, EPS.

GERITOL output on logical unit LUN consists of the three ENDF records (HEAD, TAB1, and SEND) in binary format with the MAT, MF, and MT identifiers specified in the input. If flux values are input (NTYPE = 0), then the output values have units of flux per unit energy. If cross sections are input (NTYPE = 1), the output has the same units as the input. Positions N1 and N2 in the HEAD record contain the input option variables NTYPE and IPLOT. The series of three ENDF records are repeated on LUN for each input group function (i.e., each set of Blocks 2 and 3 data). After the final series is written in LUN, the logical unit is rewound and read as a final check on the validity of the data. The integrals by group are recomputed and compared with the true integrals.

Two particularly useful applications of the string libraries on LUN are (1) for use as pointwise weighting functions in the neutron- and photon-production cross-section modules XLACS-77 and LAPHNGAS, respectively, and (2) for input to VEL, the AMPX module that converts pointwise data to multigroup data. Note that a GERITOL-VEL sequence could be used to change multigroup data from one group structure to another group structure. One must exercise caution, however, to ensure that the application of the pointwise function does not exceed the limitations of the input group function. If the input group values represent an integral of a function over an energy range in which the function has significant variation, then the subsequent use of this point function to calculate integrals over a much smaller energy range may not be valid.

An option is provided for producing point and multigroup data libraries for the subsequent plotting of the data with the VASELINE module. If the option is triggered (IPLOT = 1), a string library is produced on logical unit ISCR similar to the string library described above. The difference between the LUN and ISCR libraries is that, if fluxes are input, the units of the data on ISCR are flux times energy and, if cross sections are input, the units are the same as the data input in 4* data. Thus, the data on ISCR are in the units required for plotting point data with VASELINE. Also, the Blocks 2 and 3 multigroup data are changed to the appropriate units, described below, and placed in AMPX working library format on logical unit KSCR — a format which can be input to VASELINE. If only one set of Blocks 2 and 3 data is input, the abbreviated AMPX working library is placed on KSCR1. If more than one set of Blocks 2 and 3 data is input, GERITOL places all multigroup sets of data with the number of groups equal to IGM of the first Block 2 input on KSCR1. Multigroup data for the next value of IGM are placed on KSCR2, etc. GERITOL has provisions for a maximum of five KSCR units (i.e., has provisions for a maximum of five different values of IGM). If fluxes are input, the data on KSCR1 have units of flux/lethargy width; if cross sections are input, the units are the same as the 4* data. In each case, the data on KSCR1 are in the units required for plotting multigroup data with VASELINE.

3.GERITOL.1 GERITOL Input Data

Input to GERITOL is made in the free-form FIDO schemes employed throughout AMPX.

Block 1.

0$ Logical Assignments [7]

1. LUN – String Library (31)
2. ISCR
3. KSCR1
4. KSCR2
5. KSCR3 (0)(0)(0)(0)(0)(0)
6. KSCR4
7. KSCR5

If the plot preparation option is triggered (IPLOT = 1), the string library for input to VASELINE is placed on ISCR. The abbreviated working library is placed on KSCR1 and, if required, other working libraries are placed on KSCR2, …, KSCR5.

T Terminate Block 1.

Blocks 2 and 3 are repeated for each set of group constants for which a point function is desired, and the run is terminated by specifying a zero for the number of groups. Redundant information, such as the group boundaries, does not need to be repeated in successive cases.

Block 2.

1$ General Information [6]

1. IGM – Number of groups
2. MAT3. MF4. MT ENDF identifiers given to output point function
5. NTYPE – 0, Group constants are fluxes (0)
   1, Group constants are cross sections
6. IPLOT – 0, No plot tapes are desired (0)
   1, Plot tapes should be generated

2* Tolerances [2]

1. DVMIN – Fractional difference allowed in group reconstruction (0.05)
2. EPS – Fractional difference allowed in thinning. This applies to function values reconstructed at group boundaries from parameters in adjacent regions and to the parameters themselves. (0.05)

T Terminate Block 2.

Block 3.

3* Energy group boundaries, high to low in eV [IGM+1]
4* Group constants [IGM]

T Terminate Block 3.

3.GERITOL.2 GERITOL Input/Output Specifications

GERITOL requires the following devices during a normal calculation:

Logical No.	Purpose
5	Card input
6	Standard output
LUN(31)	Output string library
47	Built-in group structure library*

If plotting output is generated (IPLOT=1), the following devices are also required:

Logical No.	Purpose
ISCR(0)	Output string library for VASELINE
KSCR1(0)	Abbreviated working library for first IGM structure
KSCR2(0)	Abbreviated working library for second IGM structure
KSCR3(0)	Abbreviated working library for third IGM structure
KSCR4(0)	Abbreviated working library for fourth IGM structure
KSCR5(0)	Abbreviated working library for fifth IGM structure

---

*See Sect. 4.MISCELLANEOUS.4.

3.ICE — MODULE TO MIX DATA ON A WORKING LIBRARY TO PRODUCE MACROSCOPIC LIBRARIES

ICE (Initiate Compression Exercise) is a module that uses an AMPX working library in conjunction with a user-supplied set of instructions on how to mix cross sections to produce macroscopic cross sections which can be written in any of several popular library formats, including:

- an AMPX working library,
- an ANISN library, or
- a library for the KENO program.

Any or all of these libraries can be made in the same execution of ICE.

3.ICE.1 ICE Input Data

Card A (20A4) Title Card

Block 1.

−1$ Direct-Access Specifications [4]

1. NB8 – Number of blocks for the first direct-access unit (200)
2. NL8 – Length in units of 4-byte words of a block for the first direct-access unit (880)
3. NB9 – Number of blocks for the second direct-access unit (400)
4. NL9 – Length of a block for the second direct-access unit (880)

0$ Logical Unit Specifications for Various Cross-Section Libraries [5]

1. INTAPE – Input AMPX working library unit (4)
2. IOT1 – Output AMPX working library unit (3)
3. IOT2 – Output ANISN library unit (20)*
4. IOT3 – Output ANISN group-independent library unit (21)
5. IOT4 – Output Monte Carlo processed cross-section library unit (14)

If punched output is desired, the unit should be set to 7.

1$ Problem Size and Major Options [7]

1. MIX – Number of cross-section mixtures to be made
2. NMIX – Number of mixing operations (elements times density operations) to be performed
3. IFLAG(1) – Set greater than zero if AMPX working library output desired.
4. IFLAG(2) – Set greater than zero if ANISN format output desired.

---

*If punched output is desired, the unit should be set to 7.

5. IFLAG(3) – Set greater than zero if group-independent ANISN output desired.
6. IFLAG(4) – Set greater than zero if Monte Carlo processed cross-section library output desired.
7. KOPT – Option to be used to calculate χ of the mixture (2)
   - KOPT = 0, χ of element with the largest sum of $\nu\Sigma_f\phi$ over all groups is used
   - KOPT = 1, χ calculated based on an input flux distribution
   - KOPT = 2, χ calculated based on a default thermal reactor flux distribution
   - KOPT = 3, χ calculated based on a default fast reactor flux distribution
   - KOPT = 4, χ calculated based on the fluxes provided in the input tape for each element in the working library

2$ Core Allocation* [1]

1. NWORD – Number of words allocated to ICE (100000)

T Terminate Block 1.

The following table contains the options which can be used in the 1$ array:

	IFLAG options
Print options	
0	No cross-section printing
1	Print 1-D cross sections (available only in AMPX working library format)
2	Print 1-D cross sections and P_0 cross sections (not available in ANISN group-independent format)
3	Complete cross-section printing
Output options	
00	No tape or punch output
10	Binary tape output
20	Free-form FIDO punch output (available only in ANISN and group-independent ANISN formats)
30	Fixed-form FIDO punch output (available only in ANISN and group-independent ANISN formats)

Note that IFLAG should be set to the sum of the print option and output option desired.

Block 2.

2$ [NMIX]

1. (KM(I),I=1,NMIX)	Mixture numbers in the mixture specification table — values range from 1 to MIX

3$ [NMIX]

1. (KE(I),I=1,NMIX)	Element identifiers for the mixture specification table

4* [NMIX]

1. (RHO(I),I=1,NMIX)	Atom densities for the mixture specification table

5$ [MIX]

1. (NCOEF(I),I=1,MIX)	Number of Legendre coefficients, including P_0, to be mixed for each mixture

6* [NG+4]

1. (FLUX(I),I=1,NG)	Flux to be used in calculation of χ if KOPT = 1; default (FLUX(I) = 1.0, I=1, NG) where NG = number of neutron groups

Note: The four following parameters are required only if KOPT = 2 (i.e., a standard thermal reactor flux is calculated)

2. TEMP	Temperature in Kelvin to be used for Maxwellian distribution (300)
3. THETA	Temperature in eV to be used for fission spectrum (1.3×10^6)
4. AKT	Number of kT at which 1/E distribution and Maxwellian distribution join (5)
5. FCUT	Energy in eV at which fission spectrum and 1/E distribution join (67.5×10^3)

7$ [10]

1. IHT	Position of σ_T in ANISN format output (3)
2. IHS	Position of within-group scattering in ANISN format output (IHT plus number of thermal groups)
3. IHM	Table length in ANISN format output (IHS plus total number of groups)
4. LOPT	Set greater than zero if truncations of cross sections defined by the above parameters are to be applied to the AMPX working library and Monte Carlo processed cross-section library (0)

5. NNGA	The number of neutron groups for which Monte Carlo cross sections will be processed (the number of neutron energy groups on the input library)
6. NGGA	The number of gamma groups for which Monte Carlo cross sections will be processed (the number of gamma energy groups on the input library)
7. NOPT	Option to be used if energy groups are truncated 0 downscatters to missing groups kept 1 downscatters to missing groups are summed into last downscatter cross section present 2 downscatters to missing groups are dropped (0)
8. NSCT	Number of discrete scattering angles calculated (0)
9. IADJM	Set greater than zero to produce a library for an adjoint problem (0)
10. NNGTP	Set greater than zero if a completely coupled cross-section set is desired (0)

T Terminate Block 2.

Block 3.

8$ [MIX] {Required only if IFLAG (1) > 0 }

1. (MID)(I),I=1,MIX) Mixture numbers for AMPX working library

9$ [N] {Required only if IFLAG (2) or IFLAG(3) > 0 }

1. (MAD)(I),I=1,N) ANISN mixture ID numbers. NCOEF (I) ID's are required for each mixture for a total of

$$N = \sum_{I=1}^{MIX} NCOEF(I)$$

Default as follows:

P_0 for 1st mixture	ID=100
P_1 for 1st mixture	ID=101
P_2 for 1st mixture	ID=102
	.
	.
	.
P_0 for 2nd mixture	ID=200
P_1 for 2nd mixture	ID=201
	.
	.
	.

10$ [IHT] {Required only if IFLAG (2) or IFLAG(3) > 0 }

1. (IMT(I),I=IHT)	ENDF-MT number of the ID cross sections to be used in the ANISN cross-section tables in *inverted order* (first five positions): 1(σ_T), 1452($\nu\sigma_f$), 27(σ_a), 18(σ_f), and 1018(χ). All other positions: 0

11$ [1+MIX] {Required only if IFLAG (4) > 0 }

1. LID	Monte Carlo processed cross-section library identification number (1)
2. (MUD(I),I=1,MIX)	Mixture ID numbers for Monte Carlo processed cross-section library (MUD(I)=I, I=1, MIX)

T Terminate Block 3.

3.ICE.2 ICE Input/Output Specifications

An ICE calculation may require the following input/output devices:

Logical No.	Purpose
5	Card input
6	Printed output
7	Punched output
8	Direct-access scratch
9	Direct-access scratch
INTAPE(4)	Input AMPX working library
IOT1(3)	Output AMPX working library
IOT2	ANISN library
IOT3	ANISN library in group-independent format
IOT4	Monte Carlo (KENO) library

3.JERGENS — MODULE TO GENERATE WEIGHT FUNCTIONS AND TO COMBINE ENDF/B TAB1 RECORDS

JERGENS (Just an Excellent Routine to GENerate Strings) is the module to use when it is necessary to construct a weighting spectrum, such as is needed by XLACS77, VEL, or LAPHNGAS. It can be used for a large variety of operations involving the combination of more than one ENDF/B TAB1 record. The TAB1 record might, for example, contain the energy-value pairs for a cross section for a particular process. All the arithmetic operations in JERGENS are performed to a user-controllable accuracy. The output from the module is a file containing the new functions written in "TAB1" format.

3.JERGENS.1 JERGENS Input Data

Block 1.

−1$ Options [20]

1. IOPT1(2) Used in conjunction with interpolation values
2. IOPT2(2) specified below
3. IOPT3 – Maximum number of interpolation regions which can be generated (100)
4. IOPT4 – MAT number for all the functions to be produced by this JERGENS run (99)
5. IOPT5 – MF (file) number for all the functions to be produced by this JERGENS run (3)
6. INT1 – First interpolation scheme used (1)
7. INT2 – Second interpolation scheme used (2)
8. INT3 – Third interpolation scheme used (3)
9. INT4 – Fourth interpolation scheme used (4)
10. INT5 – Fifth interpolation scheme used (5)
11. ICORE – Number of words to allocate to JERGENS (100000)
12. Not used
13. Not used
14. Not used
15. Not used
16. Not used
17. Not used
18. Not used
19. Not used
20. Not used

The combination of IOPT1, IOPT2 with INT1, INT2,... INT5 allows a very flexible way of selecting the kinds of interpolation schemes allowed in the functions produced.

Recall that the interpolation schemes are the following:

Code	Type
1	Histogram
2	Linear x – linear y
3	Linear x – log y
4	Log x – linear y
5	Log x – log y

IOPT1 points to the word in INT1...INT5 which contains the first interpolation code to be tried. IOPT2 points to the last word in the string containing the code to be tried. JERGENS cycles through the codes specified in INT(IOPT1) to INT (IOPT2) to determine the "best code" to use. By default, IOPT1 and IOPT2 are both 2, indicating a linear-linear function is being constructed. IOPT = 1 and IOPT2 = 5 would try types 2, 3, 4, and 5 in exactly that order. Making IOPT1 = 1 and IOPT2 = 2, and INT1 = 5 with INT2 = 2 would cycle between a log-log and a linear-linear scheme, etc. Attempting INT = 1 (histogram) would be fruitless, because one would never satisfy accuracy specifications; therefore, it should be avoided.

0$ Logical Assignments [3]

1. NDFB – All external functions required by JERGENS must reside here (The CREST module can be used to collect multiple functions onto a single file.)
2. MWT – The library produced by JERGENS is written here
3. MSC – Scratch file (default = 18)

1$ Problem Information [1]

1. NMWT – Number of functions to be written on MWT

2* Energy Range [2]

1. ELO – Low-energy cutoff of functions to be generated (in eV) (default = 0.00001)
2. EHI – High-energy cutoff of functions to be generated (in eV) (default = 2.0×10^7)

T Terminate Block 1. Repeat the following two blocks NMWT times.

Block 2.

3$ Identifier and Option Selectors [3]

1. IDWT – Identifier for function to be created. This is equivalent to the MT number in ENDF/B
2. NC – Number of "commands" associated with the construction of this function
3. IW – Special function generator option. This is used when NC = 0.
    0 – 1/E
    1 – flat
    2 – Maxwellian–1/E–fission spectrum

3 – E
4 – Maxwellian–1/E–fission spectrum–1/E above 10 MeV
5 – Neutron dose factors per ANSI/ANS 6.1.1-1977
6 – Gamma-ray dose factors per ANSI/ANS 6.1.1-1977
7 – 1/V (normalized to 1.0 at 2200 m/s)

4* Special Constants [6]

1. TMAX – "Temperature" of the Maxwellian spectrum (K) (default = 300)
2. AKT – Multiplier on KT to determine Maxwellian to 1/E join point (default = 5)
3. THETA – Effective temperature in eV of the fission spectrum (default = 1.27×10^6)
4. FCUT – Point at which to join 1/E to fission spectrum (default = 67.4×10^3)
5. SIGD – Not used
6. EPS – Accuracy to which functions are to be generated (default = 0.001)

T Terminate Block 2.

Block 3. "Commands"

This block is only required when NC > 0. It is written in free form in columns 1–72 of a card and should not be terminated by a T. Each "command" consists of six words:

1. IDCREATE – The identifier of a set "created" by the operation. Use any unique integer
2. IDINTACT – The identifier of a set previously created which is required by this command
3. OPERATION – An alphanumeric word describing the command
4. A – Constant which may be needed by the command (default = 1.0)
5. IDUSE – The identifier (MAT number) of the set of data on logical NDFB which is needed for this command
6. MTUSE – The MT number of the set of data on logical NDFB which is needed for this command

The commands, in groups of six items, are stacked one after the other until NC commands are specified.

As a general rule, the following type of operation is performed:

IDCREATE=IDINTACT{OPERATION}A*IDUSE .

That is to say, IDCREATE is a string of data points created by combining the string IDINTACT in conjunction with some form of operation with A times the string IDUSE.

Before two strings input on logical NDFB can be used in a command, one of them must be moved to the "intact" file by issuing a "MOVE" or an "ADD" command.

At least one IDCREATE should equal IDWT. This command will cause the string to be written to logical MWT; otherwise, strings are written onto MSC.

The possible commands and their actions are described as follows:

IDCREATE	IDINTACT	OPERATION	A	IDUSE	ACTION
IDC	0	MOVE	A	IDU	IDC = A × IDU
IDC	IDI	ADD	A	IDU	IDC = IDI + A × IDU
IDC	IDI	SUB	A	IDU	IDC = IDI - A × IDU
IDC	IDI	DIV	A	IDU	IDC = IDI/(A × IDU)
IDC	IDI	MULT	A	IDU	IDC = IDI × A × IDU
IDC	IDI	ADD	A	0	IDC = IDI + A
IDC	IDI	SUB	A	0	IDC = IDI − A
IDC	IDI	MULT	A	0	IDC = IDI × A
IDC	IDI	DIV	A	0	IDC = IDI/A
IDC	0	ADD	A	IDU	IDC = IDU + A
IDC	0	SUB	A	IDU	IDC = IDU − A
IDC	0	DIV	A	IDU	IDU × A
IDC	0	MULT	A	IDU	IDU/A
IDC	IDI	NORM	A	0	IDC = $\int_{ELO}^{EHI}$ IDI
0	IDI	PRT	0	0	Print IDI
IDC	IDI	MAX	0	0	IDC = Maxwellian joined to function IDI
IDC	IDI	FISS	0	0	IDC = IDI joined to a fission spectrum
0	IDI	PNCH	0	0	Punch IDI in ENDF TAB1 format
IDC	IDI	FUNC	A	IDU	Use a special function generator as described in the following table. In all cases the function y(x) is identified by IDI,and the option is selected by IDU

Note that in the above table, IDC is an abbreviation for IDCREATE, IDI for IDINTACT, and IDU for the combination of IDUSE and MTUSE.

The following is a table of options for the "FUNC" operation:

IDU (option)	Function to be constructed
1	$G(x) = A\ y(x)$
2	$G(x) = A/y(x)$
3	$G(x) = xAy(x)$
4	$G(x) = \frac{A}{xy(x)}$
5	$G(x) = \frac{1.0}{y(x) + A}$
6	$G(x) = \frac{1.0}{x[y(x) + A]}$
7	$G(x) = A\ x/y(x)$

3.JERGENS.2 JERGENS Input/Output Specifications

JERGENS requires the following input/output devices:

Logical No.	Purpose
5	Card input
6	Standard output
NDFB	Input functions
MWT	Output functions
MSC	Scratch device

3.LAPHNGAS — MODULE FOR GENERATING MULTIGROUP SECONDARY GAMMA-RAY PRODUCTION CROSS SECTIONS

LAPHNGAS (Los Alamos PHotoN GenerAtion Scheme) retrieves photon production data from the ENDF data file and calculates either multigroup secondary gamma-ray production cross sections (SGRPXS) and/or multigroup secondary gamma-ray yields (multiplicities) that will be written to an AMPX master interface. To form coupled neutron-gamma cross sections, the SGRPXS or yields are passed to other AMPX modules, CHOX and NITAWL, to be combined with multigroup neutron and photon interaction cross sections. When used as a stand-alone code, LAPHNGAS can calculate either fine-neutron-group or broad-neutron-group SGRPXS for use with other codes.

D. J. Dudziak et al. of the Los Alamos Scientific Laboratory wrote a series of codes to prepare multigroup photon-production matrices from ENDF data.[1] These codes have evolved from an early code called LAPH[2] through a series of codes that incorporated various ENDF format changes to the LAPHAN0[3] code, which served as the starting point for the development of LAPHNGAS. The following modifications were made to LAPHAN0 to produce LAPHNGAS:

- The code was flexibly dimensioned.
- The capability of computing anistropic photon-production matrices was added.
- Various weighting options were provided.
- The input format was restructured to incorporate the FIDO (ANISN) input system described in Sect. 7.FIDO.
- A cross section or yield matrix for each reaction type processed is uniquely identified and made available to other AMPX modules. Yield matrices are calculated for the fission and capture reactions of resonance materials. This allows "self-shielded" gamma production matrices to be formed.
- Data management changes were made to reduce input/output operations and to allow processing of both unformatted (binary) and formatted (BCD) ENDF libraries.
- Cross-section and yield matrices are printed and punched only when indicated via input data (see 2$ array, items 7 and 8).
- Binary search techniques were implemented to locate specific energy points within energy arrays arranged in ascending order.
- Capabilities were included to process both ENDF/B-IV and ENDF/B-V data.

The LAPHAN0 report[3] should be used as the theoretical reference for LAPHNGAS.

3.LAPHNGAS.1 LAPHNGAS Input Data

With the exception of the ENDF data and title cards, all data for LAPHNGAS are input in the FIDO (ANISN) format. Input data for the code are as follows:

A. Title Card (format 18A4) - Problem Title

B. 1$ Array – General Problem Information [4 entries]

1. MCR – Number of materials to be processed
2. NFG – Number of neutron groups
3. NGG – Number of gamma groups
4. IM – Neutron reaction cross section (MF = 3) and/or photon-production cross-section (MF = 13) point-weighting option:

= 1, constant weighting

= 2, 1/E weighting

= 3, fission spectrum weighting for $E_n > 6.74 \times 10^4$ eV and 1/E weighting for $E_n \leq 6.74 \times 10^4$ eV, where the fission spectrum equation used is

$$W(E) = \sqrt{\frac{4E}{\pi\theta^3}}\, e^{-E/\theta} \quad ,$$

where $\theta = 1.273$ MeV.

= 4, exact 1/E. The analytic solution of

$$\bar{\sigma} = \frac{\int \sigma(E)W(E)dE}{\int W(E)dE}$$

is programmed in LAPHNGAS. The equation used for the analytic solution depends on the interpolation scheme defined for adjacent σ(E)values. The equations are defined in ref. 4, pp 29–31.

= 5, $1/(E\sigma_T)$ weighting

= 6, arbitrary function input in 11$ and 13* arrays (enter a −6 to suppress the listing of the arbitrary weight function)
$1/(E\sigma_T)$ weighting where σ_T is obtained from the NPTXS module on logical unit 31

$\geq$ 100, the arbitrary weighting function identified by $|IM|$ will be read from the weighting function library located on logical unit 46. IM < 0 will suppress printing of the function.

Note: When either weighting option 5 or 7 is selected, a constant, σ_0, may be entered in the 13* array, which is added to σ_T. This provides the capability for Bondarenko weighting, i.e.,

$$W(E) = \left(\frac{1}{\sigma_T + \sigma_0}\right)\left(\frac{1}{E}\right) .$$

2$ Array – General Problem Information [10 entries]

All parameters in this array have default values set by the code. For problems that can run with these default values, the 2$ array may be omitted.

1. LCSM – If $|IM| \neq 6$, enter zero

   If $|IM| = 6$, enter the number of interpolation regions used to specify the arbitrary weighting spectrum (default value is 0)

2. MCSM – If $|IM| \neq 6$, enter zero

   If $|IM| = 6$, enter the number of points in the arbitrary weighting spectrum (default value is 0)

3. IZM – = 0, calculate photon-production cross sections (SGRPXs)
   = 1, calculate photon-energy-production cross sections (units will be eV·cross section)

4. MS – thermal capture cross-section representation
   = 0, no effect (i.e., weighting scheme identified by IM is used over the entire neutron energy range)
   = 1, use a Maxwellian weighting on the energy region lower than EUP (see 3* array). The temperature for the Maxwellian spectrum is given in the 3* array (default value is 1)

5. MM – maximum number of reaction types (MT numbers) to be entered in the 14$ array for this case. Default value is 1 to facilitate use of the MT = −1 option (see 14$ array)

6. IWO = 1, photon effective average energy for each gamma group is assumed to be the group midpoint energy (track 1 calculation in ref. 2)
   = 2, yield function is photon energy weighting function (track 2 calculation in ref. 2)
   = 3, photon effective average energy for each gamma group is input in the 9* array (track 1 calculation in ref. 2)
   (default value is 1)

7. I00 = −9, prints SGRPXS matrix for total only (default value is −9)
   0, print yield or SGRPXS matrix for each reaction

8. IAM = 0, no effect (default value is 0)
   = 1, punch the yield or SGRPXS matrix for each reaction

The punched data are in a format for use in the ASCC coupling code.* The punched output will not include the resonance yield data.

9. ICK = 0, no effect (default value is 0)
   = 1, print a detailed output

10. NNBDGP – Not used

End Block B with a T.

C. Thermal information, group structures, and weighting function data. Arrays not applicable to problem should be omitted.

---

*The Sample Coupling Code (ASCC) is documented is Appendix B of ref. 5.

3* Array { Enter only if MS = 1 and default values are unacceptable}

1. TEMP – Mean neutron temperature of Maxwellian distribution (K) (Default value is 293.6)
2. EUP – Upper neutron energy for application of the thermal (n, γ) correction (eV) (Default value is 5 kT = 0.125)
3. VNON – Not used

7* Array (NFG+1 entries)

Neutron energy mesh in decreasing magnitude of energy (eV units). Many "standard" group structures are built into AMPX; when one of these group structures is desired, this array is omitted. (See Sect. 4.MISCELLANEOUS.4.1 for a list of the standard structures.)

8* Array (NGG+1 entries)

Gamma-group energy mesh in decreasing magnitude of energy (eV units). If one of the "standard" gamma-group structures will suffice, this array may be omitted. See Sect. 4.MISCELLANEOUS.4.2 for a list of the standard structures.

9* Array (NGG entries)

Enter only if IWO = 3. Effective average gamma energy $\bar{E}_g$, for each group. (Same for all materials and reaction types. Code checks that $E_g < \bar{E}_g \leq E_{g+1}$.) Energies are in units of eV, high to low.

{11$ and 13* are entered only if |IM| = 6.}

11$ Array (2*LCSM entries)

Interpolation data for arbitrary weighting spectrum (NBT(I), JNT(I), I=1, LCSM).

13* Arbitrary weighting spectrum (per unit energy), (E(I),W(I), I=1,MCSM) low-to-high energy. Units of E(I) are eV.

End Block C with a T.

D. 14$ Array (5+MM entries), Material-Dependent Data

Enter a 14$ array for each material to be processed.

1. Material identification (ENDF MAT number)
2. IQA – Order of P_n (default value is 0)
3. NDFB – Logical unit for the ENDF/B cross-section library (default value is 11)
4. MODE = 1, ENDF/B library in unformatted (binary) mode (default value is 1)
   = 2, ENDF/B library in formatted (BCD) mode
5. MTSL – Number of reaction types to be processed. Default value is 1 to accommodate the normal case where MT = −1. MTSL must be ≤ MM (see 2$ array).

6. MT – Enter the ENDF/B MTs, reaction-type identifiers, to be processed. If the default is not being used, MM (item 5, 2$ array, this section) entries are required. MT = −1 means use all MT numbers for which photon-production data exist. (default value is −1.)
7. NDFTYP = 4, the cross-section library on logical unit NDFB is in ENDF/B-IV format
   = 5, the library is in ENDF/B-V format (default value is 5)

End each Block D with a T.

This concludes the input to LAPHNGAS.

3.LAPHNGAS.2 LAPHNGAS Input/Output Specifications

Input/output devices required for LAPHNGAS are as follows:

Logical No.	Purpose
5	Input
6	Printed output
7	Punched card output
14	Scratch device
15	Scratch device
16	Scratch device
17	Scratch device
18	Scratch device
19	Scratch device
24	AMPX interface
31	Total cross section from the NPTXS module, used only when weighting option 7 is selected
32	Scratch device
33	Scratch device
35	Scratch device
36	Scratch device
46	Weighting function library, used only when selected by input option
NDFB (14$ array)	ENDF cross-section library (default value is 11)

The logical unit numbers for the input, printed output, and punched card output — IS0, ISI, and NPU, respectively — are "set" in LAPHNGAS subroutine LAPHOR. These numbers can be easily redefined for LAPHNGAS by changing the appropriate statements in LAPHOR.

3.LAPHNGAS.3 LAPHNGAS Error Messages

Various error stops are included in LAPHNGAS which cause the module to stop computing and return control to the DRIVER module when an error condition is encountered. The fatal error returns are as follows:

Error No.	Detecting subroutine	Explanation
50	LAPHOR	Input error, see code output for an explanation
100	PROB1	Input error, the neutron fine- and broad-group energy boundaries must be given in order of decreasing magnitude in energy
110	PROB1	Input error, arbitrary weighting function energies must be input in ascending order
133	TERP1	Interpolation code not in range 1–5
134	TERP1	$X \leq 0$ cannot be interpolated by logs
150	MUSH	σ_T not found, check ENDF library file 3, MT = 1
200	INTG	The flag indicating dependence of $Y(X)$ on X is 0, but must be in range 1–5; error is probably a program bug
400	MUSH	Number of points at which σ_T is defined plus number of neutron groups exceeds 5000 plus some additional energy points to ensure at least ten energies within each fine neutron group. Increase dimension of IBIG in PROB1
501	PR15	The neutron energy must not lie outside the range of energies for which the photon yield is tabulated or photon distribution given, check ENDF data
502	PR15	Interpolation table incorrect – probable program bug
504	PR15	File 15 data incompatible with mesh formed by merger of energy points at which σ_T is defined and neutron energy group boundaries. See subroutine PR15, Statement 606, for additional information
506	PR15	Gamma group structure and file 15 data incompatible. Check gamma group structure for input error and then ENDF/B file 15 data files
507	PR15	See error message 506
550	MATT	σ_T not found, check ENDF library file 3, MT = 1
600	TRC2	Error in determining from which level in a cascade a transition occurs. If an MT number for inelastic scattering is input in the 2$ array, the MT numbers for all lower levels must also be included
603	TRC2	Interpolation table incorrect; see code output for additional information
604	TRC2	Subsequent cascades for file 12, LO = 2 data exceeded the core allocation parameter MNC (set in MATT). Increase MNC and resubmit case
610	TRC2	The energy range of the arbitrary weighting function read in may be incomplete. Check the 13* array

620	TRC2	Interpolation table for arbitrary weighting function read in is probably incorrect. Check the 11$ array
630	TRC2	Denominator was $\leq$ zero in weighting calculation. Check group structures and 3* array input
640	TRC2	Interpolation table for σ_T incorrect; check ENDF library MF = 3, MT = 1
701	XSEC	Interpolation table probably in error. See code output for additional information
702	XSEC	Cross sections in file 3 cannot be found corresponding to the MT number written on unit 15 or unit 17. Check ENDF data
710	XSEC	The energy range of the arbitrary weighting function read in may be incomplete. Check the 13* array
720	XSEC	Interpolation table for arbitrary weighting function read in is probably incorrect. Check the 11$ array
730	XSEC	Interpolation table for σ_T may be incorrect. Check ENDF library MF = 3, MT = 1
740	XSEC	Denominator was ≤ 0 in weighting calculation. Check group structures and 3* array input
750	XSEC	Code is attempting to execute an impossible path. Check all input relevant to the weighting options
1001	PHOTON	First card on unit IEN is not head record. Ensure that the proper library was mounted on unit IEN
1002	PHOTON	Files 12 and 13 both missing from ENDF library. LAPHNGAS cannot process this material
1200	CRAVE	Interpolation code not in range 1–5
1210	CRAVE	X1 > X2, attempting to integrate over a range where no data are given – probable program bug
1220	CRAVE	XL > X1, attempting to integrate over a range where no data are given – probable program bug
1230	CRAVE	XU > X2, see error message 1220
1250	CRAVE	XL > XU, expects limits of integration to be in ascending order – probable program bug
1300	INGATE	Lower limit of integral > upper limit of function – probable program bug
1310	INGATE	Upper limit of integral $\leq$ lower limit of function – probable program bug
1320	INGATE	No data available within integration limits – probable program bug
1330	INGATE	Interpolation code not in range 1–5
1400	LEGMOM	LI flag from file 14 data was not 0 or 1
1410	LEGMOM	Could not find file 14 data
1420	LEGMOM	Isotropic calculation requested via input parameter IQA, attempting anisotropic calculation – probable program bug
1440	LEGMOM	Interpolation table incorrect. Check ENDF file 14 data
1450	LEGMOM	LTT flag from file 14 was not 1 or 2

1460	LEGMOM	ILO > NPTS, data not available for processing; see subroutine LEGMOM in the vicinity of statement 755 for details
1510	BRDGP	Broad group numbers not in increasing order
1520	BRDGP	Process ID numbers must be 3, 18, or 102
1530	REDUCE	NBG > NFG, requesting an impossible operation; check input data

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4. R. Q. Wright, N. M. Greene, J. L. Lucius, and C. W. Craven, Jr., *SUPERTOG: A Program to Generate Fine Group Constants and* P_n *Scattering Matrices from ENDF/B*, ORNL-TM-2679, Union Carbide Corp., Nucl. Div., Oak Ridge Natl. Lab., September 1969.
5. W. E. Ford, III, and J. S. Gillen, *The Testing of* ^{238}U *Secondary Gamma-Ray Production Data Sets From the POPOP4 Library*, ORNL-TM-3482, Union Carbide Corp., Nucl. Div., Oak Ridge Natl. Lab., February 1972.

3.LAVA — AMPX MODULE TO MAKE AN AMPX WORKING LIBRARY FROM AN ANISN LIBRARY

LAVA (Let ANISN Visit AMPX) is a module that can convert an ANISN library (neutron, gamma, or coupled neutron-gamma) to an AMPX working library such as is used in XSDRNPM. ANISN cross sections can be input on cards (fixed or free-form FIDO format) or on a binary library.

3.LAVA.1 LAVA Input Data

Block 1.

−1$ Core Allocation [1]

1. NWORD – Number of words to allocate to LAVA (50000)

0$ Logical Definitions [6]

1. N1 – ANISN library (20)
2. N2 – AMPX working library (4)
3. N3 – Scratch (18)
4. N4 – Scratch (19)
5. N5 – Input (5)
6. N6 – Output (6)

1$ ANISN Library Parameter Data [8]

1. NNUC – Number of isotopes to be put on new library
2. IGM – Number of neutron groups
3. IHT – Position of σ_t
4. IHS – Position of $\sigma_{g \to g}$
5. IHM – Table length
6. IFTG – First thermal group
7. IPM – Number of gamma groups
8. IFM – Format of ANISN library
    −1, binary
    0, free-form BCD
    1, formatted BCD
9. IFLAG – Flag that selects the method for calculating scattering cross sections from scattering matrices — 0 or 1 (default = 1)

ANISN matrices are the sum of all the individual scattering matrices (elastic, inelastic, n2n, n3n, etc.) for processes possible for the particular nuclide. LAVA attempts to arbitrarily determine values for an elastic (MT = 2) and an n2n (MT = 16) cross section, recognizing that elastic scattering is generally the most dominant scattering process, and that n2n is the most common scattering process that yields more than a single exit neutron. In order to accomplish this, the absorption cross section in the ANISN data must be the true absorption value (not an energy absorption cross section as in some older gamma-ray sets, or whatever alternative value). When IFLAG = 1, requiring the correct absorption, the elastic value is taken as

$$\sigma^g_{el} = \sigma^g_t - \sigma^g_a ,$$

while the n2n is taken from

$$\sigma^g_{n2n} = \sum_{g'} \sigma_0(g \rightarrow g') - \sigma^g_{el} .$$

When IFLAG = 0, no attempt is made to calculate an n2n value, and the elastic value is simply

$$\sigma^g_{el} = \sum_{g'} \sigma(g \rightarrow g') .$$

T Terminate Block 1.

Block 2.

2$ Identifiers of P_0 Block of Data for the Nuclide on the ANISN Library [NNUC]

3$ Order of Scattering for the Nuclide on the ANISN Library [NNUC]

If an order of scattering for a nuclide is negative, the P_ℓ ($\ell > 0$) matrices for the nuclide will be multiplied by $(2\ell + 1)$ to account for differences in the way different computer programs expect these to be normalized.

4$ AMPX Identifiers for the Nuclides Selected From ANISN Library [NNUC]

5$ Process Identifiers for the Top Positions in the ANISN Cross-Section Tables [IHT]

The order is from position IHT to position 1 (i.e., it is backwards from the way it is in the cross-section tables). Note, MT numbers of frequently used data appearing in the 1-D positions are as follows:

Reaction	MT No.
σ_T	1
$\nu\bar{\sigma}_f$	1452
σ_a	27
$\bar{\nu}$	452
χ	1018
σ_f	18

ANISN always expects σ_T in position IHT, with $\nu\bar{\sigma}_f$ above that, and σ_a above that. The contents of the other positions are arbitrary.

6* Fission Spectrum [IGM]

If a nuclide has a nonzero fission cross section, and either no fission spectrum (MT=1018) is specified in the ANISN library, or the fission spectrum (CHI) flag for that nuclide has been set in the 9$ array, then the fission spectrum specified in the 6* array is used for that nuclide.

7* Neutron Energy Group Boundaries* [IGM+1]

8* Gamma-Ray Energy Group Boundaries* [IPM+1]

9$ Nuclide CHI Flags [NNUC]

0/1 – Use the fission spectrum from the ANISN library/use the fission spectrum from the 6* array.

T Terminate Block 2.

3.LAVA.2 LAVA Input/Output Specifications

The following devices are usually needed in running the LAVA module:

Logical No.	Purpose
N2	AMPX working library written by LAVA (4)
N5	Card input (5)
N6	Standard output (6)
N3	Scratch device (18)
N4	Scratch device (19)
N1	ANISN library (20)
47	Standard AMPX Group Boundary Library

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*Read high to low in energy (eV).

3.MAD — MODULE TO MAKE CHANGES IN THE NUCLIDE DIRECTORY ON A MASTER INTERFACE

MAD (Modify AMPX Directory) is a module to make changes to individual entries in the nuclide directory of an AMPX master cross-section library. In this respect, it offers no new capabilities other than simplification over the capabilities provided in CLAROL.

Recall that the directory of an AMPX master library contains 50 words for each nuclide arranged as shown below:

Words	Contents	Type
1–18	Nuclide description	Text
19	Nuclide identification number	Integer
20	Number of resolved resonance sets	Integer
21	Number of unresolved resonance energy points	Integer
22	Number of temperature-independent 1-D neutron cross sections	Integer
23	Number of 2-D neutron processes	Integer
24	Number of temperature-dependent 1-D neutron cross sections	Integer
25	Number of 1-D gamma cross sections	Integer
26	Number of 2-D gamma processes	Integer
27	Number of gamma production processes	Integer
28	(Maximum order of L) × 32768 + total number of 2-D arrays	Integer
29	Mass number (neutron equivalent)	Floating
30	ZA	Floating
31	Neutron weighting option	Integer
32	Not used	
33	Gamma weighting option	Integer
34	Power per fission (watt-s/fission)	Floating
35	Capture energy release (watt-s/capture)	Floating
36	Maximum length of 2-D record in this set	Integer
37	Number of Bondarenko processes	Integer
38	Number of σ_0's in Bondarenko data	Integer
39	Number of temperatures in Bondarenko data	Integer
40	Maximum number of groups in Bondarenko data	Integer
41	Not used	
42	Not used	
43	Potential scattering cross section	Floating
44	Gamma production weighting option	Integer
45	Source of fast neutron data	Integer
46	Source of thermal neutron data	Integer
47	Source of gamma data	Integer
48	Source of gamma production data	Integer
49	Standard CITATION identifier	Integer
50	Number of records in this set of data	Integer

3.MAD.1 MAD Input Data

Block 1.

0$ Logical Unit Assignments [2]

1. MOLD – Original master library (default = 1)
2. MNEW – New master library (default = 2)

1$ Options [2]

1. IORDER – 0, Input data are blocked by word position in the string of 50 numbers by nuclide; 1, Input data by nuclide
2. NWORD – Number of words of core to allocate to MAD (50000)

T Terminate Block 1.

Block 2.

2$ Input Block Description [2]

1. IIB – 0, Terminate reading input Blocks 2 and 3
   N, Word position this data block applies to if IORDER (1$ array) is input as zero, or nuclide identifier for this block if the nuclide block option (IORDER = 1) is selected.
2. LB – Length of arrays in Block 3

3$ Overrides on First Record on Master Library [10]

1. Enter a new value for the first word in the first record
2. Enter a new value for the second word

.
.
.

10. Enter a new value for the tenth word.

T Terminate Block 2.

Block 3.

4$ Nuclide Identifier or Word Positions Depending on IORDER [LB]

1. (NN(i),i=1,LB)

5$ or 5* or 5U Values to be Replaced in Directory–corresponding in one-to-one ordering to entries in 4$ array [LB]

1. (Value(i), i=1,LB)

T Terminate Block 3.

3.MAD.2 MAD Input/Output Specifications

MAD requires the following I/O assignments:

Logical No.	Purpose
5	Card input
6	Standard output
MOLD(1)	Original master cross-section library
MNEW(2)	New master cross-section library

3.MAD.3 MAD Examples

The input description for MAD is confusing at best. Its structure is designed to cover two cases:

1. the case wherein one wants to modify a single type of variable for many nuclides, and
2. the case wherein one wants to modify many parameters for a nuclide.

An example of the first case might be to input a potential scattering cross section for many nucides. In this case, one would choose IORDER=0 and would set IIB=43 (σ_p position), after which the 4$ array would contain the nuclide identifiers and the 5* array the corresponding cross-section values.

If, on the other hand, one had a series of more random changes to make for several nuclides, IORDER=1 would seem more appropriate, with IIB set to the nuclide identifier, after which the 4$ array would specify the word position to change and the 5$, 5*, or 5U array would be used to specify the changes.

3.MALOCS — MODULE TO COLLAPSE AMPX MASTER CROSS-SECTION LIBRARIES

MALOCS (Miniature AMPX Library Of Cross Sections) is a module to collapse AMPX master cross-section libraries. The module can be used to collapse neutron, gamma-ray, or coupled neutron-gamma master libraries.

3.MALOCS.1 MALOCS Input Data

Block 1.

−1$ Core Allocation [1]

1. NWORD – Number of words of core to allocate to MALOCS (100000)

1$ Case Description [6][*]

1. NNEUT – Number of neutron fine groups
2. IGMF – Number of neutron broad groups
3. NGAMM – Number of gamma-ray fine groups
4. IPMF – Number of gamma-ray broad groups
5. IWN – Neutron weighting option (0)[†]
    - −N1 – Use the 1-D data identified with an MT number of IOPT2 (see 3$ array) from the IOPT1 master data set on logical unit N1 for the neutron weighting spectrum for all neutron data sets being collapsed
    - 0 – Input neutron weighting spectrum in the 5* array
    - 1 – Use MT=1099 1-D neutron data from each fine-group master data set for the neutron weighting spectrum
6. IWG – Gamma-ray weighting spectrum option (0)
    - −N2 – Use the 1-D data identified with an MT number of IOPT6 from the IOPT5 master data set on logical unit N2 for the gamma-ray weighting spectrum for all gamma-ray data sets being collapsed
    - 0 – Input gamma-ray weighting spectrum in the 7* array
    - 1 – Use MT=1099 1-D gamma-ray data from each master data set for the gamma-ray weighting spectrum

2$ Library Logical Unit Numbers [2]

1. NOLD – Logical number of device containing fine-group AMPX master library (1)
2. NNEW – Logical number of device containing broad-group AMPX master library (22)

3$ Option Triggers [10]

1. IOPT1 – Auxiliary neutron weighting spectrum trigger (IWN = −N1) (0)

---

[*] Number of entries in array.

[†] Default value.

0 – No effect
ID – Identification number of master data set from which the neutron weighting spectrum (IOPT2 data) will be obtained

2. IOPT2 – Process identifier (MT number) of neutron weighting spectrum in IOPT1 master data set (used when IWN = −N1) (0)
3. IOPT3 – Trigger to print broad-group 1-D cross section (1)
   - 0 – Print the data
   - 1 – Do not print
4. IOPT4 – Trigger to print broad-group transfer matrices (1)
   - 0 – Print the data
   - 1 – Do not print
5. IOPT5 – Auxiliary gamma-ray weighting spectrum trigger (used when IWG = −N2) (0)
   - 0 – No effect
   - ID – Identification number of master data set from which the gamma-ray weighting spectrum (IOPT6 data) will be obtained
6. IOPT6 – Process identifier (MT number) of gamma-ray weighting spectrum in IOPT5 master data set (IWN = −N2) (0)
7. IOPT7 – Trigger to collapse out upscatter terms if nonzero (0)
8. IOPT8 – Trigger to truncate downscatters to a maximum of IOPT8 terms below the within group if IOPT8 is nonzero (0)
9. IOPT9 – Not used. Enter zero (0)
10. IOPT10 – Not used

T Terminate Block 1.

Block 2.

4$ Neutron broad-group numbers by fine group* [NNEUT]

5* Neutron weighting spectrum [NNEUT] {Enter only if IWN=0}

6$ Gamma-ray broad-group numbers by fine group† [NGAMM]

7* Gamma-ray weighting spectrum [NGAMM] {Enter only if IWG=0}

T Terminate Block 2.

---

*A zero "suppresses" a fine group.

†When collapsing the gamma groups in a coupled master library, the 6$ entries are the actual group numbers and do not need to include the number of neutron groups.

3.MALOCS.2 MALOCS Input/Output Specifications

MALOCS generally requires the following input/output assignments:

Logical No.	Purpose
NOLD(1)	Fine-group AMPX master library
5	Card input
6	Standard output
17	Scratch device
18	Scratch device
19	Scratch device
NNEW(22)	Broad-group AMPX master library produced by MALOCS
N1(0)	Logical number of master library containing data that are to be used as a weighting spectra for neutron cross sections
N2(0)	Logical number of master library containing data that are to be used as weighting spectra for gamma-ray cross sections

3.NITAWL-II — MODULE TO CONVERT MASTER LIBRARIES TO WORKING LIBRARIES AND TO PERFORM RESONANCE SELF-SHIELDING CALCULATIONS

An AMPX master library is not in a form where it can be directly used in most analysis programs. Instead of containing the "summed" transfer matrices, such as one might use in a flux calculation, it carries the matrices for each of the constituent processes. It also carries resonance parameters, which must be used in order to obtain self-shielded cross-section values. It is the role of the NITAWL (Nordheim Integral Treatment And Working Library Production) module to perform these functions. It and the WORKER module provide the capability for converting from AMPX master to working format that many of the other modules use.

The optional resonance self-shielding calculation is for the resolved energy range and employs the Nordheim Integral Treatment.

The Nordheim Integral Treatment is a two-region integral transport theory method, a fuel lump surrounded by a moderator region, in which the moderator region is assumed to have an asymptotic (1/E) flux everywhere and at all energies. Escape probabilities are used to account for coupling between the two regions. NITAWL uses tabulations of exact probabilities for slabs, cylinders, and spheres as developed by Case, de Hoffman, and Placzek, but which are based on assuming the flux in the fuel lump is flat and that the scattering is isotropic. To account for lattice effects, a Dancoff factor can be specified, though it is a single value, which must be used for all energies of all resonances.

Aside from the fact that this treatment considers only one resonance nuclide in its calculation (i.e., the overlap between resonances of different nuclides is not treated), it performs a separate calculation for each resonance, which also assumes the resonances of a nuclide do not overlap.

Certainly, resonance-resonance overlap effects can be important. For nuclides such as ^{233}U and ^{241}Pu, which have several large and important overlapping low-energy resonances, one would not expect the treatment to be very accurate. The same is true for multinuclide systems that contain many overlapping resonances. Examples are

1. systems containing mixed oxides of plutonium and uranium, such as solutions in LMFBRs, and
2. advanced thorium-converter systems.

For LMFBR systems, the effects are not as severe as one might expect for criticality studies, because the most important energy region is high relative to the resolved energy regions for most nuclides.

For systems involving primarily ^{235}U and ^{238}U, such as the light-water reactor, the treatment is quite good, because the resonances of these two nuclides do not overlap that much.

An area in which the treatment is particularly weak is that of calculating small, tightly packed lattices, wherein the flux in the moderator is significantly different from the asymptotic value. This is the case with the analysis of the HTGR fuel pellet, which uses tiny fuel pellets coated with a graphite moderator.

The use of escape probabilities based on flat flux and isotropic scattering assumptions has been shown to lead to errors in some cases. Even fixups involving making transport corrections to the scattering have not proved that satisfactory.

The fact that the treatment only treats free-atom elastic scattering may introduce errors in some cases where inelastic sources may be important or for very low-energy resonances where upscattering effects should be included.

In general, however, the Nordheim treatment does quite well on a variety of criticals and is certainly superior to many treatments based on the narrow resonance approximation, such as the Bondarenko method (see the BONAMI module description).

3.NITAWL-II.1 NITAWL-II Input Data

−1$ Core Assignment [1]

1. NWORD – Number of words to allocate to NITAWL (200000)

0$ Logical Assignments [9]

This array is input only if a user needs to modify default values (shown in parentheses).

1. N1 – Input master cross-section interface (1)
2. N2 – Input working/weighted cross-section interface (2)
3. N3 – Input working/weighted cross-section interface (3)
4. N4 – Working cross-section interface produced by NITAWL (4)
5. N5 – Scratch (18)
6. N6 – Scratch (19)
7. N7 – Random access scratch (9)
8. N8 – Not used
9. N9 – Master sensitivity interface produced by NITAWL (20)

1$ Integer Parameters [12]

1. MSCM – Not used (0)
2. MMT – Number of nuclides to read from the master cross-section library mounted on N1. Resonance calculations can be made with "resonance" nuclides from a master library, but not from a working/weighted library (0)
3. MWT – Number of nuclides to read from the working/weighted library on logical N2 (0)
4. MXT – Number of nuclides to read from the working/weighted library on logical N3 (0)
5. MCR – Sensitivity output trigger (0)
   = 0, do not produce master sensitivity library
   >0, produce master sensitivity library

   Note – Master sensitivity library will contain only nuclides selected from the master cross-section library on logical N1.
6. MXX – Not used (0)
7. MS – Not used (0)

8. IRES – Number of resonance calculations to be performed (0)
   Resonance is required in the 3* array discussed below.
9. IQM – Not used (0)
10. IPM – Not used (0)
11. IPP – Output option trigger (0)
    0 – no cross-section edits
    1 – edit reaction cross sections
    >1 – edit reaction cross sections and transfer arrays through expansion order IPP-2 (e.g., five edits through P_3 cross sections)
12. IFG – Print for resonance mesh generation (0)

    If IFG is 10, then debug messages from resonance mesh generator will be printed.

6$$ Direct-Access Device Space [6]

1. NBLK8 – Number of direct-access blocks on logical 8 (not used in NITAWL)
2. LBLK8 – Length of direct-access blocks in words on logical 8 (not used in NITAWL)
3. NBLK9 – Number of direct-access blocks on logical 9 (NITAWL typically determines this parameter from the cross-section library directory, but uses this value, if input)
4. LBLK9 – Length of direct-access blocks in words on logical 9 (as above, NITAWL calculates a value for this parameter, but will use this value, if input)
5. NBLK10 – Number of direct-access blocks on logical 10 (not used in NITAWL)
6. NBLK10 – Length of direct-access blocks in words on logical 10 (not used in NITAWL)

T Terminate Block 1.

Block 2.

2$ Identification Numbers of Nuclides to be Placed on the Working Library [MMT+MWT+MXT]

NITAWL can combine data from three sources to make a working library on logical unit N4. This working library contains only those nuclides selected and is intended for use by another module, such as XSDRNPM/S or KENO V.a. The nuclide identifications are input in this order:

1. MMT identifications for nuclides from the master library on N1,
2. MWT identifications for nuclides from the working/weighted library on N2, and
3. MXT identifications for nuclides from the working/weighted library on N3.

Within each group, the identifications can be in any order.

A facility is provided for creating duplicate sets for a particular nuclide. For example, a resonance nuclide might occur in different compositions, thereby requiring different resonance calculations. To create a new set, place a unique negative number in the identification string after the nuclide's identification that is to be duplicated. The new set will use this as its identifier. As many sets as needed can be had, merely by stringing out negative numbers. All subsequent references to the new sets of data should use a positive identification. The values MMT, MWT, and MXT must be increased to reflect the inclusion of these sets.

3* Resonance Data [IRES*15] (IRES>0)

For each resonance calculation, 15 items are required. These blocks of data are placed, one set after the other, in any order in the 3* array. Note that only one 3* array is input. Resonance calculations can only be performed on resonance nuclides from a master library. The 15 items are

1. Nuclide's identification number.
2. Temperature (K).
3. Geometry for Nordheim treatment:
   0 – homogeneous,
   1 – slab,
   2 – cylindrical, and
   3 – spherical.
4. Absorber lump dimension in centimeters (i.e., the thickness of the slab or radius of a sphere or cylinder). A zero is used for the homogeneous case.
5. Dancoff correction factor. This factor corrects for shadowing effects caused by the presence of other absorber lumps (e.g., fuel elements) in the neighborhood of the lump being calculated. It is zero for the homogeneous and the single lump case.
6. a_i, the inner radius of the spherical or cylindrical shell, if a "shell" geometry is required. (Note that a value of zero specifies a solid sphere or cylinder. If the inner region does not contain a light-mass moderating material, the absorber should be treated as a solid.) (0.0)
7. N_a, absorber number density in the lump.
8. Treatment of absorber's contribution to the collision density:
   1 – Nordheim integral method,
   2 – narrow resonance approximation, and
   3 – infinite mass approximation.
9. Atomic mass of the first moderator in the lump. (The resonance routines have provisions for treating two moderators. Note that these absorbers are in the lump mixture and are not the external moderator.)
10. σ_{s1}, first moderator scattering cross section per absorber atom,

$$\sigma_{s1} = N_1 \ \sigma_s \text{ (moderator 1)}/N_a \ ,$$

    where N_1 is the number density of the first moderator.
11. Treatment of the first moderator's contribution to the collision density:
    0 – no first moderator,
    1 – Nordheim's integral method, and
    2 – asymptotic approximation.
12. Atomic mass of the second moderator in the lump.
13. σ_{s2}, the second moderator scattering cross section per absorber atom.

14. Treatment of the second moderator's contribution to the collision density:
    0 – no second moderator,
    1 – Nordheim's integral method, and
    2 – asymptotic approximation.
15. Volume fraction of the absorber lump in the cell. This parameter is used for "cell-averaging" the resonance cross sections. If a value other than 1.0 is input, the output cross sections are appropriate for use in a smeared cell calculation. If your cross sections are meant for use in an explicit mock-up of the cell (e.g., in XSDRNPM), input 1.0.

4* Thermal-Scattering Kernel Temperatures for Nuclides Selected (K) [MMT]

Scattering kernels are sometimes provided at several temperatures for a nuclide. NITAWL will pick the one closest to the temperature input in this array. This array has no effect for sets of data with zero or one thermal kernel.

6$ MT Number of the Incoherent Thermal-Scattering Kernel [MMT]

These allow selecting thermal-scattering kernels with MT (identifying) numbers other than the default (1007).

T Terminate Block 2.

3.NITAWL-II.2 NITAWL-II Input/Output Specifications

NITAWL typically requires the following input/output devices during an execution:

Logical No.	Purpose
NT1 (1)	Master cross-section library
NT2 (2)	Previously prepared working/weighted library
NT3 (3)	Previously prepared working/weighted library
NT4 (4)	New working library
NT5 (18)	Scratch unit
NT6 (19)	Scratch unit
NT7 (9)	Random access scratch unit
NT9 (20)	Sensitivity-produced master library
5	Card input
6	Printed output

3.NPTXS — MODULE TO PRODUCE POINT DATA FOR RESONANCE NUCLIDES

NPTXS (Neutron PoinT X-Section) is provided to "preprocess" resonance or nonresonance ENDF nuclides and make point files containing the total, fission, elastic scattering, and (n, γ) cross sections. It is a predecessor of the POLIDENT module, which also performs this function.

The point cross-section library written by NPTXS on logical unit 31 looks very much like file 3 of an ENDF library. (See Sect. 3.NPTXS.3 for the format of the pointwise file.) One of the important uses of the library is to provide σ_T data for the 1/E σ_T weighting of a resonance nuclide. This information can be input to JERGENS for appropriate processing into the inverse form.

Other features of NPTXS are as follows:

1. The module can process single-level Breit-Wigner (SLBW) and multilevel Breit-Wigner (MLBW) resolved resonance data. The resonance data can be Doppler-broadened using the numerical integration techniques developed by Cullen (subroutine BROADN) or the PSI-CHI method (subroutine VOGAM). Note that the background ENDF file 3 data will be Doppler-broadened if subroutine BROADN is used, but will not be Doppler-broadened if the PSI-CHI method is used.
2. Unresolved processing uses the same techniques employed in XLACS. These techniques were originally developed for the MC-2 code.
3. ENDF MAT numbers are used as identifiers for data sets on the point cross-section library. When NSIGP > 1, the first σ_0 in the 4* array is used to calculate the unresolved component of the point data set placed in the point cross-section library. Unresolved cross-section data for the second through NSIGP σ_0's are punched on cards.

The resolved resonance treatment used in NPTXS is described in refs. 1 and 2; the unresolved resonance treatment, in refs. 3 and 4; and the Doppler-broadening, in refs. 5–10.

3.NPTXS.1 NPTXS Input Data

Block 1.

0$ Doppler-Broadening Option [1]

1. IDPL - 0/1 use BROADN/VOGAM method (0)

1$ Case Description [1]

1. NNUC - Number of ENDF nuclides to be processed
2. NVER - 4/5 version of ENDF being processed (4)

T Terminate Block 1.

Repeat blocks 2 and 3 for NNUC nuclides.

Block 2.

2$ Nuclide Selection Array [5]

1. MATNO – ENDF MAT number for nuclide
2. NDFB – Logical unit containing the ENDF data (11)
3. IDTAP – Check the library label (0/1: no/yes) (1)
4. MODE – ENDF library mode (0/2: binary/BCD) (0)
5. NSIGP – Number of σ_0 values [*] (1)

3* Nuclide Options [4]

1. RFACT[†] – The resolved resonance region energy mesh is based directly on this parameter. Points are chosen such that the ratio of total cross section from point to point is roughly RFACT (0.9)
2. SFACT – Number of practical widths over which the RFACT scheme is used for a particular resonance (10)
3. SIGP – σ_0 for the unresolved calculation (10^8)
4. TDEGIC – Temperature in Kelvin for Doppler-broadening in the resolved and unresolved resonance regions (0)

T Terminate Block 2.

Block 3. {NSIGP > 1}

4* σ_0 array for the unresolved calculation. [NSIGP[**]] {NSIGP > 1 }
(SIGNL(N),N=1,NSIGP)

The σ_0 values should be input high to low and NSIGP must not exceed 7.

T Terminate Block 3.

---

[*] The NPTXS σ_0 and the XLACS potential scattering cross section, σ_p, are identical.

[†] A reasonable range for RFACT is $0.70 \leq$ RFACT ≤ 1.0. If the input RFACT is not within the reasonable range, NPTXS resets the parameter to the default value.

[**] If NSIGP = 1, the desired σ_0 should be input in the 3* array, and the 4* array is not required.

3.NPTXS.2 NPTXS Input/Output Specifications

The following input/output assignments are required by NPTXS:

Logical No.	Purpose
5	Card input
6	Standard output
7	Standard punch (required if NSIGP > 1)
14	Scratch device
15	Scratch device
16	Scratch device
17	Scratch device
18	Scratch device
19	Scratch device
31	Point files produced by NPTXS
NDFB(11)	ENDF library

3.NPTXS.3 NPTXS Output Format

The NPTXS point cross-section library, written on logical unit 31, is in essentially the same format as file 3 (MF = 3) of an ENDF library. The only difference is that the NPTXS output files are not restricted to a maximum of 5000 points as required for ENDF file 3. The NPTXS output files are unformatted. For a given material, MAT, and a given reaction type, MT, the structure of a section is

(MAT, 3, MT/ZA, AWR, LIS, LFS, 0, 0)HEAD

(MAT, 3, MT/S , Q , LT, LR , NR, NP/$E_{\text{int}}/\sigma(E)$)TAB1

(MAT, 3, 0 /0.0, 0.0, 0, 0, 0, 0)SEND

See ref. 1 for definitions of the variables used and for additional details concerning the format.

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3.PAL — MODULE TO PUNCH 1-D CROSS SECTIONS FROM AMPX LIBRARIES

PAL (Punch AMPX Libraries) is provided to allow punching the 1-D cross-section arrays on either an AMPX master or an AMPX working library. Data can be punched in a fixed-form (1P,6E12.5) or the free-form FIDO format.

3.PAL.1 PAL Input Data

Block 1.

0$ Logical Unit Assignments [1]

1. MMT - Master working library logical unit (0)
2. MWT - Working library logical unit (0)
3. N7 - Punch device (7)

1$ Options [3]

1. NPUNCH - Number of nuclides for which data are to be punched. A zero causes data for all nuclides on the library to be punched. (0)
2. IFORM - 0, Fixed format (i.e., 1P,6E12.5 format)
   1, Free-form FIDO format (1)
3. ICORE - Number of words to allocate to PAL (50000)

2$ MT Numbers to be Punched [100]

Stack up to 100 MT numbers for the processes to be punched in this array [e.g., to punch the (n,γ) data]. 2$$ 102 F0. (Note that MT = 999 can be used to punch the energy group boundaries from the library.)

T Terminate Block 1.

Block 2. {Input if NPUNCH > 0}

3$ Identifiers for Nuclides Whose Cross Sections are to be Punched {NPUNCH}

T Terminate Block 2.

A card is punched between each set of cross sections which identifies the data set and process.

3.PAL.2 PAL Input/Output Specifications

PAL requires the following input/output devices:

Logical No.	Purpose
5	Standard input
6	Printed output
7	Punched output
MMT	Master library
MWT	Working library

3.PERFUME — MODULE TO CORRECT LEGENDRE POLYNOMIAL FITS TO SCATTERING MATRICES

PERFUME (PERmute FaUlty Moment Expansions) is a module that examines scattering matrices to locate those that yield nonphysical fits and adjusts them to produce acceptable distributions. The procedure involves an examination of the moments of the cross section, as described in Appendix F9.D.2 of the SCALE documentation. With these prescriptions, a range of possible coefficients is determined, after which PERFUME arbitrarily picks a value in the range.

3.PERFUME.1 PERFUME Input Data

−1$ Core Assignment [1]

1. NWORD - Number of words to allocate to PERFUME (100000)

0$ Logical Assignments [3]

1. NTP - Input master library (23)
2. NOT - Output master library (1)
3. NER - Error message output file (6)
   Assign this to a unit other than 6 to suppress the voluminous error message listing that may be produced by some libraries, if you do not wish to view this information.

1$ Output Suppression Factor [1]

1. EPS - Information concerning bad moments is edited when the zeroeth moment of the transfer term (i.e., σ_0) satisfies the following expression (default = 0.0001):

$$\sigma_0 > \epsilon * N^3,$$

where N is the order of Legendre fit to the cross section. [Warning: For a library with a large number of energy groups and nuclides, the amount of output can be substantial.]

T Terminate Block 1.

3.PERFUME.2 PERFUME Input/Output Specification

PERFUME uses the following input/output assignments:

Logical No.	Purpose
5	Card input
6	Printed output
NTP(23)	Input master library
NOT(1)	Output master library

3.POLIDENT — MODULE TO PRODUCE POINT DATA FROM RESONANCE DATA

POLIDENT (<u>PO</u>int <u>LI</u>braries of <u>D</u>ata from <u>EN</u>DF/B <u>T</u>apes) is a module that accesses the resonance parameters in File 2 of an ENDF/B library, generates point cross sections from them, and combines these with the point data in File 3. As such, it is intended to replace NPTXS.

POLIDENT has several characteristics that distinguish it from the earlier NPTXS module:

- It outputs essentially all point data on File 3 of the ENDF/B library, not just the total, elastic, fission, and neutron-gamma values, as does NPTXS.
- It processes Adler-Adler parameters.
- It can process multi-isotope nuclides that have different resonance ranges.
- It will produce more accurate representations of cross sections in the resolved region than NPTXS because of a restructuring of the way it combines strings of cross sections.

<u>3.POLIDENT.1 POLIDENT Input Data</u>

Block 1.

−1$ Core Allocation [1]

1. NWORD – Number of words to allocate to POLIDENT (100000)

0$ Output Library [1]

1. LOGP – Output from POLIDENT written here (31)

1$ Number of Cases [1]

1. NNUC – Number of nuclides to process

T Terminate Block 1.

Repeat Block 2 NNUC times.

Block 2.

2$ ENDF/B Data Source [3]

1. MATNO – Material identifier for the nuclide on the ENDF/B library
2. NDFB – Logical unit on which the ENDF/B library is mounted (11)
3. MODE – Format of the ENDF/B library (1-binary/2-BCD) (default = 1)

3* Parameters for Resonance Processing [2]

1. SIG0 – Background cross section, σ_0, value to use in processing unresolved resonance data, if appropriate
2. T – Temperature in Kelvin at which resonances are to be Doppler-broadened

4* Floating-Point Parameters [14]

1. EPS – To construct a final function, POLIDENT must combine strings of point data from File 3 with resolved and unresolved data arrays. The final function contains enough points such that any intermediate value is accurate to EPS (0.001 or 0.1%).
2. R – The ratio factor used in a cross-section energy mesh.
3. XNP – The number of points taken equally spaced in lethargy in between "resonance bodies" (50.0).
4. XGT – The multiplier on the total width above and below a resonance over which the ratio mesh scheme is used (50.0).
5. OPT(1) – Not used.

.

.

.

14. OPT(10) – Not used.

5$ Options [8]

1. IOPT1 2. IOPT2	These are used in conjunction with IOPT4 through IOPT8 to select the ENDF/B interpolation options to be tried. These are both set to 1 by default.
3. IOPT3 –	Maximum number of interpolation regions allowed in the output ENDF/B function.
4. IOPT4 5. IOPT5 6. IOPT6 7. IOPT7 8. IOPT8	Interpolation types to be tried. IOPT4 is a 2 by default, while the others are zero.

IOPT4 through IOPT8 are used to specify the interpolation types and their order which will be tried in combining two or more ENDF/B functions. The types are as follows:

Value	Type of interpolation
1	Histogram
2	Linear x, linear y
3	Linear x, log y
4	Log x, linear y
5	Log x, log y

IOPT1 and IOPT2 specify which entries in the five-position table are to be used (e.g., the default values of 1 say to use only the first entry in the table, or linear-linear interpolation by default).

6$ Input Function Limits [1]

1. N1MAX – Maximum number of interpolation regions in any "input" ENDF/B function (20)
2. N2MAX – Maximum number of points in any input ENDF/B TAB1 array (5000)

T Terminate Block 2.

3.POLIDENT.2 POLIDENT Input/Output Specifications

POLIDENT requires the following input/output units:

Logical No.	Purpose
5	Card input
6	Printed output
LOGP(31)	Functions produced by POLIDENT are written here
14	Scratch device
15	Scratch device
16	Scratch device
17	Scratch device
18	Scratch device

3.PRELL—MODULE TO PRODUCE AND MANIPULATE AN ENERGY LIMITS LIBRARY

PRELL (Produce Reordered Energy Limits Library) is an AMPX module to create, copy, modify, punch, or list an AMPX energy-group-limits library. The new library will be reordered in increasing number of groups for neutron structures, then in order of increasing groups for gamma structures. The new library may be printed. Modification features include adding new structures to an existing library and changing boundaries in an existing structure.

3.PRELL.1 PRELL Input Data

Block 1.

0$ Logical Unit Assignments [3]

1. NO – Logical unit number of the old library (47)
2. NW – Logical unit number of the new library (18)
3. NS – Logical unit number of a random-access scratch unit (8)

1$ Options [2]

1. NOPT – Option flag NOPT < 0 – punch new library (0)
   Option flag $|\text{NOPT}| < 1$ – print new library (0)
2. NSETS – Number of sets to be added and modified (0)

T Terminate Block 1.

If NSETS = 0, no more data are input.

Block 2.

3$ Flags [3*NSETS]

1. IG – Number of groups in set
2. ITYPE – A flag

   ITYPE = ITP + 10*NUP
   where,
   ITP = 0 for a neutron-group-structure library
   = 1 for a gamma-group-structure library
   NUP = 0 if the NSETSth entry is new group structure
   > 0 if the NSETSth entry is an existing structure where NUP modifications will be made to the structure
3. IVER – Version number (only 0 can be used at present)

Repeat above three entries NSETS times.

T Terminate Block 2.

Block 3. **{Repeat NSETS times}**

7* [IG+1] if NUP=0

E – Group boundaries (in decreasing order) of a new group structure to be added to the library. Boundaries should be in eVs.

8* [NUP]

IBND – Indices of boundaries to be changed

9* [NUP]

ENEW – New values of boundaries to be changed

T Terminate Block 3.

End of Block 3.

3.PRELL.2 PRELL Logical Assignments

PRELL requires the following input/output assignments:

Logical No.	Purpose
5	Card input
6	Standard output
NO(47)	Old AMPX energy-group-limits library
NW(18)	New AMPX energy-group-limits library
NS(8)	Random access scratch unit

3.PRUDE — AMPX MODULE TO CREATE CROSS SECTIONS FOR THE UNRESOLVED RESONANCE ENERGY REGION

PRUDE (PRocess Unresolved Data on ENDF/B) is a module that accesses the unresolved resonance data in file 2 of an ENDF/B library and writes out a file which gives the energy variation of "average" cross sections for several important processes as a function of temperature and the weighting parameters, σ_0. Its primary use is to pass these data to the TABU module, which creates Bondarenko factors that ultimately become part of an AMPX master interface. The Bondarenko factors are used by the BONAMI module for performing self-shielding in the unresolved region.

Recall that in the development of the Bondarenko treatment, a narrow-resonance weighting of the form

$$\bar{\sigma}(\sigma_0, T) = \frac{\int_g \frac{\sigma(E,T)\phi(E)dE}{\sigma_T(E)+\sigma_0}}{\int_g \frac{\phi(E)dE}{\sigma_T(E)+\sigma_0}}$$

is used, where $\phi(E)$ is a smooth weighting function (generally 1/E in the unresolved region), T is the temperature at which the cross sections were Doppler-broadened, and σ_0 is the cross section that accounts for the cross sections of other nuclides in the mix with the resonance nuclide.

PRUDE accepts an arbitrary number of temperatures and σ_0 values as input. At each pair of values, T and σ_0, it makes a calculation to determine "shielded" cross sections. The energy mesh is picked to be either the energy mesh at which the unresolved parameters are specified in the ENDF/B library or at 100 points equally spaced in lethargy over the unresolved region, when the parameters are constant.

The output from PRUDE is a file of records written in the ENDF/B "TAB1" format, as follows:

Record 1: MAT, MF, MT, 0, 0, 0, 0, 0, 0

Record 2: MAT, MF, MT, T, σ_0, 0, 0, NR, NP,
(NBT$_i$, JNT$_i$, i=1, NR),
(E_i, σ_i (T, σ_0), i=1, NP)

Record 3: MAT, MF, 0, 0, 0, 0, 0, 0, 0

.
.
.
.
.

where MAT is the material identifier,
MF is the "file" number,
MT is the process identifier,
T is the temperature in Kelvin,
σ_0 is the background cross section,
NR is the number of interpolation regions,
NBT$_i$, JNT$_i$ comprise the interpolation table,

E, σ are the energy cross-section values.

Each T, σ_0 pair will generate the triplet of records shown above for each of six processes:

MT = 1, total cross section
MT = 2, elastic scattering
MT = 102, (n,γ)
MT = 18, fission
MT = 1000, transport cross section
MT = 4, inelastic scattering

3.PRUDE.1 PRUDE Input Data

Block 1.

−1$ Core Allocation [1]

1. NWORD – Number of words to allocate to PRUDE (50000)

0$ Point File Assignment [1]

1. LOGP – Logical unit where point data are to be written (31)

1$ Processing Option [1]

1. NNUC – Number of materials to process

T Terminate Block 1.

Repeat blocks 2 and 3 NNUC times.

Block 2.

2$ Data Source and Problem Options [5]

1. MATNO – Material number for the ENDF/B data
2. NSIGO – Number of σ_0 values
3. NTEMP – Number of temperatures
4. NDFB – Logical unit containing the ENDF/B data (11)
5. MODE – Format of ENDF/B data (1-binary, 2-BCD) (default = 1)

T Terminate Block 2.

Block 3.

3* Background Cross Sections [NSIGO]

(σ_0, i = 1, NSIGO) Specify these values in descending order.

4* Temperatures [NTEMP]

(T_i, i = 1, NTEMP) Specify these in ascending order in Kelvin.

T Terminate Block 3.

3.PRUDE.2 PRUDE Input/Output Specifications

PRUDE requires the following input/output assignments:

Logical No.	Purpose
5	Card input
6	Printed output
LOGP(31)	Point data file is written here
NDFB(11)	ENDF/B library
14	Scratch device
15	Scratch device
16	Scratch device
17	Scratch device
18	Scratch device

3.RADE — MODULE TO CHECK AMPX MASTER CROSS-SECTION LIBRARIES

RADE (Rancid AMPX Data Exposer) is provided to check AMPX- and ANISN-formatted multigroup libraries. It will check neutron, gamma, or coupled neutron-gamma libraries.

Some of the more important checks are made to ensure that:

1. $\sigma_t = \sigma_a + \sigma_s$
2. $\sigma_{in} = \Sigma\, \sigma_{in}^{\text{partial}}$
3. $\sigma_a = \sigma_c + \sigma_f$
4. $\sigma_c = \sigma_{n\gamma} + \sigma_{n\alpha} + \sigma_{np} + \sigma_{nd} + \ldots$
5. $\sigma_{el}^{g} = \sum_{g'} \sigma_{el,0}(g \rightarrow g')$ (also made on any process with a scattering matrix)
6. $\sigma_{0(g \rightarrow g')} > 0$
7. $\sigma_T,\ \sigma_a, \sigma_f, \sigma_{n\gamma}, \sigma_{np}, \ldots > 0$
8. $f_\ell^{\text{min}} \leq f_\ell(g \rightarrow g') \leq 1.0$,

   where $f_\ell(g \rightarrow g') = \dfrac{\sigma_\ell(g \rightarrow g')}{(2\ell + 1)\sigma_0(g \rightarrow g')}$

   and $f_\ell^{\text{min}} = -1.0$ for all odd ℓ, and is given in the following table for even ℓ

ℓ	f_ℓ^{min}
2	−0.5
4	−0.433
6	−0.419
8	−0.414

In addition to these checks, the code will compute an estimate of the capture-binding energy for each neutron group in a coupled neutron-gamma set. On option, one can request a display of differential cross sections.

3.RADE.1 RADE Input Data

Block 1.

−1$ Core Assignment [1]

1. NWORD - Number of words to allocate to RADE (100000)

1$ Checking Commands [4]*

1. MMT - Check the AMPX master interface on logical MMT. This can be a neutron, gamma, or a coupled neutron-gamma library
2. MWT - Check the AMPX working/weighted interface on logical MWT
3. MAN - Check the ANISN binary-formatted library on logical MAN
4. IFM - −1, ANISN library is binary formatted
   0, ANISN library is BCD free form
   1, ANISN library is BCD fixed form

---

*Number of entries in the array.

2$ Options [20]

1. IOPT1 – Number of angles at which a display of differential cross sections is desired. These angles will be equally spaced in the cosine range, −1 to +1. These edits are for the group-integrated cross sections and not for each group-to-group transfer.
2. IOPT2 – The ϵ, in 1/1000's of a percent, to which checks are made (e.g., IOPT2 = 1) is equivalent to 0.001% checking. This is the default value when IOPT2 is not input or when a zero value is input.
3. IOPT3 –Enter a 1 to suppress printing the estimated binding energy tables for processes with gamma production data.

.

. Future checking options; skip or input zeroes

.

20. IOPT20

3$ ANISN Options [7] {MAN $\neq$ 0}

1. NSET – Number of ANISN sets to check
2. IHT – Position of σ_T
3. IHS – Position of σ_{gg}
4. ITL – Table length
5. NL – Maximum order of scattering
6. IGM – Number of neutron groups
7. IPM – Number of photon groups

T Terminate Block 1.

Block 2. {Input only when MAN > 0 }

4$ Identification Numbers of P_0 Sets on ANISN Binary Library on Logical MAN [NSET]

5$ Order of Scattering for Sets of ANISN Data on Logical MAN [NSET]

7* Neutron Group Structure, high to low in eV [IGM+1]

8* Gamma Group Structure, high to low in eV [IPM+1]

T Terminate Block 2.

3.RADE.2 RADE Input/Output Specifications

RADE requires the following input/output assignments:

Logical No.	Purpose
5	Card input
6	Printed output
18	Scratch device
19	Scratch device
MMT	Master library
MWT	Working library
MAN	ANISN library

3.ROLAIDS — MODULE FOR TREATING RESONANCE SHIELDING IN MULTIREGION GEOMETRIES

The ROLAIDS (Resonance OverLap Analysis In Discretely Represented Systems) module is provided in AMPX for treating problems in which either resonance overlap causes mutual shielding or severe spatial attenuation of the neutron flux indicates the need for spatially dependent resonance cross sections. Given a point cross-section library and an AMPX master cross-section library, ROLAIDS performs an integral transport calculation for the energy-pointwise, slowing-down flux distribution in each zone of a 1-D multiregion geometry. (The ROLAIDS geometry and boundary condition specifications are fully compatible with those of XSDRNPM.[1,2]) ROLAIDS provides resonance-shielded fine-group constants (on logical unit N10) to be folded into the existing AMPX master data sets. The folding is subsequently done with the CLAROL module. The modified AMPX master library can be used in NITAWL to generate a working library for use in XSDRNPM discrete-ordinates analyses (which yield the higher order transport effects over the entire energy range) or to generate other multigroup libraries for use with other transport codes. Detailed documentation of the neutronics theory and numerical methods applied in ROLAIDS is given in ref. 3. Included here is a brief description of the operations performed by ROLAIDS.

The first operation that ROLAIDS performs in executing a problem is to calculate and store the first-flight escape and transmission probabilities needed for the transport analysis. For spherical and cylindrical geometries, these parameters are functions of both curvature and optical thickness. Therefore, the user should be cognizant of the extra container ("D") array storage (~80 K bytes) required by these geometries relative to the storage required for the homogeneous and slab geometries. Also, evaluation of the probabilities for cylindrical geometry requires about 2 additional minutes of CPU91 time (compared with the execution time for other geometries) due to the large number of numerical integrations performed. (CPU time is central processing unit time on the ORNL IBM 360/91 computing system.)

Pointwise energy files and corresponding unshielded cross sections prepared by the NPTXS module (N1 and N2) and the energy boundaries in the existing AMPX master library (MASTU) are input to ROLAIDS. An energy array is formed for the ROLAIDS transport calculation from all of the NPTXS pointwise files, the multigroup energy structure in the AMPX master library, and 99-point equal-lethargy-based structure inserted for optional fine-group boundaries. Also inserted is an energy grid determined by successive neutron downscatterings, with the heaviest nuclide to be placed on the data file. This set of minimum slowing-down intervals ensures an adequate coverage of all energy ranges. Then follows a determination of slowing-down parameters for each nuclide at each energy point. ("Slowing-down parameters" are described in ref. 3.) This determination provides the array sizes used to flexibly dimension the slowing-down sequence. A ROLAIDS data file containing the pointwise cross sections and slowing-down parameters for all nuclides is then created (N7).

A ROLAIDS data file is created for a class of problems (e.g., light-water-reactor analysis) by combining NPTXS data for all the pertinent nuclides. *Once created, a ROLAIDS data file cannot be altered.* Therefore, it is advisable to include any nuclides that might eventually be required for analyzing similar systems. The ROLAIDS data file is geometry independent and can be used for any problem for which the fine-group boundaries and nuclide information have been included. Creation of the file requires approximately CPU91 (min) = (the total number of NPTXS energy points) × 10^{-4}.

The slowing-down calculation performed by ROLAIDS is based on isotropic elastic-scattering theory with an assumed linear variation of the scattering density between energy points. All downscattered source terms are explicitly calculated and stored. Since ROLAIDS does not treat inelastic scattering, the maximum problem energy, EHI, should be set below any significant inelastic thresholds (~20 keV), and the minimum energy, ELO, should be above the range of upscattered sources (~2 eV). Neutron fluxes in the source range above EHI are assumed to vary asymptotically as (energy)·exp(−EZP), EZP being an input parameter with a default value of 1. Execution of a ROLAIDS slowing-down calculation requires approximately CPU91 (min) = T_0 + No. energies × No. zones × No. densities × 4.2 × 10^{-7}, where $T_0 = 3$ for cylindrical geometry and $T_0 = 1$ for slab, spherical, and homogeneous geometries. In this expression, the number of densities is the total number of densities in the total number of nonzero atom densities for all materials in all zones. The expression does not hold for cases with periodic boundaries that require a full matrix solution for the interface currents and, therefore, run much longer.

Where applicable, an effort was made to maintain commonality between ROLAIDS and XSDRNPM problem descriptions. Thus the input parameters IGE, IZM, IM, IBL, IBR, MXX, and MS have identical functions in the two modules. However, for many applications, the integral transport solution applied in ROLAIDS does not require as fine a spatial mesh as the finite-difference calculation performed by XSDRNPM. When a ROLAIDS-CLAROL-...-XSDRNPM sequence is being executed, the user may set the number of mesh intervals ROLAIDS and XSDRNPM to be equal [i.e., IM(ROLAIDS) = IM(XSDRNPM)] and input the XSDRNPM radii (IM + 1). Then, the number of zones, IZM, can be specified in the range IM ≤ IZM (ROLAIDS) ≥ IZM (XSDRNPM). The ROLAIDS output of fine-group cross sections is averaged over contiguous ROLAIDS zones of the same material specification ("superzones"). For most problems, these ROLAIDS superzones will correspond to the XSDRNPM zones.

The ROLAIDS superzone-weighted cross sections are written on logical unit N10, a CLAROL data file. These cross sections include scattering terms expanded to Legendre order specified by ISCT (3$ array). The identification numbers from the NPTXS data sets are used by ROLAIDS as identifiers for the data sets on the CLAROL data file. CLAROL should be executed to update the AMPX master library (MASTU) with the ROLAIDS-produced library (N10). As noted above, an AMPX working library is produced by using NITAWL to process the CLAROL-updated AMPX master library. Master data sets that have been processed with ROLAIDS-CLAROL will not contain resonance parameters. (This fact must be considered when determining the value of IRES for the NITAWL 1$ array.)

Printed output options in ROLAIDS include fine-group cross sections averaged according to standard cell, zone, and region definitions and according to the superzone specification discussed above. For comparison purposes, the 1/E weighted fine-group cross sections and infinitely dilute and effective resonance integrals (by zone) for the entire problem energy range are also printed. The user has the option of selectively suppressing printed output.

An option is provided (ICOM = 6) to save the energy-pointwise flux distributions in lieu of producing a CLAROL data file on N10. In this instance, ROLAIDS joins a fission spectrum and a thermal Maxwellian to the appropriate ends of the flux distributions as follows:

Energy range	Spectrum
20 MeV to EHI	$\chi(E)$, with a spectrum temperature of 1.29 MeV, at 100 energies
EHI to ELO	ROLAIDS energies and fluxes
ELO to 1.0×10^5 eV	Maxwellian, with a spectrum temperature of TK (input), at 100 energies

No AMPX module uses the energy-pointwise flux distributions *per se* when saved on N10. However, the data have been used to prepare point-to-fine-group weighting spectra for use with XLACS-2 and LAPHNGAS calculations. Format of the data is as follows:

Record	Variable
1	1. IZM – number of zones 2. NB – number of energies
2, NB + 1	1. E – energy (eV) 2. PHI(IZM) – fluxes, zone 1 through IZM (neutrons/cm^2·s·eV)

Provision has been made to generate a problem restart file on an output device for problems that run longer than an input time estimate (TE). When CPU time used equals TE, ROLAIDS "dumps" pertinent data onto N10. To continue the calculation, the ROLAIDS data files N7 and N10 from the first case are remounted, a value of −2 is entered for IPRB, and the ROLAIDS case is resubmitted to continue. To use the restart feature, the ROLAIDS calculation must have passed the point where the phrase "DATA TAPE COMPLETE" is written on the case printout. Execution time required to prepare the ROLAIDS data file is not included in the time-check algorithm. Therefore, the user should have his job request time exceed his restart time estimate by at least the estimated time required to create a ROLAIDS data file (see above).

3.ROLAIDS.1 ROLAIDS Input Data

Block 1.

−1$ Core Assignment [1]

1. NWORD – Number of words to allocate to ROLAIDS (200000)

0$ Array [10]

1–10. Logical number of devices N1–N10
See Sect. 3.ROLAIDS.2, ROLAIDS Input/Output Specifications

1$ Array [6]

1. IGE – Problem geometry
   0 – homogeneous
   1 – slab
   2 – cylinder
   3 – sphere
2. IZM – Number of zones for the integral transport calculation
3. IM – Number of spatial intervals
4. IBL – Boundary condition at the left-hand boundary of the system
   0 – vacuum (slab geometry only)
   1 – isotropic reflection (always for cylinders and slabs)
   2 – periodic (slab geometry only)
5. IBR – Boundary condition at the right-hand boundary of the system
   0 – vacuum
   1 – isotropic reflection
   2 – periodic (only when IBL = 2)
6. IPRB – Problem type
   1 – create a ROLAIDS data file and perform a slowing-down calculation
   0 – create a ROLAIDS data file
   −1 – use a previously made ROLAIDS data file and perform a slowing-down calculation
   −2 – use a previously made ROLAIDS data file and a problem restart file and perform a slowing-down calculation

2$ Array [8]

1. NDF1 – Number of nuclides to be picked from NPTXS library on device N1
2. NDF2 – Number of nuclides to be picked from NPTXS library on device N2
3. NMAST – Not used, enter zero
4. NFLAT – Number of nonresonance nuclides treated with specified flat scattering and 1/v absorption cross sections (if NFLAT > 0, the 16**–19** arrays are required)
5. MXX – Number of compositions used in the problem mockup
6. MS – Number of entries in the mixing table which specify the makeup of the MXX compositions
7. ICON – Print control for weighted 1-D cross sections (e.g., ICON = 0 triggers the printing of both superzone and zone-weighted 1-D cross sections)
   7 – superzone

6 – energy pointwise fluxes by zone[*]
5 – superzone, region, zone, cell
4 – superzone, region, zone
3 – superzone, region, cell
2 – superzone, zone, cell
1 – superzone, region
0 – superzone, zone
−1 – superzone, cell
−7 – none

8. MASTU – Unit number of the AMPX master library. ROLAIDS will search the library energy group structure for boundaries between EHI and ELO, thus determining the number of resonance groups (28)

3$ Array [2]

1. ISCT – The P_N-scattering cross-section expansion order (−1)[†]
2. MM – Not used in this version. Enter unity

4* Array [5]

1. ELO – Minimum problem energy (eV)
2. EHI – Maximum problem energy (eV)
3. EZP – Magnitude of exponent of assumed flux shape above EHI (1.0)
4. TK – Temperature (K) for thermal Maxwellian, used only if ICON = 6
5. TE – Time estimate (CPU min) corresponding to the requested time for the job. Used for terminating a slowing-down calculation and generating a restart file. Used only if TE > 0

T Terminate Block 1.

Block 2.

5* Array [IM + 1]

Mesh interval boundaries from left to right (cm)

6$ Array [IM]

Zone numbers by interval

7$ Array [IZM]

Mixture numbers by zone

9* Array [NMT = NDF1 + NDF2 + NFLAT]

---

[*] ICON = 6 produces the same printed cross sections as ICON = 5. In addition, the pointwise fluxes by zone are written on the output file (N10). An update file for CLAROL is not produced when ICON = 6.

[†] ISCT = −1 bypasses the calculation of multigroup transfer arrays; thus, a CLAROL data file is not generated. For a "typical" ROLAIDS calculation, ISCT ≥ 0. ROLAIDS uses the elastic-scattering cross-section data from the NPTXS-produced point library to prepare the transfer arrays.

Temperature of each nuclide (K). These values are checked against those on libraries N1 and N2. This check provides the capability of using NPTXS data for a single ENDF MAT number at more than one temperature.

11$ Array [NMT]

Nuclide identification numbers in order of NDF1, NDF2, NFLAT. These may have any order within NDF1 and NDF2. NFLAT nuclide ID numbers must be specified in the same sequence with which the mass numbers are input in the 16** array.

12$ Array [NMT]

These are in one-to-one correspondence with the 11$ array and give the identifier of the nuclide on the AMPX master library, if it is different from that on the point library.

13$ Array [MS]

Mixture numbers in mixing table ranging from one to MXX

14$ Array [MS]

Nuclide identification numbers in the mixing table

15* Array [MS]

Nuclide atom densities (atoms/b-cm) in the mixing table

16* Array [NFLAT] Entries

Atomic weights for the NFLAT nuclides (e.g., example values for oxygen and flourine would be 16.0, 19.0)

17* Array [NFLAT] Entries

Constant microscopic scattering cross sections (b) for the NFLAT nuclides (e.g., 3.75, 3.6)

18* Array [NFLAT] Entries

Thermal (0.0253 eV) fission cross sections (b) for the NFLAT nuclides (e.g., 2E-4, 9E-3)

19* Array [NFLAT] Entries

Thermal (0.0253 eV) fission cross sections (b) for the NFLAT nuclides (e.g., 0.0, 0.0)

T Terminate Block 2.

3.ROLAIDS.2 ROLAIDS Input/Output Specifications

ROLAIDS generally requires the following input/output devices:

Logical No.		Purpose
N1	(31)	First NPTXS library (required if IPRB $\geq$ 0, and NDF1 > 0)
N2	(32)	Second NPTXS library (required if IPRB $\geq$ 0, and NDF2 > 0)
N3	(16)	Scratch device (required if IPRB $\geq$ 0)
N4		Scratch device. Default logical number depends on IPRB as follows:

IPRB	Default Logical No.
≥0	18
<0	29

N5	(5)	Card input device
N6	(6)	Printed output device
N7	(29)	ROLAIDS data file (note that this file is written if IPRB $\geq$ 0, and is read if IPRB <0)
N8	(17)	Scratch device (required if ICON = 6, and IPRB < 0)
N9	(9)	Direct access scratch device (required if either IPRB $\geq$ 0 or ISCT $\geq$ 0)
N10	(26)	Requirement for and use of N10 depends on IPRB and ICON as follows:

IPRB	ICON	Use
0	–	Device required for possible restart file
≠0	≠6	CLAROL data file
≠0	6	Energy-pointwise flux distribution file

MASTU	(28)	Existing AMPX master library

3.ROLAIDS.3 ROLAIDS Error Messages

ROLAIDS makes various checks during problem execution and terminates jobs for inconsistent data or insufficient storage. Printed error messages bear a close resemblance to the following.

1. INPUT DATA NOT IN REQUIRED ORDER.
2. PERIODIC BOUNDARY CONDITION IS ONLY VALID FOR SLAB GEOMETRY.
3. SEASON COULD NOT DETERMINE ZONE BOUNDARIES FROM INPUT DATA.
4. PLUCK COULD NOT FIND NUCLIDE X, AT TEMPERATURE Y, ON TAPE NO. N.
5. MDATA TAPE SEQUENCE STORAGE EXCEEDS LIMIT VALUE OF N.

6. M POINTWISE ARRAY EXCEEDS LMDUM VALUE OF N.
7. N ENERGY POINTS EXCEEDED LIME AT NUCLIDE I, MT = M.
8. ATTEMPT TO WRITE A NEW DATA TAPE WITH NO NUCLIDE FROM ENDF1 SPECIFIED.
9. M DOWN-SCATTERING SEQUENCE STORAGE EXCEEDS LIMIT VALUE OF N, DUM DIMENSIONED AT N1.
10. X EV MAX PROBLEM ENERGY EXCEEDS MAX NDATA ENERGY OF Y.
11. X EV MIN PROBLEM ENERGY LESS THAN MIN NDATA ENERGY OF Y.
12. POSITION I NUCLIDE, TAPE ID N DISAGREES WITH PROBLEM ID M.
13. NUMBER OF NDATA NUCLIDES N, DISAGREES WITH NUMBER OF PROBLEM NUCLIDES M.
14. X EV VALUE OF EHI NOT ON NDATA.
15. BOUNDARY OF FINE GROUP I, BEG = X NOT INCLUDED ON NDATA WHEN E = Y FELL BELOW ELO = Z.
16. M OUTPUT SEQUENCE STORAGE EXCEEDS LIMIT VALUE OF N.

REFERENCES

1. N. M. Greene et al., *AMPX: A Modular Code System for Generating Coupled Multigroup Neutron-Gamma Libraries from ENDF/B*, ORNL/TM-3706, Union Carbide Corp., Nucl. Div., Oak Ridge Natl. Lab., March 1976; see Sect. 8.0, "XSDRNPM: AMPX Module with One-Dimensional S_n Capability for Spatial Weighting."
2. N. M. Greene and C. W. Craven, Jr., *XSDRNPM: A Discrete Ordinates Spectral Averaging Code*, ORNL-TM-2500, Union Carbide Corp., Nucl. Div., Oak Ridge Natl. Lab., July 1969.
3. R. M. Westfall, *Theory and Validation of ROLAIDS: AMPX Module for Treating Resonance Shielding in Multiregion Geometries*, ORNL/CSD/TM-63, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab. (to be published).

3.RUFFLES — MODULE TO CHANGE THE ENERGY GROUP STRUCTURE FOR AN ANISN OR XSDRNPM SCALAR FLUX TAPE

RUFFLES (Regroup, Undulate, and Fix Fluxes in Your Library's Energy Structure) is a module to change the energy-group structure for an ANISN or XSDRNPM scalar flux tape. The output group structure is independent of the input structure. The group structures may be read from cards, or default neutron and/or gamma-ray structures from the AMPX group structure library may be used. Where an input group is split between two or more output groups, the flux is divided by assuming a constant flux in lethargy within the input group. If there are flux moments on the tape, the same assumption is applied to the moments.

3.RUFFLES.1 RUFFLES Input Data

Block 1.

0$ Array [2]

1. N1 – Logical unit for input scalar flux tape (14)
2. N2 – Logical unit for output scalar flux tape (15)

1$ Array (IGE, ISCT, IM, IGM1, and IGG1 are obtained from the XSDRNPM or ANISN case that produced the flux tape on N1)

1. IGE – Geometry type: 0/1/2/3 – homogeneous/slab/cylinder/sphere
2. ISCT – Order of scattering
3. IM – Number of mesh points
4. ISN – Order of S_n quadrature
5. IGM1 – Number of neutron energy groups for input scalar flux tape
6. IGM2 – Number of neutron energy groups for output scalar flux tape
7. IGG1 – Number of gamma-ray energy groups for input scalar flux tape
8. IGG2 – Number of gamma-ray energy groups for output scalar flux tape

2$ Array [2]

1. ITYPE – Type of scalar flux tape 0/1 – ANISN/XSDRNPM (0)
2. IPRT – Print control flag: 0/1/2/.../N – Minimum printout/0. Print plus scalar flux printout/1 print plus current. Printout/.../ (N–1) print plus Nth moment printout. (0)

T Terminate Block 1.

Block 2.

4* Array [IGM1 + 1]

Energy boundaries (high to low in eVs) of neutron group structure used in XSDRNPRM or ANISN case that produced scalar flux tape on N1. (Defaults to AMPX neutron-group-structure library.)

5* [IGM2 + 1]

Energy boundaries of output neutron group structure (defaults to AMPX neutron group structure library)

6* [IGG1 + 1]

Energy boundaries of input gamma-ray group structure (defaults to AMPX gamma-ray group structure library)

7* [IGG2 + 1]

Energy boundaries of output gamma-ray group structure (defaults to AMPX gamma-ray group structure library)

T Terminate Block 2.

3.RUFFLES.2 RUFFLES Input/Output Specifications

RUFFLES generally requires the following input/output devices:

Logical No.	Purpose
5	Card input device
6	Printed output device
47	"Built-in" group structure library
8	Random access scratch
N1 (14)	Input scalar flux tape
N2 (15)	Output scalar flux tape

3.SALVAGE — AMPX MODULE TO RECOVER USABLE PORTIONS OF MASTER LIBRARIES WHICH ARE INCOMPLETE

There are at least two abnormal occurrences that result in the actual number of data sets contained in an AMPX master library being less than the number specified by the NNUC parameter in the first record of the library. The most prevalent occurrence is the AMPX master library tape which "goes bad" somewhere in the middle (due to age, mishandling, etc.). Another occurrence is when there is an abortion during the execution of an XLACS case (code failure, job pulled by operator, machine error, etc.).

Because of the great expense in creating a large nuclide master library, it is highly desirable to be able to "SALVAGE" any portion of the library that can be accessed. The SALVAGE (Save A Library Vitch 'As Gone Escew) module was written expressly for this purpose. The user first determines the number of data sets in the library which can be read (by running RADE or DIAL, for example), inputs this information to SALVAGE, and makes a new master library containing the good portion of the old library. The SALVAGE-produced master library is a complete library (i.e., the NNUC parameter, the master library table of contents, and the number of data sets contained in the library agree).

3.SALVAGE.1 SALVAGE Input Data

One data block (two arrays) of data is required by this module.

Block 1.

0$ Logical Unit Assignments [2]

1. MIN - Old master library (23)
2. MOU - New master library (1)

1$ Set Selector [2]

1. NEWNUC - Number of data sets which can be copied
2. NWORD - Number of words to allocate to SALVAGE (50000)

T Terminate Block 1.

3.SALVAGE.2 SALVAGE Input/Output Specifications

SALVAGE requires the following input/output devices:

Logical No.	Purpose
5	Card input
6	Standard output
17	Scratch
18	Scratch
MIN (23)	Old master
MOU (1)	New master

3.SMILER — AMPX MODULE TO CONVERT NJOY GENDF FILES TO AMPX MASTER LIBRARIES

The SMILER module (Second MILER*) was written in response to a need to circumvent inefficiencies observed in the use of the original code.

MILER[1] provides a means of converting group-averaged cross sections from the NJOY[2] system for use by modules written for the AMPX system. By default, NJOY writes these data in a format called the GENDF format, which is an ENDF/B-like format.

SMILER is not, in any sense, a revision of MILER. Rather, it is a response to the observation that many situations will cause MILER to require exorbitant input/output operations in order to convert between GENDF format and the AMPX master library format. SMILER uses procedures that take advantage of the current large-computer memories, which allow one to liberally use core-size allocations, as opposed to the situation which existed only a few years ago, wherein one had to shuttle data in and out of core to accommodate many problems. Because of this change in programming style, SMILER uses simpler procedures than might have been previously employed, thereby making it more compact and easier to maintain.

As with MILER, SMILER requires little input over simply specifying the GENDF files that are to be combined and converted. Like MILER, a SMILER run produces cross sections for only one nuclide. These one-nuclide master libraries can be easily collected by the AJAX (see Sect. 3.AJAX) module. SMILER accepts the BCD or binary formats of GENDF files.

Unlike MILER, SMILER produces a master interface that is compatible with the Nordheim Integral Treatment for resonance self-shielding, when these are used with the NITAWL-II module from AMPX-77 or from SCALE-4. This feature would require the addition of resonance parameters, for example, by using the UNITAB (see Sect. 3.UNITAB) module, to the master library produced by SMILER.

Note that no code which prepares an AMPX master library should include an array identified by 1452 ($\overline{\nu\sigma_f}$) in the 1-D arrays. SMILER does not, and should never be modified to do this, as it will result in completely erroneous results, when used in some code combinations.

3.SMILER.1 SMILER Input Data

SMILER uses the FIDO input schemes employed in the AMPX system. It requires one block of data.

Block 1.

−1$ Core Allocation [1]

1. ICORE – Number of words of core to allocate to SMILER (300000)

0$ Logical Assignments (4)

1. MMT – Logical unit of AMPX master interface (1)

---

*MILER[1] is an acronym for Master Interface Library MakER.

2. MG1 - First GENDF file (0)
3. MG2 - Second GENDF file (0)
4. MG3 - Third GENDF file (0)
   (Note that because photo-only GENDF files do not strictly follow the GENDF format specifications and specify the number of photon groups in the word designated for the number of neutron groups, we have reserved MG3 as the location for this type of file. Logical units MG1 and MG2 can both contain either neutron-only or coupled neutron-gamma data. Borrowing an idea from MILER, positive values for MG1, MG2, MG3 are used for BCD files, whereas negative values are used for binary files.)

1$ Nuclide Identifier and Direct-Access File Status [2]

1. ID19 - Identifier of the set of data produced by SMILER (1)
2. N9STAT - Status of direct-access scratch file (0/1 - create new file/use existing file) (0)
   N9STAT is a provision for minimizing the number of input/output operations associated with direct-access files. At least on IBM systems using standard FORTRAN features, the initialization of a new direct-access file requires two input/output operations for every block in the file. Saving and reusing this file reduces the penalty to a negligible number.

2$ NJOY/AMPX Thermal Identifier Correspondence List [100]

(Up to 50 doublets which give the NJOY identifiers for a thermal-scattering process followed by its corresponding AMPX identifier. By default, this array contains 221 1007, followed by 98 zeroes, which says to use an AMPX identifier of 1007 on the arrays which NJOY identifies with 221.)

6$ Direct-Access Storage Parameters [2]

1. NBLK - Number of blocks to initialize in the direct-access scratch file (500)
2. LRECL - Length of direct-access file blocks in words (1000)

T Terminate Block 1.

3.SMILER.2 SMILER Logical Assignments

SMILER uses the following I/O assignments:

Logical No.	Purpose
5	Standard input
6	Standard output
9	Direct-access scratch file
MMT(1)	AMPX master interface
MG1(0)	First GENDF file
MG2(0)	Second GENDF file
MG3(0)	Third GENDF file

3.SMILER.3 SMILER Procedures

Converting between different multigroup cross-section formats is a very common requirement. That it is not trivial is due to the wide variety of choices that one can make in designing a format.

The differences in GENDF and AMPX formats clearly demonstrate areas that can be different.

- There is a difference in the ordering of energy groups. Traditionally, group 1 is the highest energy group, as it is in the AMPX master interface. On a GENDF file, group 1 is the lowest energy group.
- The Legendre coefficients in scattering matrices in the AMPX master interface include the $(2\ell+1)$ multiplier following conventions established for the ANISN and DOT programs in the mid-1960s. GENDF does not.
- The matrices for reactions that produce multiple secondary particles, such as n2n, contain the multiplicity on GENDF files. In AMPX, they do not.
- The units of the temperatures associated with scattering matrices are in eV in AMPX, versus K in GENDF. Definitely, Kelvin units are preferable.
- Various process identifiers for averaged cross sections need to be carefully monitored in order to interact properly with various AMPX modules. For example, the GENDF-scattering matrices for fission are identified by MT = 18, which is perfectly logical and as it should be; however, use of this identifier on the AMPX master interface would lead to undesirable results, and it is redefined to be 9018. Likewise, MT = 221, ... for thermal-scattering processes are converted to MT = 1007, 1008, ... to interface with the AMPX procedures.
- The fission spectrum on the GENDF file is in scattering-matrix form (a more correct form), whereas it is generally expected to be a single array on the AMPX interface.

The basic procedure in SMILER is very simple. Note that even though a GENDF file can contain many (up to the number of groups) collections of records for a process at a single temperature, these can be collected into a single record, before they are shuttled to a direct-access scratch file. Furthermore, if one chooses a procedure that constructs all of the matrices for Legendre coefficients of scattering processes in-core, prior to writing to the direct-access file, the requisite I/O operations are minimized.

As each process is finalized and written, a directory is constructed which consists of the following attributes:

MAT - the ENDF/B MAT number
MT - the ENDF/B process identifier
L - the length of the record in the direct-access file
NREC - the block number in the direct-access file
TYPE - the ENDF/B "file" number
ORDER - the order of the Legendre coefficient
T - the temperature associated with the process

The up-to-three GENDF files are read and their contents noted in the above directory as they are written to the direct-access file.

After this, the direct-access directory contains all the information necessary to determine the structure of the AMPX master.

In a subroutine called MASTER, this structure is determined, along with performing most of the other operations necessary to create the AMPX master interface. For example, to create Bondarenko factors (which will derive from averaged cross sections as a function of σ_0 and temperature on the GENDF files), MASTER first finds the lowest temperature for a process. This set is denoted as the reference infinite dilution set, after which all nonzero temperatures are located and the Bondarenko factors determined by dividing the averaged values by corresponding values in the reference set.

In a subroutine called CHI1D, the fission-scattering matrix is combined with the fission cross section, the $\bar{\nu}$ value, and the flux to create a fission spectrum array appropriate for use in codes used at Oak Ridge and elsewhere.

A subroutine called YIELD calculates photon yields for MT = 18 and MT = 102 by dividing the photon cross-section production matrices by averaged cross sections for the appropriate process.

Test cases comparing SMILER to MILER clearly demonstrate the efficacy of the alternative approach. Converting a 201-neutron/42-gamma-group library for ^{55}Mn required around 70,000 I/Os with MILER. SMILER required slightly over 2000 I/Os for this case.

REFERENCES

1. G. C. Panini and A. Barbieri, *MILER: A Computer Code for Interfacing NJOY/THEMIS With SCALE System*, PSR-271, Radiation Shielding Information Center, Oak Ridge National Laboratory, 1989.
2. R. E. McFarlane, D. W. Muir, and R. M. Boicourt, *The NJOY Nuclear Data Processing System, Volume I: User's Manual*, LA-9303-M, Vol. I (ENDF-324), May 1982.

3.SMUG — MODULE FOR GENERATING MULTIGROUP PHOTON CROSS SECTIONS

SMUG (Simple MUltigroup Gammas) is a revision of the MUG[1] code incorporating the necessary programming changes to create a functional module in the AMPX system. It calculates multigroup photon cross sections, with transfer coefficients represented by a Legendre approximation of an arbitrary order. The scattering moments are computed from the Klein-Nishina[2] equation. The photoelectric and pair-production cross sections are obtained from ENDF/B.[3] Three sets of dose factors[4] are built in and can be averaged over the problem group structure. The MUG report is the reference for the theory used in SMUG, and the primary programming differences are outlined below.

MUG solves the Klein-Nishina equation by treating each moment independently. In SMUG the programming is restructured to take advantage of the recursive properties of the Legendre polynomial. This reduces the impact of the order of P_n as a factor in calculation time. Reductions by a factor of 5 to 10 have been observed.

SMUG is flexibly dimensioned, permitting efficient use of core storage. Problem size is limited only by total core storage available rather than the size of any single parameter.

SMUG produces an averaged energy absorption coefficient, denoted by MT = 1527, which has units of MeV-b.

3.SMUG.1 SMUG Input Data

A. Title Card (20A4)

Block 1.

−1$ Core Assignment [1]

1. NWORD - Number of words to allocate to SMUG (3500)

0$$ Logical Assignments [3]

1. NEWS - Master library (26)
2. N14 - Scratch file (14)
3. N15 - Scratch file (15)

1$ Array [3]

1. NGG - Number of gamma groups
2. NNUC - Number of nuclides to process
3. LMAX - Order of P_n

2$ Array [8]

Default values are set for all parameters in this array. If all of the default values are acceptable for the calculation, the array may be omitted.

1. MF = 1, Flat weighting (default = 1)
   = 2, 1/E weighting
   = 6, Arbitrary weighting spectrum to be entered in 6$ and 7* arrays

2. NWR = Number of interpolation regions used to specify the arbitrary weighting spectrum (default = 0)
3. NWP = Number of points in the arbitrary weighting spectrum (default = 0)
4. NUF = 0, Energy-dependent flux,
   = 1, Photon number flux (default = 1)
5. NSP = Number of intervals in outer integral (default = 31)
6. NPHI = Number of intervals in inner integral (default = 51)
7. NDS = Number of downscatters required (default = NGG − 1)
8. NDF = 0, No print
   = 1, Print a set of factors for the problem group structure (default = 1)
   = 2, Print and punch the dose factors

T Terminate Block 1.

Block 2. {6$ and 7* arrays are entered only if MF = 6}

6$ (2*NWR entries): Interpolation table for arbitrary weighting spectrum (NBT(I),JNT(I),I=1,NWR)

7* (2*NWP entries): Arbitrary weighting spectrum (per unit energy), (E(I),W(I),I=1,NWP), ascending in energy. Units of energy are eV.

8* Array (NGG + 1 entries): Gamma group energy mesh in decreasing magnitude of energy. Energies are in units of eV. Several "standard" group structures are built into AMPX and when one of these is desired this array is omitted. See Sect. 4.MISCELLANEOUS.4.2 for a list of the standard structures.

T Terminate Block 2.

The following block is repeated NNUC times (i.e., input a 10$ array for each nuclide).

Block 3.

10$ Array [5]

1. LEMNO - ENDF/B material number
2. LORDER - Highest order of P_n to be printed/punched for this nuclide (default = 0)
3. ILT - Logical number of cross-section library for this material (default = 11)
4. MODE = 0, Indicates cross-section library is unformatted (binary) (default = 0)
   = 2, Indicates cross-section library is formatted (BCD)
5. LPUN - Controls printing and punching of P_n cross-section arrays
   = 0, print, no punch
   = 1, print and punch

= −1, no print, no punch (default = −1)
= 2, punch, no print

Note: Punched cards are free-form format.

T Terminate Block 3.

3.SMUG.2 SMUG Input/Output Specifications

SMUG requires the following input/output devices during an execution:

Logical No.	Purpose
5	Input
6	Printed output
7	Punched card output
14	Scratch
15	Scratch
26	AMPX interface which contains the multigroup gamma libraries
ILT (supplied by user in 10$ array of input)	Cross-section library

3.SMUG.3 SMUG Error Messages

When errors are encountered which SMUG cannot overcome, one of the following messages will be printed and the control returned to the AMPX DRIVER.

Message: CORE USED XXXXXXXX LIMIT XXXXXXXX
Detecting Routine: SMUG
Cause: Inadequate space available. Reduce problem complexity or increase space allotted in SMUG main program.

Message: MATERIAL XXXXXX NOT ON ENDF TAPE
Detecting Routine: FINDXS
Cause: Self-explanatory. Check input data and contents of ENDF library requested.

Message: FILE 23 OF MATERIAL XXXXXX NOT ON ENDF TAPE
Detecting Routine: FINDXS
Cause: Self-explanatory. Check contents of ENDF library requested.

Message: SECTION XXXX OF FILE 23 OF MATERIAL XXXXXX NOT ON ENDF TAPE
Detecting Routine: FINDXS
Cause: SMUG expects to find reaction types 501, 502, 504, 516, 602 in file 23. The calculation cannot be performed if these data are not available.

Message: STOP IN FINDXS, NRI, XXXXXX NPI XXXXXX
Detecting Routine: FINDXS
Cause: Programming error; ENDF data more voluminous than anticipated. Programming changes are required in subroutines SMUG and FINDXS.

Message: DATA FOR MATERIAL XXXXXX SECTION XXX ARE TEMPERATURE DEPENDENT
Detecting Routine: FINDXS
Cause: This version of SMUG does not accept temperature-dependent file 23 data.

Message: ENERGY ARRAY OUT OF SEQUENCE MATERIAL XXXXXX SECTION XXXX
Detecting Routine: FINDXS
Cause: Energies not in increasing order; check ENDF data.

3.SMUG.4 SMUG Warning Messages

When data are not defined by ENDF to cover the entire energy range required by the problem, SMUG defines the cross sections in the undefined range as zero, prints a warning message, and continues the calculation. If any of these warnings should occur, the user must assess the validity of the calculation.

REFERENCES

1. J. R. Knight and F. R. Mynatt, *MUG: A Program for Generating Multigroup Photon Cross Sections*, CTC-17, Union Carbide Corp., Nucl. Div., Oak Ridge Gaseous Diffusion Plant, January 1970.
2. R. D. Evans, *The Atomic Nucleus*,Chapter 23, McGraw-Hill, 1955.
3. D. J. Dudziak, *ENDF Formats and Procedures for Photon Production and Interaction Data*, LA-4549 (ENDF-102), Rev. Vol. II, Los Alamos Scientific Lab., July 1971.
4. B. J. Henderson, *Conversion of Neutron or Gamma Ray Flux to Absorbed Dose Rate*, XDC-59-8-179, General Electric Co., Cincinnati, Ohio, August 1959.

3.TABU — AMPX MODULE TO CREATE BONDARENKO FACTORS FOR THE UNRESOLVED RESONANCE ENERGY REGION IN ENDF/B

TABU (Tailor AMPX Bondarenko Factors for the Unresolved Region) is a module that is intended to prepare an AMPX master cross-section file which only contains Bondarenko factor data for the unresolved energy regions of ENDF/B nuclides. Because the unresolved energy range in ENDF/B can vary from nuclide to nuclide, the same sort of generality is required for TABU and, of course, the formats of the AMPX master file.

TABU does not process the ENDF/B files directly, but assumes that these files have been preprocessed into point "average" values by some other code, such as PRUDE. These average values are expected to be available in ENDF/B TAB1 formats, separated out according to MAT (material), MT (process), T (temperature), and SIG0 (sigma-0, the "background" cross section associated with Bondarenko data).

In order to convert the point data to group-averaged form, TABU requires a smooth weighting spectrum. This can be supplied in the same TAB1 formats as used for the cross-section data on logical MWT, though it is probably reasonable to use the default 1/E weighting in the unresolved region.

Input to TABU is particularly brief and requires little knowledge on the part of the user as to details of the ENDF/B unresolved data or on how many processes, temperatures, sigma-0's, etc., went into the point file.

3.TABU.1 TABU Input Data

Block 1.

−1$ Core Assignment [1]

1. LLLL – Number of words of core allocated to this module (50000)

0$ Logical Unit Assignments [3]

1. MMT – Logical unit number on which the master file will be written (default = 1)
2. MXS – Logical unit number containing point cross sections (default = 31)
3. MWT – Logical unit number containing weighting spectra (for 1/E weighting spectrum, input MWT = 0 along with MATW = 99, MFW = 3, and MTW = 1 in 11$$ array) (default = 0)

1$ Problem Size [3]

1. NNUC – Number of materials which will be processed
2. IGM – Number of energy groups
3. IFTG – First thermal group

2$$ Options [10]

1. IOPT1 – 0 – Cross sections are calculated in PRUDE and input on logical MXS
   N – Cross sections are from the UNRESR module of NJOY and are input on logical N
2. IOPT2 – Not used

.

4. IOPT4 – 0/1 – do not/do print energy-group boundaries (default = 0)

.

10. IOPT10 – Not used

T Terminate Block 1.

Block 2.

7* Energy Group Boundaries (high to low in eV)
(Omission of this input will select a standard AMPX structure.)

T Terminate Block 2.

Block 3. {This block will be repeated NNUC times.}

Title Card for the Material

10$ Material Designation [1]

1. MATN – ENDF/B material number (i.e., MAT number)

11$ Smooth Weighting Function [3]

1. MATW – MAT number of weighting spectrum (default = 99)
2. MFW – MF number of weighting spectrum (default = 3)
3. MTW – MT number of weighting spectrum (default = 1) (for 1/E weighting spectrum, these three parameters must be 99, 3, and 1, respectively)

T Terminate Block 3.

3.TABU.2 TABU Input/Output Specifications

TABU requires the following logical unit assignments:

Logical No.	Purpose
5	Standard input
6	Standard output
MMT (1)	AMPX master file written here
MXS (31)	Point cross-section file
MWT (46)	Smooth weighting spectra file
17	Scratch file
18	Scratch file

3.TIDE — MODULE TO CORRECT AN AMPX MASTER LIBRARY DIRECTORY

TIDE (TIdy AMPX Master Library Directories Easily) is a module to correct the table of contents of an AMPX master library, including an accounting of the number of records for each nuclide. The input consists of specifying the logical unit number that the master library resides on. Optionally, two scratch units may be overridden.

3.TIDE.1 TIDE Input Data

Block 1.

1$ Master Logical Unit [1]

   1. Logical unit number of the master library

2$ Other Input Items [3]

   1. NS – Logical unit number of the first scratch unit (default = 18)
   2. NT – Logical unit number of the second scratch unit (default = 19)
   3. NWORD – Number of words to allocate to TIDE (100000)

T Terminate Block 1.

3.TIDE.2 TIDE Input/Output Specifications

The following are typical I/O assignments in TIDE:

Logical No.	Purpose
5	Card input
6	Standard output
18	Scratch unit
19	Scratch unit
NT1	Master library

3.UNITAB — AMPX MODULE TO MERGE SELECTED PORTIONS OF MASTER LIBRARIES INTO HYBRID MASTER SETS

UNITAB (UNITe Anything Briskly) is provided to allow merging data at the cross-section-set level from up to 12 different sources (master libraries). UNITAB is so general that it practically allows constructing any sort of "hybrid set," so long as energy-group structures match. For example, one can use it as CHOX is presently used, where neutron, gamma-ray interaction, and gamma-ray production data are input on separate libraries and end up in a single library, or, more interestingly, the coupled neutron-gamma library can be split apart into its separate components. Better yet, selected individual components of the data can be placed into a new data set. For example, the new data set can have resonance data (Bondarenko factors, etc.) from one data set, 1-D data from another, elastic transfer data from another, etc. A user can create a mess if he/she is not careful.

3.UNITAB.1 UNITAB Input Data

Block 1.

−1$ Core Assignment [1]

1. NWORD – Number of words to allocate to UNITAB (100000)

0$ Logical Assignments [16]

1. NEW – New master library (1)
2. MSC – Scratch device (18)
3. MDA – Direct-access scratch (9)
4. MDB – Direct-access scratch (8)
5. MM1 – First master library (23)
6. MM2 – Second master library (24)
7. MM3 – Third master library (26)
8. MM4 – Fourth master library (0)
9. MM5 – Fifth master library (0)
10. MM6 – Sixth master library (0)
11. MM7 – Seventh master library (0)
12. MM8 – Eighth master library (0)
13. MM9 – Ninth master library (0)
14. MMA – Tenth master library (0)
15. MMB – Eleventh master library (0)
16. MMC – Twelfth master library (0)

1$ Coupling Information [2]

1. NNNC – Number of sets to be created
2. NCOM – Number of "coupling" commands

6$ Direct-Access Parameters for MDA * [2]
1. NBLK – Number of direct-access blocks (200)
2. LREC – Length of direct-access blocks (880)

T Terminate Block 1.

Block 2.

This block contains one array of information (the coupling commands) which tells how the data are to be combined.

2$ Coupling Commands (NCOM*4)

The "commands" are in groups of four entries, stacked one after the other. The entries are

1. Identifier of the data set on the new master library
2. Logical number of the device containing data wanted in the new master data set
3. Identifier of the master data set on the old library containing the desired data
4. "Type" of data desired (allowed types are specified below):

"Type" selectors	Function
1111	All neutron data
2222	All gamma-ray production data
3333	All gamma-ray interaction data
4444	Bondarenko data
5555	Nordheim resonance data
6666	1-D neutron data
7777	1-D gamma data
MT	Selects transfer matrix for process MT
−MT	When used in conjunction with a select all option, allows excluding transfer matrix for process MT

Note that individual portions of the "all" selectors can be overridden with the other selection options. The selection of a specific component (e.g., Bondarenko data) takes precedence over a global request.

T Terminate Block 2.

The title of the new set is determined in a hierarchal manner. It is the title from the set containing the first neutron data request; or, if none, it is the title from the set containing the first gamma request; or, if still none, it is the title from the first gamma production request.

---

*The new master library is "built" on MDA prior to finally being placed on NEW. Therefore, NBLK × LREC must be $\geq$ the number of words in the new master library.

3.UNITAB.2 UNITAB Input/Output Specifications

The following input/output specifications are required by UNITAB.

Logical No.	Purpose
5	Card input
6	Standard output
MDB(8)	Direct-access scratch
MDA(9)	Direct-access scratch
MSC(18)	Scratch space
NEW(1)	New master library
MM1(23)	First existing master library
MM2(24)	Second existing master library
MM3(0)	Third existing master library, if any
MM4(0)	Fourth existing master library, if any
.	.
.	.
.	.
MMC(0)	Twelfth existing master library, if any

3.VASELINE — AMPX MODULE TO PLOT ENDF POINT AND AMPX GROUP-AVERAGED CROSS SECTIONS

VASELINE (Visual Aids SELected IN Ecstasy) is a plotting module for AMPX. It is written to plot point-versus-point data, point-versus-multigroup data, or multigroup-versus-multigroup data. Any ENDF array from files 3, 13, or 23 can be plotted as can any 1-D group-averaged neutron or gamma cross sections on a master or working/weighted cross-section interface. Selections can be made from any combination of ENDF or multigroup sources. The number of curves on any plot is arbitrary.

3.VASELINE.1 VASELINE Input Data

Block 1.

−1$ Core Assignment [1]

1. ICORE – Number of words to allocate to VASELINE (100000)

1$ Plot Selection

1. MPLOT – Number of plot commands given below
2. IPLOT[*]—What to plot
    - 0 – points only
    - 1 – lines between points
    - 2 – points and lines
    - 3 – histogram

2$ Plot Options [10]

1. IOPT1 – Plot type (default = 4)
    - 1 – linear-linear
    - 2 – x log - y linear
    - 3 – x linear - y log
    - 4 – log-log
2. IOPT2 – Number of special plot titles (default = 0)
3. IOPT3 – Number of special ordinate labels (default = 0)
4. IOPT4 – Not used
5. IOPT5 – Not used
6. IOPT6 – Not used
7. IOPT7 – If greater than 0, plots will be subtitled with an identifier selected by the MT of the first executed command for that plot
8. IOPT8 – Not used
9. IOPT9 – Points that are plotted will be printed, if greater than 0
10. IOPT10 – Not used

T Terminate Block 1.

---

[*] This parameter applies to data taken from ENDF libraries only.

Block 2.

This block of three arrays will be repeated MPLOT times.

3$ Identifiers of Data to be Plotted [5]

1. NPLOT – Plot number on which the data selected by this block will be plotted
2. MT – Process to be plotted. ENDF process identifiers are employed where applicable
3. IDM – The identification number of a set of data on an AMPX master interface which contains the "MT" data. A zero indicates that this command does not select from a master interface.
4. IDW – The identification number of a set of data on an AMPX working interface which contains the "MT" data. A zero indicates that this command does not select from a working interface.
5. IDE – The ENDF "MAT" number for the set of data which contains "MT"

4$ Library Selectors [5]

Omit this array if default values are acceptable.

1. MMTN – Logical number of AMPX master interface (default = 1)
2. MWTN – Logical number of AMPX working interface (default = 4)
3. MENDF – Logical number of the ENDF library (default = 11)
4. MODE – Tape mode of MENDF (default = 1)
   1 – binary
   2 – BCD
5. MFILE – File number containing ENDF data (default = 3)
   (Note that data can only be plotted from files 3, 13, and 23 in the present version of VASELINE.)

5* Plot Range [2]

1. ELO – Low-energy limit of plot (eV)
2. EHI – High-energy limit of plot (eV)

This array can be omitted, in which case the range is automatically determined to be the full range of the data selected.

T Terminate Block 2.

Special plot titles [IOPT2] (I6,A52)

1. IPLOT – The plot number for which this title is to be used
2. PTITL – The plot title (52 characters)

Special labels [IOPT3] (I6,A36/6X,A36)

1. IPLOT – The plot number for which this label is to be used
2. OLABL – The x-axis label (36 characters)
3. ALABL – The y-axis label (36 characters)

3.VASELINE.2 VASELINE Input/Output Specifications

VASELINE generally requires the following I/O assignments:

Logical No.	Purpose
5	Card input
6	Standard output
18	Scratch device
MMTN(1)	AMPX master interface
MWTN(4)	AMPX working interface
MENDF(11)	ENDF library
70	DISSPLA DVSD file
71	DISSPLA VSCR file
72	DISSPLA POPF file
73	DISSPLA ISC1 file
74	DISSPLA ISC2 file
75	DISSPLA ISC3 file

Note that the DISSPLA files are required, depending on the particular situation. Logical 72 is the metafile and will always be required, since this is the file which will be passed to a postprocessing routine that actually produces the plots. In our experience with the present version of DISSPLA (version 10.5), the other files have not been required by VASELINE and need not be allocated.

3.VEL — A MODULE FOR GROUP-AVERAGING POINT DATA

VEL (VEctor Libraries) is a module for producing group-averaged cross sections from point cross-section data strings. It expects its point cross sections to be input in the library formats such as are written by NPTXS (module to process ENDF/B files 2 and 3 data into point data) or CREST (module to collect together point data from several ENDF/B libraries, AMPX master or working libraries), or CASTROL (module to create a binary point library from card input). The weighting spectrum used in VEL is also expected to be input in the same format as the point data. The JERGENS module contains a wide variety of options for creating weighting spectra and outputs its data in this format. The output from VEL is a master library containing the group-averaged data. Either neutron or gamma data can be processed.

3.VEL.1 VEL Input Data

Block 1.

0$ Logical Assignments [3]

1. MMT – Master library is written here (1)
2. MXS – Point data are input here (31)
3. MWT – Weighting spectra are input here (46)

1$ General Case Data [5]

1. NC – Number of weighting commands specified in Block 3
2. IGM – Number of neutron energy groups
3. IPM – Number of gamma energy groups
4. ICORE – Number of words of core to use (50000)
5. IS – Not used at present

T Terminate Block 1.

Block 2. (Energy Boundaries)

7* Neutron Energy Group Boundaries – high to low in eV (IGM + 1)

8* Gamma Energy Group Boundaries – high to low in eV (IPM + 1)
(The 7* and 8* arrays can be omitted if standard AMPX group structures are being used; however, the "T" which ends Block 2 must be specified.)

T Terminate Block 2.

Block 3. (Weighting Commands)

This block is repeated NC times. One "command" is required for each process to be weighted, and specifies the identifier on the master library under which several group-averaged functions may be collected and the identifiers of process and the weighting spectrum.

10$ Process and Set Description [3]

1. ID19 – The identifier on the master library for the set containing the process
2. NP – The identifier of the process on the master library
3. NORG– Not used

11$ Point Data and Weighting Spectrum Selection Parameters [6]

1. MATX – The "MAT" number of the point data to be read from logical MXS
2. MTX – The "MT" number of the point data
3. MFX – The "MF" number (normally 3) of the point data
4. MATW – The "MAT" number of the weighting spectrum to be read from logical MWT
5. MTW – The "MT" number of the weighting spectrum
6. MFW – The "MF" number (normally 3) of the weighting spectrum

12$ Multigroup Weighting Spectrum Identifier for the Set of Data Identified by ID19 [1]

1. NPW – The process identifier for the group-integrated weighting spectrum values (normally 1099). (Note that the 12$ array should be used in only one of the commands that describe processes to be collected under the identifier, ID19. Multiple entries will cause the weighting spectrum to be included that number of times on the master library.)

T Terminate Block 3.

This is the end of the data input typically required for VEL; however, in the event you wish to supply a title for any of the sets of cross sections VEL produces, you can include them at this point in an (I12/18A4) format, where you put the set identifier (ID19) right-justified in the first 12 characters of one line, followed by a line containing the new title. Stack as many of these two-line overrides as you wish.

3.VEL.2 VEL Input/Output Specifications

The following devices are required by VEL:

Logical No.	Purpose
5	Standard input
6	Standard output
7	Punched output
8	Direct-access scratch space
MMT(1)	Master interface written here
MXS(31)	Point cross-section library
MWT(46)	Weighting function library

3.WAX — MODULE TO MERGE, COLLECT, ASSEMBLE, REORDER, JOIN, COPY SELECTED NUCLIDES FROM AMPX WORKING INTERFACES

WAX (Working Library AJAX) is a module to combine data on AMPX working libraries. Options are provided to allow merging from any number of files in a manner that will allow the user to determine the final nuclide ordering, if desired. WAX is equivalent to the AJAX module, except that it deals with working libraries instead of master libraries.

3.WAX.1 WAX Input Data

Block 1.

−1$ Core Assignment [1]

1.NWORD – Number of words to allocate to WAX (50000)

0$ Logical Assignments [2]

1. MWT – Logical number of new library (default = 1)
2. NWAX – Not used

1$ Number of Files [1]

1. NFILE – Number of files from which data will be selected

T Terminate Block 1.

Blocks 2 and 3 are stacked, one after the other, NFILE times.

Block 2.

2$ File and Option Selection [2]

1. NF – Logical number of file considered
2. IOPT* = −N Delete N nuclides from NF to create the new file on MWT
   = 0 Add all nuclides to the new file on MWT
   = N Add N nuclides from NF to create the new file on MWT

T Terminate Block 2.

Block 3. (Enter only when IOPT≠0)

3$ Nuclides Selected [|IOPT|]

Identifiers of nuclides that are to be added or deleted from NF

4$ New Identifiers [|IOPT|]

---

*Sets with duplicate identifiers will not be entered on MWT. The first occurrence of an identifier selects that set for the new library.

This array allows changing the identifier given in the 3$ array when it is selected for the new library.

T Terminate Block 3.

3.WAX.2 WAX Input/Output Specifications

The following devices are typically needed to execute WAX:

Logical No.	Purpose
5	Card input
6	Standard output
15	Scratch device
16	Scratch device
18	Scratch device
19	Scratch device
MWT(1)	Working file to be created
NF	File(s) to be merged onto MWT

3.WINE — AMPX MODULE TO FORCE NORMALIZATION OF SELECTED PORTIONS OF AMPX WORKING LIBRARIES

WINE (WorkIng NormalizEr) is a module to manipulate data in an AMPX working library. The module can create new 1-D arrays in a working data set by algebraically summing existing 1-D arrays, replace data set titles, and change the data set identification numbers. WINE performs the specified 1-D manipulations on all data sets in the input working library.

The characteristics of an AMPX working library impose limitations to data manipulations. Because a working data set has a single 2-D transfer array that cannot be separated into components by reaction type, WINE includes no provisions for manipulating data in the 2-D array. Cross sections for a specific reaction may be a separate 1-D array and may also be included in the 2-D array. Consequently, the use of WINE to manipulate 1-D data for such reactions (and the corresponding manipulation of the 1-D total cross section) should be approached with caution because there is no way to manipulate the 2-D array.

3.WINE.1 WINE Input Data

Block 1.

−1$ Vector Commands [200] (Default = all zeros)

Simple "vector commands" are used to specify the 1-D data manipulations. A "vector command" is composed of a primary MT number, followed by one or more secondary MT numbers, and a zero that serves as a delimiter on the command string, that is,

Primary MT number—Secondary MT numbers—Zero.

A positive primary MT number says that the 1-D array to be created is an algebraic sum of the 1-D arrays identified by the secondary MT numbers. A negative primary MT number triggers the uniform normalization of the 1-D arrays identified by the secondary MT numbers such that they sum to the reaction cross sections identified by the absolute value of the primary MT number. A negative value for a secondary MT number is taken as a directive to subtract the process.

0$ Logical Unit Assignments and Core Assignment [3]

1. N1 – Logical unit number for existing working library (20)
2. N2 – Logical unit number for new working library (4)
3. NWORD – Number of words to allocate to WINE (50000)

1$ Option Trigger [1]

1. NTIT – Number of data set titles to be replaced (0)

T Terminate Block 1.

If NTIT is zero, the WINE input is complete; otherwise, enter NTIT data block 2's. Note that the data block 2's are used to change the identification numbers and/or titles of data sets in the working library.

Block 2.

2$ ID - Identification number of data set (on N1) [1]

3$ IDNEW - New identification number of the set. If the ID number is not to be changed, omit the 3$ array. [1]

4U Array - The new title card for the data set—(18A4) format. (Any time a data block 2 is entered, there must be a 4U array. If the objective is to only change the data set identification number, the old title card must be entered in the 4U array.) The alphanumeric data are entered as follows:
4U
(18A4)
-Title Card-

3.WINE.2 WINE Input/Output Specifications

WINE requires the following logical unit devices:

Logical No	Purpose
5	Standard input
6	Standard output
N1 (20)	Input working library
N2 (4)	Output working library
17	Scratch device
18	Scratch device

3.WISK — A MODULE TO CREATE A SENSITIVITY LIBRARY FROM AN AMPX MASTER INTERFACE

WISK (WorkIng Library Sensitivity Keys) is an AMPX module that takes an AMPX master interface and separates each process into a set of data on an AMPX working interface. Each process contains all the necessary cross-section information for cross-section sensitivity calculations. For applications requiring an ANISN-formatted library (as per NITAWL), the working library from WISK can be input to the CONTAC module, which makes the necessary format conversion.

The identifiers of the sets of data on the working library start at 1 and range to N, where N is the total number of unique processes for all nuclides found on the master interface. The structure of each set is standard and generally consists of the following:

1. The title record.
2. A record with a single vector of cross sections for the process identified by the proper ENDF MT number.
3. Records containing the transfer matrices for all orders required to represent the angular variation of the process. Note that these arrays contain any "multiplicity" of secondary particles [e.g., the $P_0(n,2n)$ matrix will sum to twice the $(n,2n)$ reaction values].

WISK constructs "total" sets for inelastic scattering, capture, fission, absorption, and total neutron cross sections. The structure is as above except that the fission, absorption, and total cross sections contain several vectors in the 1-D array. The fission set contains MT = 18, MT = 1018, and no transfer matrices, even though the absorption and total contain these processes, in addition to the absorption and total vectors, and can contain transfer matrices.

3.WISK.1 WISK Input Data

Block 1.

−1$ Core Allocation [1]
  1. ICORE - Number of words to allocate to WISK (100000)

1$ Logical Unit Assignments [2]
  1. MMT - Master library to be converted to sensitivity form (default = 1)
  2. MWT - Sensitivity library in working library format (default = 4)

6$ Direct Access Space Parameters [4]
  1. NBLK8 - Number of blocks to assign to logical unit 8 (350)
  2. LBLK8 - Length of blocks in words on logical unit 8 (500)
  3. NBLK9 - Number of blocks to assign to logical unit 9 (350)
  4. LBLK9 - Length of blocks in words on logical unit 9 (500)

T Terminate Block 1.

3.WISK.2 WISK Input/Output Specifications

WISK requires the following input/output devices:

Logical No.	Purpose
5	Card input
6	Standard output
8	Direct access scratch
9	Direct access scratch
17	Scratch device
18	Scratch device
MMT(1)	Mater library (read)
MWT(4)	Sensitivity library in working format (written)

3.WORKER — A MODULE TO CONVERT FROM AMPX MASTER FORMAT TO AMPX WORKING FORMAT

WORKER (WORKing Library MakER) is a module that will read nuclides from an AMPX master library and write them in an AMPX working library. As such, its capabilities are similar to those of NITAWL, which also allows Nordheim Integral Treatment calculations for nuclides with resonance parameters.

WORKER does not provide the resonance calculational option. It is primarily intended for use with those libraries that use Bondarenko methods for self-shielding and do not use the Nordheim method. In addition, it allows one to linearly interpolate within thermal-scattering matrices to obtain cross sections for intermediate temperatures. This temperature interpolation is only performed within the range of temperatures on the library. Requests for values outside the range will use the end sets.

3.WORKER.1 WORKER Input Data

Block 1.

−1$ Core Allocation [1]

1. ICORE – Number of words to allocate to WORKER (200000)

0$ Logical Assignments [2]
This array is input only if a user needs to modify default values (shown in parentheses).

1. N1 – Input master cross-section interface (1)
2. N2 – Output working cross-section interface (4)

1$ Integer Parameters [2]

1. MMT – Number of nuclides to read from the master cross-section library mounted on N1.
2. IPP – Output option trigger (-2)
   - −2 – no cross-section edits
   - −1 – edit reaction cross sections
   - > −1 – edit reaction cross sections and transfer arrays through order IPP

T Terminate Block 1.

Block 2.

2$ Identification Numbers of Nuclides to be Placed on the Working Library [MMT]
MMT identifications for nuclides from the master library on N1.

3$ Thermal Scattering Kernel Temperatures for Nuclides Selected (K) [MMT]

4$ MT Number of the Incoherent Thermal Scattering Kernel [MMT] (default = 1007)

T Terminate Block 2.

3.WORKER.2 WORKER Input/Output Specifications

WORKER typically requires the following I/O devices:

Logical No.	Purpose
NT1 (1)	Master cross-section library
NT4 (4)	New working library
NT5 (18)	Scratch unit
NT6 (19)	Scratch unit
NT7 (9)	Random access scratch unit
5	Card input
6	Printed output
97	Binary input

3.WORM — AMPX MODULE TO CONVERT AN AMPX WORKING LIBRARY TO AN AMPX MASTER LIBRARY

WORM (WORking to Master Converter) is an AMPX module to convert a binary AMPX working library into a binary AMPX master library. WORM works with any working library to produce a master library containing neutron and/or gamma and/or gamma-production information. In the case of the working library containing more than one of the above types of data, WORM automatically splits the transfer matrices such that all neutron data are carried together and identified by MT = 1, gamma production data are carried together and identified by MT = 1, and, likewise, gamma data are carried together and identified by MT = 501. One-dimensional (reaction averages) cross sections are carried on a process-by-process basis, exactly as in the master library. Only the "total" transfer matrices are available, since it is impossible to split out individual transfer processes, in a general manner, once they are added together to produce the working library.

3.WORM.1 WORM Input Data

Block 1.

−1$ Core Allocation [1]

1. ICORE - Number of words to allocate to WORM (50000)

0$ Logical Unit Assignments [2]

1. MMT - Master library is written on this logical unit (default = 1)
2. MWT - Working library is mounted on this logical unit (default = 4)

T Terminate Block 1.

3.WORM.2 WORM Input/Output Specifications

WORM requires the following I/O devices:

Logical No.	Purpose
5	Card input
6	Standard output
17	Scratch file
18	Scratch file
MMT(1)	Master file (written)
MWT(4)	Working file (read)

3.XLACS — MODULE TO PRODUCE GROUP-AVERAGED NEUTRON CROSS-SECTION LIBRARIES ON AN AMPX MASTER LIBRARY

XLACS-77 (EXtract a Library of Averaged Cross Sections) is the latest of the XLACS[1] series of programs and produces a multigroup library in the AMPX master library format by averaging point-neutron cross-section data taken from ENDF/B libraries.

XLACS-77 has several distinguishing features from its predecessors (through XLACS-II):

1. It is written in FORTRAN-77.
2. It makes use of the dynamic core allocations in AMPX which makes it easier to increase the sizes of working data arrays.
3. It contains a new thermal processing package taken from the Australian version of XLACS-II, which effectively circumvents processing problems of other versions of XLACS.
4. It does not produce data for older versions of NITAWL, thereby requiring NITAWL-II, a new and improved resonance processor.
5. It does not require external resonance processing to produce elastic scattering arrays that are used to produce elastic transfer matrices (internal schemes are provided which should perform this task as well or better than external processors).
6. It contains a new treatment[2] for generating elastic matrices for hydrogen.
7. The evaporation model processing procedures are new and much more accurate, general, and efficient than those from other versions of the program.
8. It allows for processing file 6 ENDF/B data (at present this treatment is limited to the thermal energy region).

Perhaps the most notable improvement in the new program is its increased accuracy that resulted from its use to generate cross sections for a 620-group processing codes comparison study. This led to many improvements, particularly in resonance parameter processing.

3.XLACS.1 XLACS-77 Input Data

As with earlier versions, the initial input to XLACS-77 consists of five title cards that are used to provide a title for its multigroup library.

Five Title Cards (80A1)

Block 1.

This data block is used to describe general data (such as the number of energy groups) for the problem.

0$ Major Logical Assignments [3]

1. NDFBFF - Primary source of regular ENDF/B data (default = 11)
2. NDFBTT - Not used

3. MASTER – Master library (default = 23)

1$ Major Problem Parameters [3]

1. NUMNUC – Number of nuclides processed by this run
2. NEGF – Total number of energy groups
3. NEGT – Number of thermal energy groups (These are the bottom groups and upscatter extends to the first of these.)

2$ Working Array Sizes [3]

1. MAXN1 – Maximum number of interpolation regions allowed in a TAB1 function (default = 50)
2. MAXN2 – Maximum number of points allowed in a TAB1 function (default = 5000)
3. MAXA – Number of words to allocate to XLACS (default = 150000)

3$$ Special Calculational Options [25]

1. IFORCE(1) – MLBW calculation option (0/1 – treat as specified/force MLBW even when SLBW is specified in the ENDF file) (default = 0)

.

.

.

.

25. IFORCE(25) – Not used

T Terminate Block 1.

Block 2.

This data block is given one time for a problem and contains the energy group boundaries. The "T" which ends this block must be specified, even when one of the default group structures is selected.

7* Energy Group Boundaries (NEGF + 1)

Specify the energy group boundaries in eV (high to low). If the group structure is a standard AMPX set, do not input the array. See Sect. 4.MISCELLANEOUS.4.1 for standard neutron group structures.

T Terminate Block 2.

The following two data blocks are to be repeated NUMNUC times.

Block 3.

This data block selects the ENDF/B materials and options to be used in producing multigroup cross sections.

Title Card for the Nuclide (18A4). This card must always be present and must always be the first card in block 3.

10$ Nuclide Selection and Identification [3]

1. ID19 – Identifier of the multigroup set of data on the master library.

2. MATF – ENDF/B material identifier for the data for fast and epithermal cross sections.
3. MATT – ENDF/B material identifier for thermal-scattering low data (or File 6 thermal data) to be used in the thermal range (This is specified as zero when free gas thermal values are desired.)

11$ Weighting Function Selection Parameters [4]

1. IWC – Weighting option
   - 0 – $\phi(E) = 1/E$
   - 1 – $\phi(E) = 1.0$
   - 2 – $\phi(E) \sim Ee^{E/kTMAX}$ $(E < EMAX)$
     - $\sim 1/E$ $(EMAX < E < EFISS)$
     - $\sim \sqrt{E}e^{-E/TFISS}$ $(EFISS < E < 10^7)$
     - $\sim 1/E$ $(10^7 < E)$

     where c and d are determined to make these functions join smoothly with the 1/E function and the other parameters can be specified in the 18* array.
   - 3 – Not used
   - 4 – $\phi(E)$ is input in the 20$ and 21* arrays
   - 5 – Not used
   - 6 – $\phi(E)$ is input on logical 46

   (Note: The JERGENS module is expected to be employed to form other special weighting functions, such as $1/E\sigma_T$.)
2. N1W – Number of points in the interpolation table of the arbitrary spectrum to be input as card images (this is only needed when IWC = 4).
3. N2W – Number of points in the arbitrary spectrum (this is only needed when IWC = 4).
4. MTW – The "MT" number of the weight function from logical 46 (this is only used when IWC = 6). Note that the weight function must have MAT = 8000 and MF = 3.

12$ Scattering Matrix Calculational Parameters [4]

1. NLF – The order of Legendre fit to be made to scattering matrices in the fast and epithermal energy ranges. This order is used for elastic scattering and discrete level inelastic scattering.
2. NLT – The order of Legendre fit to thermal-scattering matrices. This order is used, for example, with the free gas treatment or with thermal-scattering law data.
3. MMME – The number of angles to be used in the treatment that calculates elastic-scattering matrices. This parameter is automatically set and will be of no interest to most users.
4. MMMI – The number of angles to be used in calculating inelastic-scattering matrices. This parameter is automatically set and will be of no interest to most users.

13$ ENDF/B Data Libraries [5]

1. NDFBF – The logical unit of the file containing the ENDF/B data to be used in the epithermal and fast energy ranges (default = 11).
2. MODEF – The "mode" (1 for binary and 2 for BCD) of the files on logical NDFBF (default = 1).
3. NDFBT – The logical unit of the file containing the ENDF/B data (scattering law or File 6 data) to be used in the thermal energy range (default = 12).
4. MODET – The mode of the thermal data (default = 1).
5. NATOM – The number of atoms in the molecule when scattering law data are used (default = 1). In the case of H_2O and D_2O, the scattering law data are for H_2 and D_2, such that this should be input as 2.

14$ ENDF/B Versions [2]

1. IVERF – Version of the fast ENDF/B data from NDFBF (default = 5) XLACS-77 is presently only able to process versions 4 or 5.
2. IVERT – Version of the thermal ENDF/B data from NDFBT (default = 4)

15$ Thermal Kernel Count [1]

1. MTEMP – The number of temperatures at which thermal scattering matrices are to be calculated.

17$ Print Options [10]

The print options in XLACS-77 are generally in one-to-one correspondence with the particular ENDF/B "file" that is being processed. For example, File 2 is used for resonance data; option 2 controls the printing of various parameters related to resonance processing. As a rule, a higher value for a particular option also selects all the output generated by any lower number. For example, if a 3 specifies a certain kind of output, a 4 and any higher value also selects this output. In the following table, a 3 is the lowest value used to select output. Values 1 and 2 are reserved for output options of interests primarily for code-checking purposes and are not documented here.

1. I0PT1 – File 1 – Not used
2. I0PT2 - File 2 – 0 – No effect
   3 – Print the parameters written on the AMPX master interface
   10 – List the ENDF/B resonance data
3. I0PT3 – File 3 – 0 – No effect
   3 – List the averages for File 3
4. I0PT4 – File 4 – 0 – No effect
   3 – List P_0 scattering matrices for processes with File 4 data
   4 – List P_ℓ scattering matrices for processes with File 4 data
5. I0PT5 – File 5 – 0 – No effect
   3 – List scattering matrices derived from File 5 data
6. I0PT6 – File 6 – 0 – No effect
   3 – List P_0 scattering matrices derived from File 6 data
   4 – List P_ℓ scattering matrices derived from File 6 data

7. I0PT7 – File 7 – 0 – No effect
   3 – List P_0-scattering matrices derived from scattering law data <u>or</u> from the free-gas treatment
   4 – List P_ℓ matrices
8. I0PT8 – Not used
9. I0PT9 – Not used
10. I0PT10 – Weighting spectrum – 0 – No effect
    3 – List weighting spectrum

18* Weighting Spectrum and Other Floating-Point Parameters [10]

1. TMAX – The temperature of the Maxwellian spectrum (300 K)
2. EMAX – The upper energy limit on the Maxwellian spectrum (0.125 eV)
3. TFISS – The temperature of the fission spectrum (1.273×10^6 eV)
4. EFISS – The lower energy limit of the fission spectrum (67.4 keV)
5. SIGP – Not used
6. EFISSH – The upper limit of the fission spectrum (1×10^7 eV) (a 1/E spectrum is tacked on above this energy)
7. Not used
8. RFACT –The ratio factor used in constructing the cross-section mesh in the resolved range (0.8)
9. ANDEC – The number of points taken equally spaced in lethargy per decade in between resonance bodies (50)
10. XFACT – The multiple of Γ_t on either side of a resonance for which the ratio mesh scheme is used (50.0)

19$ Triggers to Control Processing of ENDF/B Files [25]

This array can be used to turn on or off the processing of the various ENDF/B files. It should not be used unless the user is very familiar with both the structure of an ENDF/B neutron cross-section library and the processing details of the XLACS module. There is one exception to this directive, as will be noted below. The reason for the precautionary notes just given is best evident when one realizes that it would make no sense to tell the code to process File 4 or File 5 ENDF/B data without telling the code to also process File 3 data (i.e., point data are required to be used with either angular or energy distribution data, etc.) In any event, the dimension of the array (25) is clearly more files than XLACS uses, is a tipoff that this is the code developer's array for testing various options, without requiring the program to always exercise every nuance of its capabilities. It is, unfortunately, required in order to process File 6 data into thermal scattering matrices. In this case, the code user will want to "turn off" the regular File 7 scattering law processing and to "turn on" the File 6 processing. This will require a 19$ array specified as follows:

```
19$$  6R1  0  E
```

which says to process the first 6 ENDF/B files and ignore the 7th.

T Terminate Block 3.

Block 4. {Required only when MTEMP > 0 or when IW = 4}

20$ Interpolation Table for Arbitrary Weighting Function [N1W*2]

($NBTW_i$, $JNTW_i$, i = 1, N1W)

where $NBTW_i$ is the energy point up to which the ith interpolation type is to be used and $JNTW_i$ is the interpolation type:

JNTW	Interpolation
1	Histogram
2	Linear x – linear y
3	Linear x – log y
4	Log x – linear y
5	Log x – log y

21* Arbitrary Weighting Function [N2W*2]

(X_i, Y_i, i = 1, N2W),

where these energy-value pairs specify the arbitrary weighting function.

22* Temperatures at Which to Calculate Thermal Scattering Matrices [MTEMP]

(T_i, i = 1, MTEMP) – units are Kelvin

T Terminate Block 4.

3.XLACS.2 XLACS-77 Input/Output Specifications

An XLACS-77 execution will generally require some combination of the following I/O devices:

Logical No.	Purpose
5	Standard input
6	Standard output
14	Scratch device
15	Scratch device
16	Scratch device
17	Scratch device
18	Scratch device
NDFBF(11)	ENDF/B library (fast data)
NDFBT(12)	ENDF/B library (thermal data)
MASTER(23)	AMPX master library produced by XLACS-77
46	Weighting function library
47	Built-in group structures

3.XLACS.3 XLACS-77 Error Message

During execution, XLACS-77 makes many checks to determine if a calculation is proceeding correctly. If difficulties are encountered, a message is printed, and the problem may be terminated. Some of the messages are printed by the routine where they are detected; others are "numbered" messages from the error subroutines, ERROR.

There are several places in the module wherein checks are made in order to determine if enough core is available to perform a procedure. As a general rule, a "header" line telling what file is being processed will be produced, and, in the case where there is insufficient core, a message will be issued in the form:

"INADEQUATE SPACE AVAILABLE—NEED ________ WORDS—
HAVE ________"

In this case, the user should check his input for obvious errors (too many groups, etc.), and either correct any errors or allocate more space and resubmit. The places where checks are made are

FILE6 - Main File 6 processing routine,
FLANGE - Thermal processing,
INELAS - File 5 processing,
MAIN - Overall control routine, and
XLACS - Primary control routine.

Another error message that can originate from several places is that caused by a bad interpolation parameter. Except for the case where the user inputs a bad specification in an arbitrary weighting function or on a library input to XLACS-77, which was improperly prepared in an auxiliary module, these are usually due to program problems having to do with the particular problem. In the event these messages occur, if a review of the user's input fails to locate problems, personnel responsible for this software should be contacted. Interpolation problems are generally well described and will be flagged by the following routines:

ECSI - Integration module
GRATE - Integration module
KERC (error 232) - $S_{\alpha,\beta}$ processing
KERC2 (error 232) - $S_{\alpha,\beta}$ processing
PROF7 (error 230) - $S_{\alpha,\beta}$ processing
TERPN - Interpolation routine
TERPO - Interpolation routine
TERP1 (error 133) - Interpolation routine
XTWO - Production of free-atom scattering matrices for hydrogen

In another error related to interpolation, a message is produced that indicates that a negative or zero value has been improperly used with a scheme which requires taking the log of the value. This requires the same attention as with the previous error. This error may be written by TERP1 as error 134 or by XTWO.

Both of the above errors can arise when the interpolation table for a function is incomplete (e.g., when interpolation specifications are not given for all energy points).

Another type of error involves the detection of an improper record sequence in the input file. Even though this certainly can arise from a bad ENDF library, it is more commonly due to a coding problem. Keep in mind that the ENDF/B formats are very general, such that all combinations of options and situations have not been (and may never be) used. When these errors occur, the user is generally stuck with notifying the personnel responsible for XLACS-77.

Examples of these error messages are given below.

A routine named CONT is used to read various "control" records on ENDF/B. It may write the following line:

TPID RECORD IS INCORRECT OR MISSING,

indicating that the "tape identification" record on the ENDF/B library is not correct. This may be due to the user referencing a file that is not an ENDF library or which is in improper mode (BCD when a binary library was designated, for example).

It will also issue messages exactly as above, except with the record type HEAD, SEND, FEND, MEND, or TEND, indicating errors in trying to read a head, section end, file end, material end, or tape end record, respectively.

The primary routine for processing File 3 data is called FILE3 and produces an error message if it does not find a proper file end record for File 2:

LIBRARY POSITIONING ERROR AT THE END OF FILE2

This message probably indicates problems in the resonance processing routines.

Some processing routines use a routine, RDENDF, to read ENDF/B records. This routine produces messages of the form:

TAPE POSITIONING ERROR—WANTED MAT=_____—AT MAT=_____

or the same sort of line for MF or MT, indicating a record for the wrong material, file, or process, respectively, has been read.

Another error that can occur arises when a particular kind of data cannot be found. In some cases, it is due to referring to the wrong ENDF/B library, or simply because the data are not on the file. In some cases, it is of no consequence, because the processing code can take alternative action or ignore the fact that it doesn't exist.

When one requests thermal scattering matrices and $S_{\alpha,\beta}$ data are requested, if the data are not found, messages are written by PROF7. If it is found, FLINK1 tries to find File 3 thermal data. A message is produced if it is not present, but the execution continues, expecting the requisite values to have been produced when the fast data were processed.

If data for a nuclide cannot be found, TMAT produces a message:

DESIRED MATERIAL NUMBER _____ IS NOT ON TAPE OR IS OUT OF ORDER. TAPE HAS BEEN SEARCHED TO MATERIAL NUMBER _____

In this case, the user should determine if the material really should be on the library that is referred to in the input.

In some cases, the routine, TPOS, may produce a message indicating the data for a nuclide has been read to its end without finding the necessary data:

DATA FOR MATERIAL _____ EXHAUSTED WHILE SEARCHING FOR
MF= _____, MT= _____

A nonfatal TPOS error message is of the form:

NO MF= _____ DATA FOR MAT= _____, MT= _____, LIBRARY
POSITIONED AT MAT= _____, MF= _____, MT= _____

This message generally just indicates the data are not present, such that no action is necessary.

A message from TMF1,

ERROR LNU = __ BUT MUST BE 1 OR 2,

indicates the ENDF/B evaluation is improper as this parameter, showing how ν(E) is presented, is improper. Processing may be adequate, however, if values for ν(E) are not needed in the particular application.

If the REATS routine produces error message 224, it probably indicates the temperature dependence of the $S_{\alpha,\beta}$ data was improperly described. If it writes

ALPHA VALUE EXPECTED = _____, ACTUAL = _____

it also indicates inconsistencies in the evaluation. Because these may be of little consequence, ten of these errors are allowed before the program aborts.

If the user asks for $S_{\alpha,\beta}$ data to be processed outside the range it is specified, REATS issues ERROR 223. The user should correct his request and resubmit.

Also in thermal processing, PROF7 may issue ERROR 231 which says the mass ratio is zero. This is a probable error in the data evaluation. It may also write out a message

FREE ATOM CROSS SECTION = 0.0
IT IS RESET TO 1.0,

and continue processing, indicating a problem in the evaluation or problem set-up. (The library produced from this run can be properly adjusted, when a good value for the free-atom value is determined, using the FRESH module, which is not part of this release.)

If the TMF5 routine writes

FILE 5 PROCESSING NO LONGER ALLOWED FOR LF = _____

it indicates the data evaluator has improperly used an archaic data form, or that the user is trying to process data earlier than Version 4.

Another message that sometimes is written by the MASH routine when it processes SLBW or MLBW resonance parameters is

SPACING PARAMETER ADJUSTMENT—MESH = _____, EO = _____,
R = _____, S = _____,

indicating a problem in assigning enough core for cross-section arrays for resonance processing. In most cases, this message will be of little consequence unless it is issued several times for a resonance, which means that resonance may have a poor energy mesh. Increasing the core allocated for the job will automatically increase the space that can be assigned.

3.XLACS.4 XLACS-77 Procedures

XLACS-77 is a fairly complicated program involving many steps and procedures. Several persons have noted the lack of any detailed documentation on the code. Certainly it should be thoroughly documented, and will be, provided adequate funding and time are made available. In the interim, it is hoped that this section will serve to at least describe in a macroscopic sense what data are processed, where they are processed, and how they communicate with each other. In parallel with how the data are presented on ENDF/B, the subsections will be named according to the ENDF/B file.

3.XLACS.4.1 File 1 processing

File 1 is primarily information that describes an evaluation. The only data in the file processed by XLACS are the three $\bar{\nu}$'s:

1. MT = 452, total $\bar{\nu}$
2. MT = 455, $\bar{\nu}$ for delayed neutrons
3. MT = 456, $\bar{\nu}$ for prompt neutrons

These data may be tabulated or given in a parameterized fit. In the latter case, XLACS constructs a 50-point mesh equally spaced in lethargy from 10^{-5} to 2×10^7 eV. The values for the three functions are written to scratch unit ITP4 for later processing with File 3 data by the FILE3 routine.

3.XLACS.4.2 File 2 processing

The processing of File 2 data is controlled by RESN, which starts by calling TMF2 to read all of the resonance data into core. This includes both resolved and unresolved data for one or more isotopes. These data are indexed into "blocks," with a block consisting of a particular kind of data for an individual isotope (e.g., the unresolved data for an isotope or the Adler-Adler, etc.). These blocks will later be processed in a manner completely independent of each other, which means one can accommodate multiple representations for data—Adler-Adler, SLBW, MLBW, etc.—and can have overlapping energy ranges, if these are necessary for the evaluation.

Optionally, EDF2 is called to produce a listing of all the resonance parameter data.

The primary control of the resonance calculations is by RESN1, which is called next. RESN1 is blocked into sections, which call a calculational routine for the type of data in a block.

In the case of SLBW or MLBW parameters, the RESS and RESR routines are called; RESS, for absorption and fission processing, and RESR, for elastic scattering.

In RESS, it is recognized that the sum of averages is the average of sums and that the absorption cross sections of Breit-Wigner resonance fits are independent of each other. This allows one to take each resonance and construct an energy mesh over the entire resonance range for the single resonance, calculate the cross section using the VOGAM routine that is based on ψ and χ techniques for Doppler broadening, and then average the resonance pieces into the group structure. The energy mesh itself is constructed using the following schemes:

1. Inside the range $E_0 \pm 4\Gamma_t$ a mesh is constructed such that the ratio of cross-section values is 0.92, except at low energies for very broad resonances ($\frac{\Gamma_t}{E_0} > 0.075$) where the ratio is taken at 0.999. The ratio scheme is described below.
2. In the two surrounding regions, out to $E_0 \pm 300\Gamma_t$, the ratio scheme uses 0.9 (or 0.98 for broad resonances).
3. In the regions outside this, a mesh equally spaced in lethargy with 200 points per energy decade is used.

The ratio scheme is simple and is based on solving the $1/(1+x^2)$ SLBW shape, where $x \equiv (E - E_0)/2\Gamma_t$, for the energy points. This quadratic equation has two solutions, one applicable above E_0 and the other below.

There is nothing elegant about these methods to establish a resonance mesh. Rather, they have developed over the years in response to practical observations on real problems. In most cases, they probably assign more points than necessary to yield resonance fits that are generally more accurate than 1%. While there are more correct and efficient schemes that have been developed, these generally require considerably more computer time because of extra points that are calculated to ensure an adequate mesh.

Two special integration routines are used in RESS, XTWO, and JTWO: (1) the former for averaging cross sections over the problem-weighting spectrum and (2) the latter to produce reference infinite dilution values that are needed by the NITAWL-II formulation of the Nordheim integral treatment.

Elastic-scattering processing for Breit-Wigner resonances is handled by RESR. This routine takes all the resonances for a single ℓ-state of a single isotope and calls a routine called SMESH to determine an energy mesh over the resolved energy range, after which it calculates the cross sections, using VOGAM for Doppler-broadening. Routines ATWO and BTWO are called for averaging the cross sections, ATWO corresponding to XTWO discussed earlier and BTWO for JTWO. The point-elastic cross sections are also written to scratch unit, ITP2, for later processing by RESA for averaging the data and X2D to make elastic transfer matrices. SMESH uses the ratio scheme for resonances within $E_0 \pm \Gamma_t$ where the ratio is 0.8 and uses a lethargy spacing of the ℓn of 0.1 divided by 50 outside this region. In cases where the scheme generates more points than can be accommodated by the space assigned, RESR calculates cross sections for a string, determines a new mesh above the old mesh, calculates more, etc., until the entire resonance range is covered.

For Adler-Adler parameters, routine ADLER calls SMESHA to perform an analogous function to SMESH, except that in this case both absorption and scattering processes are calculated. ATWO and BTWO are used as in RESR. Multiple strings may be written to ITP2. Doppler-broadening uses VOGAM.

For unresolved resonance data, RESU is called to control the calculation. It calls RESN1 to determine an energy mesh over which to calculate cross sections. If the parameters are given as a function of energy, the mesh is the same as that of the parameters, consistent with the directives for processing the data in the ENDF/B procedures manual. When the parameters are constant, an equal lethargy spacing of 100 points over the unresolved resonance range is taken. Subsequently, the RESU2 routine is called to calculate cross sections. As with previous routines, ATWO and BTWO are used to produce averaged data. Point values are written to logical ITP2 for later processing by the X2D routine to make elastic-scattering transfer matrices.

Next, RESD is called to select the resonance parameters to be passed for processing by the NITAWL-II module. At present, this means all $\ell = 0$ resonances whose energies are positive. These data are written to scratch unit IO8.

3.XLACS.4.3 File 3 processing

File 3 processing is relatively straightforward and consists of reading the data from File 3 and performing one of the following operations:

1. All processes with MTs between 2 and 50 and 101 to 900.

   ATWO is called to average the data over the selected weighting spectrum. BTWO is also called for MT = 2, 18, and 102 to produce infinite dilution averages.
2. Processes that generate scattering matrices (MT = 2, 6, 7, 8, 9, 16, 17 51–91) have their cross sections written to logical ITP2 for later processing.
3. Process MT = 1 and those with MT > 900 are ignored.
4. A special section is included for averaging the 3 ν's. This parameter is passed to FILE3 on logical ITP1.

The proper weighting of ν, the number of neutrons produced per fission, requires that it be weighted over $\sigma_f \phi$, not ϕ like most other cross sections. When the fission cross section (MT = 18) is read, logical ITP1 is also read to access the ν functions. The routine ATWO is called to obtain the integral of the product of the fission cross section times the flux, which is subsequently to be divided by the integral of the flux to produce the averaged fission cross section. ATHREE is called to obtain the integral of the product of ν times σ_f times ϕ, and this is divided by the result from ATWO to produce $\bar{\nu}_g$.

3.XLACS.4.4 File 4 processing

The processing of this file is used to produce transfer matrices for elastic scattering (MT = 2) and for discrete level inelastic scattering (MT = 51–90). It is also used for the special "n2n" processes (MT = 6–9) for ^{9}Be. In these cases the distribution of the angles a neutron will scatter through at a particular source energy is given in the ENDF/B file, either tabulated in angles or as a Legendre fit in angles. These representations are generally in the center-of-mass system (CM), though the laboratory system may be used. In all cases, the kinematics deals with conserving energy and momentum and is such that, when an initial energy and scattering angle is specified, there is only one possible energy at which the neutron can emerge from the collision.

These calculations are all controlled by X2D, which reads the data on ITP2, after which it calls TMG4 and TMH4 to try to find any File 4 data that may be present on the ENDF/B file. GDDD is then called which generates $\sigma_s(E, \mu_m)$ (i.e., the differential scattering cross section for the process at a set of angles in the laboratory system). The angles are predetermined by calling ANGL, which has all even-ordered Lobatto quadratures up through order 96. GDDD may have to use tabulated data or Legendre fits to determine data and may have to convert from the CM system to the laboratory system.

The angles picked are in Lobatto quadrature schemes which are Gaussian quadrature sets that force one to always pick the $\mu = -1.0$ and $+1.0$ angles for inclusion in the set. These sets are built into XLACS through order 96 and have the very nice property that, if the functional to be integrated is a polynomial of order $2n - 1$, or less, where n is the number of angles taken, then the integration is exact.

The subroutine XFER is called which uses the differential cross sections at each angle in the quadrature to generate transfer matrices for the angle. These are subsequently summed to produce a "total" transfer matrix for the process (level). This summing is performed in the subroutine called DRUG.

The procedure used in XFER is particularly simple. The expression to be evaluated is

$$\sigma_\ell(g \rightarrow g') = \frac{\frac{1}{2\ell+1} \int_{-1}^{1} d\mu P_\ell(\mu) \int_g dE \sigma_s(E, \mu) \phi(E) \int_{g'} dE' f(E \rightarrow E', \mu)}{\int_g dE \phi(E)} ,$$

where for the discrete processes the "transfer" function, $f(E \rightarrow E', \mu)$, is a δ function, $\delta(E \rightarrow E', \mu)$.

First we choose to perform the angular integral using a simple quadrature that is based on the angles and weights for the Lobatto quadratures mentioned above. This reduces our integral:

$$\sigma_\ell(g \rightarrow g') = \frac{1}{2\ell H} \frac{\sum_{m=1}^{MM} W_m P_\ell(\mu_m) \int_g dE \sigma_s(E, \mu_m) \phi(E) \int_{g'} dE' \delta(E \rightarrow E', \mu_m)}{\int_g dE \phi(E)} .$$

The averaged cross section for scattering through an angle whose cosine is μ_m is

$$\sigma(g \rightarrow g', \mu_m) = \frac{\int_g dE \sigma_s(E, \mu_m) \phi(E) \int_{g'} dE' \delta(E \rightarrow E', \mu_m)}{\int_g dE \phi(E)} ,$$

such that

$$\sigma_\ell(g \rightarrow g') = \frac{1}{2\ell + 1} \sum_{m=1}^{MM} W_m P_\ell(\mu_m) \sigma(g \rightarrow g', \mu_m) .$$

If we examine the expression for $\sigma(g \rightarrow g', \mu_m)$, it is immediately apparent that what the δ function does is to delimit a region out of group g which can scatter to group $g\prime$ for the angle, μ_m. Since the integral over a δ function is unity by definition, we need merely to use the δ function to determine the appropriate part of g and make the integration:

$$\sigma(g \rightarrow g\prime, \mu_m) \;=\; \frac{\int_{E_L(g\rightarrow g\prime,\mu_m)}^{E_H(g\rightarrow g\prime,\mu_m)} dE\sigma(E,\mu_m)\phi(E)}{\int_g dE\phi(E)} \;.$$

This is precisely what is programmed in XFER. A closer examination of the procedure will note that all required integrations are very simple, that the computer time requirements vary linearly with the number of energy groups, that it can accommodate any process wherein the differential behavior is characterized by a δ function.

There are two areas, however, where this simple procedure produces disturbing, though probably usable, results. These are related and are (1) for very light nuclides, such as hydrogen, and (2) for very fine group structures.

Both of these situations will frequently miss many transfer cross sections for practical angular quadratures (say 8 to 50 angles). However, though the individual transfers are missed, the procedure does account for them by putting their contributions into the closest transfers that the procedure does "see." This effect is not observed by other methods which calculate group-to-group values because they, in essence, take each transfer and use the δ function to explicitly determine necessary integration limits, etc.

In summary, the above procedure has been successfully employed to produce multigroup libraries here at Oak Ridge. It is not only much faster and simpler than most alternative approaches, yielding results that almost always seem to fall within the accuracy limits of those approaches, but it has a very interesting possible new application. Several people have experimented with schemes that avoid Legendre fits to cross sections. This approach calculates the transfer matrices needed by many of these schemes (i.e., the group-to-group terms for scattering through a particular angle) and does that essentially without approximation.

After the summing is complete over all angles, CMPR is called to compress out zero and impossible values. The final matrices are written to scratch unit IO8.

Hydrogen is treated as a special case in File 4 processing. First, it is recognized that elastic scattering in hydrogen is isotropic in the CM except at energies in the MeV range. Because of this, it is elected to ignore the File 4 data and to call SIGH, which performs an analytic calculation to determine the scattering matrices. The treatment accounts for the energy variation in both the cross section and flux as opposed to earlier analytic treatments in XLACS, which assumed the flux was 1/E and that the cross section had a very smooth variation.

Given these assumptions, a routine called XTWO, which calls XSMUD, which calls XBEAX and XEALNC in some cases, is used to perform the integrations. Subroutines DRUG and CMPR are used, as described above, except that there is no requirement to sum over angles.

3.XLACS.4.5 File 5 processing

In cases where the inelastic levels are so closely spaced that they cannot be resolved, the secondary energy distribution of neutrons may be expressed in terms of a smooth distribution as a function of scattering energy. Note that a situation of this sort always implies a large number of levels and will generally ignore any angular variation in the scattering (i.e., the scattering is assumed isotropic in the laboratory system).

Subroutine INELAS controls the generation of scattering matrices for these processes. The data on ITP2 are read, and those which have File 5 data are processed.

The routine called TMF5 is called to read File 5 data.

File 5 processing makes use of an observation which greatly simplifies the problem (viz., that the Cartesian interpolation schemes in ENDF/B allow one to perform the integrations over its distributions in any order). The basic problem is stated as follows:

$$\sigma(g \rightarrow g\prime) = \frac{\int_g dE\ \phi(E)\sigma(E)\rho(E) \int_{g\prime} dE' f(E \rightarrow E')}{\int_g dE \phi(E)} \ ,$$

where $\sigma(g \rightarrow g\prime)$ is the group-to-group scattering term, $\phi(E)$ is the weighting flux, $\sigma(E)$ is the cross section, $\rho(E)$ is an ENDF/B option which allows the evaluator to include multiple distributions for describing the scattering, and $f(E \rightarrow E')$ is any one of the distributions defined in File 5.

It is recognized that one can simplify the above equation by integrating the File 5 function over the secondary group structure and using these, which are now like "vectors" that vary as a function of initial energy, in the final calculation:

$$\sigma(g \rightarrow g\prime) = \frac{\int_g dE \phi(E)\sigma(E)\rho(E)F(E \rightarrow g\prime)}{\int_g dE \phi(E)} \ .$$

To further simplify the processing, it is recognized that $F(E \rightarrow g\prime)$ is linear in E per the recommendations of ENDF/B specifications, and that it is a smoothly varying function in an energy mesh which is taken as the union of energy points in $F(E \rightarrow g\prime)$ and the problem group structure.

If we look at the ith panel in the mesh, which is inside the two panel energy boundaries E_a and E_b,

$$F(E_a \rightarrow g\prime) \qquad\qquad\qquad\qquad\qquad F(E_b \rightarrow g\prime)$$

$$E_a \qquad\qquad\qquad E_i \qquad\qquad E_{i+1} \qquad\qquad E_b \ ,$$

and we note that since the group boundaries are always part of the mesh, the panel i must be totally contained in some group, g, then the contribution for the panel for the group g can be written as

$$\sigma(i \epsilon g \rightarrow g\prime) = \frac{\int_g dE \phi(E)\sigma(E)\rho(E)\overline{F}(i \rightarrow g\prime)}{\int_g dE \phi(E)} \ ,$$

where $\overline{F}(i \rightarrow g\prime)$ is the simple arithmetic average of $F(E \rightarrow g\prime)$ over the ith panel:

$$\overline{F}(i \rightarrow g\prime) = \frac{\int_i dE\ F(E \rightarrow g\prime)}{E_{ith} - E_i} \ ,$$

where

$$F(E \rightarrow g\prime) = F(E_a \rightarrow g\prime) + \frac{E - E_a}{E_b - E_a}\ [F(E_b \rightarrow g\prime) - F(E_a \rightarrow g\prime)] \ .$$

When all substitutions are made, and the integration is performed,

$$\begin{aligned}\overline{F}(i \rightarrow g\prime) &= F(E_a \rightarrow g\prime)\left[1 - \frac{E_{i+1} + E_i}{2(E_b - E_a)} + \frac{E_a}{E_b - E_a}\right] \\ &+ F(E_b \rightarrow g\prime)\left[\frac{E_{i+1} + E_i}{2(E_b - E_a)} - \frac{E_a}{E_b - E_a}\right] \\ &\equiv F(E_a \rightarrow g\prime)\ W_{ia} + F(E_b \rightarrow g\prime) W_{ib}\end{aligned} \ .$$

Note that since $F(E_a \rightarrow g\prime)$ and $F(E_b \rightarrow g\prime)$ sum to 1, and since $\overline{F}(i \rightarrow g\prime)$ must sum to 1, the sum of W_{ia} and W_{ib} will always sum to 1.

INELAS is the control routine for generating cross sections with the above procedure. As with the X2D procedure, an "outer" loop in the code reads cross sections from logical ITP2. As each process is read, a call is made to TMF5 to determine if evaporation data are present and, if they are, to read the data. Processes with no data are skipped.

The next consideration is to obtain tabulated distributions. When the data are presented in tabular form, it will be used directly. Otherwise, MLF1 is called, which determines an energy mesh equally spaced in lethargy over the possible range of values prescribed in the $\rho(E)$ array. After this, INT5 is called, which takes each of the tabular distributions and integrates them to produce the $F(E \rightarrow g\prime)$ functions.

Next, SETPAN is called to determine the panel energy mesh and to set arrays that set the energy group for the panel and the weights (W_{ia} and W_{ib}) to be used with the panel.

Next, IMAT1 is called, which has an outside loop that reads in each of the $F(E \rightarrow g\prime)$ vectors. For each of these, another loop is made over the panels determined by SETPAN. For the panels marked to use the particular $F(E \rightarrow g\prime)$, the code then calls ATHREE to integrate the product of σ times ϕ times ρ. This product is multiplied by each of the $F(E \rightarrow g\prime)$ times the weight determined in SETPAN and put into the transfer matrix for the process. After the processing is complete, CMPR is called to compress out zero and impossible transfer terms, after which the scattering matrix is written to logical IO8.

The fission cross section (MT = 18) receives a special treatment. In this case, a transfer matrix for fission is generated as described above. The terms in the matrix are then multiplied by $\bar{\nu}$ to create a fission neutron scattering matrix in a routine called CHIMAT. This matrix is output on logical IO8 in two parts, each identified with MT = 1452. This splitting is done to reduce the size of the arrays, because fission generally requires a matrix dimensioned by the number of groups squared. A routine called CHI is also called to produce the χ function required by most analysis codes which assumes that the neutrons produced by fission are not a function of energy. For this function, the full transfer matrix is used and $\chi(g \rightarrow g')$ is weighted over the product of ν times σ_f times ϕ, as should be done.

3.XLACS.4.6 File 6 processing

In XLACS-77, at present, the processing of File 6 data is strictly limited to several in-house sets of specialized thermal-scattering data which use this presentation form, though it could be easily modified to handle other situations. File 6 is not used in any of the standard ENDF/B evaluations for Version 5 and earlier.

The procedure to process these data closely parallels that for processing File 5 data and makes use of the same observation that the order of the integrations can be taken in any order. The equation to be processed is

$$\sigma_\ell(g \rightarrow g') = \frac{\frac{1}{2\ell+1} \int_{-1}^{1} d\mu P_\ell(\mu) \int_g dE \sigma_s(E) \phi(E) \int_{g'} dE' \, f(E \rightarrow E', \mu)}{\int_g dE \phi(E)} .$$

The tabular function $f(E \rightarrow E', \mu)$ is given as a series of tabulations at discrete values of initial energy, E, and cosine angle, μ.

If we note that the variation of the tabulations is linear in cosine of angle and use the same procedure for initial energy as was used for File 5 data, the above equation simplifies to

$$\sigma_\ell(g \rightarrow g') = \frac{\frac{1}{2\ell+1} \sum_{m=1}^{M} W_{\ell m} \sum_{i \epsilon g} W_i \bar{F}_i(i \rightarrow g') \int_g dE \sigma_s(E) \phi(E)}{\int_g dE \phi(E)} ,$$

where, as before, the W_i are the "weights" associated with panels in group g, and $W_{\ell m}$ is determined by integrating the product of a linear function times a Legendre polynomial of order ℓ

$$f(\mu) = f_m + \frac{\mu - \mu_m}{\mu_{m+1} - \mu_m} \left(f_{m+1} - f_m \right) .$$

If we integrate this variation times the Legendre polynominal for all intervals in the angular mesh, a point m will contribute to two panels. The terms for the two panels are combined to form the $W_{\ell m}$ for the various orders.

FILE6 uses TMF6 to read the File 6 data. As the panels are read, they are integrated over the secondary energy into the problem group structure and are then written onto direct-access File N9, where they can be randomly accessed based on indexing by the angle and the particular source energy.

WT6 is called to calculate the $W_{\ell m}$ discussed above, after which SETPAN is called to calculate the W_i using exactly the same procedures as used with File 5 data.

Following this, IMAT6 is called to perform the final calculation. The outer loop in this case is over the order of the matrix to be calculated. Inside this is a loop over the angles in the tabulation. Inside this is a loop over the source energies, and on the inside of this is a loop over the "panels" in a group. The parameters set in SETPAN specify the energy range for the integration and the group to which a panel belongs. Using these, ATWO is called to calculate

$$\int_{\text{panel}} dE\ \sigma_s(E)\phi(E)\ ,$$

which is, in turn, multiplied by $W_{\ell m}$ and W_i and then by $\overline{F}_i \rightarrow g$ to sum into the transfer matrix.

After all panels are processed, CMPR is called to compress the scattering matrix, which is then written to logical unit IO8.

3.XLACS.4.7 File 7 processing

The processing of File 7 involves using a procedure developed by Mr. G. S. Robinson of the Australian Atomic Energy Commission which he graciously supplied to us.

Mr. Robinson noted glaring deficiencies for many cases arising from using the original procedures in XLACS-II. His new procedure is essentially a total rewrite of the schemes used in the original program and, based on our experiences in using it, is significantly more accurate, while requiring much less computer time.

This calculation is controlled by a routine named FLANGE.

FLANGE starts by calling FLINK1, which tries to access any File 3 and File 4 data supplied with the thermal file for describing the coherent scattering data. If present, these are averaged and are introduced to the within-group scattering terms of the thermal-scattering matrices, based on the assumption that the coherent scattering is that form arising from lattice coupling of the atoms in such a manner as to make them appear to the neutron as an atom with a very large mass.

Next, MESH is called to determine an energy mesh over which the differential scattering cross sections will be calculated.

PROF7 is then called to control the processing of the $S_{\alpha,\beta}$ data in File 7. For nuclides (most nuclides) which don't have these data, PROF7 calls routines that generate $S_{\alpha,\beta}$ data consistent with a free-gas thermal-scattering treatment.

When $S_{\alpha,\beta}$ data are present, PROF7 calls REATS to read these data. A routine named FENT controls the computation of scattering kernels and cross sections. For the case where no $S_{\alpha,\beta}$ data are given, FENA is the controlling module.

FENT calls KERC and KERC2 to calculate differential cross sections, $\sigma(E \rightarrow E', T)$, from $S_{\alpha,\beta}$ data. These are stored in a packed-core array using a routine named STORK.

Both KERC and KERC2 call a variety of routines (GNCRA, GNCRB, CLAM, KERAS) for performing the necessary transformations, moment fits, etc.

FENA makes extensive use of a routine called KERA for calculating free-gas differential-scattering cross sections. As with FENT, STORK is called to stuff these into a packed-core array.

After all differential data are calculated, REKON is called to read the data back from the packed-core array (using STORK) and to form the final scattering matrices. These are compressed using CMPS and are written to logical unit IO8.

3.XLACS.4.8 Collecting data for the AMPX master interface

At the end of the loop over nuclides in the XLACS routine, there is a call to REC4, whose function is to read all the information from logical unit IO8 and to reassemble it into the formats needed on the master interface written on logical unit ITXN. Optionally, routines such as PRT1D and MWLS may be called to produce edits of the data as they are collected.

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3.XSDRNPM — MODULE WITH ONE-DIMENSIONAL S_n CAPABILITY FOR SPATIAL WEIGHTING

The XSDRNPM (X-Section Dynamics for Reactor Nucleonics with Petrie Modifications) module is provided in AMPX for two purposes:

1. to provide a 1-D transport calculation capability for calculating reaction rates, eigenvalues, and critical dimensions, and
2. to allow spatial cross-section weighting to be performed.

XSDRNPM* differs from its predecessor XSDRN,[1] in several important respects.

- It will do coupled neutron-gamma calculations.
- It allows any mixture to be represented to an arbitrary order of anisotropic representation.
- It will do an adjoint calculation.
- The resonance calculation is removed and is provided in AMPX in the NITAWL module.
- It employs improved thermal flux scaling techniques for better problem convergence.
- Input specifications have been reordered, and more defaults have been provided to make the use of this module easier.
- It will calculate S_n constants for any even order for any of the 3 1-D geometries available.
- Mixture-dependent fission spectra are calculated and used in XSDRNPM, which takes into account all fissionable nuclides in a problem.

The collapsed cross sections from XSDRNPM are written as an AMPX-weighted library on logical 3 which can be used directly by the module to do transport calculations (an AMPX-weighted library uses the same format as a working library). They can also be output on cards or in a binary format suitable for the ANISN, DOT, or MORSE codes.

3.XSDRNPM.1 Cross-Section Weighting Options

XSDRNPM weights cross sections according to the following four options:

1. "cell" weighting
2. "zone" weighting
3. "region" or "vein" weighting
4. "inner-cell" weighting

In all cases, the "averaged" cross sections are defined in a manner that conserves reaction rates, that is,

$$\bar{\sigma}_G \int_{\text{Space}} \overrightarrow{dr} N_D(\vec{r}) \int_G dE \psi(E,\vec{r}) = \int_{\text{Space}} \overrightarrow{dr} N(\vec{r}) \int_G dE \sigma(E,\vec{r}), \psi(E,\vec{r}) \; , \quad (1)$$

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*XSDRN with Petrie Modifications. The original acronym for XSDRN was suggested by W. A. Rhoades.

where

$\bar{\sigma}_G$ ≡ average cross section in group G,
$N_D(\vec{r})$ ≡ number density used in the definition for the weighting option selected,
$\psi(E,\vec{r})$ ≡ weighting spectrum
$N(\vec{r})$ ≡ real number density as a function of spatial position,
$\sigma(E,\vec{r})$ ≡ cross section in unreduced form.

If we convert to multigroup notation and use W for the weighting spectrum (instead of ψ), Eq. (1) becomes

$$\bar{\sigma}_G \sum_{j}^{\substack{applicable\\spatial\\regions}} N_D^j \sum_{g\epsilon G} W_g^j = \sum_{j}^{\substack{applicable\\spatial\\regions}} N^j \sum_{g\epsilon G} \sigma_g^j W_g^j \, , \tag{2}$$

where

$$W_g^j \equiv \int_j \vec{dr} \int_g dE\psi(E,\vec{r}) \, . \tag{3}$$

3.XSDRNPM.1.1 "Cell" weighting

Cell weighting is consistent with homogenizing the cross sections in a heterogeneous cell. This is the recommended option to prepare cross sections for a real reactor calculation that will be made with a 2- or 3-D model of the reactor. Most of these codes have no provisions for explicitly representing individual fuel elements which are interspersed in a moderator region. Hence, regions of this type are mocked in a homogeneous representation.

Cell-weighted cross sections are defined in a manner that attempts to preserve the reaction rates that occur in a representative cell from the reactor. In Eq. (2) the weighting involves the following substitution:

$$N_D^j \equiv \overline{N} = \frac{\sum_j^{cell} V^j N^j}{\sum_j^{cell} V^j} \, , \tag{4}$$

where

V^j ≡ volume of zone j.

3.XSDRNPM.1.2 "Zone" weighting

Zone weighting is the simplest of the three XSDRNPM weighting options. Each zone produces a unique set of cross sections which preserves reaction rates for the zone. In Eq. (2), the spatial sum is over the zone considered, and N^j and N_D^j are unity.

Zone weighting is used very frequently, especially for problems whose collapsed cross sections are to be used in a problem whose geometrical and material layout is similar to that in the weighting problem.

3.XSDRNPM.1.3 "Region" weighting

"Region-" or "vein-" weighted cross sections are weighted "where the nuclide is." In most problems, there are nuclides of secondary importance which do not need a separate "zone-weighted" set for every region in which the nuclide occurs. Examples are the components of stainless steel. Stainless steel is encountered in a variety of locations and flux environments, but generally one set of cross sections for iron, chromium, manganese, nickel, etc., will suffice for most reactor calculations.

In Eq. (2), the spatial sum is over all zones that contain the nuclide of interest with

$$N_D^j = N^j \ . \tag{5}$$

3.XSDRNPM.1.4 "Inner-cell" weighting

For inner-cell weighting, cell weighting is performed over specified innermost regions in the problem. Nuclides outside these regions are not weighted.

This option is generally employed as follows: A "cell" is described in exactly the same manner as for cell weighting except that in this case it is surrounded by a homogeneous representation for the remainder of the core and by blankets, reflectors, etc. The flux calculation is made over this complete system, which should have a more realistic treatment of the leakage across the outer boundary of the interior cell. The cell weighting is subsequently made only over the interior cell.

3.XSDRNPM.1.5 Multigroup weighting equations

The following are the multigroup forms of the weighting equations used in XSDRNPM:

1. Cell weighting

$$\bar{\sigma}_G \equiv \frac{\sum\limits_{j}^{IZM} N^j \sum\limits_{g \epsilon G} \sigma_g^j W_g^j}{\overline{N} \sum\limits_{j}^{IZM} \sum\limits_{g \epsilon G} W_g^j} \ , \tag{6}$$

where

$$\overline{N} \equiv \frac{\sum_{j}^{IZM} V^j N^j}{\sum_{j}^{IZM} V^j} , \tag{7}$$

$$W_g^j \equiv \psi_g^j = \int_j \psi_g(\vec{r})\vec{dr} . \tag{8}$$

2. Zone weighting

$$\bar{\sigma}_G^j \equiv \frac{\sum_{g\epsilon G} \sigma_g^j W_g^j}{\sum_{g\epsilon G} W_g^j} . \tag{9}$$

3. Region weighting

$$\bar{\sigma}_G \equiv \frac{\sum_{j} N^j \sum_{g\epsilon G} \sigma_g^j W_g^j}{\sum_{j} N^j \sum_{g\epsilon G} W_g^j} . \tag{10}$$

3.XSDRNPM.1.6 Transfer matrices

Collapsing transfer matrices is not quite as simple as collapsing cross sections with a single value per group. A group-to-group term in the broad group sense conserves the scattering rate from one group to the other, that is,

$$\overline{N}^* \bar{\sigma}(G \to G')\psi_G \equiv \int_{Space} \vec{dr} N(\vec{r}) \int_g dE \psi(E,\vec{r}) \int_{g'} dE' \sigma(E \to E') , \tag{11}$$

where the asterisk (*) denotes that the number density on the left side of the equation is consistent with the weighting desired. Therefore, the multigroup forms of the weighting equations for components of the transfer matrices are as follows:

1. Cell weighting

$$\bar{\sigma}_{G \to G'} \equiv \frac{\sum_{j}^{IZM} N^j \sum_{g\epsilon G} W_g^j \sum_{g'\epsilon G'} \sigma^j(g \to g')}{\overline{N} \sum_{j}^{IZM} \sum_{g\epsilon G} W_g^j} . \tag{12}$$

2. Zone weighting

$$\bar{\sigma}^{j}_{G\rightarrow G'} \equiv \frac{\sum\limits_{g\epsilon G} W^{j}_{g} \sum\limits_{g\epsilon G'} \sigma^{j}(g \rightarrow g')}{\sum\limits_{g\epsilon G} W^{j}_{g}} . \tag{13}$$

3. Region weighting

$$\bar{\sigma}_{G\rightarrow G'} \equiv \frac{\sum\limits_{j} N^{j} \sum\limits_{g\epsilon G} W^{j}_{g} \sum\limits_{g'\epsilon G'} \sigma^{j}(g \rightarrow g')}{\sum\limits_{j} N^{j} \sum\limits_{g\epsilon G} W^{j}_{g}} . \tag{14}$$

Theoretically, the higher-than-zero order $\sigma_l(g \rightarrow g')$ should be weighted over ψ_l. Since these functions are generally positive-negative, ψ_l weighting does not always work in practice, and XSDRNPM weights the $\sigma_l(g \rightarrow g')$, $\ell > 0$, by the scalar flux, which is positive. This procedure gives usable values for most cases.

3.XSDRNPM.1.7 Weighting of $\bar{\nu}$

In weighting parameters such as $\bar{\nu}$, the average number of neutrons produced per fission, one is interested in preserving the fission source; therefore, the weighting is over $\sigma_f\psi$ instead of just ψ. The weighting procedure in XSDRNPM is to calculate $(\overline{\nu\sigma_f})_G$ and $(\overline{\sigma_f})_G$ using the appropriate choice from Eq. (12), (13), or (14). Then,

$$\bar{\nu}_G = \frac{(\overline{\nu\sigma_f})_G}{(\overline{\sigma_f})_G} .$$

3.XSDRNPM.1.8 Transport cross sections

Transport cross sections are not as directly related to the physical properties of a material as other group-averaged values. Instead of a reaction rate, these numbers must attempt to preserve a "flux gradient," which not only depends on the cross sections of the material, but is also very strongly influenced by the geometry and the other nuclides in the vicinity of a material.

Two options are provided in XSDRNPM to generate transport cross sections—options based on the "consistent" and "inconsistent" methods for solving the P_1 transport equations. These approximations are referred to as the "outscatter" and "inscatter" approximations because of the nature of the equations used.

Outscatter approximation (inconsistent method). In the outscatter approximation, the assumption is made that

$$\sigma^{g}_{tr} = \sigma^{g}_{t} - \bar{\mu}^{g}\sigma^{g}_{s} . \tag{15}$$

When one notes that

$$\bar{\mu}^g \equiv \frac{\sigma_1^g}{3\sigma_0^g} \tag{16}$$

and that

$$\sigma_1^g = \sum_{g'} \sigma_1(g \to g') \ , \tag{17}$$

where the $\sigma_1(g \to g')$ terms are the P_1 coefficients of the scattering matrix, the origin of the term "outscatter" to designate the approximation is evident.

Inscatter approximation (consistent method). In the "consistent" solution of the P_1 point transport equations, it can be shown that

$$\sigma_{tr}(E) = \sigma_t(E) - \frac{1}{3J(E)} \int_0^\infty dE' \sigma_1(E' \to E) J(E') \ , \tag{18}$$

where $J(E')$ is the current.

If one multiplies the equation by $J(E)$, integrates over group g, and converts to group-averaged form by dividing by $\int_g J(E)dE$, the following expression is derived:

$$\sigma_{tr}^g = \sigma_t^g - \frac{1}{3J_g} \sum_{g'} \sigma_1(g' \to g) J_{g'} \ . \tag{19}$$

This is the "inscatter" approximation. It is consistent because the transport values are explicitly derived from the P_0 and P_1 equations. As a general rule, the transport values from this treatment are "better" than those from the "inconsistent" treatment. However, in some cases (notably hydrogen at lower energies), negative numbers may be calculated which are unusable, and the more approximate approach must be used.

Weighting function for transport cross section. Unfortunately, the matter of choosing a current to use in the "transport" weighting is not simple. In real problems, currents are positive-negative as a function of energy and space. When cross sections are averaged over positive-negative functions, the "law-of-the-mean" no longer holds and the average value can take on any value. These nonphysical values are unusable in diffusion calculations.

Approximations that inherently guarantee positive currents are generally used in other codes that circumvent the positive-negative weighting problem. For example, in B_n theory, the current is given by

$$j \sim B\psi \ ,$$

where B and ψ are both positive.

In XSDRNPM, more direct routes that ensure positivity are taken (e.g., one might set $W_g \equiv |W_g|$). This is crudely supported by the following argument.

Consider a 1-D cylindrical calculation. In two dimensions, the current is a vector combination, that is,

$$\bar{J} = \bar{J}_r + \bar{J}_z \ . \tag{20}$$

In XSDRNPM, the z direction is treated by using a buckling approximation, that is,

$$\overline{J}_z = B\psi \quad . \tag{21}$$

In the weighting calculation, we want to weight over the magnitude of the current. In XSDRNPM, the z-current is imaginary, since we are not calculating a z-direction:

$$\overline{J} = \overline{J}_r + \bar{i}B\psi \quad . \tag{22}$$

The magnitude of a complex quantity is

$$J = \frac{(\overline{J}_r + \bar{i}B\psi)(\overline{J}_r - \bar{i}B\psi)}{\sqrt{(\text{Value}_{\overline{r}})^2 + B^2\psi^2}} \ , \tag{23}$$

which is always positive.

In a discrete-ordinates calculation, the current is easily obtained because it is the first flux moment. XSDRNPM has the following options for calculating the current:

$$J_g = \sqrt{(\psi_l^g)^2 + (DB\psi_g)^2} \ , \tag{24}$$

$$J_g = |\psi_l^g| \ , \tag{25}$$

$$J_g = DB^2\psi_g + \int_0^1 d\mu\mu\psi\,(g, r_{\text{outside}}, \mu) \ , \tag{26}$$

$$J_g = \frac{\psi_0^g}{\Sigma_t^g} \ , \tag{27}$$

$$J_g = DB\psi_g \ . \tag{28}$$

The first option is the recommended option. Option 2 treats only the current in the primary direction. Option 3 will always be positive and is a weighting over the total leakage from the system. Option 4 is sometimes referred to as a "bootstrap" approximation. Option 5 is equivalent to that used in codes that employ B_n theory.

Once the currents are determined, the transport values are determined as set forth in the equations discussed above. For example, consider cell weighting and the "inscatter" approximation,

$$\sigma_{tr}^G = \frac{\sum\limits_j N^j \sum\limits_{g\epsilon G} \left[J_g\sigma_t^g - \frac{1}{3} \sum\limits_{g\prime} \sigma_1(g\prime \to g)J_{g\prime} \right]}{\overline{N} \sum\limits_j^{IZM} \sum\limits_{g\epsilon G} J_g} \ . \tag{29}$$

For cell weighting and the "outscatter" approximation,

$$\sigma_{tr}^G = \frac{\sum\limits_j N^j \sum\limits_{g\epsilon G} J_g \left[\sigma_t^g - \frac{1}{3} \sum\limits_{g\prime} \sigma_1(g \to g\prime) \right]}{\overline{N} \sum\limits_j^{IZM} \sum\limits_{g\epsilon G} J_g} \ . \tag{30}$$

3.XSDRNPM.2 XSDRNPM Input Data

Title Card—Format (20A4)

This is the title card for the problem. It will be used to label the problem output.

Block 1.

This block contains information to set up various array dimensions and most calculational and editing options. Various convergence criteria and special constants can be input.

−1$ Core Allocation [1]

1. NWORD - Number of words of core to use for the calculation (100000)

0$ Logical Assignments [11]

1. LPUN - Logical number for punched card output (7)
2. LRSF - Random access scratch for fluxes (10)
3. LAWL - Input AMPX working library (4)
4. LANC - ANISN binary or CCCC ISOTXS library (20)
5. LOWL - Output weighted library (3)
6. LANG - Angular flux scratch file (16)
7. LSF1 - Sequential scratch space (17)
8. LSF2 - Sequential scratch space (18)
9. LSF3 - Sequential scratch space (19)
10. LRSM - Random access scratch for macroscopic cross sections (8)
11. LRSX - Random access scratch for macroscopic cross sections (9)

1$ General Problem Description [15]

1. IGE - Problem geometry (1)
    - 0 - homogeneous (this causes a B_N calculation to be made for all zones)
    - 1 - slab
    - 2 - cylinder
    - 3 - sphere
2. IZM - Number of separate material regions or zones (1)
3. IM - Number of spatial intervals in the problem (1)
4. IBL - Boundary condition at the left-hand boundary of the system (1)
    - 0 - vacuum boundary
    - 1 - reflected boundary
    - 2 - periodic boundary
    - 3 - white/albedo boundary
5. IBR - Boundary condition at the right-hand boundary of the system (1)
    - 0 - vacuum boundary
    - 1 - reflected boundary
    - 2 - periodic boundary
    - 3 - white/albedo boundary
6. MXX - Number of compositions used in the problem mockup

7. MS – Number of entries in the mixing table which specifies the makeup of the MXX compositions
8. ISN – Order of angular quadrature to be used. If ISN > 0, XSDRNPM will calculate an angular quadrature for the appropriate geometry. If ISN < 0, the calculation is bypassed, and the user can supply a set in the 42* and 43* arrays.
9. ISCT – Order of scattering. Flux moments will be calculated through this order.
10. IEVT – Type of calculation (1)
    - 0 – fixed source
    - 1 – k calculation
    - 2 – α calculation (flux is assumed to have an $e^{-\alpha t}$ time variation)
    - 3 – inoperable in present version
    - 4 – zone width search
    - 5 – outer radius search
    - 6 – buckling search
    - 7 – direct buckling search
11. IIM – Inner iteration maximum used in an S_n calculation (10)
12. ICM – Outer iteration maximum (10)

    After ICM outer iterations, the problem will be forced into the termination phase, and the program will continue as if full convergence was attained. A message to this effect is printed.
13. ICLC – Theory option (0)
    - 0 – use S_n theory always
    - N – use alternative theory (diffusion, infinite medium, or B_n for N outer iterations, after which change to S_n theory
    - −N – always use alternative theory
14. ITH – Forward/adjoint selector (0)
    - 0 – solve the forward Boltzmann equation
    - 1 – solve the adjoint Boltzmann equation
15. IFLU – Not used (0)

2$ Editing and Special Options [10]

1. IPRT – Fine-group mixture cross-section edits (−1)
    - −2 – no edits
    - −1 – edit 1-D cross sections
    - 0 – edit through P_N cross sections
    - N – 1-D edits are also made

2. ID1 – Flux editing options (0)

The flux editing options are:

ID1	Print angular fluxes	Print scalar fluxes	Punch scalar fluxes
−1	No	No	No
0	No	Yes	No
1	Yes	Yes	No
2	No	Yes	Yes
3	Yes	Yes	Yes

Note that \|ID1\| > 3 fluxes are written on \|ID1\| in binary format. Fluxes will be punched in a format suitable for restarting an XSDRNPM calculation.

3. IPBT – Balance table edits (0)
   - −1 – none
   - 0 – make fine-group balance tables
   - 1 – make fine- and broad-group balance tables
4. ISX – Broad-group flux edit as a function of interval (0) (0/1 = no/yes)
5. ISEN – Outer iteration acceleration. Input a zero.
6. IBLN – Logical unit on which to output activity file (0)
7. NBANDS – Number of flux rebalance bands
   <0, then the number of bands in the thermal range is the absolute value of NBANDS.
8. IFSN – If >0, means no fission source if IEVT = 0
9. NBL – Logical unit on which to output balance table file (0)
10. IDM4 – Not used

The structure of the "activity" and the "balance table" files is described in Sect. 3.XSDRNPM.2.2.

3$ Various Options [12]

1. IFG – Cross-section weighting (0)
   - 0 – none required
   - 1 – collapse cross sections
2. IQM – Volumetric sources (0)
   - 0 – none
   - N – N volumetric source spectra will be input in the 31* array
3. IPM – Boundary sources (0)
   - 0 – none
   - N – N boundary source spectra will be input in the 32* array
4. IFN – Starting guess (0)
   - 0 – flux guess (33# array)
   - 1 – fission density guess (34# array)
   - N>3 – unit on which fluxes are stored in a binary format

The binary flux tape is written by XSDRNPM at the end of the problem in a routine called WRTF. The format is as follows, with one record per energy group, beginning with group 1:

(XN(i),i=1,IM),
(XJ(i),i=1,IMT),
(B(i),i=1,MM),

where XN is the scalar flux, IM is the number of intervals, XJ contains the flux moments (higher than order zero) stacked one after the other for IM intervals, with IMT moments, and B is the boundary angular flux for the MM angles in the quadrature for the problem. In the case of a P_o calculation, only the XN array is written.

5. ITMX – Maximum time allowed for the flux calculation in minutes. A value of zero specifies that the calculation should not be terminated because of time; otherwise the problem will be forced into the termination phase when ITMX is exceeded (0). Bear in mind that this is an internal timing check and has no connection with operator or system terminations due to excessive times.
6. IDAT1 – External data storage. If IDAT1 is input as zero, XSDRNPM will automatically select the most efficient means of storing data.
   - 0 – keep all arrays in core if possible
   - 1 – store mixture cross sections externally on a direct access device
   - 2 – store cross sections and fixed sources externally on direct access devices
   - 3 – store cross sections, fixed sources, and flux moments externally on direct access devices
7. IPN – Diffusion coefficient option for transverse leakage corrections (0)
   - 0 – determine a transport cross section for each zone using P_0 and P_1 cross sections and, hence, a diffusion coefficient from $1/3 \sum_{tr}$
   - 1 – spatially average the diffusion coefficients determined as for the above option and use it for all zones
   - 2 – spatially average the transport cross sections for all zones and determine a diffusion coefficient to be used in all zones by taking one over three times this value

     Typically, the first option (IPN = 0) is adequate; however, in cases involving regions of low concentration (near void) and, hence, very low-transport cross sections, the very large diffusion coefficients lead to nonphysical behavior. In this case, the IPN = 2 option has been used satisfactorily.
8. IDFM – Density factors (0)
   - 0 – none
   - 1 – read in density factors in the 38* array
9. IAZ – Activity calculation trigger (0)
   - 0 – none

N – calculate the reaction rates by material zone for N different processes specified in the 49$ and 50$ arrays

10. IAI – Spatially dependent activity rates (0)
    0 – none
    1 – calculate reaction rates in each interval for IAZ processes
11. IFCT – Thermal upscatter scaling (0)
    0 – none
    1 – use upscatter scaling for accelerated problem convergence
12. IPVT – Parametric eigenvalue search (0)
    0 – none
    1 – a search calculation will be made for an eigenvalue other than 1.0

4$ Cross-Section Weighting Options [9] {IFG = 1}

1. ICON – Type of weighting
   −N – inner cell (with N zones in the cell). Cell weighting is performed over the N innermost regions in the problem. Nuclides outside these regions are not weighted.
   −1 – cell
   0 – zone
   1 – region or vein
2. IGMF – Number of energy groups in the collapsed sets
3. ITP – Collapsed output format desired
   0–19 – cross sections are written only in the AMPX weighted library formats on logical 3. A weighted library is always written when IFG=1.
   20–29 – output in the CCCC ISOTXS version 3 format
   30–39 – output in the ANISN/DOT/MORSE card format
   40–49 – output in the ANISN/DOT/MORSE binary format on logical 20

   The various values of ITP (module 10) are used to select the different transport cross-section weighting options mentioned earlier. The options are

   ITP = 0,10,20,... $\sqrt{(\psi_1^g + (DB\psi_g)^2}$
   ITP = 1,11,21,... absolute value of current
   ITP = 2,12,22,... $DB^2\psi_g$ + outside leakage
   ITP = 3,13,23,... $\psi/\sum_t^g$
   ITP = 4,14,24,... $DB\ \psi_g$
   ITP = other values are reserved for future development and should not be used
4. IPP – Weighted cross-section print option (−1)
   −2 – none
   −1 – print 1-D data
   N – print through P_N cross-section arrays (1-D edits are given)

5. IHTF – Total cross-section position in the ANISN *format* or the number of CCCC[5] formatted cross-section sets to be output (3)
6. NDSF – Within-group scattering cross-section position in the ANISN format (4)
7. NUSF – Table length in the ANISN formats (IGMF + NDSF − 1)
8. IAP – ANISN cross-section edit option or the scattering order to be output on a CCCC ISOTXS file (−1)
   - −1 – ANISN (do not produce edits of ANISN formatted cross sections)
     CCCC (output all orders on the ISOTXS file)

$$\left\{\frac{0}{N}\right\} - \left(\frac{\text{edit} - \text{ANISN}}{\text{output} - \text{CCCC}}\right) \text{through the } P_N \text{ arrays.}$$

9. MSCM – Extra "activity" cross sections in ANISN formats. MSCM extra cross-section types are put above the absorption cross-section position in the ANISN formats. The types are specified in the 12$ array.

5* Convergence Criteria and Assorted Constants [12]

1. EPS – Overall problem convergence (10^{-4})
2. PTC – Scalar flux convergence (10^{-4})
3. XNF – Normalization factor (1.0)
   When IEVT = 0, the fixed sources are normalized to XNF
   For IEVT > 0, the fission source is normalized to XNF
   When XNF = 0.0, no normalization is made
4. EV – Starting eigenvalue guess for search calculations
5. EVM – Eigenvalue modifier used in a search calculation
   The following is a tabulation of recommended values for EV and EVM:

IEVT	Calculation type	EV	EVM
0	Fixed source	0	0
1	k-calculation	0	0
2	Direct α-search	0	0
3	Not used	–	–
4	Zone width search	0	−0.1
5	Outer radius search	Starting outer radius	−0.1*EV
6	Buckling search	1.0	−0.1
7	Direct buckling search	0.0	0.0

6. BF – Buckling factor (1.420892)
   This parameter is two times the multiplier on the "extrapolation" distance used to determine where a linearly extrapolated line from

the asymptotic flux shape would go to zero (e.g., for slabs, the extrapolation distance is $\simeq 0.71\lambda_{tr}$ and, hence, BF $\simeq$ 1.42).

7. DY – First transverse dimension in centimeters used in buckling correction to calculate leakage normal to the principal calculation direction (i.e., the height of a slab or a cylinder)
8. DZ – Second transverse dimension in centimeters used for a buckling correction (i.e., the width of a slab)
9. VSC – Void streaming correction
   This is the height of a void streaming path in a cylinder or slab in centimeters.
10. PV – Parametric eigenvalue
    When IPVT = 1 and IEVT > 1, this is the value of k-effective on which the search calculation is to be made.
11. EQL – Eigenvalue convergence for a search (10^{-3})
12. XNPM – New parameter modifier used in search calculations (0.75)

T Terminate Block 1.

Block 2.

This block contains information about the composition of the materials used in the calculation. Also included is an array to select special cross sections for ANISN and an array to identify cross sections written on the CCCC ISOTXS library.

10$ CCCC Transport Cross-Section Selection [IHTF]

This array contains the process identifier for the transport cross section which is to be used on the CCCC ISOTXS library. It is defaulted to 1001 for all nuclides, which selects the "inscatter" or "consistent" transport values. The other option is 1000, which selects the "outscatter" values. Use of this array can become necessary when negative transport values are encountered, such as is the case in some problems with hydrogen in its lower energy groups. This array is input in a one-to-one correspondence with the 16$ and 18U arrays.

12$ Special Cross-Section ENDF/B Identifiers for Inclusion in ANISN Libraries [MSCM]

This option allows the placement of "activity" cross sections in positions 1 through MSCM of ANISN formatted data. The user must ensure that MSCM is consistent with other positional parameters given in the 4$ array. Use ENDF MT numbers to select processes.

The next arrays (13$, 14$, and 15*) comprise the mixing table in XSDRNPM. The entries in the arrays go together in a one-to-one correspondence to form triplets:

13$	14$	15*
M	N	X

This command instructs that nuclide N is to be added into mixture M with a concentration (atoms/b-cm) of X.

13$ Mixture Numbers in Mixing Table [MS]

The values range from 1 to MXX.

14$ Isotope Identifiers in Mixing Table [MS]

A set of data with this identification must be on logical 4, the XSDRNPM working library, though the code will not make checks to ensure this is the case.

15* Isotope Concentrations in Mixing Table [MS]

16$ CCCC Set Selection Identifiers [IHTF]

These are the identifiers for the sets of cross sections on the AMPX weighted library that are to be put on the CCCC ISOTXS library.

18U CCCC Set Identifiers [IHTF]

Cross-section sets on the CCCC ISOTXS library are identified by six-character Hollerith strings (e.g., PU239 could be used for ^{239}Pu, etc.). Since IBM single-precision word lengths will only hold four characters, this array will require the reading of two times IHTF words. One way to accomplish this is to use the "variable format" (U) option, whereby, the user specifies a two-word format for each six-character string. For example, one can use the following scheme to read these data:

```
18U
((12(A4,A2)))
```

Enter 12 identifiers per card as if they were read in a "12A6" format.

A second way to accomplish reading this array is to use the Hollerith field option, where one could use:

```
18## 6Hxxxxxx 6Hyyyyyy ........
```

where xxxxxx, yyyyyy, etc., are the identifier strings. This array is input in a one-to-one ordering with the 10$ and 16$ arrays.

T Terminate Block 2.

Block 3. {IEVT = 0}

This block is used to specify fixed sources.

30$ Source Spectrum Number by Interval [IM]

31* Volumetric Source Spectra [IQM*IGM]

32* Surface Source Spectra [IPM*IGM*MM]

Each of the IQM or IPM spectra is specified in the 31* or 32* array and are stacked one after the other in that array. If both volumetric and surface sources are used in the same problem, the surface source number is multiplied by (IPM + 1) when entered in the 30$ array.

A volumetric spectrum will consist of IGM (number of energy groups) entries that are the relative integrated values of the source in each group.

A surface source is always assumed to be on the right-hand side of a spatial interval. It is input as was the volumetric source, except that each group contains entries for the MM angles in the S_n quadrature chosen for the problem. Note that a surface source is an integrated value and is actually a flux condition in the S_n equations.

In the 30$ array, a zero entry specifies that no source is in an interval.

T Terminate Block 3.

Block 4.

This data block contains starting guesses for fluxes and fission densities. If fluxes are read from an external device (IFN > 3), this data block is omitted. The binary flux tape is written by XSDRNPM at the end of the problem in a routine called WRTF. The format is as follows, with one record per energy group, beginning with group 1:

(XN(i),i=1,IM),
(XJ(i),i=1,IMT),
(B(i),i=1,MM),

where XN is the scalar flux, IM is the number of intervals, XJ contains the flux moments (higher than order zero) stacked one after the other for IM intervals, with IMT moments, and B is the boundary angular flux for the MM angles in the quadrature for the problem. In the case of a P_0 calculation, only the XN array is written. Both arrays in this block are double-precision arrays, which will require the use of the "#" array designator; otherwise, the number of entries read into the arrays will be incorrect or may contain nonsensical values for the starting guess.

33# Flux Guess [IM*IGM] {IFN=0}

A guess for the scalar flux is specified in the order: ((FLUX(I,J),I=1,IM),J=1,IGM), where IM is the number of spatial intervals and IGM is the total number of energy groups. For fixed-source problems, without better information, use zeroes. For eigenvalue problems, a nonzero flux guess must be used. The fluxes punched by using the ID1 parameter in the 2$ array can be used here in restart calculations.

34# Fission Density Guess [IM] {IFN=1}

This is a guess at the number of fission neutrons produced in an interval. When IFN = 1, XSDRNPM uses diffusion theory for the first outer iteration, after which it reverts to the normal mode.

T Terminate Block 4.

Block 5.

This block contains the remaining data needed for an XSDRNPM calculation.

35* Interval Boundaries [IM+1] (cm)

This array describes the spatial quadrature into which the problem mock-up is divided. The boundaries are nonnegative and in increasing order. Usually they will start with a zero value, though this is not necessary.

36$ Zone Number for Each Spatial Interval [IM]

Spatial zones should be contiguous.

38* Density Factors by Interval [IM] {IDFM≠0} (1.0)

These factors are used to effect a density variation in a mixture as a function of spatial interval. Zero for a density factor affords a convenient way for mocking a void region.

39$ Mixture Numbers by Zone [IZM]

The mixture that is in a zone is specified here.

40$ Order of Scattering by Zone [IZM] (ISCT)

This is the order, l, of the S_n P_l calculation, which is desired in a zone. This number should be no larger than the ISCT.

41* Radius Modifiers by Zone [IZM] {IEVT = 4}

These parameters specify the relative movement of the width of a zone in a zone width search. A zero indicates that a zone's width is fixed.

42* Weights of the Angles in the Discrete-Ordinates Quadrature [MM*]

Input this array if you wish to override those provided by XSDRNPM.

43* Cosines of the Angles in the Discrete-Ordinates Quadrature [MM]

Input this array if you wish to override those provided by XSDRNPM.

46$ Calculational Option by Group [IGM] {ICLC>0}

0 – Perform discrete-ordinates calculation for this group
1 – Perform a diffusion calculation for this group for ICLC outer iterations and then use discrete-ordinates theory
2 – Perform a homogeneous calculation for this group for ICLC outer iterations and then use discrete-ordinates theory
3 – Perform a homogeneous calculation using B_n theory for this group for ICLC outer iterations and then use discrete-ordinates theory

47* Right-Boundary Albedos by Group [IGM] {IBR = 3} (1.0)

A right-boundary albedo is specified for each fine group. The return current is distributed isotropically in angle.

48* Left-Boundary Albedos by Group [IGM] {IBL = 3} (1.0)

As for the 47* array but for the left boundary. Note that if IBR or IBL is 3 and the corresponding 47* or 48* array is omitted, XSDRNPM fills the array with 1.0's, effecting a boundary with zero net current and with isotropic neutron return.

49$ Material Number for Activities [IAZ] {IAZ ≠ 0}

50$ Process Number for Activities [IAZ] {IAZ ≠ 0}

MM = ISN + 1 for slabs and spheres; MM = ISN(ISN + 4/4) for a cylinder.

The 49$ and 50$ arrays provide a means of obtaining the activity (reaction rate) for any process for which cross sections are available in the XSDRNPM calculation. A representative activity table entry is shown below:

ACTIVITY	TABLE ENTRY
49$	50$
M	N

This entry specifies that the activity N for material M be calculated for all parts of the system which contain that material.

If N is <0, a density of 1.0 is used to calculate activities instead of densities in the mixing table. Allowable process identifiers are given in Sect. 4.MISCELLANEOUS.6.

51$ Broad Group Numbers [IGM] $\{IFG \neq 0\}$

This array contains the broad-group numbers into which the fine groups are collapsed in a flux-weighting calculation. For example, if the first five fine groups are to be collapsed to the first broad group, the first entries in the 51$ array are 1, etc. A zero value can be used to ignore (or truncate) a group.

52$ Lower Band Group Numbers [NBANDS]

Group numbers giving the last group in a flux rebalance band. Overrides the default set supplied by XSDRNPM.

3.XSDRNPM.2.1 Abbreviated XSDRNPM input description

After several problem setups have been made for XSDRNPM, the user will probably establish a familiarity, such that the more detailed notes given above are not necessary or desirable. Because of this, the following abbreviated list is given which will, hopefully, benefit many users.

Title card — (18A4)

DATA BLOCK 1

0$– Logical assignments [11]
1. Punched cards (7)
2. Direct access - fluxes (10)
3. Working library (4)
4. ANISN or ISOTXS (20)
5. Weighted library (3)
6. Angular fluxes (16)
7. Scratch (17)
8. Scratch (18)
9. Scratch (19)
10. Direct access (8)

1$– General description [15]
1. IGE - geometry
2. IZM - number of zones
3. IM - number of intervals
4. IBL - left boundary condition
5. IBR - right boundary condition
6. MXX - number of mixtures
7. MS - mixing table length
8. ISN - angular quadrature
9. ISCT - order of scattering
10. IEVT - problem type

11. Direct access (9)

11. IIM – inner-iteration maximum
12. ICM – outer-iteration maximum
13. ICLC – optional theory
14. ITH – forward or adjoint
15. IFLU – zero

2$– Editing and control options [10]
1. Fine-group mixture edit
2. Fine-group flux edit
3. Balance table edit
4. Broad-group flux edit
5. Zero
6. Logical unit for activities
7. Number of bands
8. Suppress fixed source fission
9. Logical unit for balance tables
10. Zero

3$– Other options [12]
1. IFG – weighting option
2. IQM – volumetric sources
3. IPM – boundary sources
4. IFN – starting guess
5. ITMX – time shut-off
6. IDAT1 – storage scheme
7. IPN – diffusion coefficient option
8. IDFM – density factors
9. IAZ – activities by zone
10. IAI – activities by interval
11. IFCT – thermal scaling
12. IPVT – search on k $\neq 1$

4$– Weighting options [9]
1. Type of weighting
2. Number of broad groups
3. Output format
4. Edit option
5. σ_T position or number CCCC
6. σ_{gg} position
7. Table length
8. ANISN edit option
9. Extra cross sections

5*– Floating point values [12]
1. EPS – overall convergence
2. PTC – point flux convergence
3. XNF – normalization
4. EV – starting guess for search
5. EVM – modifier for search
6. BF – buckling factor
7. DY – height
8. DZ – width
9. VSC – void streaming height
10. PV – k for search

11. EQL - search convergence
12. XNPM - search modifier

T Terminate Block 1.

DATA BLOCK 2

10$ CCCC transport cross-section selector [IHTF]

12$ Additional processes to be put on ANISN library [MSCM]

13$ Mixture numbers [MS]

14$ Isotope identifiers [MS]

15$ Isotope concentrations [MS]

16$ CCCC identifiers from working library [IHTF]

18U or 18# CCCC identifiers on ISOTXS [IHTF]

T Terminate Block 2.

DATA BLOCK 3

Required only when IQM or IPM is nonzero.

30$ Spectrum number by interval (IQM>0) or
right-hand interval boundary (IPM>0) [IM]

31* Volumetric sources [IQM*IGM]

32* Boundary sources [IPM*IGM*MM]

T Terminate Block 3.

DATA BLOCK 4

When fluxes are read from an external device—IFN>3—this block is omitted.

33# Flux guess [IM*IGM] {IFN=0}

34# Fission density guess [IM] {IFN=1}

T Terminate Block 4.

DATA BLOCK 5

35* Interval boundaries [IM+1]

36$ Zone numbers by interval [IM]

38* Density factors [IM]

39$ Mixture number by zone [IZM]

40$ Order of scattering by zone [IZM]

41* Radius modifier by zone [IZM] IEVT=4

42* Discrete-ordinates cosines [MM]

43* Discrete-ordinates weights [MM]

46$ Alternate theory selection [IGM] ICLC>0
47* Right boundary albedos [IGM]
48* Left boundary albedos [IGM]
49$ Activity material or nuclide numbers [IAZ]
50$ Activity process numbers [IAZ] (see Appendix B).
51$ Broad group numbers [IGM] IFG>0
52$ Lower band group numbers [NBANDS]

T Terminate Block 5.

3.XSDRNPM.2.2 Special XSDRNPM files

Two special files that can be optionally produced by XSDRNPM are described in this section. (See Sect. 3.XSDRNPM.2 and the discussion of parameters in the 2$ array.)

3.XSDRNPM.2.2.1 Activity file

The following is the record structure of the activity file which can be produced on logical unit IBLN.

Record 1 – (Title(I),I=1,18),IGM,NNEUT,NGAMM,IM,IAZ,IAI
1. Title –
2. IGM –
3. NNEUT –
4. NGAMM –
5. IM –
6. IAZ –
7. IAI –

Record 2 – (EN(I),I=1,NNEUT+1)
When NNEUT > 0, this record contains the energy boundaries for the neutron group structure (high to low).

Record 3 – (EG(I),I=1,NGAMM+1)
When NGAMM > 0, this record contains the energy boundaries for the gamma group structure (high to low).

Record 4 – (R(I),I=1,IP)
Radii corresponding to all interval boundaries in the system starting at the left side of the system.

Record 5 – (MA(I),I=1,IM)
Zone numbers by interval.

Record 6 – (J3(I),I=1,IAZ)
"Material" numbers for activities.
(This is the 49$ array.)

Record 7 – (J4(I),I=1,IAZ)

"Process" identifiers for activities. (This is the 50$ array.)

These seven records are followed by IAZ records which have the following structure and contain the activities as a function of interval:

(ACT(I),I=1,IM)

3.XSDRNPM.2.2.2 Balance table file

The structure of the "balance table file" to be written on logical NBL when NBL > 0 is:

Record 1 - AKEFF, SP, IZP, IGP

1. AKEFF - k_{eff} for problem
2. SP - search parameter for case
3. IZP - number of zones plus one
4. IGP - number of groups plus one

Record 2

3.XSDRNPM.3 XSDRNPM Input/Output Specifications

The following logical units can be required in an XSDRNPM calculation:

Logical No.	Purpose
3	Weighted library (produced by XSDRNPM)
4	Working library (input)
5	Card input
6	Standard output
7	Punch fluxes or ANISN libraries
8	Scratch direct access device for external cross-section storage
9	Scratch direct access device for mixing and weighting operations
10	Scratch direct access device for external flux moment storage
16	Angular fluxes
17	Scratch device
18	Scratch device
19	Scratch device
20	ANISN binary library or CCCC ISOTXS interface

3.XSDRNPM.4 Error Messages

During the course of a problem, XSDRNPM makes many checks to determine if input data is in the required form. If inconsistencies are spotted, a message is printed, and the problem may be terminated. Some of these messages are listed below, along with a brief description of their possible cause.

CORE	N	Insufficient core storage, N = required storage locations
DATA	N	N arrays have been input with incorrect length. See the messages produced as arrays are read to determine specific arrays.
SN-1	N	The Nth entry in the S_n quadrature direction is zero (43* array)
SN-2	0	The S_n weights do not sum to 1.0 (42* array)
SN-3	0	The sum of the products of S_n weights and directions is not 0.0 [i.e., the directions are not symmetric (42* and 43* arrays)]

Cause: Self-explanatory. Increasing IDT1 may correct this difficulty.

SUMMARY TABLE STORAGE INSUFFICIENT SYSTEM TREATED AS ONE ZONE

Cause: Insufficient core is available to set up all the arrays needed for balance tables. Increasing IDT1 may correct this difficulty.

TAPE N Insufficient storage is available to produce a library tape for another code in the form specified. N locations needed.

***** CAUTION ***** CAUTION ***** CAUTION *****

THIS CELL HAS ZERO LEAKAGE—THE SCALAR FLUX WILL BE USED TO WEIGHT CROSS SECTIONS

Cause: The definition of a transport cross section requires a leakage spectrum. A completely reflected cell has been specified.

REFERENCE

1. N. M. Greene and C. W. Craven, Jr., *XSDRN: A Discrete Ordinates Spectral Averaging Code*, ORNL/TM-2500, Union Carbide Corp., Nucl. Div., Oak Ridge Natl. Lab., July 1969.

3.ZEST — A MODULE TO MANAGE STRING LIBRARIES

ZEST (Zippy Ensembler of STrings) is a module that is analogous to AJAX, except ZEST uses "string" libraries, such as the libraries produced by NPTXS. A string is a TAB1 record in ENDF nomenclature. Options are provided to allow merging from any number of files in a manner to allow the user to determine the final nuclide ordering, if desired.

3.ZEST.1 ZEST Input

Block 1.

−1$ Core Assignment [1]
  1. NWORD - Number of words to allocate to ZEST (50000)

0$ Logical Assignments [2]
  1. LOG - Logical number of library to be written (31)
  2. LBIG - Logical number of string library (input) with largest block size (0)

1$ Library Selector [1]
  1. NLOG - Number of "commands" (or libraries) required to create LOG

T Terminate Block 1.

Blocks 2 and 3 are stacked, one after the other, NLOG times.

Block 2.

2$ Input Library Selection
  1. NLIN = Logical number of input library
  2. NC = −N Delete N strings from NLIN to create LOG
     0 Accept all strings from NLIN which have not been placed on LOG by a previous command
     N Add N strings from NLIN to create LOG

T Terminate Block 2.

Block 3. {Required only if NC≠0)}

3$ MAT Numbers From NLIN (0 selects all materials)

4$ MF Numbers From NLIN (0 selects all files)

5$ MT Numbers From NLIN (0 selects all processes)

Note that a triplet of values in the 3, 4, and 5$ arrays selects a string from NLIN. If the identifiers are to be changed, enter the new numbers in the corresponding locations in the 6, 7, and 8$ arrays:

6$ New MAT Numbers

7$ New MF Numbers

8$ New MT Numbers

Note that a zero value or the omission of values from the 6, 7, and 8$ arrays will leave the old identifiers intact.

T Terminate Block 3.

3.ZEST.2 ZEST Input/Output Specifications

The following devices are normally needed to execute ZEST:

Logical No	Purpose
5	Card input
6	Printed output
LOG (31)	String library to be created
NLIN	String libraries to be merged onto LOG

4. AMPX-77 MISCELLANEOUS USEFUL INFORMATION

This section contains descriptions of several AMPX features, including:

Subsection	Topic
4.INFORMATION.1	AMPX Master Library Format
4.INFORMATION.2	AMPX Working Library Format
4.INFORMATION.3	ANISN Library Format
4.INFORMATION.4	Standard Energy Group Structures
4.INFORMATION.5	Weighting Function Library
4.INFORMATION.6	Reaction Type Identifiers
4.INFORMATION.7	Glossary of Terms

4.INFORMATION.1 AMPX MASTER LIBRARY FORMAT

An AMPX master library is not structured for direct use in a multigroup particle transport calculation. The intent is to provide a means to present a library that has the potential of being problem independent, which can be tailored at run time for a particular problem. The library carries data at a sufficient level of detail to allow satisfying many of the less common, but very useful, analyses such as cross-section sensitivity studies and coupled neutron-gamma transport calculations. The library can contain data to allow resonance self-shielding to be performed using the Nordheim method, the Bondarenko method, or an integral transport calculation. Temperature dependence of data is allowed. Any number of scattering processes can be included to an arbitrary order of anisotropic representation.

The AMPX master format has been designed to allow a generality paralleling that of the ENDF/B point libraries, for example:

1. The formats can accommodate neutron libraries, gamma libraries, or coupled neutron-gamma libraries.
2. An arbitrary number of reaction cross sections can be included that generally use ENDF/B identifiers for processes (see Sect. 4.INFORMATION.6).
3. An arbitrary order of anisotropy can be presented which can vary from nuclide to nuclide or from process to process.
4. Temperature dependence is allowed.
5. Resonance parameters may be included for use in Nordheim resolved resonance calculations.
6. The library can contain Bondarenko data for resonance self-shielding.
7. The library can include scattering matrix data for an arbitrary number of processes.

In the case of the resonance data, partial energy range data can be specified. For example, in CSRL-V the Bondarenko data are only for the unresolved region which will vary from nuclide to nuclide.

Potentially, the most space-consuming data on a cross-section library are the transfer matrix data. AMPX uses so-called "magic-word" arrays for these data which help to eliminate zero and/or impossible data elements. This is especially important for the master library, where the library may contain data for ~50 separate processes represented to an arbitrary level of anisotropy.

The master format is written using a combination of seven kinds of information, each of which has one or more record types associated with it:

1. Header information – written on the front of the library to specify the number of neutron and/or gamma groups, the number of nuclides, etc., contained in the library (record type 1).
2. Energy structure information – contains the group boundaries (record type 2).
3. Nuclide directory information – fifty words which give a title for the nuclide along with other parameters which specify the kinds of information included for the nuclide, such as number of records in the library for the nuclide and how much neutron and gamma data are given (record type 3).
4. Resonance parameter data – provisions for resolved resonance parameters in the SLBW or MLBW formats (record type 4).
5. Bondarenko data – four record types are used for this information:
    a. A record that gives the values of σ_0 and temperature at which the factors are tabulated, along with cut-off energies for the Bondarenko calculation (record type 5).
    b. A directory record containing information about the specific processes for which the Bondarenko factor data are given, such as the process, the energy groups for which data are given, etc. (record type 6).
    c. A record containing infinite dilution values for a process (record type 7).
    d. A record containing the Bondarenko factors for a process (record type 8).
6. A record containing average cross sections by process (record type 9).
7. Three record types are used to present transfer matrices:
    a. A directory record that specifies the processes, orders of anisotropy, lengths, units, etc (record type 10).
    b. A record to specify temperatures when the matrices are temperature-dependent (record type 11).
    c. A "magic-word" record to store a transfer matrix (record type 12).

The structure of the various record types is now discussed.

Record type 1 (header record)

The header record is the first record on the library and contains 110 words:

1. IDTAPE – An identification number for the library
2. NNUC – The number of sets of data on the library
3. IGM – The number of neutron energy groups on the library
4. IFTG – The first thermal neutron group on the library (i.e., the first group that *receives* an upscatter source)
5. MSN – 0 – pre-NITAWL-II library
   2 – library for use with NITAWL-II
6. IPM – The number of gamma-ray energy groups on the library
7. I1 – Zero

8. I2 - (0/1 = no/yes) A trigger that specifies that this library was produced by weighting a working library in the AMPX XSDRNPM module. This applies only to a working library, which will be discussed in Sect. 4.INFORMATION.2.
9. I3 - Zero
10. I4 - Zero
11.-110. (TITLE(I), I=1,100) - One hundred words of text describing the cross-section library

Record type 2 (energy boundaries)

This record specifies the energy boundaries in eV of the neutron groups and/or gamma groups, followed by the corresponding lethargy boundaries. The energy boundaries are arranged in descending order, followed by the lethargy boundaries in ascending order. The "lethargy zero" is taken at 10 MeV. The structure is

(EB(I),I=1,IGP), (UB(I),I=1,IGP)

where IGP is the number of groups plus one.

Record type 3 (cross-section set directory record)

Each set of data has a 50-word directory record that specifies certain parameters needed to determine dimensions required to process the data and to describe the makeup of the set of data. The following table describes these data:

Word(s)	Content
1–18	18 words of text describing the set (72 characters)
19	Identifier of the set
20	Number of six-parameter sets of resolved resonance data
21	Zero
22	Number of 1-D neutron processes (temperature independent)
23	Number of 2-D neutron processes
24	Zero
25	Number of 1-D gamma processes
26	Number of 2-D gamma processes
27	Number of 2-D neutron-to-gamma processes
28	(Maximum order of scattering) * 32768 + (total number of separate 2-D arrays for this set)
29	A—neutron equivalent mass number
30	ZA—1000 * Z + A
31	Zero
32	Zero
33	Zero
34	Power per fission in W-s/fission
35	Energy release per capture in W-s/capture
36	Maximum length of any 2-D record in the set

37	Number of sets of Bondarenko data
38	Number of σ_0's in Bondarenko data
39	Number of temperatures in Bondarenko data
40	Maximum number of groups in Bondarenko data
41	Zero
42	Zero
43	σ_p—potential scattering cross section
44	Zero
45	ENDF MAT for fast neutron data
46	ENDF MAT for thermal neutron data
47	ENDF MAT for gamma data
48	ENDF MAT for gamma production data
49	Nuclide symbol (4 characters of text)
50	Number of records in this set

Note that the 50-word records are made up of integer, character, and floating-point words. Words 1 to 18 and word 49 are character data. Words 29, 30, 34, 35, and 43 are floating point. All other words are integers. For both neutron and gamma libraries, many parameters may have no meaningful interpretation. Zero values are used when a parameter is not applicable.

Record type 4 (resonance parameters)

This record is present only when the number of six-word resonance sets, NRES, is nonzero. Its length is

$$9 + 6*\mathrm{NRES}\ .$$

All values are in floating point.

The first nine words contain parameters used in both the resolved and unresolved resonance calculations:

1. A, the mass ratio for the isotope or mixture of isotopes
2. σ_{P_0}, the potential scattering cross section
3. Zero
4. NRES, the number of six-parameter resonance sets
5. S, a factor used in the Nordheim calculation to determine the range over which the calculation will be made
6. Zero
7. Zero
8. Zero
9. Zero

The next 6*NRES words consist of six-word sets of data used in the Nordheim calculation.

1. Zero
2. NBLK, the number of blocks of resolved data
3. Zero
4. Zero

5. Temperature is Kelvin at which the infinite dilution cross sections were produced (if 0.0, it defaults to 300 K).
6. Zero

Following these six words are NBLK six-word groups, which are used to specify information concerning blocks of resonance data that apply to, for example, different isotopes, different energy regions, different kinds of data (s-wave or p-wave resonances), etc. These word groups are stacked as follows:

1. AWR, mass ratio for this isotope
2. ABUN, the abundance for the block of data
3. NRE, the number of resonances in the block
4. ℓ, the value of spin for the resonances in the block
5. EL, the lower energy cutoff for resonances in the block
6. EH, the upper energy cutoff for resonances in the block

.
.
.

After the NBLK groups of six words, the six-word sets of resonance parameters are arranged as follows:

1. E_0, the resonance energy
2. Γ_n, the neutron width of the resonance
3. Γ_γ, the gamma width of the resonance
4. Γ_f, the fission width of the resonance
5. r, a factor used in the Nordheim treatment for determining the range of calculation
6. g, the statistical factor for the resonance

The following chart illustrates the structure just described:

	1	2	3	4	5	6
	0	NBLK	0	0	TEMP	0
	AWR_1	$ABUN_1$	NRE_1	ℓ_1	EL_1	EH_1
	AWR_2	$ABUN_2$	NRE_2	ℓ_2	EL_2	EH_2
	•					
	•					
	•					
	AWR_{NBLK}	$ABUN_{NBLK}$	NRE_{NBLK}	ℓ_{NBLK}	EL_{NBLK}	EH_{NBLK}
first block	E_0	Γ_n	Γ_γ	Γ_f	r	g
	•	•	•	•	•	•
	•	•	•	•	•	•
	•	•	•	•	•	•

Record type 5 (first record of Bondarenko block)

This record is used to specify the σ_o and temperature values at which all Bondarenko factors for the nuclide will be given. It also specifies the upper and lower energies that factors cover. The number of values, NSIG0, is specified in the 38th word in the set directory, and the 39th word specifies the number of temperatures, NT. The record structure is

$$(\sigma_0(I), I=1, NSIG0), (T(I), I=1, NT), ELO, EHI .$$

The σ_0 values can either ascend or descend, but the temperatures are in Kelvin in ascending order.

Record type 6 (directory for Bondarenko data)

This record type is used to specify the processes that have Bondarenko data in the set. Its length is six times NBOND, the number of Bondarenko processes, specified in the 37th word in the set directory. The structure is

$$(MT(I), I=1, NBOND)$$
$$(NF(I), I=1, NBOND)$$

(NL(I), I=1, NBOND)
(IORDER(I), I=1, NBOND)
(IOFF(I), I=1, NBOND)
(NZ(I), I=1, NBOND)

The parameters have the following interpretation: MT is the identifier of the process (e.g., MT = 2 is for elastic scattering as in ENDF/B). NF is the number of the first energy group for which parameters are given. NL is the last group for which parameters are given. IORDER is used to specify the order of the scattering matrix in the event it is to be self-shielded. IOFF is the offset from the "magic word" in the transfer matrices (e.g., for elastic scattering, the first word after the magic word is generally the within-group term such that IOFF = 1 would specify the shielding for the within-group terms). (This parameter will be clearer in the discussion of AMPX transfer matrices given below.) NZ is presently unused and has a zero value.

Record type 7 (infinite dilution values for Bondarenko data)

Each process that has Bondarenko data has one of these records which contains the infinite dilution values or reference cross sections for the process. Its structure is

$$(\sigma^{\infty}(\mathrm{I}),\ \mathrm{I{=}NF,\ NL}),$$

where NF and NL are the first and last groups with data for the process.

Record type 8 (Bondarenko factors)

This record is a 3-D array and contains the Bondarenko factors for a process. Its structure is

$$(((\mathrm{BF(I,J,K),\ I{=}1,\ NSIG0),\ J{=}1,\ NT),\ K{=}NF,\ NL}) .$$

Record type 9 (temperature-independent average cross sections)

This record type is used to present average cross sections (sometimes called 1-D cross sections) on the library.

Its structure is

$$\begin{aligned}&\mathrm{MT}_1,\ (\sigma_1(\mathrm{I}),\ \mathrm{I{=}1,\ IGM}),\\&\mathrm{MT}_2,\ (\sigma_2(\mathrm{I}),\ \mathrm{I{=}1,\ IGM}),\\&\quad\vdots\\&\mathrm{MT}_{\mathrm{LAST}},\ (\sigma_{\mathrm{LAST}}(\mathrm{I}),\ \mathrm{I{=}1,\ IGM}),\end{aligned}$$

where the MTs are the process identifiers, and the cross sections, σ, are given for all groups. (Note that the MTs are given as floating-point numbers.)

Note that a process identified by 1452 ($\overline{\nu\sigma_f}$) should never be used in this record to avoid the possibility that some module may pass these values without accounting for self-shielding. Use processes 18 (σ_f) and 452 ($\bar{\nu}$) instead.

Record type 10 (scattering matrix directory)

An AMPX master library can include a directory that identifies the scattering matrices that are given for a nuclide. The structure is

(MT(I), I=1, N2D),
(L(I), I=1, N2D),
(NL(I), I=1, N2D),
(NT(I), I=1, N2D),

where N2D is the number of scattering (2-D) processes, MT is the process identifier, L is the maximum length of any of the scattering matrices for the process, NL is the order of Legendre fit to the scattering matrix, and NT is a parameter whose definition depends on the type of data (whether neutron, gamma production, or gamma) given as follows:

1. For neutron-neutron data, NT is the number of temperatures at which scattering matrices are given.
2. For gamma production data, NT is zero if the data are in yield units and is unity if they are in cross-section units.
3. For gamma-gamma data, NT is zero.

Record type 11 (scattering matrix temperatures)

This record type specifies the temperatures (in eV) of the scattering matrices. It is only used for neutron-neutron data and is given when NT > 0 (see record type 10). The temperatures are in ascending order as follows:

(T(I), I=1, NT) .

Record type 12 (scattering matrix)

This record type is used to store scattering matrix data (sometimes called 2-D data). As will be illustrated, it has provisions for truncating zero and/or impossible elements from the array. It exists in two forms: (1) a self-defining form used for gamma production data and (2) a form that is not self-defining. The only difference is that the self-defining form specifies the length as the first word, while the other does not; that is,

L, (X(I), I=1, L)

or

(X(I), I=1, L) .

The structure of the X-array is as follows:

Magic word for a group
Terms for scattering to the group
Magic word for the next group
Terms for scattering to this group
Etc., etc.

In some cases, a negative or zero magic word is used to specify the end of data in the record.

A "magic word" is used to define:

1. the sink group number, III;
2. the first group number, JJJ, which scatters to this group; and
3. the last group number, KKK, which scatters to this group.

The magic word is then defined as

$$MW = 1000000{*}JJJ + 1000{*}KKK + III$$

such that it is composed of three 3-digit integers:

$$MW : JJJKKKIII \ .$$

The scattering terms below a magic word are in reverse ordering (following typical practice for transport theory programs) (i.e., the scattering term for scattering from the last group is first, etc.):

MW for group III
$\sigma(\text{KKK}\rightarrow\text{III})$
$\sigma(\text{KKK-1}\rightarrow\text{III})$
.
.
.
$\sigma(\text{JJJ}\rightarrow\text{III})$

A scattering matrix record will contain one P_ℓ matrix for a process.

Consider an elastic scattering matrix for hydrogen which will be a full triangular matrix and assume three energy groups. The scattering matrix will look as follows:

1001001
$\sigma(1\rightarrow1)$
1002002
$\sigma(2\rightarrow2)$
$\sigma(1\rightarrow2)$
1003003
$\sigma(3\rightarrow3)$
$\sigma(2\rightarrow3)$
$\sigma(1\rightarrow3)$

A characteristic of AMPX libraries which is of paramount importance to note is the higher ordered scattering matrices, $\sigma_\ell(g \rightarrow g')$, $\ell > 0$ include a $2\ell + 1$ multiplier.

Note that the record is a mixture of integer and floating-point terms.

The overall structure of an AMPX master library is given below:

	Record type
Header record	1
Nuclide directory (one record per nuclide)	3
Neutron energy boundaries	2
Gamma energy boundaries	2

Records for nuclide 1

Records for nuclide 2

Etc.

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The structure of the records of a nuclide is

	Record type
Nuclide directory record	3
Bondarenko data	5,6,7,8
Resonance parameter data	4
Temperature-independent group-averaged neutron cross sections	9
Scattering matrix data for neutrons	10,11,12
Scattering matrix data for gamma production	10,12
Group-averaged gamma cross sections	9
Scattering matrix data for gammas	10,12

The internal structure for Bondarenko data is

	Record type
(σ_0(I),I=1,NSIG0), (T(J),J=1,NT), EL, EH	5
Bondarenko data directory (MT(I), I=1, NB) (NF(I), I=1, NB) (NL(I), I=1, NB) (ORDER(I), I=1, NB) (IOFF(I), I=1, NB) (NZ(I), I=1, NB)	6
The following records are given in pairs for all NB Bondarenko processes.	
Infinite dilution values (σ^∞(I), I=NF, NL)	7
Bondarenko factors (((BF(I,J,K), I=1, NSIG0), J=1, NT), K=NF, NL)	8

The internal structure of the scattering matrix data for neutrons is

	Record type
Scattering matrix directory (MT(I), I=1, N2D) (L(I), I=1, N2D) (NL(I), I=1, N2D) (NT(I), I=1, N2D)	10
The following structure is repeated N2D times.	
Temperature values (NT>0) (T(I), I=1, NT)	11
The following record is repeated MAX(1,NT)*(NL+1) times.	
Scattering matrix (X(I), I=1, L)	12

The internal structure for gamma production scattering is

	Record type
Scattering matrix directory (MT(I), I=1, N2D) (L(I), I=1, N2D) (NL(I), I=1, N2D) (NT(I), I=1, N2D)	10
For each process, I=1, N2D, the following record type given NL + 1 times corresponding to the P_0, P_1, ... P_{NL} matrices.	
Self-defining scattering matrix length LENGTH, (X(I), I=1, LENGTH)	12

The internal structure for gamma-gamma scattering is

	Record type
Scattering matrix directory (MT(I), I=1, N2D) (L(I), I=1, N2D) (NL(I), I=1, N2D) (NT(I), I=1, N2D)	10
For each process, I=1, N2D, the following record type is given NL+1 times corresponding to the P_0, P_1, ... P_{NL} matrices.	
Scattering matrix (X(I), I=1, L)	12

4.INFORMATION.2 AMPX WORKING LIBRARY FORMAT

The preceding section described the format of an AMPX master library with all its generality and detail. The other format used by AMPX modules is called the working, or weighted, library format. As contrasted with the master format, it has neither the detail nor the complexity, since its data are derived by taking data from a master library and collecting them into forms ready for use in a flux calculation of some sort. For these needs it carries only three kinds of data for a nuclide:

1. a directory record describing the cross sections;
2. group-averaged data; and
3. a total (sum of all processes) group-to-group scattering matrix, which, of course, will consist of several matrices for anisotropic cases.

The overall structure of a working library is given below:

	Record type
Header record	1
Neutron energy boundaries	2
Gamma energy boundaries	2
Nuclide directory (one record per nuclide)	3
Records for nuclide 1	
Records for nuclide 2	
Etc.	

The structure of the records for a nuclide is

	Record type
Nuclide directory record	3
Group averaged neutron cross sections	9
Group averaged gamma cross sections	9
The P_0, P_1 ..., P_{NL} total scattering matrices are presented in self-defining records.	
L, (X(I), I=1, L)	12

The record types are the same as those described in Sect. 4.INFORMATION.1 for the AMPX master, except for two cases:

1. The directory records have a different structure, as shown below:

Word	Contents
1–18	18 words of text describing the set (72 characters)
19	Identifier of the set
20	Identifier of the set from which this set derived
21	Zone number in which the nuclide occurred
22	Number of zones in problem which produced this set
23	Length of P_0 total scattering matrix
24	Order of expansion of total scattering matrix
25	Sequence of this set in all zone-weighted sets
26	Number of zone-weighted sets for this nuclide
27	Maximum length of any P_ℓ array in the total transfer matrix
28	Number of 1-D neutron processes
29	A—neutron equivalent mass number
30	ZA—1000 * Z + A
31	Zero
32	Zero
33	Zero
34	Power per fission in W-s/fission
35	Energy release per capture in W-s/capture
36	Zero
37	Zero
38	Zero
39	Zero
40	Zero
41	Number of 1-D gamma processes
42	Zero
43	Zero
44	Zero
45	ENDF MAT for fast neutron data
46	ENDF MAT for thermal neutron data
47	ENDF MAT for gamma data
48	ENDF MAT for gamma production data
49	Nuclide symbol (4 characters of text)
50	Number of records in this set

2. For the case of the weighted library only (I2=1 in the library header record), the neutron group structure record contains the inverse velocities for each group (2200 m/s units) followed by the fission spectrum from the problem which produced the weighted library.

4.INFORMATION.3 ANISN LIBRARY FORMAT

The CONTAC, ALPO, and XSDRNPM modules in AMPX all can write a library in the ANISN format. These libraries can be output in two forms: (1) a BCD or card-image form, or (2) a binary form.

In both cases, "blocks" of cross sections are specified using two types of records. A "block" of data in the ANISN context consists of values for one P_ℓ matrix of the cross sections of a nuclide or a mixture. The first record or card for a block contains 16 words as follows:

1. NOG – Number of energy groups in the block
2. IHM – Table length of the cross sections in the block
3. ICT – Control word which is 0 normally and is 7 for the last record in the cross-section library
4. ID – Numeric identifier for the cross-section block

5–16. (TEXT(I), I=1,12) – 48 characters of text to describe the cross-section block

In the case of the card-image format, the above is written:

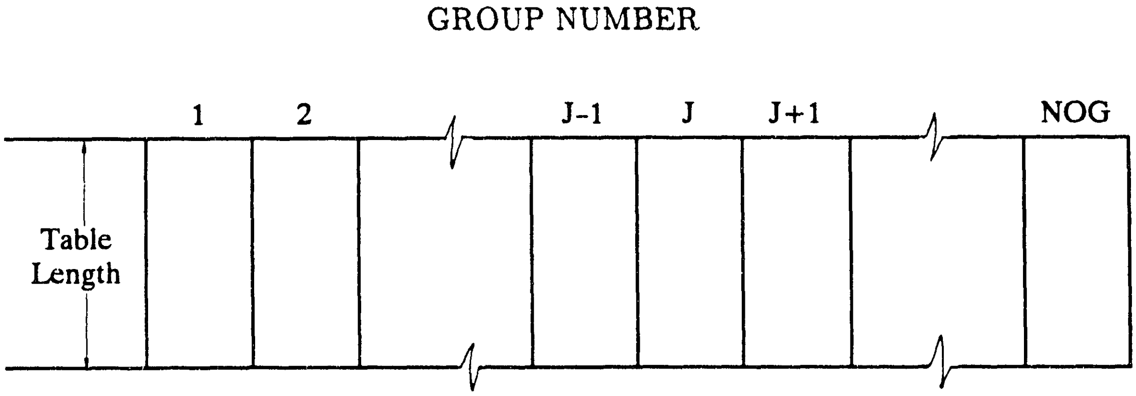
(1H',2I6,I4,I6,12A4)

The cross sections in a block are in a rectangular array and are written:

((XS(I,J), I=1, IHM), J=1, NOG)

In the case of card output, the values are written using the free-form FIDO schemes discussed in Sect. 7.FIDO.

A schematic of the structure is shown below:



Within a column for a group, the group-averaged values for various processes along with the values for scattering *to* the group G are given:

Position	Type of value
1	(user specified)
.	
.	
.	
.	
IHT−4	χ
IHT−3	Σ_f
IHT−2	Σ_a
IHT−1	$\nu\Sigma_f$
IHT	Σ_t
.	.
.	.
.	.
IHS−2	$\Sigma(G+2\rightarrow G)$
IHS−1	$\Sigma(G+1\rightarrow G)$
IHS	$\Sigma(G\rightarrow G)$
IHS+1	$\Sigma(G-1\rightarrow G)$
.	.
.	.
.	.
.	.
IHM	

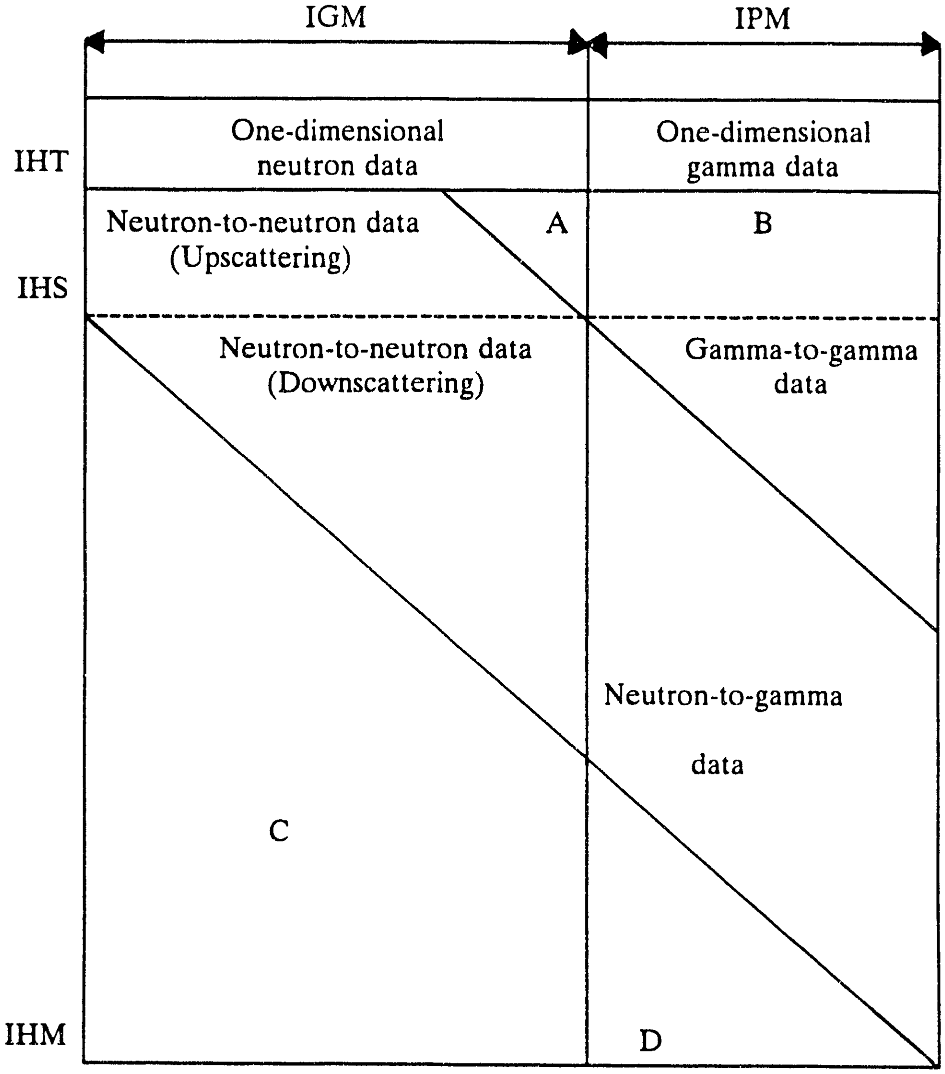
where IHT is the position of the total cross-section values in the table, IHS is the within-group scattering position, and IHM is the table length. Note that positions that are undefined contain zeroes. For example, when IHT = 3, there are no values for Σ_f in the table, etc., or if IHT = 3 and IHS = 4, there are no upscatters in the table. When IHM is less than (IHS + total number of groups less one), some possible downscatters are truncated, etc.

Another characteristic to note concerning ANISN values is that the matrices are multiplied by $(2\ell + 1)$ (i.e., P_0 terms are multiplied by unity, P_1 terms by three, etc.).

In some analyses, especially for certain shielding problems, calculations are made with ANISN cross sections which contain both neutron and gamma cross-section information. These libraries contain three kinds of scattering data:

1. neutron-to-neutron
2. neutron-to-gamma
3. gamma-to-gamma

For the forward (as opposed to adjoint) case, the cross sections will be arranged as in the following diagram:


IGM
IPM
IHT
IHS
IHM
One-dimensional neutron data
One-dimensional gamma data
Neutron-to-neutron data (Upscattering)
A
B
Neutron-to-neutron data (Downscattering)
Gamma-to-gamma data
Neutron-to-gamma data
C
D

where IGM and IPM are the number of neutron and gamma groups, respectively, areas C and D are zero because they represent transfers from nonexistent groups, A is zero because gammas do not generally transfer to neutron groups, through there are nuclides which do have reactions which do transfer, and B is zero because gammas do not upscatter.

4.INFORMATION.4 STANDARD ENERGY GROUP STRUCTURES

For convenience, a group boundary library is provided with the AMPX system which contains several structures that have been used at ORNL to make neutron and gamma cross-section libraries. AMPX modules requiring this input automatically access this library. The library is indexed by the data type (neutron or gamma) and the number of groups. To override a standard group structure, simply input your own structure in the appropriate input array.

4.INFORMATION.4.1 "Standard" Neutron Boundaries

The available neutron group structures are listed on the following pages. They include:

1. a 16-group Hansen-Roach structure
2. a 22-group structure designed for atmospheric transport calculations
3. a 27-group structure used in the SCALE system
4. a 37-group Defense Nuclear Agency structure
5. a 39-group structure selected for use in the design of the Advance Neutron Source Reactor
6. a 50-group structure derived from the GAM-II structure and intended for fast reactor applications
7. a 51-group structure identical to the 50-group structure, but having one extra thermal group
8. an 84-group structure for the thermal application
9. a 100-group structure consisting of the GAM-II structure with one thermal group
10. a 104-group structure formed by adding 4 groups to the 100-group structure to include important variations in the cross sections for major components of the atmosphere
11. a 105-group structure which is the 104-group structure with one group above 15 MeV
12. a 119-group structure tailored for fast reactor, air transport, and several shielding applications
13. a 123-group structure which consists of the GAM-II boundaries combined with a 30-group THERMOS structure below 1.86 eV
14. a 126-group structure for fast reactor and shielding applications
15. a 171-group structure for fast reactor and shielding applications,
16. a 174-group structure which is the 171-group structure with three additional groups
17. a 218-group structure developed for shipping cask analyses and other thermal applications
18. a 227-group structure developed from the 218-group structure
19. a 231-group structure based on the 238-group CSEWG structure but which has more thermal groups and no groups above 15 MeV
20. a 238-group structure developed by adding extra groups in the very low-energy thermal range to the 227-group structure

These 20 structures are shown on the following pages.

```
16 NEUTRON GROUP STRUCTURE

 BDY    ENERGY       BDY    ENERGY
   1 1.5000E+07       11 3.0000E+01
   2 3.0000E+06       12 1.0000E+01
   3 1.4000E+06       13 3.0000E+00
   4 9.0000E+05       14 1.0000E+00
   5 4.0000E+05       15 4.0000E-01
   6 1.0000E+05       16 1.0000E-01
   7 1.7000E+04       17 1.0000E-03
   8 3.0000E+03
   9 5.5000E+02
  10 1.0000E+02
```

```
22 NEUTRON GROUP STRUCTURE

 BDY    ENERGY       BDY    ENERGY       BDY    ENERGY
   1 1.4918E+07       11 1.8268E+06       21 1.1253E+00
   2 1.2214E+07       12 1.1080E+06       22 4.1400E-01
   3 1.0000E+07       13 5.5023E+05       23 1.0000E-05
   4 8.1873E+06       14 1.1109E+05
   5 6.3600E+06       15 3.3546E+03
   6 4.9659E+06       16 5.8295E+02
   7 4.0657E+06       17 1.0130E+02
   8 3.0120E+06       18 2.9023E+01
   9 2.4660E+06       19 1.0677E+01
  10 2.3500E+06       20 3.0590E+00
```

```
27 NEUTRON GROUP STRUCTURE

 BDY    ENERGY       BDY    ENERGY       BDY    ENERGY
   1 2.0000E+07       11 5.5000E+02       21 4.0000E-01
   2 6.4340E+06       12 1.0000E+02       22 3.2500E-01
   3 3.0000E+06       13 3.0000E+01       23 2.2500E-01
   4 1.8500E+06       14 1.0000E+01       24 1.0000E-01
   5 1.4000E+06       15 3.0000E+00       25 5.0000E-02
   6 9.0000E+05       16 1.7700E+00       26 3.0000E-02
   7 4.0000E+05       17 1.3000E+00       27 1.0000E-02
   8 1.0000E+05       18 1.1300E+00       28 1.0000E-05
   9 1.7000E+04       19 1.0000E+00
  10 3.0000E+03       20 8.0000E-01
```

```
37 NEUTRON GROUP STRUCTURE

 BDY    ENERGY       BDY    ENERGY       BDY    ENERGY       BDY    ENERGY
   1 1.9640E+07       11 8.1873E+06       21 1.1080E+06       31 5.8295E+02
   2 1.6905E+07       12 7.4082E+06       22 5.5023E+05       32 1.0130E+02
   3 1.4918E+07       13 6.3763E+06       23 1.5764E+05       33 2.9023E+01
   4 1.4191E+07       14 4.9659E+06       24 1.1109E+05       34 1.0677E+01
   5 1.3840E+07       15 4.7237E+06       25 5.2475E+04       35 3.0590E+00
   6 1.2840E+07       16 4.0657E+06       26 2.4788E+04       36 1.1254E+00
   7 1.2214E+07       17 3.0119E+06       27 2.1875E+04       37 4.1400E-01
   8 1.1052E+07       18 2.3852E+06       28 1.0333E+04       38 1.0000E-05
   9 1.0000E+07       19 2.3069E+06       29 3.3546E+03
  10 9.0484E+06       20 1.8268E+06       30 1.2341E+03
```

39 NEUTRON GROUP STRUCTURE

BDY	ENERGY	BDY	ENERGY	BDY	ENERGY	BDY	ENERGY
1	2.0000E+07	11	5.5000E+02	21	4.7900E-01	31	4.4500E-03
2	6.4340E+06	12	1.0000E+02	22	3.9700E-01	32	3.2500E-03
3	3.0000E+06	13	3.0000E+01	23	3.3000E-01	33	2.6000E-03
4	1.8500E+06	14	1.0000E+01	24	2.7000E-01	34	2.1500E-03
5	1.4000E+06	15	3.0000E+00	25	2.1500E-01	35	1.8000E-03
6	9.0000E+05	16	1.7700E+00	26	1.6200E-01	36	1.4500E-03
7	4.0000E+05	17	1.3000E+00	27	1.0400E-01	37	1.1500E-03
8	1.0000E+05	18	1.0000E+00	28	5.0000E-02	38	8.5000E-04
9	1.7000E+04	19	7.6500E-01	29	3.0000E-02	39	5.5000E-04
10	3.0000E+03	20	5.8800E-01	30	1.0000E-02	40	1.0000E-05

50 NEUTRON GROUP STRUCTURE

BDY	ENERGY	BDY	ENERGY	BDY	ENERGY
1	1.4918E+07	21	2.7324E+05	41	4.5400E+02
2	1.2214E+07	22	2.2371E+05	42	2.1445E+02
3	1.0000E+07	23	1.8316E+05	43	1.0130E+02
4	8.1873E+06	24	1.4996E+05	44	4.7851E+01
5	6.7032E+06	25	1.2277E+05	45	2.2603E+01
6	5.4881E+06	26	8.6517E+04	46	1.0677E+01
7	4.4933E+06	27	5.2475E+04	47	5.0435E+00
8	3.6788E+06	28	4.0868E+04	48	2.3824E+00
9	3.0120E+06	29	3.1828E+04	49	1.1253E+00
10	2.4660E+06	30	2.4788E+04	50	4.1400E-01
11	2.0190E+06	31	1.9305E+04	51	1.0000E-05
12	1.6530E+06	32	1.5034E+04		
13	1.3534E+06	33	7.1018E+03		
14	1.1080E+06	34	4.3074E+03		
15	9.0718E+05	35	3.3546E+03		
16	7.4274E+05	36	2.6126E+03		
17	6.0810E+05	37	2.0347E+03		
18	4.9787E+05	38	1.5846E+03		
19	4.0762E+05	39	1.2341E+03		
20	3.3373E+05	40	9.6112E+02		

51 NEUTRON GROUP STRUCTURE

BDY	ENERGY	BDY	ENERGY	BDY	ENERGY
1	1.4918E+07	21	2.7324E+05	41	4.5400E+02
2	1.2214E+07	22	2.2371E+05	42	2.1445E+02
3	1.0000E+07	23	1.8316E+05	43	1.0130E+02
4	8.1873E+06	24	1.4996E+05	44	4.7851E+01
5	6.7032E+06	25	1.2277E+05	45	2.2603E+01
6	5.4881E+06	26	8.6517E+04	46	1.0677E+01
7	4.4933E+06	27	5.2475E+04	47	5.0435E+00
8	3.6788E+06	28	4.0868E+04	48	2.3824E+00
9	3.0120E+06	29	3.1828E+04	49	1.1253E+00
10	2.4660E+06	30	2.4788E+04	50	4.1400E-01
11	2.0190E+06	31	1.9305E+04	51	1.0000E-01
12	1.6530E+06	32	1.5034E+04	52	1.0000E-05
13	1.3534E+06	33	7.1018E+03		
14	1.1080E+06	34	4.3074E+03		
15	9.0718E+05	35	3.3546E+03		
16	7.4274E+05	36	2.6126E+03		
17	6.0810E+05	37	2.0347E+03		
18	4.9787E+05	38	1.5846E+03		
19	4.0762E+05	39	1.2341E+03		
20	3.3373E+05	40	9.6112E+02		

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84 NEUTRON GROUP STRUCTURE

BDY	ENERGY	BDY	ENERGY	BDY	ENERGY
1	1.0000E+07	31	4.5400E+02	61	2.3151E-01
2	7.7880E+06	32	2.7536E+02	62	1.9412E-01
3	6.0653E+06	33	1.6702E+02	63	1.6451E-01
4	4.7237E+06	34	1.3007E+02	64	1.4091E-01
5	3.6788E+06	35	1.0130E+02	65	1.2190E-01
6	2.8651E+06	36	7.8893E+01	66	1.0632E-01
7	2.2313E+06	37	6.1442E+01	67	9.2297E-02
8	1.7377E+06	38	4.7851E+01	68	8.0160E-02
9	1.3534E+06	39	3.7266E+01	69	6.9717E-02
10	1.0540E+06	40	2.9023E+01	70	6.0783E-02
11	8.2085E+05	41	2.2603E+01	71	5.3193E-02
12	6.3928E+05	42	1.7603E+01	72	4.6109E-02
13	4.9787E+05	43	1.3710E+01	73	3.9531E-02
14	3.8774E+05	44	1.0677E+01	74	3.3459E-02
15	3.0197E+05	45	8.3153E+00	75	2.7893E-02
16	2.3518E+05	46	6.4759E+00	76	2.2833E-02
17	1.8316E+05	47	5.0435E+00	77	1.8279E-02
18	1.4264E+05	48	3.9278E+00	78	1.4231E-02
19	1.1109E+05	49	3.0590E+00	79	1.0689E-02
20	8.6517E+04	50	2.3824E+00	80	7.6532E-03
21	6.7379E+04	51	1.8554E+00	81	5.1232E-03
22	4.0868E+04	52	1.4395E+00	82	3.0992E-03
23	2.4788E+04	53	1.1253E+00	83	1.5812E-03
24	1.5034E+04	54	8.3369E-01	84	5.6925E-04
25	9.1188E+03	55	7.8493E-01	85	1.0000E-05
26	5.5308E+03	56	6.3250E-01		
27	3.3546E+03	57	5.1119E-01		
28	2.0347E+03	58	4.1498E-01		
29	1.2341E+03	59	3.3891E-01		
30	7.4852E+02	60	2.7887E-01		

100 NEUTRON GROUP STRUCTURE

BDY	ENERGY	BDY	ENERGY	BDY	ENERGY	BDY	ENERGY
1	1.4918E+07	31	7.4274E+05	61	7.1018E+03	91	3.9279E+00
2	1.3499E+07	32	6.7206E+05	62	5.5309E+03	92	3.0590E+00
3	1.2214E+07	33	6.0810E+05	63	4.3074E+03	93	2.3824E+00
4	1.1052E+07	34	5.5023E+05	64	3.3546E+03	94	1.8554E+00
5	1.0000E+07	35	4.9787E+05	65	2.6126E+03	95	1.4450E+00
6	9.0484E+06	36	4.5049E+05	66	2.0347E+03	96	1.1253E+00
7	8.1873E+06	37	4.0762E+05	67	1.5846E+03	97	8.7644E-01
8	7.4082E+06	38	3.6883E+05	68	1.2341E+03	98	6.8257E-01
9	6.7032E+06	39	3.3373E+05	69	9.6112E+02	99	5.3159E-01
10	6.0653E+06	40	3.0197E+05	70	7.4852E+02	100	4.1400E-01
11	5.4881E+06	41	2.7324E+05	71	5.8295E+02	101	1.0000E-04
12	4.9659E+06	42	2.4724E+05	72	4.5400E+02		
13	4.4933E+06	43	2.2371E+05	73	3.5358E+02		
14	4.0657E+06	44	2.0242E+05	74	2.7536E+02		
15	3.6788E+06	45	1.8316E+05	75	2.1445E+02		
16	3.3287E+06	46	1.6573E+05	76	1.6702E+02		
17	3.0120E+06	47	1.4996E+05	77	1.3007E+02		
18	2.7253E+06	48	1.3569E+05	78	1.0130E+02		
19	2.4660E+06	49	1.2277E+05	79	7.8893E+01		
20	2.2313E+06	50	1.1109E+05	80	6.1442E+01		
21	2.0190E+06	51	8.6517E+04	81	4.7851E+01		
22	1.8268E+06	52	6.7380E+04	82	3.7267E+01		
23	1.6530E+06	53	5.2475E+04	83	2.9023E+01		
24	1.4957E+06	54	4.0868E+04	84	2.2603E+01		
25	1.3534E+06	55	3.1828E+04	85	1.7603E+01		
26	1.2246E+06	56	2.4788E+04	86	1.3710E+01		
27	1.1080E+06	57	1.9305E+04	87	1.0677E+01		
28	1.0026E+06	58	1.5034E+04	88	8.3153E+00		
29	9.0718E+05	59	1.1709E+04	89	6.4760E+00		
30	8.2085E+05	60	9.1188E+03	90	5.0435E+00		

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104 NEUTRON GROUP STRUCTURE

  BDY    ENERGY      BDY    ENERGY      BDY    ENERGY      BDY    ENERGY
    1 1.4918E+07      31 1.1080E+06      61 1.9305E+04      91 1.0677E+01
    2 1.3499E+07      32 1.0026E+06      62 1.5034E+04      92 8.3153E+00
    3 1.2214E+07      33 9.0718E+05      63 1.1709E+04      93 6.4760E+00
    4 1.1052E+07      34 8.2085E+05      64 9.1188E+03      94 5.0435E+00
    5 1.0000E+07      35 7.4274E+05      65 7.1018E+03      95 3.9279E+00
    6 9.0484E+06      36 6.7206E+05      66 5.5309E+03      96 3.0590E+00
    7 8.1873E+06      37 6.0810E+05      67 4.3074E+03      97 2.3824E+00
    8 7.4082E+06      38 5.5023E+05      68 3.3546E+03      98 1.8554E+00
    9 7.0000E+06      39 4.9787E+05      69 2.6126E+03      99 1.4450E+00
   10 6.7032E+06      40 4.5049E+05      70 2.0347E+03     100 1.1253E+00
   11 6.3600E+06      41 4.0762E+05      71 1.5846E+03     101 8.7644E-01
   12 6.0653E+06      42 3.6883E+05      72 1.2341E+03     102 6.8257E-01
   13 5.4881E+06      43 3.3373E+05      73 9.6112E+02     103 5.3159E-01
   14 4.9659E+06      44 3.0197E+05      74 7.4852E+02     104 4.1400E-01
   15 4.7500E+06      45 2.7324E+05      75 5.8295E+02     105 1.0000E-04
   16 4.4933E+06      46 2.4724E+05      76 4.5400E+02
   17 4.0657E+06      47 2.2371E+05      77 3.5358E+02
   18 3.6788E+06      48 2.0242E+05      78 2.7536E+02
   19 3.3287E+06      49 1.8316E+05      79 2.1445E+02
   20 3.0120E+06      50 1.6573E+05      80 1.6702E+02
   21 2.7253E+06      51 1.4996E+05      81 1.3007E+02
   22 2.4660E+06      52 1.3569E+05      82 1.0130E+02
   23 2.3500E+06      53 1.2277E+05      83 7.8893E+01
   24 2.2313E+06      54 1.1109E+05      84 6.1442E+01
   25 2.0190E+06      55 8.6517E+04      85 4.7851E+01
   26 1.8268E+06      56 6.7380E+04      86 3.7267E+01
   27 1.6530E+06      57 5.2475E+04      87 2.9023E+01
   28 1.4957E+06      58 4.0868E+04      88 2.2603E+01
   29 1.3534E+06      59 3.1828E+04      89 1.7603E+01
   30 1.2246E+06      60 2.4788E+04      90 1.3710E+01
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105 NEUTRON GROUP STRUCTURE

  BDY    ENERGY      BDY    ENERGY      BDY    ENERGY      BDY    ENERGY
    1 1.7000E+07      31 1.2246E+06      61 2.4788E+04      91 1.3710E+01
    2 1.4918E+07      32 1.1080E+06      62 1.9305E+04      92 1.0677E+01
    3 1.3499E+07      33 1.0026E+06      63 1.5034E+04      93 8.3153E+00
    4 1.2214E+07      34 9.0718E+05      64 1.1709E+04      94 6.4760E+00
    5 1.1052E+07      35 8.2085E+05      65 9.1188E+03      95 5.0435E+00
    6 1.0000E+07      36 7.4274E+05      66 7.1018E+03      96 3.9279E+00
    7 9.0484E+06      37 6.7206E+05      67 5.5309E+03      97 3.0590E+00
    8 8.1873E+06      38 6.0810E+05      68 4.3074E+03      98 2.3824E+00
    9 7.4082E+06      39 5.5023E+05      69 3.3546E+03      99 1.8554E+00
   10 7.0000E+06      40 4.9787E+05      70 2.6126E+03     100 1.4450E+00
   11 6.7032E+06      41 4.5049E+05      71 2.0347E+03     101 1.1253E+00
   12 6.3600E+06      42 4.0762E+05      72 1.5846E+03     102 8.7644E-01
   13 6.0653E+06      43 3.6883E+05      73 1.2341E+03     103 6.8257E-01
   14 5.4881E+06      44 3.3373E+05      74 9.6112E+02     104 5.3159E-01
   15 4.9659E+06      45 3.0197E+05      75 7.4852E+02     105 4.1400E-01
   16 4.7500E+06      46 2.7324E+05      76 5.8295E+02     106 1.0000E-04
   17 4.4933E+06      47 2.4724E+05      77 4.5400E+02
   18 4.0657E+06      48 2.2371E+05      78 3.5358E+02
   19 3.6788E+06      49 2.0242E+05      79 2.7536E+02
   20 3.3287E+06      50 1.8316E+05      80 2.1445E+02
   21 3.0120E+06      51 1.6573E+05      81 1.6702E+02
   22 2.7253E+06      52 1.4996E+05      82 1.3007E+02
   23 2.4660E+06      53 1.3569E+05      83 1.0130E+02
   24 2.3500E+06      54 1.2277E+05      84 7.8893E+01
   25 2.2313E+06      55 1.1109E+05      85 6.1442E+01
   26 2.0190E+06      56 8.6517E+04      86 4.7851E+01
   27 1.8268E+06      57 6.7380E+04      87 3.7267E+01
   28 1.6530E+06      58 5.2475E+04      88 2.9023E+01
   29 1.4957E+06      59 4.0868E+04      89 2.2603E+01
   30 1.3534E+06      60 3.1828E+04      90 1.7603E+01
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INFORMATION

119 NEUTRON GROUP STRUCTURE

BDY	ENERGY	BDY	ENERGY	BDY	ENERGY	BDY	ENERGY
1	1.4918E+07	31	1.1648E+06	61	2.0242E+05	91	2.1875E+04
2	1.2214E+07	32	1.1080E+06	62	1.9255E+05	92	1.9305E+04
3	1.0000E+07	33	1.0026E+06	63	1.8316E+05	93	1.5034E+04
4	8.1873E+06	34	9.6164E+05	64	1.7422E+05	94	1.1709E+04
5	6.7032E+06	35	9.0718E+05	65	1.6573E+05	95	9.1188E+03
6	5.4881E+06	36	8.6294E+05	66	1.5764E+05	96	7.1017E+03
7	4.4933E+06	37	8.2085E+05	67	1.4996E+05	97	5.5308E+03
8	3.6788E+06	38	7.8082E+05	68	1.4264E+05	98	4.3074E+03
9	3.1664E+06	39	7.4274E+05	69	1.3569E+05	99	3.7074E+03
10	3.0119E+06	40	7.0651E+05	70	1.2907E+05	100	3.3546E+03
11	2.8650E+06	41	6.7206E+05	71	1.2277E+05	101	3.0354E+03
12	2.7253E+06	42	6.3928E+05	72	1.1679E+05	102	2.7465E+03
13	2.5924E+06	43	6.0810E+05	73	1.1109E+05	103	2.6126E+03
14	2.4660E+06	44	5.7844E+05	74	9.8037E+04	104	2.0347E+03
15	2.3852E+06	45	5.5023E+05	75	8.6517E+04	105	1.5846E+03
16	2.3653E+06	46	5.2340E+05	76	8.2500E+04	106	1.2341E+03
17	2.3069E+06	47	4.9787E+05	77	7.9500E+04	107	9.6112E+02
18	2.2313E+06	48	4.5049E+05	78	7.2000E+04	108	7.4852E+02
19	2.1225E+06	49	4.0762E+05	79	6.7379E+04	109	4.5400E+02
20	2.0189E+06	50	3.6883E+05	80	5.6562E+04	110	2.1445E+02
21	1.9205E+06	51	3.3373E+05	81	5.2475E+04	111	1.0130E+02
22	1.8268E+06	52	3.0197E+05	82	4.6309E+04	112	4.7851E+01
23	1.7377E+06	53	2.9850E+05	83	4.0868E+04	113	2.2603E+01
24	1.6530E+06	54	2.9720E+05	84	3.4307E+04	114	1.0677E+01
25	1.5724E+06	55	2.9452E+05	85	3.1828E+04	115	5.0435E+00
26	1.4957E+06	56	2.8725E+05	86	2.8500E+04	116	2.3824E+00
27	1.4227E+06	57	2.7324E+05	87	2.7000E+04	117	1.1254E+00
28	1.3534E+06	58	2.4723E+05	88	2.6058E+04	118	4.1399E-01
29	1.2873E+06	59	2.2371E+05	89	2.4788E+04	119	1.0000E-01
30	1.2246E+06	60	2.1280E+05	90	2.3579E+04	120	1.0000E-05

123 NEUTRON GROUP STRUCTURE

BDY	ENERGY	BDY	ENERGY	BDY	ENERGY	BDY	ENERGY
1	1.4918E+07	41	2.7324E+05	81	4.7851E+01	121	2.0000E-02
2	1.3499E+07	42	2.4724E+05	82	3.7267E+01	122	1.5000E-02
3	1.2214E+07	43	2.2371E+05	83	2.9023E+01	123	1.0000E-02
4	1.1052E+07	44	2.0242E+05	84	2.2603E+01	124	5.0000E-03
5	1.0000E+07	45	1.8316E+05	85	1.7603E+01		
6	9.0484E+06	46	1.6573E+05	86	1.3710E+01		
7	8.1873E+06	47	1.4996E+05	87	1.0677E+01		
8	7.4082E+06	48	1.3569E+05	88	8.3153E+00		
9	6.7032E+06	49	1.2277E+05	89	6.4760E+00		
10	6.0653E+06	50	1.1109E+05	90	5.0435E+00		
11	5.4881E+06	51	8.6517E+04	91	3.9279E+00		
12	4.9659E+06	52	6.7380E+04	92	3.0590E+00		
13	4.4933E+06	53	5.2475E+04	93	2.3824E+00		
14	4.0657E+06	54	4.0868E+04	94	1.8600E+00		
15	3.6788E+06	55	3.1828E+04	95	1.7100E+00		
16	3.3287E+06	56	2.4788E+04	96	1.5600E+00		
17	3.0120E+06	57	1.9305E+04	97	1.4400E+00		
18	2.7253E+06	58	1.5034E+04	98	1.2900E+00		
19	2.4660E+06	59	1.1709E+04	99	1.1250E+00		
20	2.2313E+06	60	9.1188E+03	100	1.0000E+00		
21	2.0190E+06	61	7.1018E+03	101	8.7600E-01		
22	1.8268E+06	62	5.5309E+03	102	7.7600E-01		
23	1.6530E+06	63	4.3074E+03	103	6.5000E-01		
24	1.4957E+06	64	3.3546E+03	104	5.5000E-01		
25	1.3534E+06	65	2.6126E+03	105	4.5000E-01		
26	1.2246E+06	66	2.0347E+03	106	3.5000E-01		
27	1.1080E+06	67	1.5846E+03	107	3.0000E-01		
28	1.0026E+06	68	1.2341E+03	108	2.5000E-01		
29	9.0718E+05	69	9.6112E+02	109	2.0000E-01		
30	8.2085E+05	70	7.4852E+02	110	1.8000E-01		
31	7.4274E+05	71	5.8295E+02	111	1.6000E-01		
32	6.7206E+05	72	4.5400E+02	112	1.4000E-01		
33	6.0810E+05	73	3.5358E+02	113	1.2000E-01		
34	5.5023E+05	74	2.7536E+02	114	1.0000E-01		
35	4.9787E+05	75	2.1445E+02	115	8.0000E-02		
36	4.5049E+05	76	1.6702E+02	116	7.0000E-02		
37	4.0762E+05	77	1.3007E+02	117	6.0000E-02		
38	3.6883E+05	78	1.0130E+02	118	5.0000E-02		
39	3.3373E+05	79	7.8893E+01	119	4.0000E-02		
40	3.0197E+05	80	6.1442E+01	120	3.0000E-02		

INFORMATION

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126 NEUTRON GROUP STRUCTURE

 BDY   ENERGY      BDY   ENERGY      BDY   ENERGY      BDY   ENERGY
   1 1.7333E+07     41 7.0651E+05     81 5.6562E+04    121 1.0677E+01
   2 1.2214E+07     42 6.7206E+05     82 5.2475E+04    122 5.0435E+00
   3 1.0000E+07     43 6.3928E+05     83 4.6309E+04    123 2.3724E+00
   4 8.1873E+06     44 6.0810E+05     84 4.0868E+04    124 1.1254E+00
   5 6.7032E+06     45 5.7844E+05     85 3.4307E+04    125 4.1399E-01
   6 6.0653E+06     46 5.5023E+05     86 3.1828E+04    126 1.0000E-01
   7 5.4881E+06     47 5.2340E+05     87 2.8500E+04    127 1.0000E-05
   8 4.4933E+06     48 4.9787E+05     88 2.7000E+04
   9 3.6788E+06     49 4.5049E+05     89 2.6058E+04
  10 3.1664E+06     50 4.0762E+05     90 2.4788E+04
  11 3.0119E+06     51 3.6883E+05     91 2.3579E+04
  12 2.8650E+06     52 3.3373E+05     92 2.1875E+04
  13 2.7253E+06     53 3.0197E+05     93 1.9305E+04
  14 2.5924E+06     54 2.9850E+05     94 1.5034E+04
  15 2.4660E+06     55 2.9720E+05     95 1.1709E+04
  16 2.3852E+06     56 2.9452E+05     96 9.1188E+03
  17 2.3653E+06     57 2.8725E+05     97 7.1017E+03
  18 2.3069E+06     58 2.7324E+05     98 5.5308E+03
  19 2.2313E+06     59 2.4724E+05     99 4.3074E+03
  20 2.1225E+06     60 2.2371E+05    100 3.7074E+03
  21 2.0190E+06     61 2.1280E+05    101 3.3546E+03
  22 1.9205E+06     62 2.0242E+05    102 3.0354E+03
  23 1.8268E+06     63 1.9255E+05    103 2.7465E+03
  24 1.7377E+06     64 1.8316E+05    104 2.6126E+03
  25 1.6530E+06     65 1.7422E+05    105 2.4852E+03
  26 1.5724E+06     66 1.6573E+05    106 2.2487E+03
  27 1.4957E+06     67 1.5764E+05    107 2.0347E+03
  28 1.4227E+06     68 1.4996E+05    108 1.5846E+03
  29 1.3534E+06     69 1.4264E+05    109 1.2341E+03
  30 1.2873E+06     70 1.3569E+05    110 9.6112E+02
  31 1.2246E+06     71 1.2907E+05    111 7.4852E+02
  32 1.1648E+06     72 1.2277E+05    112 4.5400E+02
  33 1.1080E+06     73 1.1679E+05    113 2.7536E+02
  34 1.0026E+06     74 1.1109E+05    114 2.1445E+02
  35 9.6164E+05     75 9.8037E+04    115 1.6702E+02
  36 9.0718E+05     76 8.6517E+04    116 1.0130E+02
  37 8.6294E+05     77 8.2500E+04    117 6.1442E+01
  38 8.2085E+05     78 7.9500E+04    118 4.7851E+01
  39 7.8082E+05     79 7.2000E+04    119 3.7267E+01
  40 7.4274E+05     80 6.7379E+04    120 2.2603E+01
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171 NEUTRON GROUP STRUCTURE

BDY	ENERGY	BDY	ENERGY	BDY	ENERGY
1	1.7333E+07	61	9.6164E+05	121	2.1875E+04
2	1.6487E+07	62	9.0718E+05	122	1.9305E+04
3	1.5683E+07	63	8.6294E+05	123	1.5034E+04
4	1.4918E+07	64	8.2085E+05	124	1.1709E+04
5	1.4550E+07	65	7.8082E+05	125	9.1188E+03
6	1.4191E+07	66	7.4274E+05	126	7.1017E+03
7	1.3840E+07	67	7.0651E+05	127	5.5308E+03
8	1.3499E+07	68	6.7206E+05	128	4.3074E+03
9	1.2840E+07	69	6.3928E+05	129	3.7074E+03
10	1.2214E+07	70	6.0810E+05	130	3.3546E+03
11	1.1618E+07	71	5.7844E+05	131	3.0354E+03
12	1.1052E+07	72	5.5023E+05	132	2.7465E+03
13	1.0513E+07	73	5.2340E+05	133	2.6126E+03
14	1.0000E+07	74	4.9787E+05	134	2.4852E+03
15	9.5123E+06	75	4.5049E+05	135	2.2487E+03
16	9.0484E+06	76	4.0762E+05	136	2.0347E+03
17	8.6071E+06	77	3.8774E+05	137	1.5846E+03
18	8.1873E+06	78	3.6883E+05	138	1.2341E+03
19	7.7880E+06	79	3.3373E+05	139	9.6112E+02
20	7.4082E+06	80	3.0197E+05	140	7.4852E+02
21	7.0469E+06	81	2.9850E+05	141	5.8295E+02
22	6.7032E+06	82	2.9720E+05	142	4.5400E+02
23	6.5924E+06	83	2.9452E+05	143	3.5358E+02
24	6.3763E+06	84	2.8725E+05	144	2.7536E+02
25	6.0653E+06	85	2.7324E+05	145	2.1445E+02
26	5.7695E+06	86	2.4724E+05	146	1.6702E+02
27	5.4881E+06	87	2.3518E+05	147	1.3007E+02
28	5.2205E+06	88	2.2371E+05	148	1.0130E+02
29	4.9659E+06	89	2.1280E+05	149	7.8893E+01
30	4.7237E+06	90	2.0242E+05	150	6.1442E+01
31	4.4933E+06	91	1.9255E+05	151	4.7851E+01
32	4.0657E+06	92	1.8316E+05	152	3.7267E+01
33	3.6788E+06	93	1.7422E+05	153	2.9203E+01
34	3.3287E+06	94	1.6573E+05	154	2.2603E+01
35	3.1664E+06	95	1.5764E+05	155	1.7603E+01
36	3.0119E+06	96	1.4996E+05	156	1.3710E+01
37	2.8650E+06	97	1.4264E+05	157	1.0677E+01
38	2.7253E+06	98	1.3569E+05	158	8.3153E+00
39	2.5924E+06	99	1.2907E+05	159	6.4760E+00
40	2.4660E+06	100	1.2277E+05	160	5.0435E+00
41	2.3852E+06	101	1.1679E+05	161	3.9279E+00
42	2.3653E+06	102	1.1109E+05	162	3.0590E+00
43	2.3457E+06	103	9.8037E+04	163	2.3724E+00
44	2.3069E+06	104	8.6517E+04	164	1.8554E+00
45	2.2313E+06	105	8.2500E+04	165	1.4450E+00
46	2.1225E+06	106	7.9500E+04	166	1.1254E+00
47	2.0190E+06	107	7.2000E+04	167	8.7642E-01
48	1.9205E+06	108	6.7379E+04	168	6.8256E-01
49	1.8268E+06	109	5.6562E+04	169	5.3158E-01
50	1.7377E+06	110	5.2475E+04	170	4.1399E-01
51	1.6530E+06	111	4.6309E+04	171	1.0000E-01
52	1.5724E+06	112	4.0868E+04	172	1.0000E-05
53	1.4957E+06	113	3.4307E+04		
54	1.4227E+06	114	3.1828E+04		
55	1.3534E+06	115	2.8500E+04		
56	1.2873E+06	116	2.7000E+04		
57	1.2246E+06	117	2.6058E+04		
58	1.1648E+06	118	2.4788E+04		
59	1.1080E+06	119	2.4176E+04		
60	1.0026E+06	120	2.3579E+04		

INFORMATION

174 NEUTRON GROUP STRUCTURE

BDY	ENERGY	BDY	ENERGY	BDY	ENERGY
1	1.9640E+07	61	1.1080E+06	121	2.4176E+04
2	1.7332E+07	62	1.0026E+06	122	2.3579E+04
3	1.6905E+07	63	9.6164E+05	123	2.1875E+04
4	1.6487E+07	64	9.0718E+05	124	1.9305E+04
5	1.5683E+07	65	8.6294E+05	125	1.5034E+04
6	1.4918E+07	66	8.2085E+05	126	1.1709E+04
7	1.4550E+07	67	7.8082E+05	127	1.0333E+04
8	1.4191E+07	68	7.4274E+05	128	9.1188E+03
9	1.3840E+07	69	7.0651E+05	129	7.1017E+03
10	1.3499E+07	70	6.7206E+05	130	5.5308E+03
11	1.2523E+07	71	6.3928E+05	131	4.3074E+03
12	1.2214E+07	72	6.0810E+05	132	3.7074E+03
13	1.1618E+07	73	5.7844E+05	133	3.3546E+03
14	1.1052E+07	74	5.5023E+05	134	3.0354E+03
15	1.0513E+07	75	5.2340E+05	135	2.7465E+03
16	1.0000E+07	76	4.9787E+05	136	2.6126E+03
17	9.5123E+06	77	4.5049E+05	137	2.4852E+03
18	9.0484E+06	78	4.0762E+05	138	2.2487E+03
19	8.6071E+06	79	3.8774E+05	139	2.0347E+03
20	8.1873E+06	80	3.6883E+05	140	1.5846E+03
21	7.7880E+06	81	3.3373E+05	141	1.2341E+03
22	7.4082E+06	82	3.0197E+05	142	9.6112E+02
23	7.0469E+06	83	2.9849E+05	143	7.4852E+02
24	6.7032E+06	84	2.9721E+05	144	5.8295E+02
25	6.5924E+06	85	2.9452E+05	145	4.5400E+02
26	6.3763E+06	86	2.8725E+05	146	3.5357E+02
27	6.0653E+06	87	2.7324E+05	147	2.7536E+02
28	5.7695E+06	88	2.4724E+05	148	2.1445E+02
29	5.4881E+06	89	2.3518E+05	149	1.6702E+02
30	5.2205E+06	90	2.2371E+05	150	1.3007E+02
31	4.9659E+06	91	2.1280E+05	151	1.0130E+02
32	4.7237E+06	92	2.0242E+05	152	7.8893E+01
33	4.4933E+06	93	1.9255E+05	153	6.1442E+01
34	4.0657E+06	94	1.8316E+05	154	4.7851E+01
35	3.6788E+06	95	1.7422E+05	155	3.7266E+01
36	3.3287E+06	96	1.6573E+05	156	2.9023E+01
37	3.1664E+06	97	1.5764E+05	157	2.2603E+01
38	3.0119E+06	98	1.4996E+05	158	1.7603E+01
39	2.8651E+06	99	1.4264E+05	159	1.3710E+01
40	2.7253E+06	100	1.3569E+05	160	1.0677E+01
41	2.5924E+06	101	1.2907E+05	161	8.3153E+00
42	2.4660E+06	102	1.2277E+05	162	6.4759E+00
43	2.3852E+06	103	1.1679E+05	163	5.0435E+00
44	2.3653E+06	104	1.1109E+05	164	3.9279E+00
45	2.3457E+06	105	9.8037E+04	165	3.0590E+00
46	2.3069E+06	106	8.6517E+04	166	2.3824E+00
47	2.2313E+06	107	8.2503E+04	167	1.8554E+00
48	2.1225E+06	108	7.9499E+04	168	1.4450E+00
49	2.0190E+06	109	7.1998E+04	169	1.1253E+00
50	1.9205E+06	110	6.7379E+04	170	8.7642E-01
51	1.8268E+06	111	5.6562E+04	171	6.8256E-01
52	1.7377E+06	112	5.2475E+04	172	5.3158E-01
53	1.6530E+06	113	4.6309E+04	173	4.1399E-01
54	1.5724E+06	114	4.0868E+04	174	1.0000E-01
55	1.4957E+06	115	3.4307E+04	175	1.0000E-05
56	1.4227E+06	116	3.1828E+04		
57	1.3534E+06	117	2.8501E+04		
58	1.2874E+06	118	2.7000E+04		
59	1.2246E+06	119	2.6058E+04		
60	1.1648E+06	120	2.4788E+04		

INFORMATION

218 NEUTRON GROUP STRUCTURE

BDY	ENERGY	BDY	ENERGY	BDY	ENERGY	BDY	ENERGY
1	2.0000E+07	61	1.5500E+03	121	1.3750E+01	181	1.0200E+00
2	6.4340E+06	62	1.5000E+03	122	1.2900E+01	182	1.0100E+00
3	4.8000E+06	63	1.1500E+03	123	1.1900E+01	183	1.0000E+00
4	4.3040E+06	64	9.5000E+02	124	1.1500E+01	184	9.7500E-01
5	3.0000E+06	65	6.8300E+02	125	1.0000E+01	185	9.5000E-01
6	2.4790E+06	66	6.7000E+02	126	9.1000E+00	186	9.2500E-01
7	2.3540E+06	67	5.5000E+02	127	8.1000E+00	187	9.0000E-01
8	1.8500E+06	68	3.0500E+02	128	7.1500E+00	188	8.5000E-01
9	1.5000E+06	69	2.8500E+02	129	7.0000E+00	189	8.0000E-01
10	1.4000E+06	70	2.4000E+02	130	6.7500E+00	190	7.5000E-01
11	1.3560E+06	71	2.1000E+02	131	6.5000E+00	191	7.0000E-01
12	1.3170E+06	72	2.0750E+02	132	6.2500E+00	192	6.5000E-01
13	1.2500E+06	73	1.9250E+02	133	6.0000E+00	193	6.0000E-01
14	1.2000E+06	74	1.8600E+02	134	5.4000E+00	194	5.5000E-01
15	1.1000E+06	75	1.2200E+02	135	5.0000E+00	195	5.0000E-01
16	1.0100E+06	76	1.1900E+02	136	4.7500E+00	196	4.5000E-01
17	9.2000E+05	77	1.1500E+02	137	4.0000E+00	197	4.0000E-01
18	9.0000E+05	78	1.0800E+02	138	3.7300E+00	198	3.7500E-01
19	8.7500E+05	79	1.0000E+02	139	3.5000E+00	199	3.5000E-01
20	8.6110E+05	80	9.0000E+01	140	3.1500E+00	200	3.2500E-01
21	8.2000E+05	81	8.2000E+01	141	3.0500E+00	201	3.0000E-01
22	7.5000E+05	82	8.0000E+01	142	3.0000E+00	202	2.7500E-01
23	6.7900E+05	83	7.6000E+01	143	2.9700E+00	203	2.5000E-01
24	6.7000E+05	84	7.2000E+01	144	2.8700E+00	204	2.2500E-01
25	6.0000E+05	85	6.7500E+01	145	2.7700E+00	205	2.0000E-01
26	5.7300E+05	86	6.5000E+01	146	2.6700E+00	206	1.7500E-01
27	5.5000E+05	87	6.1000E+01	147	2.5700E+00	207	1.5000E-01
28	4.9952E+05	88	5.9000E+01	148	2.4700E+00	208	1.2500E-01
29	4.7000E+05	89	5.3400E+01	149	2.3800E+00	209	1.0000E-01
30	4.4000E+05	90	5.2000E+01	150	2.3000E+00	210	9.0000E-02
31	4.2000E+05	91	5.0600E+01	151	2.2100E+00	211	8.0000E-02
32	4.0000E+05	92	4.9200E+01	152	2.1200E+00	212	7.0000E-02
33	3.3000E+05	93	4.8300E+01	153	2.0000E+00	213	6.0000E-02
34	2.7000E+05	94	4.7000E+01	154	1.9400E+00	214	5.0000E-02
35	2.0000E+05	95	4.5200E+01	155	1.8600E+00	215	4.0000E-02
36	1.5000E+05	96	4.4000E+01	156	1.7700E+00	216	3.0000E-02
37	1.2830E+05	97	4.2400E+01	157	1.6800E+00	217	2.5300E-02
38	1.0000E+05	98	4.1000E+01	158	1.5900E+00	218	1.0000E-02
39	8.5000E+04	99	3.9600E+01	159	1.5000E+00	219	1.0000E-05
40	8.2000E+04	100	3.9100E+01	160	1.4500E+00		
41	7.5000E+04	101	3.8000E+01	161	1.4000E+00		
42	7.3000E+04	102	3.7000E+01	162	1.3500E+00		
43	6.0000E+04	103	3.5500E+01	163	1.3000E+00		
44	5.2000E+04	104	3.4600E+01	164	1.2500E+00		
45	5.0000E+04	105	3.3750E+01	165	1.2250E+00		
46	4.5000E+04	106	3.3250E+01	166	1.2000E+00		
47	3.0000E+04	107	3.1750E+01	167	1.1750E+00		
48	2.5000E+04	108	3.1250E+01	168	1.1500E+00		
49	1.7000E+04	109	3.0000E+01	169	1.1400E+00		
50	1.3000E+04	110	2.7500E+01	170	1.1300E+00		
51	9.5000E+03	111	2.5000E+01	171	1.1200E+00		
52	8.0300E+03	112	2.2500E+01	172	1.1100E+00		
53	6.0000E+03	113	2.1000E+01	173	1.1000E+00		
54	3.9000E+03	114	2.0000E+01	174	1.0900E+00		
55	3.7400E+03	115	1.9000E+01	175	1.0800E+00		
56	3.0000E+03	116	1.8500E+01	176	1.0700E+00		
57	2.5800E+03	117	1.7000E+01	177	1.0600E+00		
58	2.2900E+03	118	1.6000E+01	178	1.0500E+00		
59	2.2000E+03	119	1.5100E+01	179	1.0400E+00		
60	1.8000E+03	120	1.4400E+01	180	1.0300E+00		

227 NEUTRON GROUP STRUCTURE

BDY	ENERGY	BDY	ENERGY	BDY	ENERGY	BDY	ENERGY
1	2.0000E+07	61	3.9000E+03	121	2.0000E+01	181	1.0900E+00
2	1.7333E+07	62	3.7400E+03	122	1.9000E+01	182	1.0800E+00
3	1.5683E+07	63	3.0000E+03	123	1.8500E+01	183	1.0700E+00
4	1.4550E+07	64	2.5800E+03	124	1.7000E+01	184	1.0600E+00
5	1.3840E+07	65	2.2900E+03	125	1.6000E+01	185	1.0500E+00
6	1.2840E+07	66	2.2000E+03	126	1.5100E+01	186	1.0400E+00
7	1.0000E+07	67	1.8000E+03	127	1.4400E+01	187	1.0300E+00
8	8.1873E+06	68	1.5500E+03	128	1.3750E+01	188	1.0200E+00
9	6.4340E+06	69	1.5000E+03	129	1.2900E+01	189	1.0100E+00
10	4.8000E+06	70	1.1500E+03	130	1.1900E+01	190	1.0000E+00
11	4.3040E+06	71	9.5000E+02	131	1.1500E+01	191	9.7500E-01
12	3.0000E+06	72	6.8300E+02	132	1.0000E+01	192	9.5000E-01
13	2.4790E+06	73	6.7000E+02	133	9.1000E+00	193	9.2500E-01
14	2.3540E+06	74	5.5000E+02	134	8.1000E+00	194	9.0000E-01
15	1.8500E+06	75	3.0500E+02	135	7.1500E+00	195	8.5000E-01
16	1.5000E+06	76	2.8500E+02	136	7.0000E+00	196	8.0000E-01
17	1.4000E+06	77	2.4000E+02	137	6.7500E+00	197	7.5000E-01
18	1.3560E+06	78	2.1000E+02	138	6.5000E+00	198	7.0000E-01
19	1.3170E+06	79	2.0750E+02	139	6.2500E+00	199	6.5000E-01
20	1.2500E+06	80	1.9250E+02	140	6.0000E+00	200	6.0000E-01
21	1.2000E+06	81	1.8600E+02	141	5.4000E+00	201	5.5000E-01
22	1.1000E+06	82	1.2200E+02	142	5.0000E+00	202	5.0000E-01
23	1.0100E+06	83	1.1900E+02	143	4.7500E+00	203	4.5000E-01
24	9.2000E+05	84	1.1500E+02	144	4.0000E+00	204	4.0000E-01
25	9.0000E+05	85	1.0800E+02	145	3.7300E+00	205	3.7500E-01
26	8.7500E+05	86	1.0000E+02	146	3.5000E+00	206	3.5000E-01
27	8.6110E+05	87	9.0000E+01	147	3.1500E+00	207	3.2500E-01
28	8.2000E+05	88	8.2000E+01	148	3.0500E+00	208	3.0000E-01
29	7.5000E+05	89	8.0000E+01	149	3.0000E+00	209	2.7500E-01
30	6.7900E+05	90	7.6000E+01	150	2.9700E+00	210	2.5000E-01
31	6.7000E+05	91	7.2000E+01	151	2.8700E+00	211	2.2500E-01
32	6.0000E+05	92	6.7500E+01	152	2.7700E+00	212	2.0000E-01
33	5.7300E+05	93	6.5000E+01	153	2.6700E+00	213	1.7500E-01
34	5.5000E+05	94	6.1000E+01	154	2.5700E+00	214	1.5000E-01
35	4.9952E+05	95	5.9000E+01	155	2.4700E+00	215	1.2500E-01
36	4.7000E+05	96	5.3400E+01	156	2.3800E+00	216	1.0000E-01
37	4.4000E+05	97	5.2000E+01	157	2.3000E+00	217	9.0000E-02
38	4.2000E+05	98	5.0600E+01	158	2.2100E+00	218	8.0000E-02
39	4.0000E+05	99	4.9200E+01	159	2.1200E+00	219	7.0000E-02
40	3.3000E+05	100	4.8300E+01	160	2.0000E+00	220	6.0000E-02
41	2.7000E+05	101	4.7000E+01	161	1.9400E+00	221	5.0000E-02
42	2.0000E+05	102	4.5200E+01	162	1.8600E+00	222	4.0000E-02
43	1.5000E+05	103	4.4000E+01	163	1.7700E+00	223	3.0000E-02
44	1.2830E+05	104	4.2400E+01	164	1.6800E+00	224	2.5300E-02
45	1.0000E+05	105	4.1000E+01	165	1.5900E+00	225	1.0000E-02
46	8.5000E+04	106	3.9600E+01	166	1.5000E+00	226	1.0000E-03
47	8.2000E+04	107	3.9100E+01	167	1.4500E+00	227	1.0000E-04
48	7.5000E+04	108	3.8000E+01	168	1.4000E+00	228	1.0000E-05
49	7.3000E+04	109	3.7000E+01	169	1.3500E+00		
50	6.0000E+04	110	3.5500E+01	170	1.3000E+00		
51	5.2000E+04	111	3.4600E+01	171	1.2500E+00		
52	5.0000E+04	112	3.3750E+01	172	1.2250E+00		
53	4.5000E+04	113	3.3250E+01	173	1.2000E+00		
54	3.0000E+04	114	3.1750E+01	174	1.1750E+00		
55	2.5000E+04	115	3.1250E+01	175	1.1500E+00		
56	1.7000E+04	116	3.0000E+01	176	1.1400E+00		
57	1.3000E+04	117	2.7500E+01	177	1.1300E+00		
58	9.5000E+03	118	2.5000E+01	178	1.1200E+00		
59	8.0300E+03	119	2.2500E+01	179	1.1100E+00		
60	6.0000E+03	120	2.1000E+01	180	1.1000E+00		

231 NEUTRON GROUP STRUCTURE

BDY	ENERGY	BDY	ENERGY	BDY	ENERGY	BDY	ENERGY
1	1.4918E+07	61	2.5924E+06	121	2.8725E+05	181	3.3546E+03
2	1.4550E+07	62	2.4660E+06	122	2.8015E+05	182	3.0354E+03
3	1.4191E+07	63	2.4251E+06	123	2.7324E+05	183	2.8635E+03
4	1.3840E+07	64	2.3852E+06	124	2.5991E+05	184	2.7465E+03
5	1.3499E+07	65	2.3653E+06	125	2.4724E+05	185	2.6126E+03
6	1.3165E+07	66	2.3457E+06	126	2.3518E+05	186	2.4852E+03
7	1.2840E+07	67	2.3069E+06	127	2.2371E+05	187	2.2487E+03
8	1.2523E+07	68	2.2689E+06	128	2.1280E+05	188	2.0347E+03
9	1.2214E+07	69	2.2313E+06	129	2.0242E+05	189	1.8411E+03
10	1.1912E+07	70	2.1225E+06	130	1.9255E+05	190	1.6659E+03
11	1.1618E+07	71	2.0190E+06	131	1.8316E+05	191	1.5846E+03
12	1.1331E+07	72	1.9691E+06	132	1.7422E+05	192	1.5073E+03
13	1.1052E+07	73	1.9205E+06	133	1.6992E+05	193	1.3639E+03
14	1.0779E+07	74	1.8731E+06	134	1.6573E+05	194	1.2341E+03
15	1.0513E+07	75	1.8268E+06	135	1.6163E+05	195	6.1120E+01
16	1.0253E+07	76	1.7377E+06	136	1.5764E+05	196	7.4852E+02
17	1.0000E+07	77	1.6530E+06	137	1.4996E+05	197	5.8295E+02
18	9.7531E+06	78	1.6122E+06	138	1.4264E+05	198	4.5400E+02
19	9.5123E+06	79	1.5724E+06	139	1.3569E+05	199	3.5358E+02
20	9.2774E+06	80	1.5335E+06	140	1.2907E+05	200	2.7536E+02
21	9.0484E+06	81	1.4957E+06	141	1.2277E+05	201	2.1445E+02
22	8.8250E+06	82	1.4227E+06	142	1.1679E+05	202	1.6702E+02
23	8.6071E+06	83	1.3534E+06	143	1.1109E+05	203	1.3007E+02
24	8.3946E+06	84	1.2873E+06	144	9.8037E+04	204	1.0130E+02
25	8.1873E+06	85	1.2246E+06	145	8.6517E+04	205	7.8893E+01
26	7.9852E+06	86	1.1943E+06	146	7.6351E+04	206	6.1442E+01
27	7.7880E+06	87	1.1648E+06	147	6.7379E+04	207	4.7851E+01
28	7.5957E+06	88	1.1080E+06	148	6.2511E+04	208	3.7267E+01
29	7.4082E+06	89	1.0540E+06	149	5.9462E+04	209	2.9023E+01
30	7.2253E+06	90	1.0026E+06	150	5.6562E+04	210	2.2603E+01
31	7.0469E+06	91	9.7783E+05	151	5.2475E+04	211	1.7603E+01
32	6.8729E+06	92	9.6164E+05	152	4.6309E+04	212	1.3710E+01
33	6.7032E+06	93	9.5369E+05	153	4.0868E+04	213	1.0677E+01
34	6.6476E+06	94	9.0718E+05	154	3.6066E+04	214	8.3153E+00
35	6.5924E+06	95	8.6294E+05	155	3.5175E+04	215	6.4760E+00
36	6.5377E+06	96	8.2085E+05	156	3.4307E+04	216	5.0435E+00
37	6.3763E+06	97	7.8082E+05	157	3.1828E+04	217	3.9279E+00
38	6.2189E+06	98	7.4274E+05	158	2.8088E+04	218	3.0590E+00
39	6.0653E+06	99	7.0651E+05	159	2.6058E+04	219	2.3824E+00
40	5.9156E+06	100	6.7206E+05	160	2.4788E+04	220	1.8554E+00
41	5.7695E+06	101	6.3928E+05	161	2.4176E+04	221	1.4450E+00
42	5.4881E+06	102	6.0810E+05	162	2.3579E+04	222	1.1254E+00
43	5.2205E+06	103	5.7844E+05	163	2.1875E+04	223	8.7642E-01
44	4.9659E+06	104	5.5023E+05	164	2.1335E+04	224	8.3368E-01
45	4.8432E+06	105	5.3665E+05	165	1.9305E+04	225	6.8256E-01
46	4.7237E+06	106	5.2340E+05	166	1.7036E+04	226	6.2506E-01
47	4.6070E+06	107	5.1047E+05	167	1.5034E+04	227	5.3158E-01
48	4.4933E+06	108	4.9787E+05	168	1.3268E+04	228	4.1399E-01
49	4.2741E+06	109	4.7359E+05	169	1.1709E+04	229	3.0000E-01
50	4.0657E+06	110	4.5049E+05	170	1.0333E+04	230	2.0000E-01
51	3.8674E+06	111	4.2852E+05	171	9.1188E+03	231	1.0000E-01
52	3.6788E+06	112	4.0762E+05	172	8.0473E+03	232	1.0000E-05
53	3.4994E+06	113	3.8774E+05	173	7.1017E+03		
54	3.3287E+06	114	3.6883E+05	174	6.2673E+03		
55	3.2465E+06	115	3.5084E+05	175	5.5308E+03		
56	3.1664E+06	116	3.3373E+05	176	5.0045E+03		
57	3.0882E+06	117	3.1746E+05	177	4.5283E+03		
58	3.0119E+06	118	3.0962E+05	178	4.3074E+03		
59	2.8650E+06	119	3.0197E+05	179	4.0973E+03		
60	2.7253E+06	120	2.9452E+05	180	3.7074E+03		

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238 NEUTRON GROUP STRUCTURE

BDY	ENERGY	BDY	ENERGY	BDY	ENERGY	BDY	ENERGY
1	2.0000E+07	61	3.9000E+03	121	2.0000E+01	181	1.0900E+00
2	1.7333E+07	62	3.7400E+03	122	1.9000E+01	182	1.0800E+00
3	1.5683E+07	63	3.0000E+03	123	1.8500E+01	183	1.0700E+00
4	1.4550E+07	64	2.5800E+03	124	1.7000E+01	184	1.0600E+00
5	1.3840E+07	65	2.2900E+03	125	1.6000E+01	185	1.0500E+00
6	1.2840E+07	66	2.2000E+03	126	1.5100E+01	186	1.0400E+00
7	1.0000E+07	67	1.8000E+03	127	1.4400E+01	187	1.0300E+00
8	8.1873E+06	68	1.5500E+03	128	1.3750E+01	188	1.0200E+00
9	6.4340E+06	69	1.5000E+03	129	1.2900E+01	189	1.0100E+00
10	4.8000E+06	70	1.1500E+03	130	1.1900E+01	190	1.0000E+00
11	4.3040E+06	71	9.5000E+02	131	1.1500E+01	191	9.7500E-01
12	3.0000E+06	72	6.8300E+02	132	1.0000E+01	192	9.5000E-01
13	2.4790E+06	73	6.7000E+02	133	9.1000E+00	193	9.2500E-01
14	2.3540E+06	74	5.5000E+02	134	8.1000E+00	194	9.0000E-01
15	1.8500E+06	75	3.0500E+02	135	7.1500E+00	195	8.5000E-01
16	1.5000E+06	76	2.8500E+02	136	7.0000E+00	196	8.0000E-01
17	1.4000E+06	77	2.4000E+02	137	6.7500E+00	197	7.5000E-01
18	1.3560E+06	78	2.1000E+02	138	6.5000E+00	198	7.0000E-01
19	1.3170E+06	79	2.0750E+02	139	6.2500E+00	199	6.5000E-01
20	1.2500E+06	80	1.9250E+02	140	6.0000E+00	200	6.2500E-01
21	1.2000E+06	81	1.8600E+02	141	5.4000E+00	201	6.0000E-01
22	1.1000E+06	82	1.2200E+02	142	5.0000E+00	202	5.5000E-01
23	1.0100E+06	83	1.1900E+02	143	4.7500E+00	203	5.0000E-01
24	9.2000E+05	84	1.1500E+02	144	4.0000E+00	204	4.5000E-01
25	9.0000E+05	85	1.0800E+02	145	3.7300E+00	205	4.0000E-01
26	8.7500E+05	86	1.0000E+02	146	3.5000E+00	206	3.7500E-01
27	8.6110E+05	87	9.0000E+01	147	3.1500E+00	207	3.5000E-01
28	8.2000E+05	88	8.2000E+01	148	3.0500E+00	208	3.2500E-01
29	7.5000E+05	89	8.0000E+01	149	3.0000E+00	209	3.0000E-01
30	6.7900E+05	90	7.6000E+01	150	2.9700E+00	210	2.7500E-01
31	6.7000E+05	91	7.2000E+01	151	2.8700E+00	211	2.5000E-01
32	6.0000E+05	92	6.7500E+01	152	2.7700E+00	212	2.2500E-01
33	5.7300E+05	93	6.5000E+01	153	2.6700E+00	213	2.0000E-01
34	5.5000E+05	94	6.1000E+01	154	2.5700E+00	214	1.7500E-01
35	4.9952E+05	95	5.9000E+01	155	2.4700E+00	215	1.5000E-01
36	4.7000E+05	96	5.3400E+01	156	2.3800E+00	216	1.2500E-01
37	4.4000E+05	97	5.2000E+01	157	2.3000E+00	217	1.0000E-01
38	4.2000E+05	98	5.0600E+01	158	2.2100E+00	218	9.0000E-02
39	4.0000E+05	99	4.9200E+01	159	2.1200E+00	219	8.0000E-02
40	3.3000E+05	100	4.8300E+01	160	2.0000E+00	220	7.0000E-02
41	2.7000E+05	101	4.7000E+01	161	1.9400E+00	221	6.0000E-02
42	2.0000E+05	102	4.5200E+01	162	1.8600E+00	222	5.0000E-02
43	1.5000E+05	103	4.4000E+01	163	1.7700E+00	223	4.0000E-02
44	1.2830E+05	104	4.2400E+01	164	1.6800E+00	224	3.0000E-02
45	1.0000E+05	105	4.1000E+01	165	1.5900E+00	225	2.5300E-02
46	8.5000E+04	106	3.9600E+01	166	1.5000E+00	226	1.0000E-02
47	8.2000E+04	107	3.9100E+01	167	1.4500E+00	227	7.5000E-03
48	7.5000E+04	108	3.8000E+01	168	1.4000E+00	228	5.0000E-03
49	7.3000E+04	109	3.7000E+01	169	1.3500E+00	229	4.0000E-03
50	6.0000E+04	110	3.5500E+01	170	1.3000E+00	230	3.0000E-03
51	5.2000E+04	111	3.4600E+01	171	1.2500E+00	231	2.5000E-03
52	5.0000E+04	112	3.3750E+01	172	1.2250E+00	232	2.0000E-03
53	4.5000E+04	113	3.3250E+01	173	1.2000E+00	233	1.5000E-03
54	3.0000E+04	114	3.1750E+01	174	1.1750E+00	234	1.2000E-03
55	2.5000E+04	115	3.1250E+01	175	1.1500E+00	235	1.0000E-03
56	1.7000E+04	116	3.0000E+01	176	1.1400E+00	236	7.5000E-04
57	1.3000E+04	117	2.7500E+01	177	1.1300E+00	237	5.0000E-04
58	9.5000E+03	118	2.5000E+01	178	1.1200E+00	238	1.0000E-04
59	8.0300E+03	119	2.2500E+01	179	1.1100E+00	239	1.0000E-05
60	6.0000E+03	120	2.1000E+01	180	1.1000E+00		

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4.INFORMATION.4.2 "Standard" Gamma Boundaries

The following gamma energy group structures are built into AMPX:

1. an 18-group structure, widely used for atmospheric transport calculations;
2. a 21-group structure, which is a Defense Nuclear Agency structure;
3. a 25-group structure;
4. a 26-group structure; and
5. a 44-group structure.

These structures are defined on the following page.

18 GAMMA GROUP STRUCTURE

BDY	ENERGY	BDY	ENERGY
1	1.4000E+07	11	1.5000E+06
2	1.0000E+07	12	1.0000E+06
3	8.0000E+06	13	7.0000E+05
4	7.0000E+06	14	4.5000E+05
5	6.0000E+06	15	3.0000E+05
6	5.0000E+06	16	1.5000E+05
7	4.0000E+06	17	6.0000E+04
8	3.0000E+06	18	3.0000E+04
9	2.5000E+06	19	1.0000E+04
10	2.0000E+06		

21 GAMMA GROUP STRUCTURE

BDY	ENERGY	BDY	ENERGY	BDY	ENERGY
1	1.4000E+07	11	1.5000E+06	21	2.0000E+04
2	1.0000E+07	12	1.0000E+06	22	1.0000E+04
3	8.0000E+06	13	7.0000E+05		
4	7.0000E+06	14	4.5000E+05		
5	6.0000E+06	15	3.0000E+05		
6	5.0000E+06	16	1.5000E+05		
7	4.0000E+06	17	1.0000E+05		
8	3.0000E+06	18	7.0000E+04		
9	2.5000E+06	19	4.5000E+04		
10	2.0000E+06	20	3.0000E+04		

25 GAMMA GROUP STRUCTURE

BDY	ENERGY	BDY	ENERGY	BDY	ENERGY
1	1.3000E+07	11	1.1461E+06	21	1.0104E+05
2	1.0197E+07	12	8.9896E+05	22	7.9252E+04
3	7.9983E+06	13	7.0513E+05	23	6.2164E+04
4	6.2737E+06	14	5.5309E+05	24	4.8760E+04
5	4.9210E+06	15	4.3383E+05	25	3.8247E+04
6	3.8599E+06	16	3.4029E+05	26	3.0000E+04
7	3.0277E+06	17	2.6692E+05		
8	2.3748E+06	18	2.0937E+05		
9	1.8628E+06	19	1.6422E+05		
10	1.4611E+06	20	1.2881E+05		

26 GAMMA GROUP STRUCTURE

BDY	ENERGY	BDY	ENERGY	BDY	ENERGY
1	1.4000E+07	11	1.5000E+06	21	7.0000E+04
2	1.0000E+07	12	1.0000E+06	22	5.0000E+04
3	8.0000E+06	13	8.3000E+05	23	4.0000E+04
4	7.0000E+06	14	7.0000E+05	24	3.0000E+04
5	6.0000E+06	15	5.5000E+05	25	2.0000E+04
6	5.0000E+06	16	4.5000E+05	26	1.3000E+04
7	4.0000E+06	17	3.0000E+05	27	1.0000E+04
8	3.0000E+06	18	2.0000E+05		
9	2.5000E+06	19	1.3000E+05		
10	2.0000E+06	20	1.0000E+05		

44 GAMMA GROUP STRUCTURE

BDY	ENERGY	BDY	ENERGY	BDY	ENERGY
1	2.0000E+07	21	1.6600E+06	41	6.0000E+04
2	1.4000E+07	22	1.5700E+06	42	4.5000E+04
3	1.2000E+07	23	1.5000E+06	43	3.0000E+04
4	1.0000E+07	24	1.4400E+06	44	2.0000E+04
5	8.0000E+06	25	1.3300E+06	45	1.0000E+04
6	7.5000E+06	26	1.2000E+06		
7	7.0000E+06	27	1.0000E+06		
8	6.5000E+06	28	8.0000E+05		
9	6.0000E+06	29	7.0000E+05		
10	5.5000E+06	30	6.0000E+05		
11	5.0000E+06	31	5.1200E+05		
12	4.5000E+06	32	5.1000E+05		
13	4.0000E+06	33	4.5000E+05		
14	3.5000E+06	34	4.0000E+05		
15	3.0000E+06	35	3.0000E+05		
16	2.5000E+06	36	2.0000E+05		
17	2.3500E+06	37	1.5000E+05		
18	2.1500E+06	38	1.0000E+05		
19	2.0000E+06	39	7.5000E+04		
20	1.8000E+06	40	7.0000E+04		

4.INFORMATION.5 AMPX WEIGHTING FUNCTION LIBRARY

The XLACS and LAPHNGAS modules in AMPX can select from a library of weighting functions. The ENDF/B "TAB1" structure is used as a format. These are written on logical unit 46 as follows (a set of three binary records is required for each function):

Record 1 - [8000, 3, MT, 0, 0, 0, 0, 0, 0]
Record 2 - [8000, 3, MT, 0, 0, 0, 0, N1, N2,
(NBT$_i$, INT$_i$, i=1, N1),
(X$_j$, Y$_j$, j=1, N2)]
Record 3 - [8000, 3, 0, 0, 0, 0, 0, 0, 0]

where MT is the function identifier, N1 is the number of points in the interpolation table, N2 is the number of points in the function, NBT and INT comprise the interpolation as described below, and X and Y describe the function.

The interpolation table is defined as follows:

NBT is the point in the X,Y table up to which the corresponding interpolation type, as specified by INT, is to be used where the following codes are used:

Code	Interpolation Type (INT)
1	Histogram
2	Linear X, linear Y
3	Linear X, log Y
4	Log X, linear Y
5	Log X, log Y

Functions are stacked on logical unit 46, one after the other.

4.INFORMATION.6 REACTION TYPE IDENTIFIERS

Reaction types in ENDF data are identified by integers called MT numbers. Within the AMPX system, the ENDF MT numbers are used where possible to identify the appropriate cross-section data. AMPX processed data that have no ENDF MT number counterpart are identified by integers outside the range of the ENDF MT numbers. The following definition of reaction types is taken from Appendix B of the ENDF manual,[1] being augmented where necessary to describe identifiers assigned to AMPX processed data.

The MT number generally refers to a specific neutron-nucleus interaction mechanism, but occasionally it indicates that a particular type of information is given. The general rules for assignment of MT numbers are as follows:

MT (range)	Description of class of reactions
1–100	Reaction types in which secondary particles of the same type as the incident particles are emitted
101–150	Reaction types in which no secondary particles of the same type as the incident particles are emitted
151–200	Resonance region information
201–450	Quantities derived from the basic data
451–699	Miscellaneous quantities
700–799	Excitation cross sections for reactions that emit charged particles
800–999	(Not assigned)
1000–9999	AMPX special identifiers

Within AMPX, different modules can assign the same MT number to a more or less inclusive set of data pertaining to the implied reaction. Specific MT assignments are given in the following table. Situations where different AMPX modules use the same MT number to identify the more or less inclusive data are identified below:

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)
5	(To be assigned)
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)
10–15	(To be assigned)
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
27	Absorption cross section (sum of MT = 18 and 101) includes particle reactions
28	(n,n'p) cross section
29	(n,n'2α) cross section
30	(n,2n2α) cross section
31	Used only in ENDF/B data as an LR flag to indicate that γ-emission is the mode of decay of the residual nucleus formed in the primary reaction[a]
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)
39	Used only in ENDF/B data to indicate that internal conversion in the mode of decay of the residual nucleus formed in the primary reaction[a]
40	Used only in ENDF/B data to indicate that electron-position pair formation is the mode of decay of the residual nucleus formed in the primary reaction[a]
41–45	(To be assigned)
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
92–100	(To be assigned)
101	Neutron disappearance (sum of all cross sections in which a neutron is not in the exit channel), i.e., MT = 101 is $\sum_{i=2}^{14}$ (MT = 100 + i)
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
115–119	(To be assigned)
120	Target destruction = nonelastic less total (n,n′γ)
121–150	(To be assigned)
151	General designation for resonance information
152–200	(To be assigned for specific resonance information)
201–202	(To be assigned)
203	Total hydrogen production
204	Total deuterium production

205	Total tritium production
206	Total ^{3}He production
207	Total ^{4}He production
208–250	(To be assigned)
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
254–300	(To be assigned)
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
453	Radioactive nuclide production
454	Fission-product yield data
455	Delayed neutrons from fission
456	Prompt neutrons from fission
457	Radioactive decay data
458	Energy release in fission
459–500	(To be assigned)
501	Total photon interaction cross section
502	Photon coherent scattering
503	(To be assigned)
504	Photon incoherent scattering
505–514	(To be assigned)
515	Pair production, electron field
516	Pair production, nuclear and electron field (i.e., pair plus triplet production)
517	Pair production, nuclear field
518	Photofission (γ,f)
519–526	(To be assigned)
527	Sum of all gamma-ray absorption processes
528–531	(To be assigned)
532	Photoneutron (γ,n)
533	Total photonuclear

534–601	(To be assigned)
602	Photoelectric
603–699	(To be assigned)
700	(n,p_0) cross section (cross section for leaving the residual nucleus in the ground state)
701	(n,p_1) cross section for first excited state
702	(n,p_2) cross section for second excited state
703	(n,p_3) cross section for third excited state
704	(n,p_4) cross section for fourth excited state
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.	
718	(n,p_c) cross section for continuum excited state
719	(n,p'_c) cross section for continuum specifically not included in total (redundant, used for describing outgoing proton)
720	(n,d_0) cross section for ground state
721	(n,d_1) cross section for first excited state
722	(n,d_2) cross section for second excited state
.	
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.	
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 first excited state
742	(n,t_2) cross section for second excited state
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.	
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 first excited state
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778	(n, ^{3}He$_c$) cross section for continuum
779	(n, ^{3}He$_c$) 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 first excited state
.	
.	
.	
798	(n,α_c) cross section for continuum
799	(n,$\alpha_{c'}$) cross section for continuum specifically not included in σ_T (redundant, used to describe outgoing α)
800–999	(To be assigned)
1000[b]	XSDRNPM-produced transport cross section based on the outscatter approximation, that is, $\sigma_{tr} = \sigma_a + (1 - \bar{\mu})\sigma_s$ (Note: σ_a is MT = 27; σ_s is MT = 2)
1001[b]	XSDRNPM-produced transport cross section based on the inscatter approximation, that is, $\sigma_{tr} \equiv \sigma_t - \frac{\int_0^\infty \sigma_1(E' \rightarrow E)j(E')dE'}{3j(E)}$
1007	Thermal scattering matrix—may contain coherent and incoherent data
1008	Thermal scattering matrix for coherent data
1018	Fission spectrum, chi (χ). The fission spectrum is represented in ENDF file 5 data as a function of neutron energy. This array is a collapse of that data
1099	Group integral of the weighting function
1452	Average of the product of $\bar{\nu}$ times the fission cross section, $\overline{\nu\sigma_f}$ (Note that this "derived" parameter should never be used on an AMPX master library, in order to avoid the possibility that it may be processed in some modules without being self-shielded.)
1500–1501	Same as 1000–1001 except for gamma-ray cross sections
1527	Gamma-ray energy absorption coefficients. These data are also called kerma factors
3002	Infinite dilution averages for elastic scattering
3018	Infinite dilution averages for fission
3102	Infinite dilution averages for (n,γ)
9901–9999	Successive values of weighting spectra that were used to produce the current version of this library

[a] The "primary" reaction could be, for example, an (n,n′), (n,p), (n,α), (n,n′p), etc., reaction.

[b] Transport cross sections are weighted with currents in XSDRNPM. All other cross sections are flux weighted.

4.INFORMATION.7 GLOSSARY OF TERMS

Multigroup cross-section processing has its own jargon. In the following glossary, terms used to describe cross-section libraries, terms applicable to cross sections used in discrete-ordinates codes, ENDF terms, AMPX format terms, CCCC format terms, resonance region and temperature effects terminology, and terms applicable to thermal cross sections are defined. References cited in the glossary give more thorough discussions of the terms.

4.INFORMATION.7.1 General Terms Used to Describe Cross-Section Libraries

BCD

Used to denote that a computer code or data library is in a formatted form, which usually can be readily exchanged between installations with different computers (could be actually in BCD or EBCDIC characters), usually in the form of card records or print records.

Binary

Used to describe an unformatted library, which will probably only be useable on the brand of computing system on which it was written.

Blocked tape

A magnetic tape written with each physical record containing a fixed number of logical records. For example, computer codes in most RSIC packages are written with 40 card images (logical records) per block.

Card image

A record on a tape or disk which is a copy of an 80-column card. Most source programs and data libraries which the Radiation Shielding Information Center (RSIC) distributes are in card-image form. Card image tapes are "BCD" in the sense defined above.

CCC

The RSIC Computer Code Collection (CCC).[1] These are packages associated with a computer code or system of codes usually designed to perform radiation transport calculations. The package consists of source program, sample input, and output data for executing one or more demonstration problems. Packages are assigned a CCC number (e.g., CCC-254/ANISN-ORNL).

DD cards

The DD (data definition) statement describes a data set that is to be used in a job step and specifies the input and output facilities required for use of the data set.

DLC

The RSIC Data Library Collection (DLC).[2] These are packages associated with a data library. A retrieval code is usually included for manipulating the data into a form suitable for use in one of the CCC's. Packages are assigned a DLC number (e.g., DLC-41/VITAMIN-C).

JCL

The Job Control Language (JCL) refers to the statements containing the information required by the operating system to initiate and control the processing of jobs.

PSR

The RSIC Peripheral Shielding Routine Collection (PSR).[3] These are packages associated with a code or code system designed to perform operations peripheral to an actual radiation transport calculation (e.g., multigroup cross-section generation). Some RSIC DLCs produced with PSR packages are assigned a PSR number (e.g., PSR-63/AMPX).

4.INFORMATION.7.2 Discrete-Ordinate Terms

ANISN activity cross section

An extra cross section inserted into an ANISN cross-section table for the purpose of calculating reaction rates, dose factors, etc., using the "activity" option in ANISN.[4]

ANISN binary format

An unformatted cross-section representation for use in ANISN. Each ANISN "material" is represented by two records, an identification record, and a record containing an ANISN cross-section table.

ANISN card-image format

A "BCD" form of cross-section representation which can be easily exchanged between installations. Most DLCs with ANISN cross sections are distributed in this form with a simple computer code to allow the user to convert to ANISN binary format.

ANISN cross-section table

A matrix of multigroup cross sections with N columns, one for each energy group, with each column containing terms describing σ_a, $\overline{\nu\sigma_f}$, σ_t and cross sections for scattering into that group (including within-group scattering). Column 1 refers to the highest energy group and column N to the lowest energy group. More than (N + 3) terms will be required if "activity" cross sections are included and/or if there are "upscattering" terms in the table.

ANISN material

Each component of a Legendre expansion of the scattering processes for a given element (e.g., oxygen) is described by an ANISN cross-section table. These are referred to as a "material." Thus, for P_3 representation, four materials are required (P_0, P_1, P_2, and P_3).

ANISN ($2\ell + 1$) term

The ANISN code does not internally multiply terms by ($2\ell + 1$) during the course of the discrete-ordinates calculation. The factor (3 for P_1, 5 for P_2, etc.) can be provided by means of the mixing table but is quite often included in the cross sections prior to input to ANISN. DLCs in RSIC in "ANISN" format have the ($2\ell + 1$) factor included. *Note that the DTF series of codes do multiply by the ($2\ell + 1$) internally.* Thus, DLCs in "ANISN" format will cause trouble if used directly in DTF-IV, and vice versa.

Coupled multigroup cross sections

Coupled refers to a cross-section data set with information describing neutron interactions, gamma-ray production from neutron interactions, and gamma-ray interactions. For N neutron groups and G gamma-ray groups, the corresponding ANISN cross-section table would have N + G columns, column 1 for the highest energy neutron group, column N for the lowest energy neutron group, column N + 1 for the highest energy gamma-ray group, and column N + G for the lowest energy gamma-ray group. A coupled cross-section set can be used to do neutron, secondary gamma-ray, and primary gamma-ray transport in a single computer run.

FIDO input

A scheme that allows many shorthand provisions for representing card input data. FIDO input is used for many codes developed at ORNL, including ANISN, DOT, and AMPX. See Sect. 7.FIDO.

Fixed and free-form FIDO

The original FIDO format was a fixed format that required rigid observance of the columns in which data were input. The later free-form formats allow the user to write his input without regard to column position, where he simply separates his input with one or more blanks.

Group-ordered form

An alternative form of cross sections for a discrete-ordinates code. All cross sections for all materials for a given energy group are located together. This reduces the amount of core storage required in running a discrete-ordinates code because data for all materials for only one energy group are needed in core at a given time. The term "group-independent" is sometimes used when referring to the group-ordered form.

4.INFORMATION.7.3 ENDF Terms

ENDF/B

The Evaluated Nuclear Data File[5] (ENDF) is a library of cross-section data for a variety of materials. Each evaluated data set ("evaluation") represents a "best" judgment for a given material of how the cross sections and energy and angular distributions of scattered particles vary with incident particle energy considering all the available measured data, and, where necessary, nuclear model calculations. Each version of ENDF/B is approved and released by the Cross Section Evaluation Working Group (CSEWG) which has members from various laboratories, industry, and universities throughout the United States. The data are available from the National Nuclear Data Center (NNDC) at Brookhaven National Laboratory. The current version is ENDF/B-V.

ENDF format (BCD and binary)

The format[2] for ENDF/B is a set of rules for representing cross sections and angular and energy distributions of neutrons and gamma rays. The BCD format is a card-image form used for transmittal between installations. The binary format is usually used to store data at a given installation. Most processing codes (including the AMPX system) will process either format. The binary format is a more efficient format that permits faster access to its data and requires considerably less space for its storage.

CSEWG

The Cross Section Evaluation Working Group (CSEWG) consists of representatives from various laboratories, universities, and industries who meet annually to discuss the status of ENDF/B. They are responsible for the evaluation, review, testing, and subsequent approval of cross sections for inclusion in the ENDF/B libraries.

Resonance parameters

ENDF/B evaluations can represent the energy region where many cross-section resonances occur with resonance parameters. For these cases, the evaluation may also have "background" point cross sections in the resonance region. The resonance parameters are used in specified formulae to generate point cross sections. These are then added to the "background" cross sections to reproduce the point cross-section representation which the evaluator intended for that material.

Resonance parameters provide a way of specifying the features of a cross section with sets of parameters, which, when used in a fitting procedure, allow one to determine an energy mesh and associated cross-section values. A variety of types of resonance parameters may be encountered, including single-level Breit-Wigner (SLBW), multilevel Breit-Wigner (MLBW), Adler-Adler, and Reich-Moore (RM). The latter two forms provide a more general means of fitting the data, but have rarely been used in earlier versions of ENDF/B. Parameters can also be found for what are referred to as unresolved resonances. In this case, the fits are for a region where the resonances are so closely spaced that it is impossible or impractical to "resolve" them and, thereby, be able to use normal resonance parameters. In this region, resonances are specified only in a statistical sense and require special processing procedures.

Gamma-ray multiplicities

An energy-dependent ratio of the gamma-ray production cross section (for a given neutron interaction) to the neutron interaction cross section. The ratio is the number of gamma rays (discrete or continuum) produced by a given neutron interaction.

Gamma-ray production cross section

The energy-dependent cross section for producing gamma rays due to a given neutron interaction. These are represented as "point" cross sections on ENDF/B. Gamma-ray production cross sections can be given in ENDF format for discrete gamma rays or for a continuum of gamma rays.

MAT

The ENDF[6] identification number for a particular material's cross sections.

MF

An ENDF file identification for a particular type of data (e.g., MF = 3 refers to neutron point cross sections, MF = 4 to neutron scattering angular distributions, etc.). These are denoted as different "files" of data but are not actually in a different physical tape file.

MT

An ENDF reaction-type identification for a particular cross section. Note that MAT and MT are sometimes used as input parameters to multigroup processing codes. MT numbers used by ENDF and in the AMPX system are defined in Sect. 4.INFORMATION.6.

NNDC

The National Nuclear Data Center (NNDC) (formerly NNCSC) at Brookhaven National Laboratory is responsible for distributing the ENDF/B data to requesters in the United States.

Point cross sections

ENDF/B evaluations normally have energy cross-section pairs to represent the energy dependence of a given reaction. This representation is termed "point cross sections." As indicated above, a point cross-section representation may be accompanied in the resonance region by a set of resonance parameters. An ENDF "resonance" evaluation may be processed by a code such as NPTXS[1] in AMPX which converts the resonance parameters into point cross sections.

Resolved resonance region

The energy region where cross sections are fit by resonance parameters is called the resolved resonance region.

Unresolved resonance region

The energy region where information about specific resonances cannot be determined. Instead, parameters which describe families or sequences of resonances in a statistical sense are given.

4.INFORMATION.7.4 Multigroup Cross-Section Terms

Collapsing

The process of weighting a multigroup library over a multigroup flux spectrum. The weighting spectrum may be guessed at or calculated. The reduction is from a "fine-" group to a "broad-" group level. In general, the collapsing procedure preserves reaction rates for each energy range.

Downscatter

Terms that refer to multigroup cross sections for transferring from a given energy group to a group at a lower energy.

Multigroup cross sections

The cross sections which are appropriate for solving a multigroup representation of the Boltzmann transport equation. Multigroup reaction cross sections and transfer matrices are generated by averaging over a weighting function with an energy dependence that is (hopefully) close to the spectrum of particles in the problem to be solved. It is presumed that the more groups that are used to represent the energy region, the better the multigroup approximation becomes.

Transfer matrix

The multigroup cross sections representing scattering between energy groups. They can be a combination of upscatter, within-group, and downscatter terms. A transfer matrix may be provided for many processes on a general library, such as an AMPX master library.

Weighting function

The energy-dependent function used to calculate the average cross sections and transfer matrices for a multigroup cross-section library. Typical functions include a Maxwellian function for the thermal energy region, 1/E in the slowing-down region above thermal and below the region where fission neutrons are born, a fission spectrum, a Gaussian distribution near 14 MeV, etc. For some applications, the reciprocal total cross section ($1/\sigma_t$) is used to handle situations where deep penetration problems in a pure material are to be solved.

Within-group scattering

The multigroup cross section for scattering and remaining in the same energy group.

4.INFORMATION.7.5 AMPX Format Terms

AMPX interface

A multigroup library in AMPX master or AMPX working library interface format.

AMPX master library interface format

A multigroup library format for representing reaction cross sections and transfer matrices for an arbitrary number of processes. Data can be provided for neutron reactions and scattering processes, gamma-ray production processes, and gamma-ray reactions and scattering processes. The formats are designed with a generality paralleling ENDF/B in that all reactions can be carried along with any associated scattering transfer matrices. In addition, resonance parameters can be carried on the interface, and/or Bondarenko factors can be provided. Identification records are included which describe all nuclides on the master library interface as well as other useful information, such as energy-group structures.

AMPX weighted library

XSDRNPM can be used to collapse an AMPX working library using a variety of options. The resulting library is referred to as a "weighted" library. It has the same format as an AMPX working library interface (see below).

AMPX working library interface

A master interface is not a convenient form for use in most nuclear calculations. NITAWL will combine cross sections, perform resonance self-shielding calculations, combine neutron and gamma-ray matrices, etc., to produce an AMPX working interface. This working library is analogous to (but more general than) an ANISN library.

BCD AMPX library

A BCD format is used to allow transmitting of AMPX libraries between installations with different computers. The AIM module of AMPX, which creates this library, can also be used to read it and convert it back to the binary form.

LAPHNGAS library

An AMPX interface created by the LAPHNGAS module to describe gamma-ray production processes. Both gamma-ray production cross sections and multiplicities can be included. This is in the AMPX master library format.

Magic word

The AMPX interfaces use a "magic-word" scheme to compact the potentially lengthy transfer matrix arrays. This effectively eliminates zero and impossible elements. A magic word is a 9-digit integer consisting of three 3-digit integers defining the energy group and the range of energy groups that can scatter into the given group. The group numbers are in the sequence of highest-source, lowest-source and sink groups.

SMUG library

An AMPX interface created by the SMUG module to describe gamma-ray reaction and scattering processes. This is in the AMPX master library format.

4.INFORMATION.7.6 CCCC Format Terms

CCCC

The Committee on Computer Code Coordination (CCCC) has devised standards and procedures for facilitating the exchange of data between various reactor physics codes. The ISOTXS library produced by the AMPX system is in the CCCC format, which is a format for multigroup neutron cross sections..

BRKOXS

This is another CCCC file and is used with the ISOTXS file when the Bondarenko self-shielding method is to be used. The file[7] contains multigroup self-shielding factors for total (current weighted), capture, fission, transport, and elastic-scattering cross sections. Data can be provided for several values of σ_0 and temperature.

ISOTXS

A nuclide ordered file[7] of neutron multigroup cross sections. Reaction cross sections and transfer matrices are provided for a selected number of reactions rather than all the possible reactions included on an ENDF tape. The reaction data are infinitely dilute cross sections and can be used in combination with the BRKOXS file in a code like SPHINX[8] to provide problem-dependent self-shielding cross sections at the problem temperature.

Total cross section (current weighted)

The calculation of diffusion coefficients requires an inverse weighting of the total cross section. These values are not equal to the sum of the multigroup partial cross sections that are produced with flux weighting.

Transport cross section

A transport cross section is needed in diffusion theory to determine a diffusion coefficient. In transport theory, it is often used to account for the effects of truncating the order of fit to the scattering matrices.

4.INFORMATION.7.7 Resonance Region and Temperature Effects

Bondarenko factors

Multigroup factors that are tabulated as a function of background cross section per atom (σ_0) and temperature (T). These factors can be used in an iterative procedure that uses infinite dilution cross sections, the Bondarenko[9] factors, and the system description to produce self-shielded cross sections. Codes such as BONAMI and SPHINX provide these kinds of calculations.

Dancoff correction factor

A factor[10] that accounts for shadowing effects caused by the presence of other absorber lumps in the neighborhood of the lump being calculated. For example, Dancoff factors can be used to account for the effects of locating fuel pins in lattice geometries in a simple calculation that only mocks up a single fuel pin and its surrounding moderator.

Doppler broadening

An accounting of the energy variation of cross sections as a function of temperature. Codes that process ENDF data usually perform Doppler broadening for a given temperature (or several temperatures) prior to the multigroup averaging.

f-factors

The same as Bondarenko factors.

Nordheim integral treatment

An integral transport theory method[11] based on reducing a two-region (fuel/moderator) system to a single region by assuming the moderator flux is 1/E. Other notable characteristics of the method are in using escape probabilities for region coupling, ψ and χ functions for Doppler broadening, and a particularly clever and efficient scheme for calculating slowing-down integrals. It has been very successfully used for a wide variety of thermal system analyses.

Self-shielding

This is an accounting for the effects that a resonance has on the flux in the vicinity of the resonance. Self-shielding depends on the temperature, composition, and geometry of the particular situation. Various approaches are taken to account for this effect in multigroup libraries, including the Nordheim integral treatment, the Bondarenko method, and integral transport theory in the AMPX system.

4.INFORMATION.7.8 Thermal Region

Free-gas model

A thermal-scattering model that assumes the target nucleus has a Maxwellian thermal energy distribution and that atoms are unbound.

Maxwell-Boltzmann distribution

This function is often used as a guess for a weighting flux in the thermal range. It is based on slowing down in a pure scattering region whose temperature is characterized by the temperature of the medium.

S(α,β)

A representation used in ENDF/B to present thermal-scattering cross sections that can include chemical, molecular, and crystalline binding effects.

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5. AMPX-77 INSTALLATION GUIDE

AMPX-77 is distributed on a standard label magnetic tape. The various files on this tape contain several types of information, including (1) the source decks for the various modules, (2) the source decks for various auxiliary programs, (3) a FORTRAN-77 source file of routines shared by several of the modules, (4) a collection of IBM assembler language routines shared by the modules, (5) a collection of FORTRAN routines to override most of the assembler programming, (6) the system driver program for both IBM and Cray computers, (7) sample problem input and output, and (8) auxiliary files for use in creating a group-structure library, supplying basic cross-section data, etc.

The contents of the files are given in the following table:

File	Contents	Language	Blocking	Entry
1	AIM	FORTRAN	80	AIM
2	AJAX	FORTRAN	80	AJAX
3	ALE	FORTRAN	80	MAIN
4	ALPO	FORTRAN	80	MAIN
5	BONAMI	FORTRAN	80	BONAMI
6	CASTROL	FORTRAN	80	MAIN
7	CLAROL	FORTRAN	80	CLAROL
8	COLLINS	FORTRAN	80	MAIN
9	COMAND	FORTRAN	80	MAIN
10	COMET	FORTRAN	80	MAIN
11	CONTAC	FORTRAN	80	CONTAC
12	CORECTOL	FORTRAN	80	CRCTOL
13	CREST	FORTRAN	80	MAIN
14	FRESH	FORTRAN	80	MAIN
15	GERITOL	FORTRAN	80	MAIN
16	ICE	FORTRAN	80	ICE2
17	JERGENS	FORTRAN	80	MAIN
18	LAPHNGAS	FORTRAN	80	MAIN
19	LAVA	FORTRAN	80	LAVA
20	MAD	FORTRAN	80	MAIN
21	MALOCS	FORTRAN	80	MALOCS
22	NITAWL-II	FORTRAN	80	NITAWL
23	NPTXS	FORTRAN	80	MAIN
24	PAL	FORTRAN	80	MAIN
25	PERFUME	FORTRAN	80	PERFUM
26	POLIDENT	FORTRAN	80	NPTXS
27	PRELL	FORTRAN	80	PRELL
28	PRUDE	FORTRAN	80	MAIN
29	RADE	FORTRAN	80	RADE
30	ROLAIDS	FORTRAN	80	RELIEF

File	Contents	Language	Blocking	Entry
31	RUFFLES	FORTRAN	80	RUFFLES
32	SALVAGE	FORTRAN	80	MAIN
33	SMILER	FORTRAN	80	SMILER
34	SMUG	FORTRAN	80	SMUG
35	TABU	FORTRAN	80	TABU
36	TIDE	FORTRAN	80	TIDE
37	UNITAB	FORTRAN	80	UNITAB
38	VASELINE	FORTRAN	80	MAIN
39	VEL	FORTRAN	80	MAIN
40	WAX	FORTRAN	80	WAX
41	WINE	FORTRAN	80	MAIN
42	WISK	FORTRAN	80	MAIN
43	WORKER	FORTRAN	80	WORKER
44	WORM	FORTRAN	80	MAIN
45	XLACS	FORTRAN	80	MAIN
46	XSDRNPM	FORTRAN	80	XSDRN
47	ZEST	FORTRAN	80	ZEST
48	Subroutine library	FORTRAN	80	
49	Subroutine library (IBM Assembler)	IBM Assembler		
50	Cray FORTRAN replacements for IBM assembler routines	FORTRAN for UNICOS		
51	ALIAS, program to produce subroutine library from the decks	PL1		
52	AMPX-77 driver program (IBM)	IBM Assembler		
53	AMPX-77 driver program (Cray)	FORTRAN for UNICOS		
54	Program to translate IBM FORTRAN to Cray FORTRAN	FORTRAN		
55	AMPX procedure for IBM MVS systems			
56	Thermal ENDF/B data for Task 1			
57	Input data for Task 1			
58	Input data for Task 2			
59	Input data for Task 3			
60	Input data for Task 4			
61	Input data for Task 5			
62	Input data for Task 6			
63	Input data for Task 7			
64	Output from Task 1			
65	Output from Task 2			
66	Output from Task 3			

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File	Contents
67	Output from Task 4
68	Output from Task 5
69	Output from Task 6
70	Output from Task 7
71	AIM unloaded copy of library from Task 2
72	Group structures

Even though any of the modules in AMPX can be made to execute independently, the modular design makes it highly advantageous to build the system of codes that will then be accessed by the AMPX driver module (File 52 or 53).

The first task to initiate is that of building a subroutine library, containing the routines shared by many of the major computational modules. Although it is possible simply to compile these and to always link them with the program routines, this method will prove very wasteful, at least on IBM MVS systems, because no program will require all of them.

5.INSTALLATION.1 CONSTRUCTION OF SUBROUTINE LIBRARY

5.INSTALLATION.1.1 IBM MVS System

This involves compiling or assembling the routines on Files 48 and 49 of the tape. Once the hex decks are obtained they can be processed through the ALIAS routine (File 51) to yield the requisite subroutine library.

The procedure is illustrated below:

```
// EXEC FORTVC
//SYSIN DD Point to File 48
// EXEC ASMHC
//SYSIN DD Point to File 49
// EXEC PGM=ALIAS
//STEPLIB DD Point to a load module file containing ALIAS from File 51
//SYSLIN DD This is your subroutine library
//SYSIN DD Point to hex decks from the two compilations, above
```

5.INSTALLATION.1.2 Cray UNICOS System

This involves compiling the FORTRAN routines in Files 48 and 50 and then using the loader to create the requisite library.

1. Create, procure, or use some method to get your subroutines into a file.

2. Execute "cft77" or other compiler specifying desired options and point to the file mentioned in the first step.
3. Execute "bld" specifying desired options and using the output from Step 2. The output from this operation is your subroutine library, and will be one of the input files to the "segldr" when you create your load modules.

5.INSTALLATION.2 AMPX DRIVER PROGRAM CONSTRUCTION

This involves either assembling the program on File 52 (IBM) or compiling the program on File 53 (Cray) to produce the requisite load module.

5.INSTALLATION.2.1 IBM MVS System

1. Assemble the program in File 52.
2. Prepare a load module named AMPX using the linkage editor. You may need to use the "NCAL" parameter, which says to ignore unresolved references.

5.INSTALLATION.2.2 Cray UNICOS System

1. Compile the program in File 53 using cft77 or alternative.
2. Execute the "segldr" and save the resulting load module.

Note that the driver in this case is really the driver program for the SCALE system and will absolutely require that the input data for the modules always be terminated by an "end" card. This driver also expects to access a file named "aliases," which can consist of one blank card, in order to make the program operate properly.

5.INSTALLATION.3 AMPX-77 MODULE CONSTRUCTION

This is the next step and involves the compilation of the source routines for any or all of the 47 modules in this release (Files 1–47) and linking with the subroutine library routines we discussed in Sect. 5.INSTALLATION.1 to produce a load module. (In the case of IBM systems, these modules can be made members of a program library that is part of the "GO" STEPLIB data collection.)

5.INSTALLATION.3.1 IBM MVS System

The procedure is as follows:

```
// EXEC FORTVCL
//SYSIN DD Point to the source deck in the appropriate file
//LKED.STEPLIB DD
// DD
.
.
```

// DD Point to the subroutine library from Sect. 5.INSTALLATION.1
//LKED.SYSLMOD DD Point to a partitioned dataset to be used
as a program library
//LKED.SYSIN DD *
ENTRY Name of entry point for the module (see table at front of Sect. 5.INSTALLATION)
NAME Module (R)

5.INSTALLATION.3.2 Cray UNICOS System

1. Put the source for the module in a file.
2. Compile the file using "cft77" or an equivalent.
3. Execute "bld" on the file to create a library file for the subroutines in the module.
4. Execute "segldr," including the file from Step 3 and the subroutine library from Sect. 5.INSTALLATION.1 to create a load module. The entry point for the module is taken from the table at the front of Sect. 5.INSTALLATION and is part of the input to "segldr."

5.INSTALLATION.4 EXECUTING A MODULE

5.INSTALLATION.4.1 IBM MVS System

The panacea (real or imagined) for using an IBM system is that of dealing with the job control language (JCL), which is used to identify all files and to specify their interrelationships. Many of these problems can be minimized by using the IBM facility that allows one to write JCL procedures which can be accessed simply by referencing the procedure; however, this method may itself be very lengthy and complicated.

The procedure shown in Fig. 5.INSTALLATION.1 and given in File 55 of the tape is such a procedure. It was used to execute all the sample problems described in Sect. 6.SAMPLE PROBLEMS of this report. The discussion of the procedure given below will not attempt to discuss the coding aspects of the procedure, but will identify the AMPX-specific characteristics.

The simplest use of the procedure involves simply executing it:

// EXEC AMPX77

This activates the procedure, which is two steps: a linkage editor step that allows one to add on and modify modules (the LKED step), and a step (the GO step) which executes the modules selected for the problems.

When there is no requirement for the linkage editor step, the card above will be immediately followed by a card pointing to a file that will be used by one of the modules. This card will generally be in the form:

//GO.FTnnF001 DD "information to point to file"

where nn is the logical number of the file.

```
//AMPX77 PROC  PLOT=DISV,GOSIZE=2048K,GOTIME=,OUT='*',OUT6='*',
//             UPDATE=ENDFILE,BLKS=6136,SBUF=6136,VER=V5,
//             DCBV='DCB=(RECFM=VBS,LRECL=X,BLKSIZE=',
//             FT13=NULLFILE,TAPE13=TAPE62,SER13=,F13=1,L13=SL,DEN=4,
//             DA=' ),UNIT=SYSDA,SPACE=( '
//*
//*   L. M. PETRIE      BLDG 6002A     EXT 4-5259
//*
//LKED   EXEC  PGM=IEWL,PARM='MAP,OVLY,LIST,SIZE=(1000K,100K)',
//             REGION=1024K
//MODULES  DD  DISP=SHR,DSN=E.LMP10287.NEAD.PGMS77
//OVLY     DD  DISP=SHR,DSN=E.LMP10287.NEAD.VSOVLY
//SYSLIB   DD  DISP=SHR,DSN=E.LMP10287.NEAD.VSSUBLIB
//         DD  DISP=SHR,DSN=SYS2.VSFLINK
//         DD  DISP=SHR,DSN=SYS2.VSFFORT
//         DD  DISP=SHR,DSN=GRAPHICS.&PLOT..LIB
//         DD  DISP=SHR,DSN=GRAPHICS.INTLIB
//SYSLIN   DD  DSN=E.LMP10287.NEAD.VSOVLY(IEFBR14),DISP=SHR
//         DD  DSN=&&LOADSET,UNIT=SYSDA,DISP=(MOD,DELETE),
//             SPACE=(TRK,0),DCB=(RECFM=FB,LRECL=80,BLKSIZE=3200)
//         DD  DISP=SHR,DSN=E.LMP10287.NEAD.UPDATE(&UPDATE)
//         DD  DDNAME=SYSIN
//SYSLMOD  DD  DSN=&&LIBRARY,UNIT=SYSDA,DISP=(,PASS),
//             SPACE=(TRK,(50,20,5),RLSE)
//SYSPRINT DD  SYSOUT=&OUT
//SYSUT1   DD  UNIT=SYSDA,SPACE=(TRK,(50,10))
//GO     EXEC  PGM=AMPX,COND=(4,LT,LKED),REGION=&GOSIZE,TIME=&GOTIME,
//             PARM='NOIOINIT,NOOCSTATUS,NOINQPCOPN'
//STEPLIB  DD  DSN=*.LKED.SYSLMOD,DISP=(OLD,DELETE)
//         DD  DISP=SHR,DSN=JZW.AMPX77.MODULES
//         DD  DISP=SHR,DSN=E.LMP10287.NEAD.PGMS77
//         DD  DISP=SHR,DSN=E.LMP10287.NEAD.PGMS
//         DD  DISP=SHR,DSN=SYS2.VSFLOAD
//AMPXPRNT DD  SYSOUT=&OUT
//FT01F001 DD  &DCBV&BLKS,BUFL=&SBUF&DA&BLKS,(200,20))
//FT02F001 DD  &DCBV&BLKS,BUFL=&SBUF&DA&BLKS,(40,20))
//FT03F001 DD  &DCBV&BLKS,BUFL=&SBUF&DA&BLKS,(200,20))
//FT04F001 DD  &DCBV&BLKS,BUFL=&SBUF&DA&BLKS,(200,20))
//FT05F001 DD  DCB=BLKSIZE=480,SPACE=(480,(100,50)),UNIT=SYSDA
//FT06F001 DD  SYSOUT=&OUT6,DCB=(RECFM=VBA,LRECL=137,BLKSIZE=1100)
//FT07F001 DD  DUMMY,DCB=(RECFM=F,BLKSIZE=80)
//FT08F001 DD  UNIT=SYSDA,SPACE=(CYL,(4,1)),DCB=(DSORG=DA,RECFM=F)
//FT09F001 DD  UNIT=SYSDA,SPACE=(CYL,(4,1)),DCB=(DSORG=DA,RECFM=F)
//FT10F001 DD  UNIT=SYSDA,SPACE=(CYL,(4,1)),DCB=(DSORG=DA,RECFM=F)
//FT11F001 DD  DISP=SHR,LABEL=(,,,IN),DSN=E.LMP10287.ENDFB.DATA.&VER
//FT12F001 DD  DISP=SHR,LABEL=(,,,IN),DSN=E.LMP10287.ENDFB.DATA.THERMAL
//FT13F001 DD  DSN=&FT13,UNIT=&TAPE13,DISP=OLD,VOL=SER=&SER13,
//             LABEL=(&F13,&L13,,IN),DCB=DEN=&DEN
//FT14F001 DD  &DCBV&BLKS,BUFL=&SBUF&DA&BLKS,(40,20))
//FT15F001 DD  &DCBV&BLKS,BUFL=&SBUF&DA&BLKS,(40,20))
//FT16F001 DD  &DCBV&BLKS,BUFL=&SBUF&DA&BLKS,(40,20))
//FT17F001 DD  &DCBV&BLKS,BUFL=&SBUF&DA&BLKS,(500,50))
//FT18F001 DD  &DCBV&BLKS,BUFL=&SBUF&DA&BLKS,(2000,50))
//FT19F001 DD  &DCBV&BLKS,BUFL=&SBUF&DA&BLKS,(40,20))
//FT20F001 DD  &DCBV&BLKS,BUFL=&SBUF&DA&BLKS,(40,20))
//FT21F001 DD  &DCBV&BLKS,BUFL=&SBUF&DA&BLKS,(40,20))
//FT22F001 DD  &DCBV&BLKS,BUFL=&SBUF&DA&BLKS,(40,20))
//FT23F001 DD  &DCBV&BLKS,BUFL=&SBUF&DA&BLKS,(40,20))
//FT24F001 DD  &DCBV&BLKS,BUFL=&SBUF&DA&BLKS,(40,20))
//FT25F001 DD  &DCBV&BLKS,BUFL=&SBUF&DA&BLKS,(40,20))
//FT26F001 DD  &DCBV&BLKS,BUFL=&SBUF&DA&BLKS,(40,20))
//FT27F001 DD  &DCBV&BLKS,BUFL=&SBUF&DA&BLKS,(40,20))
//FT28F001 DD  &DCBV&BLKS,BUFL=&SBUF&DA&BLKS,(40,20))
//FT29F001 DD  &DCBV&BLKS,BUFL=&SBUF&DA&BLKS,(40,20))
//FT30F001 DD  &DCBV&BLKS,BUFL=&SBUF&DA&BLKS,(40,20))
//FT31F001 DD  &DCBV&BLKS,BUFL=&SBUF&DA&BLKS,(40,20))
//FT40F001 DD  DISP=SHR,LABEL=(,,,IN),DSN=E.LMP10287.ENDFB.DATA.GAMMA
//FT46F001 DD  &DCBV&BLKS,BUFL=&SBUF&DA&BLKS,(40,20))
//FT47F001 DD  DISP=SHR,LABEL=(,,,IN),DSN=E.LMP10287.AMPX.GROUP.BNDS
//QATABLE  DD  DISP=SHR,LABEL=(,,,IN),DSN=NMG.AMPX77.QATABLE
```

Fig. 5.INSTALLATION.1. IBM procedure to execute AMPX-77.

The standard procedure has the following default assignments:

Logical Nos.	Default file
1–4,14–31,46	System space
5	Module data input
6	Printed output
7	Dummy (intended for punch output)
8–10	Direct access scratch space
11	General-purpose ENDF/B library
12	Thermal ENDF/B data library
13	BCD ENDF/B data on tape
40	ENDF/B gamma file
47	Group boundary file

If a module reads or writes to one of the above assignments, the user may have to override the JCL in the procedure. Following IBM replacement requirements, the overridden JCL statements must be given as the first of the "GO" DD cards and must be in exactly the order in which they are used in the procedure (which is in simple numerical order in our case).

The input for the modules is given in the SYSIN file. If a user wanted only default assignments, an execution would consist of the following JCL:

```
// EXEC AMPX77
//GO.SYSIN DD *
problem data
```

5.INSTALLATION.4.1.1 Adding or modifying a module using the IBM procedure

The procedure for compiling and executing a new program using the procedure described above is as follows:

```
// EXEC FORTRAN compiler procedure
//SYSIN DD *
FORTRAN decks
// EXEC AMPX
//SYSIN DD *
 NAME module
//GO.DD Cards
problem data
```

where "module" is the name assigned to the new module.

If it is necessary to replace a subroutine in an existing module, the subroutine must be compiled and "linked" with the other routines in the module. In this case, it is noted that the modules in AMPX are located in a file which has a DDNAME of MODULES. The procedure is the following:

```
// EXEC FORTRAN compiler procedure
//SYSIN DD *
Subroutine cards
// EXEC AMPX77
//SYSIN DD *
 INCLUDE MODULES (module)
 ENTRY entry
 NAME module
//GO.DD cards
problem data
```

In this case "module" is the name of the module to update, and "entry" is the name of the main program for the module.

5.INSTALLATION.4.2 Cray UNICOS System

1. Place the source into a separate file.
2. Use "cft77," or equivalent, to compile the file.
3. Run "bld" on the file from Step 2.
4. Run the "segldr" using the file from Step 3, the subroutine library from Sect. 5.INSTALLATION.1 to create a new program.
5. Execute the "SCALE" driver discussed in Sect. 5.INSTALLATION.2 with the input for the module placed in a file called "sysin." Note that the input for each module must be terminated by an "end" card.

6. SAMPLE PROBLEMS

This section contains a discussion of several sample problems that use AMPX modules. They will perhaps serve to clarify some of the information presented in the discussion of options and inputs. Another obvious use of this section is for checking the codes as they are implemented on your computer system. The runs selected address several common tasks one must perform in producing and using multigroup cross sections. As such, a run may require executing many AMPX modules and, thereby, will serve as mini-tutorials to identify how the codes relate to each other. The tasks that will be demonstrated are designed to do the following:

1. create a multigroup neutron library,
2. create a multigroup coupled neutron-gamma-ray library,
3. do a resonance self-shielding calculation,
4. homogenize and collapse cross sections,
5. move multigroup libraries to another computing system,
6. average point cross sections, and
7. convert the cross sections on an AMPX master library for use in the ANISN program.

6.SAMPLE PROBLEMS.1 CREATE A MULTIGROUP NEUTRON LIBRARY

This task is the most difficult, time-consuming, and expensive task one will encounter in dealing with multigroup cross sections. At least part of the problem is related to the codes and procedures one must use, but the very nature of the problem is complex, requiring several diverse and complicated developments to be used to produce a complete set of data.

One is immediately confronted by several decisions:

1. *A procedure must be selected.* In some cases, the choice of a code or a technique will automatically select the procedure. In a modular programming system, however, this may involve selecting between options, for example, to use for resonance self-shielding. These selections will need to consider the approximations as they relate to the particular application.
2. *A group structure must be selected.* Many times this will involve either picking an existing structure previously shown to be adequate for a similar application, or at least starting with an existing structure and adding or deleting boundaries, as deemed necessary. Generally speaking, the multigroup structure will not be fine enough to explicitly do resonance self-shielding calculations. This will require supplemental calculations to treat these effects.

3. *A spectrum must be picked to use in weighting the cross sections.* If the energy group structure contains on the order of a hundred or more energy groups, divided roughly according to bins of equal lethargy, an "approximate" spectrum can be taken, such as a Maxwellian-shaped function at thermal, tied to a 1/E spectrum in the slowing-down range above thermal and below a fission spectrum distribution, which may continue all the way to the upper energy boundary, although it is probably prudent to cut this distribution at 8–10 MeV, above which a 1/E variation is probably more reasonable. Note that by using this very simplistic approach, we are depending on the calculation used to collapse from the fine-group structure to a broad group (25–50 energy groups, or less), augmented by a resonance calculation, to refine the averaged values, to correct the scattering distributions, etc.
4. *A resonance self-shielding method must be selected.* If the application is for fast reactors, a treatment based on the narrow-resonance approximation, such as the Bondarenko method, may be adequate. Thermal systems may be adequately handled by the Nordheim integral treatment or even the Bondarenko method if the factors are prepared using weighting functions based on integral transport calculations. Any situation needing high accuracy or having complicated geometries may need a detailed integral transport treatment.
5. *A decision must be made on the order of fit that will be made to the group-to-group scattering matrix terms.* For many reactor applications, P_1 fits are adequate; however, for accurately calculating leakage effects, at least a P_3 fit should be taken. (Note that the cost of generating the high-ordered terms is small relative to that of generating the P_0 terms and that it is easy to throw away terms that may not be necessary. Therefore, it is prudent to generate termsat least to the highest order that one will need when making the original library.) Generally speaking, shielding applications require higher-ordered fits than do reactor applications.
6. *Consideration should be given to thermal-scattering effects.* If one is, for example, making a set of cross sections for hydrogen, its cross sections at thermal will be different, depending on whether the hydrogen atom is in gaseous form, bound in a water molecule or a polyethylene molecule, or part of ZrH, etc. The physics of all these situations is presented in ENDF/B as $S_{\alpha\beta}$ (scattering law) data.
7. *The basic cross sections must be located in ENDF/B-formatted files.* Usually, one will use the standard libraries, though there are several files available from other evaluation efforts, such as the LENDL file (a file of evaluations from Lawrence Livermore Laboratory) and the JENDL file (a file of Japanese evaluations) — both in the ENDF/B structure.

The nuclides we will process in our sample cases are from the ENDF/B Version V "standards" library (see Table 6.SAMPLE PROBLEMS.1). Even though the extent of this collection is not sufficient to solve many practical problems, there are no restrictions on its distribution, such as exist with other ENDF/B-V files.

Table 6.SAMPLE PROBLEMS.1. ENDF/B "standard" library

MAT	Nuclide	Photon production data
1146	He-3	No
1301	H	Yes
1303	Li-6	Yes
1305	B-10	Yes
1306	C	Yes
1379	Au-197	No
1395	U-235	Yes

We will process ^{235}U and C for our sample cases.

For a group structure, we will use a 238-group structure originally developed for shipping cask studies. For weighting we will select a simple spectrum consisting of a Maxwellian spectrum at thermal extending to 0.125 eV, tied to a 1/E variation up to 67.4 keV, tied to a fission spectrum which extends up to 10 MeV, which in turn is tied to a 1/E variation up to the top of the group structure. This spectrum will be used on all nuclides.

If our application had included large regions containing a single mixture, we could have decided that it was important to refine our weighting spectrum by weighting the cross sections by a $1/E\Sigma_t$ spectrum, where Σ_t might be taken as the macroscopic point cross sections for important mixtures in the problem.

The processing procedure used for this task is shown in Fig. 6.SAMPLE PROBLEMS.1. Here the processing of a nuclide will involve taking ENDF/B data and processing it through XLACS to produce an AMPX master library, which is then scanned by the RADE module to look for inconsistencies or improper values. The library is also used in the VASELINE module, which plots group-averaged data. The results of RADE and VASELINE are studied, after which the COMET module may be run to repair any moderate inconsistencies that were observed.

This procedure may be augmented with other codes when the nuclide has unresolved resonance data that can be processed into Bondarenko factors (see Fig. 6.SAMPLE PROBLEMS.2). In this case, the XLACS run is made in parallel with runs of PRUDE, which makes point cross-section strings for unresolved cross sections, and TABU, which converts them to Bondarenko factors. Finally, UNITAB couples the XLACS output with the Bondarenko factors to produce a master that is then processed as in the previous procedure.

Figure 6.SAMPLE PROBLEMS.3 shows another procedure which would have been used had we elected to do some $1/E\Sigma_t$ weighting. Here, POLIDENT is used to generate a set of point data for the nuclide, JERGENS uses it to form a $1/E\Sigma_t$ function and to tie Maxwellian and fission spectrum to it, after which XLACS uses the spectrum to weight its cross sections.

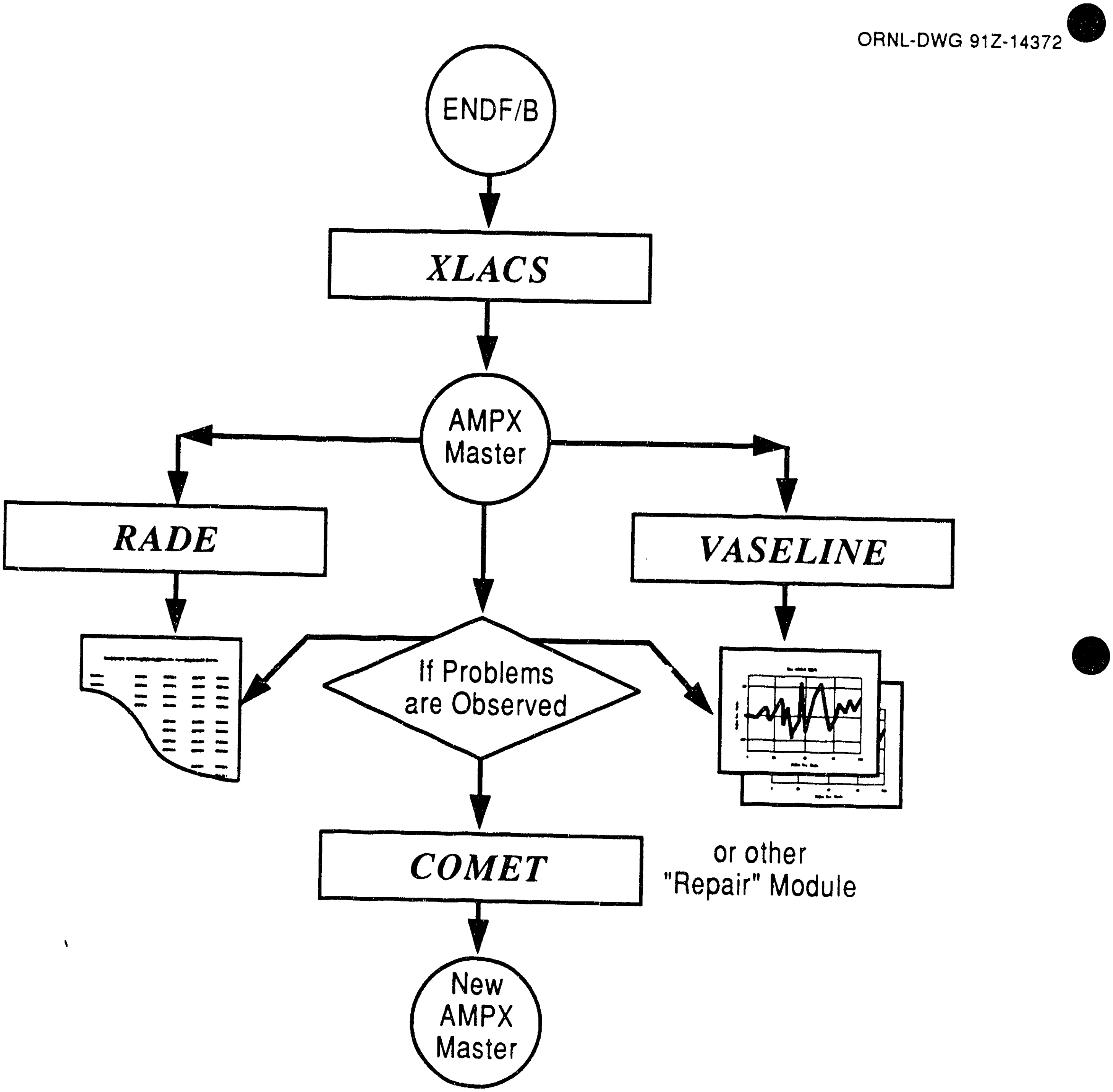


Fig. 6.SAMPLE PROBLEMS.1. Primary neutron library production procedure.

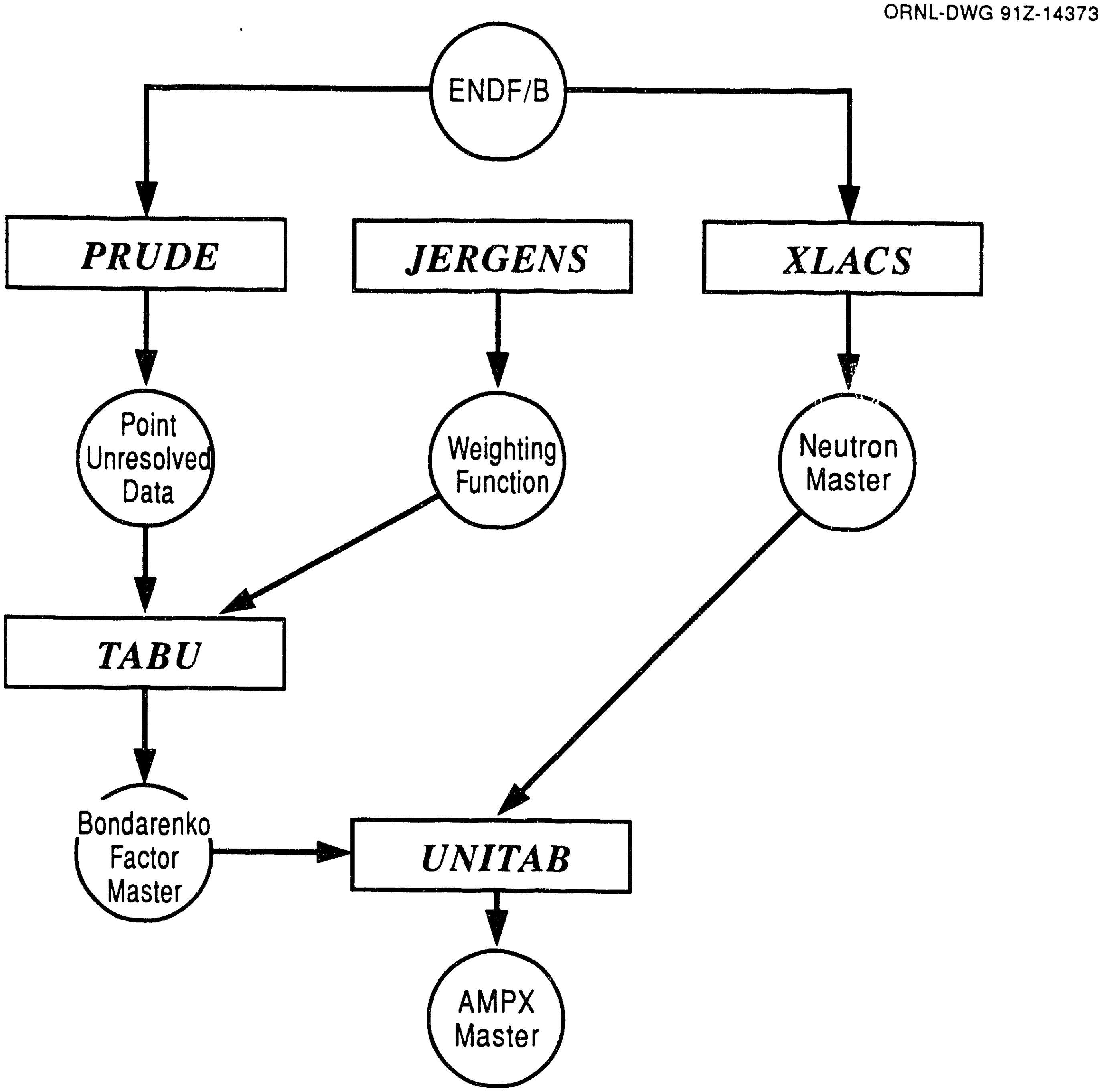


Fig. 6.SAMPLE PROBLEMS.2. Procedure to add Bondarenko factors to an AMPX master.

ORNL-DWG 91Z-14371

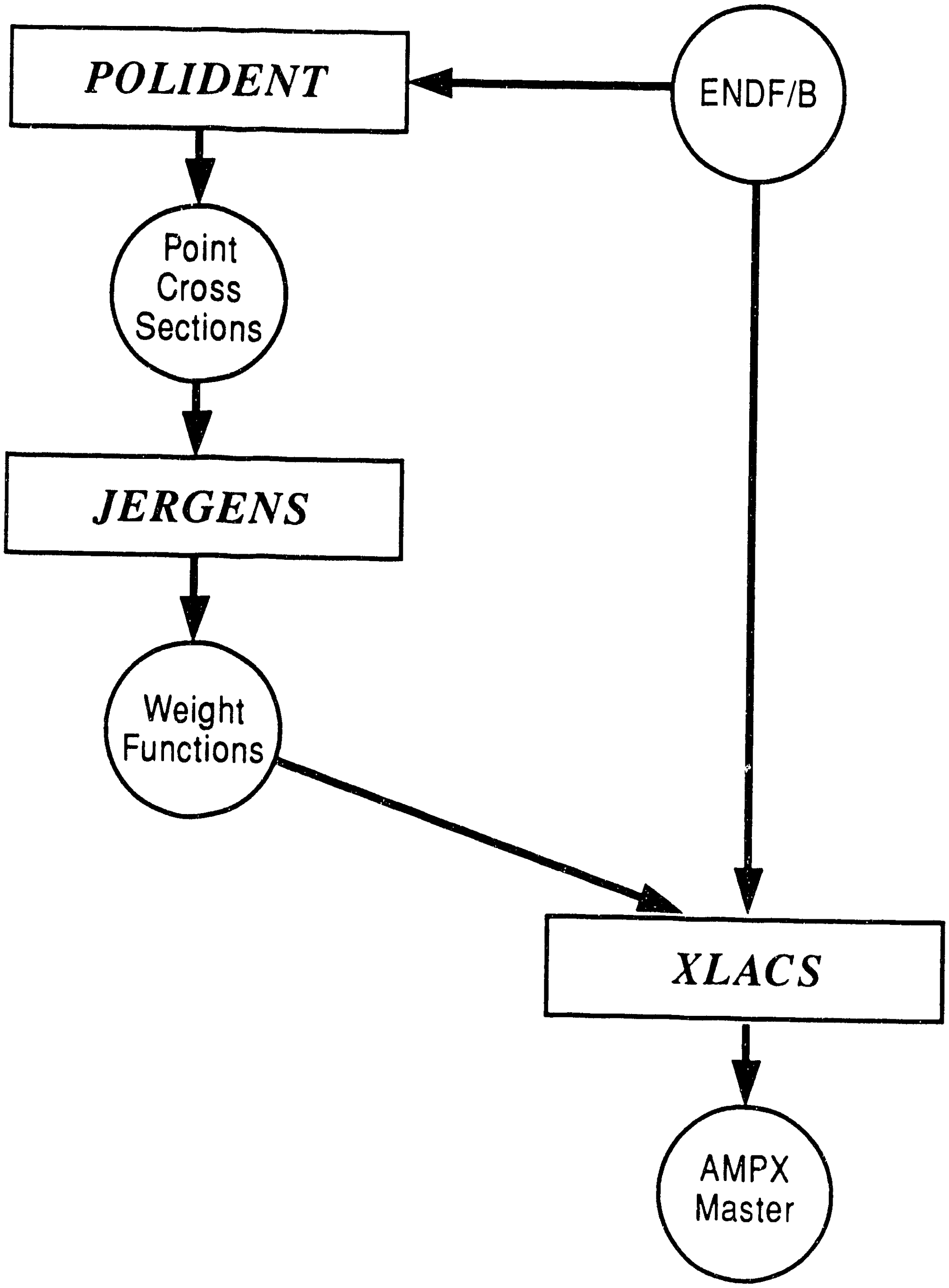


Fig. 6.SAMPLE PROBLEMS.3. Procedure to perform $1/E\Sigma_t$ weighting.

When all nuclides are processed, the individual master files are combined into a single master file using the AJAX module. This procedure is illustrated in Fig. 6.SAMPLE PROBLEMS.4.

ORNL-DWG 91Z-14374

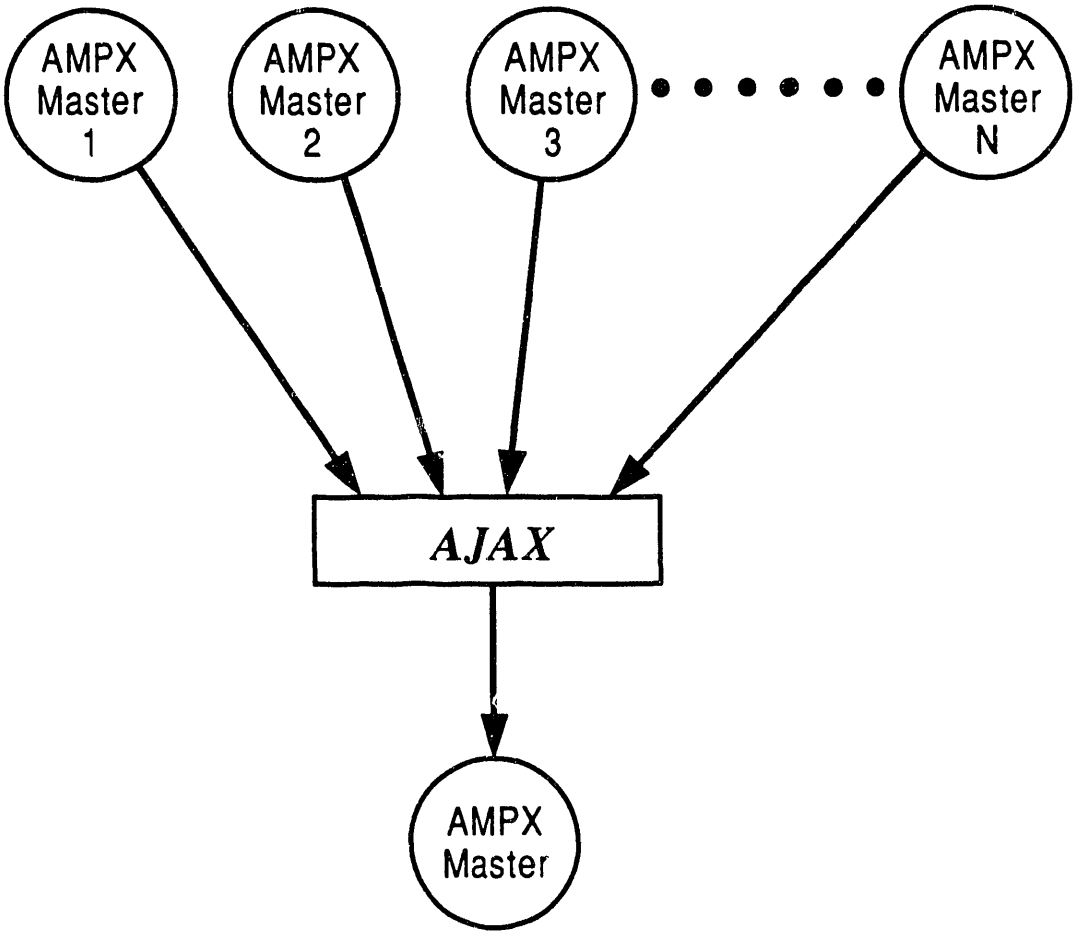


Fig. 6.SAMPLE PROBLEMS.4. Procedure to combine AMPX masters.

The input for the ^{235}U XLACS and RADE runs is shown below:

```
   AMPX MODULE LOG AND LIST OF CARD INPUT DATA
 MODULE XLACS     HAS BEEN CALLED
SAMPLE PROBLEM
FOR THE XLACS
MODULE OF THE
AMPX77 SYSTEM
+++++++++++++
0$$  11 12 23 1$$     1 238 90  T
T  USE THE STANDARD 238 NEUTRON GROUP STRUCTURE
U235
10$$         92235         1395          0
11$$             2            0          0           0
12$$             5            3          0           0
13$$            11            1         12           1          1
14$$             5            4         15$$ 3
17$$   0   0   3   0   0   0   0   0   0   0
18**   3.00000E+02 1.25000E-01 1.27300E+06 6.74000E+04 0.00000E+00 E
T
22** 293 1000 2000 T

 MODULE XLACS     IS FINISHED.
 CPU TIME    254.35 (SECONDS).   I/O'S        0 USER CODE 0000    SYSTEM CODE 000
 MODULE RADE      HAS BEEN CALLED
1$$ 23 E T

 MODULE RADE      IS FINISHED.
 CPU TIME      1.74 (SECONDS).   I/O'S        0 USER CODE 0000    SYSTEM CODE 000
```

AMPX lists the input for the modules it executes.

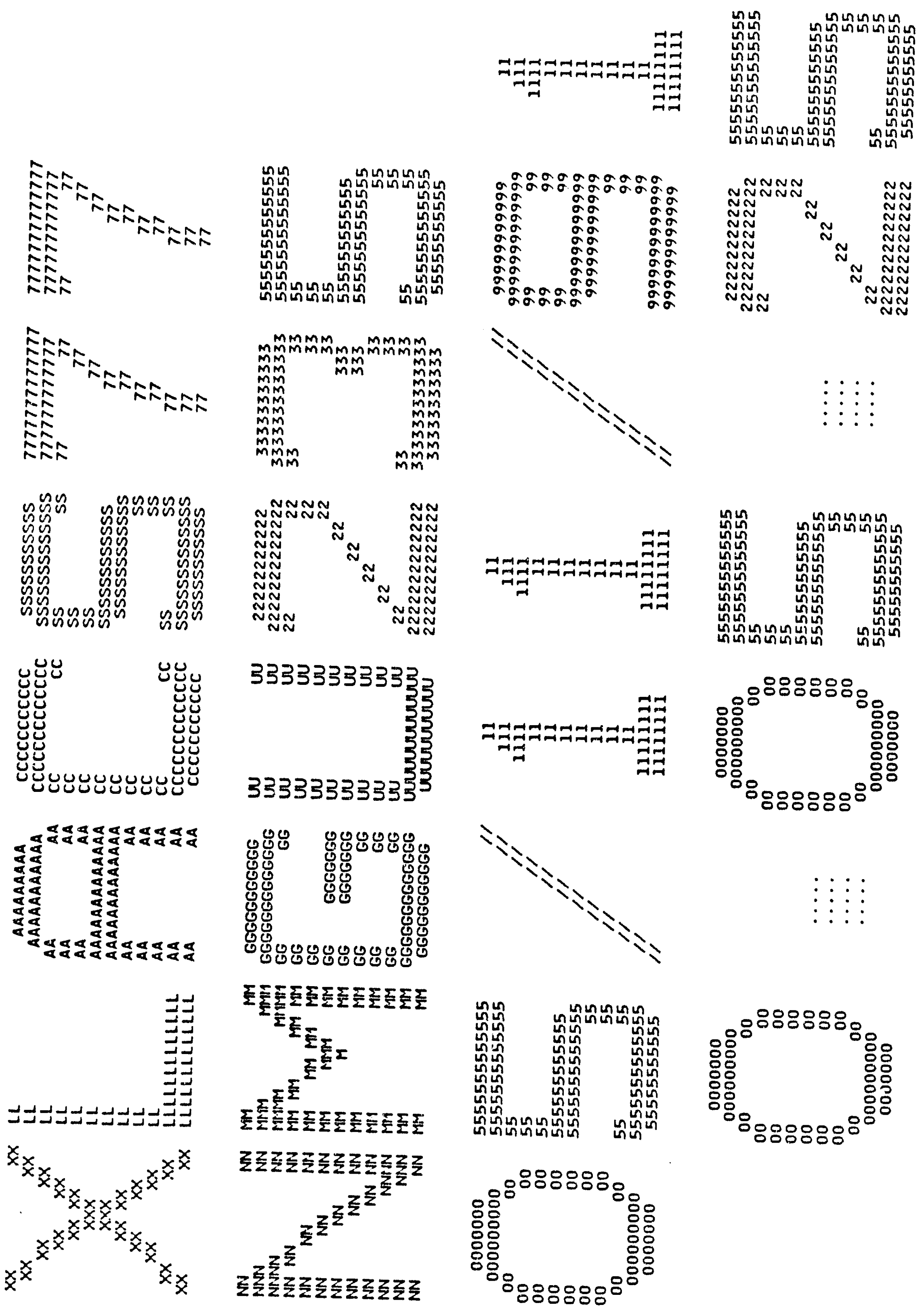
End Data Block 1

Input past a "T" is ignored.

Portions of the output for ^{235}U follow:

```
0$ ARRAY      3 ENTRIES READ
1$ ARRAY      3 ENTRIES READ
OT
```

Messages are printed for each input array and data block terminator


XLACS77
NMGU235
05/11/91
00:05:25

```
********************************************************************************
********************************************************************************
********************************************************************************
*****                                                                      *****
*****                  PROGRAM VERIFICATION INFORMATION                    *****
*****                                                                      *****
*****                   CODE SYSTEM:  AMPX77   1.0                         *****
*****                                                                      *****
********************************************************************************
********************************************************************************
*****                                                                      *****
*****                                                                      *****
*****              PROGRAM:  XLACS                                         *****
*****                                                                      *****
*****        CREATION DATE:  91.119                                        *****
*****                                                                      *****
*****              LIBRARY:  JZW.AMPX77.MODULES                            *****
*****                                                                      *****
*****                                                                      *****
*****              THIS IS NOT A QA VERSION                                *****
*****                                                                      *****
*****              JOBNAME:  NMGU235                                       *****
*****                                                                      *****
*****    DATE OF EXECUTION:  05/11/91                                      *****
*****                                                                      *****
*****    TIME OF EXECUTION:   0.05.26                                      *****
*****                                                                      *****
*****                                                                      *****
********************************************************************************
********************************************************************************
********************************************************************************
```

```
PROCESS U235                                                                    IDENTIFIER:     92235
   FAST DATA MAT: 1395 ON LOGICAL: 11 LIBRARY MODE: 1 VERSION: 5
THERMAL DATA MAT:    0 ON LOGICAL: 12 LIBRARY MODE: 1
                 LEGENDRE FIT ON FAST DATA TO ORDER:  5
               LEGENDRE FIT ON THERMAL DATA TO ORDER:  3
     NUMBER OF ATOMS IN PRINCIPAL THERMAL SCATTERER:  1
     THERMAL MATRICES WILL BE PRODUCED AT 3 TEMPERATURES
 SIGP FOR UNRESOLVED PROCESSING: 1.00000E+08
R-FACTOR FOR NORDHEIM TREATMENT: 0.00000E+00
S-FACTOR FOR NORDHEIM TREATMENT: 0.00000E+00
       POINT DATA MAT NUMBER (RESONANCE NUCLIDES ONLY):    0
                    LOGICAL UNIT CONTAINING POINT DATA:    0
  NUMBER OF ANGLES TO USE IN PRODUCING ELASTIC MATRICES:    0
NUMBER OF ANGLES TO USE IN PRODUCING INELASTIC MATRICES:    0
     POINT DATA MAT NUMBER FOR ELASTIC SCATTERING DATA:    0
WEIGHTING OPTION FOR THIS CASE:  2
WEIGHTING SPECTRUM ADJUSTMENT PARAMETERS
                       TEMPERATURE OF MAXWELLIAN SPECTRUM: 3.00000E+02 KELVIN
               UPPER ENERGY CUTOFF ON MAXWELLIAN SPECTRUM: 1.25000E-01
                EFFECTIVE TEMPERATURE OF FISSION SPECTRUM: 1.27300E+06
                 LOWER CUTOFF ENERGY FOR FISSION SPECTRUM: 6.74000E+04
                 UPPER CUTOFF ENERGY FOR FISSION SPECTRUM: 1.00000E+07
DIMENSIONAL PARAMETERS:
    MAXIMUM NUMBER OF POINTS ALLOWED IN ANY TAB1 ARRAY:  5000
          MAXIMUM NUMBER OF INTERPOLATION REGIONS USED:   100

PRINTED OUTPUT EDITING OPTIONS
 FILE 1.           HEADER INFORMATION: 0
 FILE 2.         RESONANCE PROCESSING: 0
 FILE 3.         POINT DATA AVERAGING: 3
 FILE 4.    ANGULAR DISTRIBUTION DATA: 0
 FILE 5.            EVAPORATION DATA: 0
 FILE 6.   ENERGY-ANGLE TABULATED DATA: 0
 FILE 7.          S(ALPHA,BETA) DATA: 0
 OPTION 8                (NOT USED): 0
 OPTION 9                (NOT USED): 0
 OPTION 10         WEIGHTING SPECTRUM: 0
   22* ARRAY      3 ENTRIES READ
   OT
```

Replay of most input

```
THE (TAPE) DESCRIPTION OF MATERIAL   1395 IS -
   92-U -235 BNL        EVAL-APR77 M.R.BHAT
                        DIST-MAR83 REV1-OCT80           830310
   PRINCIPAL EVALUATOR - M.R.BHAT(BNL)

   CONTRIBUTING EVALUATORS

       NU-BAR(PROMPT) - M.R.BHAT(BNL)
       F.P.YIELDS - F.P.YIELDS SUBCOMMITTEE
       DELAYED NEUTRONS - R.E.KAISER AND S.G.CARPENTER(ANL)
       RADIOACTIVE DECAY DATA - C.W.REICH(EG AND G,IDAHO,INC)
       THERMAL RANGE - B.R.LEONARD JR,D.A.KOTTWITZ,J.K.THOMPSON(BNW
                       (REF 2)
       RESOLVED RESONANCE REGION(1EV-82EV)-J.R.SMITH AND R.C.YOUNG
                                            (EG AND G)(ENDF/B-IV)
       UNRESOLVED RESONANCE REGION(82EV-25KEV)-M.S.MOORE(LASL) AND
                                                 M.R.BHAT(BNL)
       FISSION CROSS-SECTION(100KEV-20MEV)-W.P.POENITZ(ANL)(REF 31)
       IN CONJUNCTION WITH THE NORMALISATION AND STANDARDS SUBCOMM.
       OF CSEWG.
       INELASTIC SCATTERING - R.E.HUNTER,L.STEWART AND T.J.HIRONS
                              (REF 26)(ENDF/B-IV)
       FISSION NEUTRON SPECTRUM - M.R.BHAT(BNL)
       GAMMA PRODUCTION(1.0E-05EV TO 1.09MEV)-L.STEWART ET.AL.
                                               (REF 1,30)(ENDF/B-IV)
       GAMMA PRODUCTION(ABOVE 1.09MEV) - M.R.BHAT(BNL)
       COVARIANCE FILES - R.W.PEELLE(ORNL)
    *****************************************************************
     THIS EVALUATION IS THE SAME AS THE ENDF/B-IV(MAT=1261) BY
     L.STEWART(LASL),H.ALTER(AI) AND R.HUNTER(LASL) EXCEPT FOR CHANGES
     IN THE FOLLOWING MF/MT    1/
```

Text is extracted from File 1

```
  ELAPSED TIME   0.03 MIN.
```

File 2 Processing

```
 COMMENCE RESOLVED AND UNRESOLVED RESONANCE PROCESSING

    ENERGY RANGE 1 EXTENDS FROM 1.00000E+00 TO 8.20000E+01 EV

 LRF:    1 ABN: 1.00000E+00 AP: 9.56630E-01

         BREIT WIGNER PARAMETERS ARE BEING PROCESSED

 RESOLVED RESONANCE CONTRIBUTIONS FOR CAPTURE AND FISSION ARE DOPPLER BROADENED AT      300.0 KELVIN
    INPUT PARAMETERS FOR NORDHEIM TREATMENT
        R=    0.00000E+00
        S=   -5.00000E+00

 RESOLVED RESONANCE CONTRIBUTIONS
  GRP        CAPTURE          FISSION
   87    2.73420E-07     9.00633E-07     2.73420E-07     9.00634E-07
   88    6.46675E+00     1.67249E+01     6.46880E+00     1.67300E+01
   89    6.96368E+00     1.45246E+01     6.96591E+00     1.45295E+01
   90    1.34587E+01     3.91218E+01     1.34629E+01     3.91336E+01
   91    9.16382E+00     3.11687E+01     9.16679E+00     3.11787E+01
   92    6.22726E+00     7.06044E+00     6.22933E+00     7.06244E+00
   93    1.05811E+01     1.72059E+01     1.05857E+01     1.72120E+01
   94    5.93883E+00     2.76776E+01     5.94082E+00     2.76865E+01
   95    3.08727E+01     6.75227E+01     3.08826E+01     6.75434E+01
   96    7.24698E+00     5.38540E+01     7.24924E+00     5.38698E+01
   97    3.39922E+01     9.13002E+01     3.40040E+01     9.13324E+01
   98    3.62317E+01     3.14738E+01     3.62422E+01     3.14828E+01
   99    1.87213E+01     4.28849E+01     1.87316E+01     4.29003E+01
  100    2.29284E+01     4.14307E+01     2.29355E+01     4.14438E+01
  101    9.41311E+00     2.88495E+01     9.41561E+00     2.88578E+01
  102    1.05819E+01     4.68425E+01     1.05852E+01     4.68571E+01
  103    2.49268E+01     2.28896E+01     2.49352E+01     2.28964E+01
  104    3.79613E+01     4.36257E+01     3.79775E+01     4.36401E+01
  105    8.15724E+00     2.73338E+01     8.16205E+00     2.73461E+01
  106    8.04539E+01     1.39675E+02     8.04698E+01     1.39702E+02
  107    4.25024E+00     1.83205E+01     4.25250E+00     1.83268E+01
  108    1.34066E+00     9.84539E+00     1.34083E+00     9.84649E+00
  109    4.06109E+00     2.54642E+01     4.06296E+00     2.54734E+01
  110    9.23523E+01     2.35516E+02     9.23813E+01     2.35581E+02
  111    7.77448E+01     8.64365E+01     7.77709E+01     8.64621E+01
```

The 1st 2 columns come from weighting over the "problem's weighting spectrum", the latter 2 assume an infinite dilution weighting.

```
 187     1.34409E+01     6.26438E+01     1.34409E+01     6.26438E+01
 188     1.25556E+01     5.99027E+01     1.25556E+01     5.99027E+01
 189     1.18032E+01     5.76121E+01     1.18032E+01     5.76121E+01
=======================TIME FOR CAPTURE/FISSION:  0.68 MIN

A RESOLVED RESONANCE ELASTIC SCATTERING VECTOR WITH  3366 POINTS HAS BEEN CREATED FROM 1.00000E+00 TO 8.20000E+01 EV.

=======================TIME FOR THIS BLOCK:  0.85 MIN

    ENERGY RANGE 2 EXTENDS FROM 8.20000E+01 TC 2.50000E+04 EV

LRF:    2 ABN: 1.00000E+00 AP: 9.56630E-01

        UNRESOLVED SLBW PARAMETERS ARE BEING PROCESSED

A   137 POINT VECTOR OF SCATTERING CROSS SECTIONS HAS BEEN CREATED FROM PROCESSING UNRESOLVED RESONANCE DATA

=======================TIME FOR THIS BLOCK:  0.02 MIN

PREPARING TO AVERAGE SCATTERING VECTOR FOR MT= 1002 WHICH HAS    3366 ENERGY POINTS

THE VECTOR RANGES FROM 1.00000E+00 TO 8.20000E+01 EV

PREPARING TO AVERAGE SCATTERING VECTOR FOR MT= 2002 WHICH HAS     137 ENERGY POINTS

THE VECTOR RANGES FROM 8.20000E+01 TO 2.50000E+04 EV

WEIGHTED SCATTERING VALUES IN THE RESONANCE REGION:
   55 1.1343E+01    56 1.1483E+01    57 1.1628E+01    58 1.1800E+01    59 1.1783E+01
   60 1.1802E+01    61 1.1830E+01    62 1.1784E+01    63 1.1720E+01    64 1.1865E+01
   65 1.1899E+01    66 1.2150E+01    67 1.1926E+01    68 1.1835E+01    69 1.2007E+01
   70 1.2245E+01    71 1.2234E+01    72 1.2205E+01    73 1.2214E+01    74 1.2155E+01
   75 1.2028E+01    76 1.2535E+01    77 1.2745E+01    78 1.2483E+01    79 1.2376E+01
   80 1.2178E+01    81 1.2453E+01    82 1.2345E+01    83 1.2268E+01    84 1.2162E+01
   85 1.2033E+01    86 1.2365E+01    87 1.2764E+01    88 1.3596E+01    89 1.3448E+01
   90 1.4068E+01    91 1.2305E+01    92 1.2812E+01    93 1.3424E+01    94 1.3787E+01
   95 1.4852E+01    96 1.3460E+01    97 1.3398E+01    98 1.1624E+01    99 1.1904E+01
  100 1.1667E+01   101 1.1043E+01   102 1.2075E+01   103 1.2152E+01   104 1.2790E+01
  105 1.2984E+01   106 1.6056E+01   107 1.0734E+01   108 1.2080E+01   109 1.5149E+01
  110 2.0657E+01   111 1.2817E+01   112 1.5552E+01   113 1.1064E+01   114 9.1154E+00
  115 1.0188E+01   116 1.1175E+01   117 1.1496E+01   118 1.2022E+01   119 1.4303E+01
  120 1.1126E+01   121 2.2443E+01   122 7.5874E+00   123 9.7874E+00   124 1.1310E+01
  125 1.0453E+01   126 1.1264E+01   127 1.1326E+01   128 1.1617E+01   129 1.5357E+01
  130 1.3374E+01   131 1.0139E+01   132 1.2137E+01   133 1.1709E+01   134 1.0478E+01
  135 1.1082E+01   136 1.0453E+01   137 1.1915E+01   138 1.2413E+01   139 9.3518E+00
  140 1.0352E+01   141 1.0914E+01   142 1.1171E+01   143 1.1047E+01   144 1.1665E+01
  145 1.1623E+01   146 1.1577E+01   147 1.1543E+01   148 1.1557E+01   149 1.1616E+01
  150 1.1679E+01   151 1.1770E+01   152 1.1877E+01   153 1.1982E+01   154 1.2083E+01
  155 1.2180E+01   156 1.2271E+01   157 1.2371E+01   158 1.2509E+01   159 1.2591E+01
  160 1.2385E+01   161 1.2554E+01   162 1.2695E+01   163 1.2824E+01   164 1.2951E+01
  165 1.3084E+01   166 1.3195E+01   167 1.3281E+01   168 1.3375E+01   169 1.3479E+01
  170 1.3593E+01   171 1.3679E+01   172 1.3721E+01   173 1.3729E+01   174 1.3672E+01
  175 1.3612E+01   176 1.3577E+01   177 1.3540E+01   178 1.3502E+01   179 1.3475E+01
  180 1.3460E+01   181 1.3454E+01   182 1.3457E+01   183 1.3469E+01   184 1.3485E+01
  185 1.3506E+01   186 1.3529E+01   187 1.3554E+01   188 1.3579E+01   189 1.3605E+01
  190 3.2062E-05

WEIGHTED INFINITE DILUTION SCATTERING VALUES:
   55 1.1343E+01    56 1.1483E+01    57 1.1628E+01    58 1.1800E+01    59 1.1783E+01
   60 1.1802E+01    61 1.1830E+01    62 1.1784E+01    63 1.1720E+01    64 1.1865E+01
   65 1.1899E+01    66 1.2150E+01    67 1.1926E+01    68 1.1835E+01    69 1.2007E+01
   70 1.2245E+01    71 1.2234E+01    72 1.2206E+01    73 1.2214E+01    74 1.2155E+01
   75 1.2028E+01    76 1.2535E+01    77 1.2745E+01    78 1.2483E+01    79 1.2376E+01
   80 1.2178E+01    81 1.2453E+01    82 1.2345E+01    83 1.2268E+01    84 1.2162E+01
   85 1.2033E+01    86 1.2365E+01    87 1.2764E+01    88 1.3596E+01    89 1.3448E+01
   90 1.4068E+01    91 1.2305E+01    92 1.2811E+01    93 1.3424E+01    94 1.3787E+01
   95 1.4852E+01    96 1.3460E+01    97 1.3398E+01    98 1.1624E+01    99 1.1904E+01
  100 1.1667E+01   101 1.1043E+01   102 1.2075E+01   103 1.2152E+01   104 1.2790E+01
  105 1.2984E+01   106 1.6056E+01   107 1.0734E+01   108 1.2080E+01   109 1.5149E+01
  110 2.0657E+01   111 1.2817E+01   112 1.5552E+01   113 1.1064E+01   114 9.1154E+00
  115 1.0188E+01   116 1.1175E+01   117 1.1496E+01   118 1.2022E+01   119 1.4303E+01
  120 1.1126E+01   121 2.2443E+01   122 7.5874E+00   123 9.7874E+00   124 1.1310E+01
  125 1.0453E+01   126 1.1264E+01   127 1.1326E+01   128 1.1617E+01   129 1.5357E+01
  130 1.3374E+01   131 1.0139E+01   132 1.2137E+01   133 1.1709E+01   134 1.0478E+01
```

These are based on
the problem's weighting
spectrum

```
PROCESSING MAT:    1395
        PROCESS:   1
        PROCESS:   2
        PROCESS:   4
        PROCESS:  16
        PROCESS:  17
        PROCESS:  18
        PROCESS:  51
        PROCESS:  52
        PROCESS:  53
        PROCESS:  54
        PROCESS:  55
        PROCESS:  56
        PROCESS:  57
        PROCESS:  58
        PROCESS:  59
        PROCESS:  60
        PROCESS:  61
        PROCESS:  62
        PROCESS:  63
        PROCESS:  64
        PROCESS:  65
        PROCESS:  66
        PROCESS:  91
        PROCESS: 102
        PROCESS: 251
        PROCESS: 252
        PROCESS: 253
```

These are the processes from File 3 which were treated

"Infinite dilution" Elastic

```
GROUP AVERAGED ~~DATA FOR U235~~                                                              IDENTI~~FIER:~~    92235
XSEC ID       1 Total       2 Elastic    3002               4 Inelastic   16 n,2n       17 n,3n       18 Fission    1018
GRP.
  1     6.10744E+00   3.81457E+00   3.81457E+00   2.11945E-01   2.37496E-02   9.04339E-02   1.96550E+00   1.96550E+00
  2     6.02153E+00   3.56859E+00   3.56859E+00   2.16519E-01   1.11835E-01   9.28612E-02   2.03016E+00   2.03015E+00
  3     5.93941E+00   3.35500E+00   3.35500E+00   2.20591E-01   2.02400E-01   6.16327E-02   2.09781E+00   2.09781E+00
  4     5.85955E+00   3.23816E+00   3.23816E+00   2.24013E-01   2.79635E-01   3.70705E-02   2.07840E+00   2.07839E+00
  5     5.79717E+00   3.22828E+00   3.22829E+00   2.17813E-01   3.61898E-01   1.78669E-02   1.96880E+00   1.96880E+00
  6     5.75457E+00   3.35718E+00   3.35718E+00   1.84970E-01   4.50316E-01   8.78135E-04   1.75777E+00   1.75777E+00
  7     6.00574E+00   3.59133E+00   3.56617E+00   2.19007E-01   4.15244E-01   0.00000E+00   1.77323E+00   1.76999E+00
  8     6.57970E+00   4.04647E+00   3.99788E+00   6.59919E-01   2.81750E-01   0.00000E+00   1.57934E+00   1.61937E+00
  9     7.39330E+00   4.57604E+00   4.54195E+00   1.67781E+00   3.61882E-02   0.00000E+00   1.08617E+00   1.09813E+00
 10     7.80560E+00   4.84700E+00   4.84458E+00   1.83040E+00   0.00000E+00   0.00000E+00   1.10647E+00   1.10567E+00
 11     7.90381E+00   4.89052E+00   4.89766E+00   1.81351E+00   0.00000E+00   0.00000E+00   1.17080E+00   1.16668E+00
 12     7.68720E+00   4.62471E+00   4.62737E+00   1.77716E+00   0.00000E+00   0.00000E+00   1.24671E+00   1.24618E+00
 13     7.50728E+00   4.43676E+00   4.43696E+00   1.75000E+00   0.00000E+00   0.00000E+00   1.27637E+00   1.27637E+00
 14     7.24689E+00   4.15909E+00   4.16038E+00   1.74255E+00   0.00000E+00   0.00000E+00   1.29311E+00   1.29307E+00
 15     6.90241E+00   3.91270E+00   3.91233E+00   1.65101E+00   0.00000E+00   0.00000E+00   1.27269E+00   1.27256E+00
 16     6.76416E+00   3.86504E+00   3.86506E+00   1.57684E+00   0.00000E+00   0.00000E+00   1.24520E+00   1.24518E+00
 17     6.73559E+00   3.87306E+00   3.87313E+00   1.54386E+00   0.00000E+00   0.00000E+00   1.23664E+00   1.23666E+00
 18     6.72378E+00   3.88216E+00   3.88220E+00   1.52479E+00   0.00000E+00   0.00000E+00   1.23222E+00   1.23222E+00
 19     6.71505E+00   3.89995E+00   3.90005E+00   1.50038E+00   0.00000E+00   0.00000E+00   1.22656E+00   1.22656E+00
 20     6.71480E+00   3.92726E+00   3.92737E+00   1.47350E+00   0.00000E+00   0.00000E+00   1.22149E+00   1.22151E+00
 21     6.73393E+00   3.97868E+00   3.97903E+00   1.43892E+00   0.00000E+00   0.00000E+00   1.21673E+00   1.21671E+00
 22     6.79150E+00   4.07013E+00   4.07063E+00   1.39526E+00   0.00000E+00   0.00000E+00   1.21590E+00   1.21592E+00
 23     6.88877E+00   4.20995E+00   4.21107E+00   1.35280E+00   0.00000E+00   0.00000E+00   1.20648E+00   1.20624E+00
 24     6.96897E+00   4.32401E+00   4.32419E+00   1.34798E+00   0.00000E+00   0.00000E+00   1.17474E+00   1.17476E+00
 25     7.00722E+00   4.37600E+00   4.37617E+00   1.34500E+00   0.00000E+00   0.00000E+00   1.16274E+00   1.16274E+00
 26     7.04228E+00   4.42550E+00   4.42561E+00   1.33722E+00   0.00000E+00   0.00000E+00   1.15458E+00   1.15459E+00
 27     7.09551E+00   4.49044E+00   4.49079E+00   1.33279E+00   0.00000E+00   0.00000E+00   1.14507E+00   1.14505E+00
 28     7.21561E+00   4.61284E+00   4.61403E+00   1.33227E+00   0.00000E+00   0.00000E+00   1.13814E+00   1.13811E+00
 29     7.39781E+00   4.81694E+00   4.81879E+00   1.30419E+00   0.00000E+00   0.00000E+00   1.13719E+00   1.13720E+00
 30     7.51833E+00   4.96305E+00   4.96321E+00   1.27245E+00   0.00000E+00   0.00000E+00   1.13853E+00   1.13856E+00
 31     7.65848E+00   5.15600E+00   5.15950E+00   1.21071E+00   0.00000E+00   0.00000E+00   1.14161E+00   1.14168E+00
 32     7.85099E+00   5.41188E+00   5.41239E+00   1.13324E+00   0.00000E+00   0.00000E+00   1.14770E+00   1.14773E+00
 33     7.96178E+00   5.52554E+00   5.52600E+00   1.12075E+00   0.00000E+00   0.00000E+00   1.15270E+00   1.15273E+00
 34     8.13505E+00   5.69681E+00   5.69879E+00   1.10745E+00   0.00000E+00   0.00000E+00   1.16085E+00   1.16097E+00
 35     8.29937E+00   5.86643E+00   5.86733E+00   1.08327E+00   0.00000E+00   0.00000E+00   1.17131E+00   1.17137E+00
 36     8.44922E+00   6.03255E+00   6.03367E+00   1.04921E+00   0.00000E+00   0.00000E+00   1.18212E+00   1.18221E+00
 37     8.57162E+00   6.17933E+00   6.17989E+00   1.00703E+00   0.00000E+00   0.00000E+00   1.19362E+00   1.19367E+00
 38     8.67269E+00   6.30300E+00   6.30370E+00   9.69048E-01   0.00000E+00   0.00000E+00   1.20379E+00   1.20386E+00
 39     8.92926E+00   6.58876E+00   6.59760E+00   9.04251E-01   0.00000E+00   0.00000E+00   1.22683E+00   1.22756E+00
 40     9.35479E+00   7.04459E+00   7.05404E+00   8.10050E-01   0.00000E+00   0.00000E+00   1.26207E+00   1.26277E+00
 41     9.88798E+00   7.59250E+00   7.61412E+00   6.89570E-01   0.00000E+00   0.00000E+00   1.32321E+00   1.32638E+00
 42     1.05321E+01   8.22133E+00   8.24168E+00   5.66256E-01   0.00000E+00   0.00000E+00   1.41562E+00   1.41821E+00
 43     1.10250E+01   8.70168E+00   8.70741E+00   4.74866E-01   0.00000E+00   0.00000E+00   1.47833E+00   1.47915E+00
 44     1.14593E+01   9.09608E+00   9.11026E+00   4.16013E-01   0.00000E+00   0.00000E+00   1.53824E+00   1.54062E+00
 45     1.19142E+01   9.62460E+00   9.63597E+00   2.88916E-01   0.00000E+00   0.00000E+00   1.56295E+00   1.56154E+00
 46     1.21370E+01   9.86103E+00   9.86089E+00   1.93828E-01   0.00000E+00   0.00000E+00   1.61660E+00   1.61692E+00
 47     1.22614E+01   9.94023E+00   9.94032E+00   1.70163E-01   0.00000E+00   0.00000E+00   1.66323E+00   1.66476E+00
 48     1.23776E+01   9.93221E+00   9.93241E+00   1.49663E-01   0.00000E+00   0.00000E+00   1.76878E+00   1.76874E+00
 49     1.25894E+01   1.01947E+01   1.01972E+01   1.15199E-01   0.00000E+00   0.00000E+00   1.74602E+00   1.74675E+00
 50     1.29074E+01   1.04237E+01   1.04236E+01   6.75966E-02   0.00000E+00   0.00000E+00   1.83465E+00   1.83465E+00
 51     1.30632E+01   1.07079E+01   1.07079E+01   4.53260E-02   0.00000E+00   0.00000E+00   1.74534E+00   1.74534E+00
 52     1.31740E+01   1.07886E+01   1.07886E+01   3.72605E-02   0.00000E+00   0.00000E+00   1.76657E+00   1.76657E+00
 53     1.35725E+01   1.09472E+01   1.09472E+01   2.59189E-02   0.00000E+00   0.00000E+00   1.92691E+00   1.92691E+00
 54     1.39865E+01   1.11378E+01   1.11378E+01   1.55571E-02   0.00000E+00   0.00000E+00   2.07617E+00   2.07616E+00
 55     1.44913E+01   1.13434E+01   1.13435E+01   8.32403E-03   0.00000E+00   0.00000E+00   2.25282E+00   2.25283E+00
 56     1.49749E+01   1.14832E+01   1.14833E+01   2.00930E-03   0.00000E+00   0.00000E+00   2.51014E+00   2.51014E+00
 57     1.55015E+01   1.16280E+01   1.16280E+01   0.00000E+00   0.00000E+00   0.00000E+00   2.72637E+00   2.72638E+00
 58     1.62258E+01   1.17999E+01   1.17999E+01   0.00000E+00   0.00000E+00   0.00000E+00   3.03282E+00   3.03283E+00
 59     1.64726E+01   1.17829E+01   1.17829E+01   0.00000E+00   0.00000E+00   0.00000E+00   3.26029E+00   3.26030E+00
 60     1.74469E+01   1.18021E+01   1.18021E+01   0.00000E+00   0.00000E+00   0.00000E+00   4.13459E+00   4.13460E+00
 61     1.83177E+01   1.18302E+01   1.18302E+01   0.00000E+00   0.00000E+00   0.00000E+00   4.87027E+00   4.87028E+00
 62     1.82204E+01   1.17842E+01   1.17842E+01   0.00000E+00   0.00000E+00   0.00000E+00   4.82608E+00   4.82609E+00
 63     1.83511E+01   1.17205E+01   1.17205E+01   0.00000E+00   0.00000E+00   0.00000E+00   5.10843E+00   5.10844E+00
 64     1.94871E+01   1.18654E+01   1.18654E+01   0.00000E+00   0.00000E+00   0.00000E+00   5.65252E+00   5.65253E+00
 65     1.94358E+01   1.18994E+01   1.18994E+01   0.00000E+00   0.00000E+00   0.00000E+00   5.33449E+00   5.33450E+00
 66     2.12980E+01   1.21501E+01   1.21501E+01   0.00000E+00   0.00000E+00   0.00000E+00   6.28469E+00   6.28470E+00
 67     2.10432E+01   1.19264E+01   1.19264E+01   0.00000E+00   0.00000E+00   0.00000E+00   6.70149E+00   6.70150E+00
 68     1.95669E+01   1.18352E+01   1.18352E+01   0.00000E+00   0.00000E+00   0.00000E+00   5.27946E+00   5.27947E+00
 69     2.26400E+01   1.20073E+01   1.20073E+01   0.00000E+00   0.00000E+00   0.00000E+00   7.74651E+00   7.74651E+00
 70     2.41488E+01   1.22454E+01   1.22454E+01   0.00000E+00   0.00000E+00   0.00000E+00   7.61374E+00   7.61375E+00
 71     2.61861E+01   1.22343E+01   1.22344E+01   0.00000E+00   0.00000E+00   0.00000E+00   9.41797E+00   9.41799E+00
 222   5.04112E+02  1.46405E+01  1.46405E+01  0.00000E+00  0.00000E+00  0.00000E+00  4.19034E+02  4.19034E+02
 223   5.83220E+02  1.46772E+01  1.46772E+01  0.00000E+00  0.00000E+00  0.00000E+00  4.86665E+02  4.86662E+02
 224   6.63881E+02  1.47041E+01  1.47040E+01  0.00000E+00  0.00000E+00  0.00000E+00  5.55570E+02  5.55568E+02
 225   8.58695E+02  1.47391E+01  1.47391E+01  0.00000E+00  0.00000E+00  0.00000E+00  7.21913E+02  7.21908E+02
 226   1.22499E+03  1.47722E+01  1.47722E+01  0.00000E+00  0.00000E+00  0.00000E+00  1.03467E+03  1.03465E+03
 227   1.45547E+03  1.47810E+01  1.47810E+01  0.00000E+00  0.00000E+00  0.00000E+00  1.23150E+03  1.23153E+03
 228   1.72045E+03  1.47901E+01  1.47900E+01  0.00000E+00  0.00000E+00  0.00000E+00  1.45781E+03  1.45780E+03
 229   1.95342E+03  1.47902E+01  1.47900E+01  0.00000E+00  0.00000E+00  0.00000E+00  1.65680E+03  1.65678E+03
 230   2.20659E+03  1.47912E+01  1.47912E+01  0.00000E+00  0.00000E+00  0.00000E+00  1.87306E+03  1.87305E+03
 231   2.44073E+03  1.48000E+01  1.48000E+01  0.00000E+00  0.00000E+00  0.00000E+00  2.07307E+03  2.07308E+03
 232   2.76834E+03  1.48001E+01  1.48000E+01  0.00000E+00  0.00000E+00  0.00000E+00  2.35294E+03  2.35294E+03
 233   3.15386E+03  1.48001E+01  1.48000E+01  0.00000E+00  0.00000E+00  0.00000E+00  2.68228E+03  2.68224E+03
 234   3.49498E+03  1.48000E+01  1.48000E+01  0.00000E+00  0.00000E+00  0.00000E+00  2.97370E+03  2.97370E+03
 235   3.91744E+03  1.48001E+01  1.48000E+01  0.00000E+00  0.00000E+00  0.00000E+00  3.33463E+03  3.33460E+03
 236   4.63190E+03  1.48000E+01  1.48000E+01  0.00000E+00  0.00000E+00  0.00000E+00  3.94503E+03  3.94497E+03
 237   6.56351E+03  1.48000E+01  1.48000E+01  0.00000E+00  0.00000E+00  0.00000E+00  5.59534E+03  5.59527E+03
 238   1.51161E+04  1.48001E+01  1.48000E+01  0.00000E+00  0.00000E+00  0.00000E+00  1.29026E+04  1.29025E+04
XSEC ID    452 ν̄        455 ν̄d       456 ν̄p       102 n,γ      3102         251 μ̄L       252 ξ        253 γ
GRP.
   1   5.05813E+00  9.00013E-03  5.04911E+00  1.24174E-03  1.24174E-03  9.14456E-01  7.90065E-04  2.90687E-03
   2   4.75183E+00  9.00020E-03  4.74278E+00  1.56641E-03  1.56641E-03  9.10031E-01  8.25073E-04  2.94439E-03
   3   4.55621E+00  8.99985E-03  4.54714E+00  1.97537E-03  1.97537E-03  8.98894E-01  9.13090E-04  3.03870E-03
   4   4.42619E+00  9.00009E-03  4.41711E+00  2.27866E-03  2.27865E-03  8.91369E-01  9.72667E-04  3.10263E-03
   5   4.30496E+00  8.99996E-03  4.29587E+00  2.51024E-03  2.51024E-03  8.84885E-01  1.02399E-03  3.15979E-03
   6   4.02560E+00  8.99990E-03  4.01648E+00  3.46551E-03  3.46552E-03  8.65852E-01  1.17794E-03  3.42810E-03
   7   3.67370E+00  9.00007E-03  3.66455E+00  6.92812E-03  6.54889E-03  8.37857E-01  1.40831E-03  3.88145E-03
   8   3.42927E+00  9.32239E-03  3.41993E+00  1.22191E-02  1.17548E-02  8.26017E-01  1.50533E-03  3.96230E-03
   9   3.14149E+00  1.28919E-02  3.12860E+00  1.70888E-02  1.67204E-02  8.16194E-01  1.58540E-03  3.86306E-03
  10   2.98653E+00  1.53228E-02  2.97120E+00  2.17231E-02  2.16627E-02  7.99498E-01  1.72642E-03  3.88481E-03
  11   2.84803E+00  1.66408E-02  2.83139E+00  2.89683E-02  2.85038E-02  7.66165E-01  2.01039E-03  3.87701E-03
  12   2.73053E+00  1.67001E-02  2.71383E+00  3.86266E-02  3.85448E-02  7.06678E-01  2.52000E-03  4.06843E-03
  13   2.68675E+00  1.67001E-02  2.67005E+00  4.41531E-02  4.41487E-02  6.69475E-01  2.83901E-03  4.17861E-03
  14   2.64161E+00  1.67000E-02  2.62491E+00  5.21367E-02  5.20973E-02  6.29125E-01  3.18500E-03  4.29719E-03
  15   2.59610E+00  1.66998E-02  2.57939E+00  6.60051E-02  6.60535E-02  5.62626E-01  3.75522E-03  4.48272E-03
  16   2.57482E+00  1.66999E-02  2.55811E+00  7.70863E-02  7.71014E-02  5.23642E-01  4.08950E-03  4.57702E-03
  17   2.56790E+00  1.67000E-02  2.55116E+00  8.20164E-02  8.20208E-02  5.09937E-01  4.20702E-03  4.59655E-03
  18   2.56388E+00  1.67000E-02  2.54713E+00  8.46088E-02  8.46122E-02  5.02008E-01  4.27502E-03  4.60786E-03
  19   2.55874E+00  1.66999E-02  2.54198E+00  8.81624E-02  8.81736E-02  4.91859E-01  4.36204E-03  4.62232E-03
  20   2.55310E+00  1.67000E-02  2.53632E+00  9.25376E-02  9.25461E-02  4.80690E-01  4.45781E-03  4.63824E-03
  21   2.54582E+00  1.67000E-02  2.52903E+00  9.95972E-02  9.96421E-02  4.66313E-01  4.58109E-03  4.65873E-03
  22   2.53661E+00  1.67000E-02  2.51983E+00  1.10214E-01  1.10266E-01  4.48170E-01  4.73668E-03  4.68459E-03
  23   2.52791E+00  1.67000E-02  2.51114E+00  1.19545E-01  1.19577E-01  4.31039E-01  4.88359E-03  4.70546E-03
  24   2.52256E+00  1.66999E-02  2.50579E+00  1.22233E-01  1.22238E-01  4.20655E-01  4.97269E-03  4.71488E-03
  25   2.52038E+00  1.67000E-02  2.50361E+00  1.23471E-01  1.23475E-01  4.16394E-01  5.00924E-03  4.71872E-03
  26   2.51849E+00  1.67000E-02  2.50173E+00  1.24972E-01  1.24975E-01  4.12713E-01  5.04082E-03  4.72204E-03
  27   2.51582E+00  1.67000E-02  2.49906E+00  1.27218E-01  1.27231E-01  4.07502E-01  5.08554E-03  4.72675E-03
  28   2.51043E+00  1.67000E-02  2.49368E+00  1.32372E-01  1.32415E-01  3.96590E-01  5.17917E-03  4.73786E-03
  29   2.50359E+00  1.67000E-02  2.48684E+00  1.39493E-01  1.39555E-01  3.81777E-01  5.30628E-03  4.75602E-03
  30   2.49971E+00  1.67000E-02  2.48297E+00  1.44302E-01  1.44307E-01  3.73344E-01  5.37866E-03  4.76646E-03
  31   2.49588E+00  1.67000E-02  2.47913E+00  1.50154E-01  1.50254E-01  3.65008E-01  5.45020E-03  4.77679E-03
  32   2.49117E+00  1.67000E-02  2.47443E+00  1.58163E-01  1.58184E-01  3.54774E-01  5.53802E-03  4.78946E-03
  33   2.48874E+00  1.67000E-02  2.47201E+00  1.62784E-01  1.62801E-01  3.49497E-01  5.58330E-03  4.79599E-03
  34   2.48516E+00  1.66998E-02  2.46842E+00  1.69948E-01  1.70040E-01  3.41751E-01  5.64978E-03  4.80559E-03
  35   2.48129E+00  1.66999E-02  2.46456E+00  1.78363E-01  1.78401E-01  3.31452E-01  5.73816E-03  4.82499E-03
  36   2.47840E+00  1.66999E-02  2.46167E+00  1.85344E-01  1.85392E-01  3.21552E-01  5.82313E-03  4.85024E-03
  37   2.47598E+00  1.66999E-02  2.45925E+00  1.91639E-01  1.91662E-01  3.13229E-01  5.89456E-03  4.87147E-03
  38   2.47402E+00  1.66998E-02  2.45730E+00  1.96846E-01  1.96874E-01  3.06576E-01  5.95167E-03  4.88845E-03
  39   2.46967E+00  1.66998E-02  2.45294E+00  2.09423E-01  2.09850E-01  2.91676E-01  6.07954E-03  4.92645E-03
  40   2.46336E+00  1.66998E-02  2.44664E+00  2.38082E-01  2.38861E-01  2.70057E-01  6.26508E-03  4.98160E-03
  41   2.45706E+00  1.66998E-02  2.44034E+00  2.82703E-01  2.84255E-01  2.48521E-01  6.44990E-03  5.03653E-03
  42   2.45124E+00  1.66998E-02  2.43453E+00  3.28894E-01  3.30466E-01  2.06455E-01  6.81094E-03  5.15037E-03
  43   2.44774E+00  1.66997E-02  2.43104E+00  3.70076E-01  3.70628E-01  1.61941E-01  7.19297E-03  5.27353E-03
  44   2.44532E+00  1.66997E-02  2.42862E+00  4.08949E-01  4.10398E-01  1.31338E-01  7.45566E-03  5.35823E-03
  45   2.44326E+00  1.66999E-02  2.42655E+00  4.37685E-01  4.37636E-01  1.04501E-01  7.68600E-03  5.43249E-03
  46   2.44237E+00  1.67000E-02  2.42566E+00  4.65565E-01  4.65682E-01  9.33241E-02  7.78206E-03  5.46351E-03
  47   2.44188E+00  1.67000E-02  2.42518E+00  4.87793E-01  4.88374E-01  8.71920E-02  7.83452E-03  5.48036E-03
  48   2.44145E+00  1.67000E-02  2.42475E+00  5.26929E-01  5.26927E-01  8.16287E-02  7.88232E-03  5.49579E-03
  49   2.44071E+00  1.67000E-02  2.42401E+00  5.33484E-01  5.33905E-01  7.22752E-02  7.96256E-03  5.52165E-03
  50   2.43970E+00  1.67000E-02  2.42299E+00  5.81504E-01  5.81504E-01  5.93560E-02  8.07344E-03  5.55739E-03
  51   2.43921E+00  1.67000E-02  2.42251E+00  5.64604E-01  5.64604E-01  5.33118E-02  8.12529E-03  5.57410E-03
  52   2.43889E+00  1.67001E-02  2.42219E+00  5.81519E-01  5.81519E-01  4.89585E-02  8.16268E-03  5.58616E-03
  53   2.43785E+00  1.67000E-02  2.42114E+00  6.72481E-01  6.72481E-01  3.60834E-02  8.27315E-03  5.62177E-03
  54   2.43694E+00  1.67000E-02  2.42024E+00  7.56978E-01  7.56977E-01  2.43051E-02  8.37425E-03  5.65436E-03
  55   2.43670E+00  1.67000E-02  2.42000E+00  8.86713E-01  8.86715E-01  1.60834E-02  8.44481E-03  5.67711E-03
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206    2.43663E+00    1.66995E-02    2.41993E+00    2.67743E+01    2.67743E+01    2.86138E-03    8.55833E-03    5.71372E-03
207    2.43661E+00    1.66994E-02    2.41991E+00    3.40934E+01    3.40934E+01    2.86138E-03    8.55835E-03    5.71373E-03
208    2.43663E+00    1.66995E-02    2.41993E+00    4.22695E+01    4.22695E+01    2.86138E-03    8.55833E-03    5.71372E-03
209    2.43669E+00    1.66999E-02    2.41999E+00    4.77267E+01    4.77267E+01    2.86136E-03    8.55829E-03    5.71369E-03
210    2.43671E+00    1.67001E-02    2.42001E+00    4.73999E+01    4.73999E+01    2.86137E-03    8.55832E-03    5.71371E-03
211    2.43669E+00    1.66999E-02    2.41998E+00    4.33025E+01    4.33025E+01    2.86137E-03    8.55833E-03    5.71372E-03
212    2.43668E+00    1.66999E-02    2.41998E+00    3.92245E+01    3.92244E+01    2.86138E-03    8.55834E-03    5.71373E-03
213    2.43666E+00    1.66998E-02    2.41996E+00    3.67810E+01    3.67810E+01    2.86138E-03    8.55833E-03    5.71372E-03
214    2.43667E+00    1.66998E-02    2.41997E+00    3.62704E+01    3.62704E+01    2.86137E-03    8.55831E-03    5.71371E-03
215    2.43668E+00    1.66999E-02    2.41998E+00    3.76556E+01    3.76650E+01    2.86136E-03    8.55828E-03    5.71369E-03
216    2.43673E+00    1.67002E-02    2.42003E+00    4.12748E+01    4.12748E+01    2.86136E-03    8.55830E-03    5.71370E-03
217    2.43672E+00    1.67001E-02    2.42001E+00    4.48182E+01    4.48183E+01    2.86136E-03    8.55827E-03    5.71368E-03
218    2.43672E+00    1.67001E-02    2.42002E+00    4.78104E+01    4.78105E+01    2.86136E-03    8.55828E-03    5.71369E-03
219    2.43669E+00    1.66999E-02    2.41999E+00    5.15407E+01    5.15405E+01    2.86135E-03    8.55826E-03    5.71368E-03
220    2.43669E+00    1.67000E-02    2.41999E+00    5.62491E+01    5.62495E+01    2.86136E-03    8.55827E-03    5.71368E-03
221    2.43671E+00    1.67001E-02    2.42001E+00    6.23245E+01    6.23249E+01    2.86136E-03    8.55827E-03    5.71369E-03
222    2.43671E+00    1.67001E-02    2.42001E+00    7.04375E+01    7.04375E+01    2.86136E-03    8.55828E-03    5.71369E-03
223    2.43672E+00    1.67001E-02    2.42002E+00    8.18782E+01    8.18778E+01    2.86136E-03    8.55828E-03    5.71369E-03
224    2.43666E+00    1.66997E-02    2.41996E+00    9.36074E+01    9.36070E+01    2.86136E-03    8.55829E-03    5.71370E-03
225    2.43669E+00    1.66999E-02    2.41999E+00    1.22044E+02    1.22043E+02    2.86136E-03    8.55829E-03    5.71369E-03
226    2.43668E+00    1.66999E-02    2.41998E+00    1.75547E+02    1.75545E+02    2.86136E-03    8.55829E-03    5.71369E-03
227    2.43668E+00    1.66999E-02    2.41998E+00    2.09198E+02    2.09197E+02    2.86136E-03    8.55829E-03    5.71369E-03
228    2.43668E+00    1.66998E-02    2.41998E+00    2.47850E+02    2.47848E+02    2.86138E-03    8.55834E-03    5.71373E-03
229    2.43668E+00    1.66999E-02    2.41998E+00    2.81827E+02    2.81823E+02    2.86139E-03    8.55837E-03    5.71375E-03
230    2.43669E+00    1.66999E-02    2.41999E+00    3.18740E+02    3.18738E+02    2.86136E-03    8.55830E-03    5.71370E-03
231    2.43666E+00    1.66997E-02    2.41996E+00    3.52861E+02    3.52863E+02    2.86137E-03    8.55831E-03    5.71371E-03
232    2.43664E+00    1.66996E-02    2.41994E+00    4.00608E+02    4.00608E+02    2.86137E-03    8.55832E-03    5.71372E-03
233    2.43666E+00    1.66997E-02    2.41996E+00    4.56777E+02    4.56771E+02    2.86138E-03    8.55833E-03    5.71372E-03
234    2.43669E+00    1.66999E-02    2.41999E+00    5.06476E+02    5.06476E+02    2.86136E-03    8.55829E-03    5.71369E-03
235    2.43669E+00    1.66999E-02    2.41999E+00    5.68013E+02    5.68008E+02    2.86137E-03    8.55831E-03    5.71371E-03
236    2.43669E+00    1.66999E-02    2.41999E+00    6.72073E+02    6.72063E+02    2.86136E-03    8.55829E-03    5.71370E-03
237    2.43667E+00    1.66997E-02    2.41997E+00    9.53375E+02    9.53365E+02    2.86136E-03    8.55829E-03    5.71370E-03
238    2.43668E+00    1.66998E-02    2.41998E+00    2.19877E+03    2.19876E+03    2.86137E-03    8.55830E-03    5.71370E-03
XSEC ID         27 σa          101 σc         1099 Flux      3099 ←Infinite Dilution Flux
GRP.
  1    1.96674E+00    1.24174E-03    1.05712E-01    1.43120E-01
  2    2.03172E+00    1.56641E-03    7.38871E-02    1.00034E-01
  3    2.09978E+00    1.97537E-03    5.53864E-02    7.49863E-02
  4    2.08068E+00    2.27866E-03    3.69513E-02    5.00275E-02
  5    1.97131E+00    2.51024E-03    5.53943E-02    7.49969E-02
  6    1.76123E+00    3.46551E-03    1.84640E-01    2.49980E-01
  7    1.78016E+00    6.92812E-03    2.79241E-01    2.00000E-01
  8    1.59156E+00    1.22191E-02    9.75374E-01    2.40987E-01
  9    1.10326E+00    1.70888E-02    2.97758E+00    2.92980E-01
 10    1.12819E+00    2.17231E-02    1.79202E+00    1.09071E-01
 11    1.19977E+00    2.89683E-02    8.75044E+00    3.60933E-01
 12    1.28533E+00    3.86266E-02    6.06131E+00    1.90757E-01
 13    1.32052E+00    4.41531E-02    1.75427E+00    5.17388E-02
 14    1.34525E+00    5.21367E-02    8.46045E+00    2.40930E-01
 15    1.33870E+00    6.60051E-02    7.32712E+00    2.09720E-01
 16    1.32229E+00    7.70863E-02    2.32265E+00    6.89926E-02
 17    1.31866E+00    8.20164E-02    1.05424E+00    3.19325E-02
 18    1.31683E+00    8.46088E-02    9.50420E-01    2.91826E-02
 19    1.31472E+00    8.81624E-02    1.66727E+00    5.22123E-02
 20    1.31403E+00    9.25376E-02    1.27265E+00    4.08214E-02
 21    1.31633E+00    9.95972E-02    2.61689E+00    8.70113E-02
 22    1.32611E+00    1.10214E-01    2.42993E+00    8.53595E-02
 23    1.32602E+00    1.19545E-01    2.49425E+00    9.33319E-02
 24    1.29698E+00    1.22233E-01    5.62120E-01    2.19783E-02
 25    1.28621E+00    1.23471E-01    7.06578E-01    2.81706E-02
 26    1.27955E+00    1.24972E-01    3.94405E-01    1.60130E-02
 27    1.27228E+00    1.27218E-01    1.17229E+00    4.89057E-02
 28    1.27051E+00    1.32372E-01    2.01573E+00    8.92311E-02
 29    1.27668E+00    1.39493E-01    2.06141E+00    9.94513E-02
 30    1.28283E+00    1.44302E-01    2.62002E-01    1.33431E-02
 31    1.29177E+00    1.50154E-01    2.03941E+00    1.10347E-01
 32    1.30586E+00    1.58163E-01    7.85261E-01    4.60436E-02
 33    1.31548E+00    1.62784E-01    6.67823E-01    4.09669E-02
 34    1.33080E+00    1.69948E-01    1.45764E+00    9.62698E-02
 35    1.34968E+00    1.78363E-01    8.45852E-01    6.09145E-02
 36    1.36747E+00    1.85344E-01    8.52306E-01    6.59572E-02
 37    1.38526E+00    1.91639E-01    5.63461E-01    4.65198E-02
 38    1.40064E+00    1.96846E-01    5.58955E-01    4.87894E-02
 39    1.43625E+00    2.09423E-01    1.91063E+00    1.92372E-01
 190     7.48928E+01     9.10650E+00     2.53173E-02     2.53173E-02
 191     7.02747E+01     8.05401E+00     2.59754E-02     2.59754E-02
 192     6.70581E+01     7.37207E+00     2.66675E-02     2.66674E-02
 193     6.47633E+01     6.93056E+00     2.73989E-02     2.73989E-02
 194     6.25944E+01     6.52559E+00     5.71577E-02     5.71576E-02
 195     6.14020E+01     6.24055E+00     6.06247E-02     6.06246E-02
 196     6.19543E+01     6.22076E+00     6.45386E-02     6.45385E-02
 197     6.39377E+01     6.43911E+00     6.89927E-02     6.89926E-02
 198     6.72604E+01     6.87252E+00     7.41075E-02     7.41073E-02
 199     7.06097E+01     7.33674E+00     3.92208E-02     3.92207E-02
 200     7.33869E+01     7.73639E+00     4.08215E-02     4.08214E-02
 201     7.85970E+01     8.51795E+00     8.70114E-02     8.70113E-02
 202     8.77160E+01     9.96935E+00     9.53099E-02     9.53097E-02
 203     1.00921E+02     1.22616E+01     1.05360E-01     1.05360E-01
 204     1.21619E+02     1.62834E+01     1.17783E-01     1.17783E-01
 205     1.45151E+02     2.13603E+01     6.45386E-02     6.45385E-02
 206     1.67992E+02     2.67743E+01     6.89927E-02     6.89926E-02
 207     1.96456E+02     3.40934E+01     7.41075E-02     7.41073E-02
 208     2.25324E+02     4.22695E+01     8.00425E-02     8.00424E-02
 209     2.41694E+02     4.77267E+01     8.70114E-02     8.70113E-02
 210     2.37879E+02     4.73999E+01     9.53099E-02     9.53097E-02
 211     2.24647E+02     4.33025E+01     1.05360E-01     1.05360E-01
 212     2.15757E+02     3.92245E+01     1.17782E-01     1.17782E-01
 213     2.15783E+02     3.67810E+01     1.33531E-01     1.33531E-01
 214     2.25416E+02     3.62704E+01     1.54150E-01     1.54150E-01
 215     2.44879E+02     3.76556E+01     1.82322E-01     1.82321E-01
 216     2.77700E+02     4.12748E+01     2.97930E-01     2.98091E-01
 217     3.06100E+02     4.48182E+01     1.94526E-01     1.94605E-01
 218     3.28680E+02     4.78104E+01     2.56096E-01     2.56261E-01
 219     3.56076E+02     5.15407E+01     3.32879E-01     3.32744E-01
 220     3.89918E+02     5.62491E+01     4.24028E-01     4.24307E-01
 221     4.32867E+02     6.23245E+01     5.28251E-01     5.28133E-01
 222     4.89472E+02     7.04375E+01     6.35015E-01     6.35377E-01
 223     5.68543E+02     8.18782E+01     7.25687E-01     7.26105E-01
 224     6.49177E+02     9.36074E+01     3.58695E-01     3.58914E-01
 225     8.43956E+02     1.22044E+02     1.06755E+00     1.06811E+00
 226     1.21021E+03     1.75547E+02     1.25446E-01     1.25420E-01
 227     1.44069E+03     2.09192E+02     9.85623E-02     9.85914E-02
 228     1.70566E+03     2.47850E+02     3.04356E-02     3.04497E-02
 229     1.93863E+03     2.81827E+02     2.45982E-02     2.46121E-02
 230     2.19180E+03     3.18740E+02     9.95373E-03     9.95948E-03
 231     2.42593E+03     3.52861E+02     8.30153E-03     8.30728E-03
 232     2.75354E+03     4.00608E+02     6.58316E-03     6.58673E-03
 233     3.13906E+03     4.56777E+02     3.09554E-03     3.09699E-03
 234     3.48018E+03     5.06476E+02     1.69760E-03     1.69882E-03
 235     3.90264E+03     5.68013E+02     1.70305E-03     1.70375E-03
 236     4.61710E+03     6.72073E+02     1.22794E-03     1.22868E-03
 237     6.54871E+03     9.53375E+02     9.53627E-04     9.54233E-04
 238     1.51013E+04     2.19877E+03     3.97715E-05     3.97861E-05

  ELAPSED TIME    1.00 MIN.
COMMENCE DISCRETE SCATTERING PROCESSING
PROCESSING RESONANCE STRING: 1002 WITH  3366 POINTS SPANNING: 1.00000E+00 TO 8.20000E+01 EV
PROCESSING RESONANCE STRING: 2002 WITH   137 POINTS SPANNING: 8.20000E+01 TO 2.50000E+04 EV
SCATTERING MATRIX PROCESSING FOR MT=   2 REQUIRES       34307 LOCATIONS OF136770 AVAILABLE
MAT= 1395 MT=   2 WAS PROCESSED WITH A 40 ANGLE LOBATTO QUADRATURE AND REQUIRED  1.14 MIN.    XFER TIME=  0.06
SCATTERING MATRIX PROCESSING FOR MT=  51 REQUIRES       30576 LOCATIONS OF136770 AVAILABLE
MAT= 1395 MT=  51 WAS PROCESSED WITH A  8 ANGLE LOBATTO QUADRATURE AND REQUIRED  0.03 MIN.    XFER TIME=  0.02
SCATTERING MATRIX PROCESSING FOR MT=  52 REQUIRES       30589 LOCATIONS OF136770 AVAILABLE
MAT= 1395 MT=  52 WAS PROCESSED WITH A  8 ANGLE LOBATTO QUADRATURE AND REQUIRED  0.03 MIN.    XFER TIME=  0.02
SCATTERING MATRIX PROCESSING FOR MT=  53 REQUIRES       30587 LOCATIONS OF136770 AVAILABLE
MAT= 1395 MT=  53 WAS PROCESSED WITH A  8 ANGLE LOBATTO QUADRATURE AND REQUIRED  0.03 MIN.    XFER TIME=  0.02
```

File 2, 3, and 4 Processing

Elastic

1st Level Inelastic

2nd Level Inelastic

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SCATTERING MATRIX PROCESSING FOR MT=  54 REQUIRES        30585 LOCATIONS OF136770 AVAILABLE
MAT= 1395 MT=  54 HAS PROCESSED WITH A  8 ANGLE LOBATTO QUADRATURE AND REQUIRED  0.03 MIN.     XFER TIME=  0.02
SCATTERING MATRIX PROCESSING FOR MT=  55 REQUIRES        30584 LOCATIONS OF136770 AVAILABLE
MAT= 1395 MT=  55 HAS PROCESSED WITH A  8 ANGLE LOBATTO QUADRATURE AND REQUIRED  0.03 MIN.     XFER TIME=  0.02
SCATTERING MATRIX PROCESSING FOR MT=  56 REQUIRES        30583 LOCATIONS OF136770 AVAILABLE
MAT= 1395 MT=  56 HAS PROCESSED WITH A  8 ANGLE LOBATTO QUADRATURE AND REQUIRED  0.03 MIN.     XFER TIME=  0.02
SCATTERING MATRIX PROCESSING FOR MT=  57 REQUIRES        30581 LOCATIONS OF136770 AVAILABLE
MAT= 1395 MT=  57 HAS PROCESSED WITH A  8 ANGLE LOBATTO QUADRATURE AND REQUIRED  0.03 MIN.     XFER TIME=  0.02
SCATTERING MATRIX PROCESSING FOR MT=  58 REQUIRES        30579 LOCATIONS OF136770 AVAILABLE
MAT= 1395 MT=  58 HAS PROCESSED WITH A  8 ANGLE LOBATTO QUADRATURE AND REQUIRED  0.03 MIN.     XFER TIME=  0.02
SCATTERING MATRIX PROCESSING FOR MT=  59 REQUIRES        30577 LOCATIONS OF136770 AVAILABLE
MAT= 1395 MT=  59 HAS PROCESSED WITH A  8 ANGLE LOBATTO QUADRATURE AND REQUIRED  0.02 MIN.     XFER TIME=  0.01
SCATTERING MATRIX PROCESSING FOR MT=  60 REQUIRES        30575 LOCATIONS OF136770 AVAILABLE
MAT= 1395 MT=  60 HAS PROCESSED WITH A  8 ANGLE LOBATTO QUADRATURE AND REQUIRED  0.02 MIN.     XFER TIME=  0.01
SCATTERING MATRIX PROCESSING FOR MT=  61 REQUIRES        30759 LOCATIONS OF136770 AVAILABLE
MAT= 1395 MT=  61 HAS PROCESSED WITH A  8 ANGLE LOBATTO QUADRATURE AND REQUIRED  0.03 MIN.     XFER TIME=  0.02
SCATTERING MATRIX PROCESSING FOR MT=  62 REQUIRES        30742 LOCATIONS OF136770 AVAILABLE
MAT= 1395 MT=  62 HAS PROCESSED WITH A  8 ANGLE LOBATTO QUADRATURE AND REQUIRED  0.03 MIN.     XFER TIME=  0.02
SCATTERING MATRIX PROCESSING FOR MT=  63 REQUIRES        30732 LOCATIONS OF136770 AVAILABLE
MAT= 1395 MT=  63 HAS PROCESSED WITH A  8 ANGLE LOBATTO QUADRATURE AND REQUIRED  0.03 MIN.     XFER TIME=  0.02
SCATTERING MATRIX PROCESSING FOR MT=  64 REQUIRES        30722 LOCATIONS OF136770 AVAILABLE
MAT= 1395 MT=  64 HAS PROCESSED WITH A  8 ANGLE LOBATTO QUADRATURE AND REQUIRED  0.03 MIN.     XFER TIME=  0.02
SCATTERING MATRIX PROCESSING FOR MT=  65 REQUIRES        30712 LOCATIONS OF136770 AVAILABLE
MAT= 1395 MT=  65 HAS PROCESSED WITH A  8 ANGLE LOBATTO QUADRATURE AND REQUIRED  0.03 MIN.     XFER TIME=  0.02
SCATTERING MATRIX PROCESSING FOR MT=  66 REQUIRES        30694 LOCATIONS OF136770 AVAILABLE
MAT= 1395 MT=  66 HAS PROCESSED WITH A  8 ANGLE LOBATTO QUADRATURE AND REQUIRED  0.03 MIN.     XFER TIME=  0.01   16th Level Inelastic

 ELAPSED TIME    2.62 MIN.
COMMENCE EVAPORATION LAW PROCESSING                 File 2,3, and 5 Processing
EVAPORATION PROCESSING USES 33369 OF136770 LOCATIONS
COMMENCE EVAPORATION MODEL PROCESSING FOR MT =  16 ← n,2n
COMMENCE EVAPORATION MODEL PROCESSING FOR MT =  17 ← n,3n
COMMENCE EVAPORATION MODEL PROCESSING FOR MT =  18 ← σf
NORMALIZED FISSION SPECTRUM:
   1 2.59838E-06     2 8.64008E-06     3 1.96284E-05     4 2.43273E-05     5 6.68355E-05
   6 1.10114E-03     7 3.86255E-03     8 1.40156E-02     9 4.38983E-02    10 2.65149E-02
  11 1.26054E-01    12 8.51937E-02    13 2.41078E-02    14 1.14750E-01    15 9.64288E-02
  16 3.01486E-02    17 1.35515E-02    18 1.21673E-02    19 2.12635E-02    20 1.61827E-02
  21 3.31735E-02    22 3.04213E-02    23 3.09144E-02    24 6.94195E-03    25 8.71698E-03
  26 4.86578E-03    27 1.44149E-02    28 2.45570E-02    29 2.49155E-02    30 3.15864E-03
  31 2.45001E-02    32 9.36390E-03    33 7.93280E-03    34 1.72626E-02    35 9.98683E-03
  36 1.00142E-02    37 6.59299E-03    38 6.52355E-03    39 2.22097E-02    40 1.80048E-02
  41 1.93905E-02    42 1.24318E-02    43 4.92808E-03    44 5.91446E-03    45 2.86291E-03
  46 5.47459E-04   47 1.24227E-03   48 3.45604E-04   49 2.13932E-03   50 1.21651E-03
  51 2.91256E-04   52 7.04279E-04   53 1.88606E-03   54 5.42654E-04   55 7.60946E-04
  56 3.23058E-04   57 2.45321E-04   58 9.11682E-05   59 1.12691E-04   60 9.79558E-05
  61 6.57342E-06   62 2.85488E-05   63 1.47517E-05   64 9.51825E-06   65 2.83741E-06
  66 1.18988E-05   67 6.80927E-06   68 1.29975E-06   69 8.47544E-06   70 4.31403E-06
  71 5.07564E-06   72 2.25207E-07   73 1.97335E-06   74 3.36292E-06   75 2.28850E-07
  76 4.85617E-07   77 2.99768E-07   78 2.40659E-08   79 1.41329E-07   80 5.95717E-08
  81 5.28182E-07   82 2.19423E-08   83 2.88292E-08   84 4.92430E-08   85 5.43536E-08
  86 6.49326E-08   87 4.94248E-08   88 1.19937E-08   89 2.35388E-08   90 2.29272E-08
  91 2.50411E-08   92 1.35585E-08   93 2.11543E-08   94 1.03224E-08   95 2.79716E-08
  96 6.77178E-09   97 6.68120E-09   98 6.58951E-09   99 4.18682E-09  100 5.97912E-09
 101 8.14332E-09  102 5.33970E-09  103 7.00719E-09  104 6.02368E-09  105 5.92190E-09
 106 2.08965E-09  107 4.55057E-09  108 4.08010E-09  109 6.01759E-09  110 3.55015E-09
 111 3.31074E-09  112 1.92843E-09  113 5.69776E-09  114 1.86996E-09  115 4.60904E-09
 116 8.93127E-09  117 8.53415E-09  118 8.11746E-09  119 4.66093E-09  120 3.01661E-09
 121 2.94210E-09  122 1.44268E-09  123 4.21052E-09  124 2.70634E-09  125 2.36442E-09
 126 1.79140E-09  127 1.62495E-09  128 2.06723E-09  129 2.34597E-09  130 9.11708E-10
 131 3.27626E-09  132 1.85319E-09  133 1.95389E-09  134 1.74780E-09  135 2.65845E-10
 136 4.36778E-10  137 4.28760E-10  138 4.20600E-10  139 4.12264E-10  140 9.54448E-10
 141 6.07769E-10  142 3.67790E-10  143 1.04504E-09  144 3.53676E-10  145 2.91362E-10
 146 4.25220E-10  147 1.17325E-10  148 5.79482E-11  149 3.45361E-11  150 1.13865E-10
 151 1.11900E-10  152 1.09898E-10  153 1.07859E-10  154 1.05781E-10  155 9.33920E-11
 156 8.15469E-11  157 9.00583E-11  158 8.82406E-11  159 1.14764E-10  160 5.61165E-11
 161 7.34807E-11  162 8.07939E-11  163 7.87644E-11  164 7.66828E-11  165 7.45410E-11
 166 4.04632E-11  167 3.97720E-11  168 3.90680E-11  169 3.83513E-11  170 3.76196E-11
 171 1.85307E-11  172 1.83426E-11  173 1.81527E-11  174 1.79597E-11  175 7.13055E-12
 176 7.09904E-12  177 7.06705E-12  178 7.03608E-12  179 7.00454E-12  180 6.97317E-12
 181 6.94049E-12  182 6.90933E-12  183 6.87680E-12  184 6.84430E-12  185 6.81109E-12
 186 6.77918E-12  187 6.74647E-12  188 6.71362E-12  189 6.67995E-12  190 1.65532E-11
 191 1.63426E-11  192 1.61287E-11  193 1.59124E-11  194 3.11635E-11  195 3.02602E-11
 196 2.93284E-11  197 2.83671E-11  198 2.73713E-11  199 1.32998E-11  200 1.30362E-11
 201 2.52622E-11  202 2.41376E-11  203 2.29596E-11  204 2.17170E-11  205 1.03683E-11
 206 1.00284E-11  207 9.67613E-12  208 9.31086E-12  209 8.93043E-12  210 8.53319E-12
 211 8.11701E-12  212 7.67834E-12  213 7.21242E-12  214 6.71395E-12  215 6.17536E-12
 216 5.58486E-12  217 2.05356E-12  218 1.94245E-12  219 1.82453E-12  220 1.69845E-12
 221 1.56216E-12  222 1.41279E-12  223 1.24553E-12  224 5.20568E-13  225 1.34344E-12
 226 1.55698E-13  227 1.31479E-13  228 4.46736E-14  229 3.93838E-14  230 1.74665E-14
 231 1.57962E-14  232 1.39262E-14  233 7.34120E-15  234 4.41841E-15  235 4.92340E-15
 236 4.15755E-15  237 4.52232E-15  238 4.30185E-16
NO MF= 5 DATA FOR MAT= 1395 MT=  22--LIBRARY POSITIONED AT MAT=1395 MF= 5 MT=  91
NO MF= 5 DATA FOR MAT= 1395 MT=  23--LIBRARY POSITIONED AT MAT=1395 MF= 5 MT=  91
NO MF= 5 DATA FOR MAT= 1395 MT=  24--LIBRARY POSITIONED AT MAT=1395 MF= 5 MT=  91
NO MF= 5 DATA FOR MAT= 1395 MT=  25--LIBRARY POSITIONED AT MAT=1395 MF= 5 MT=  91
NO MF= 5 DATA FOR MAT= 1395 MT=  28--LIBRARY POSITIONED AT MAT=1395 MF= 5 MT=  91
NO MF= 5 DATA FOR MAT= 1395 MT=  46--LIBRARY POSITIONED AT MAT=1395 MF= 5 MT=  91
NO MF= 5 DATA FOR MAT= 1395 MT=  47--LIBRARY POSITIONED AT MAT=1395 MF= 5 MT=  91
NO MF= 5 DATA FOR MAT= 1395 MT=  48--LIBRARY POSITIONED AT MAT=1395 MF= 5 MT=  91
NO MF= 5 DATA FOR MAT= 1395 MT=  49--LIBRARY POSITIONED AT MAT=1395 MF= 5 MT=  91
NO MF= 5 DATA FOR MAT= 1395 MT=  50--LIBRARY POSITIONED AT MAT=1395 MF= 5 MT=  91

COMMENCE EVAPORATION MODEL PROCESSING FOR MT -  91

  ELAPSED TIME   2.68 MIN.

COMMENCE THERMAL SCATTERING PROCESSING

*** FREE ATOM CROSS SECTION USED IN FREE GAS CALCULATION=  1.1499990E+01

AFB208I VFNTH : PROGRAM INTERRUPT - FLOATING-POINT UNDERFLOW EXCEPTION
        VFNTH : PSW 078D2200 0066F6C, REGISTER CONTAINS 4566AF37350B820E0000000000000000
        VFNTH : LAST EXECUTED FORTRAN STATEMENT "*' PROGRAM KERA AT ISN 26 (OFFSET 000004E2).

TRACEBACK OF CALLING ROUTINES; MODULE ENTRY ADDRESS = 000309F8.
--------------------------------------------------------------------------------
 DERFC (00066E82) CALLED BY KERA (0002A8D0) AT ISN 26 AT OFFSET 000004E2.
--------------------------------------------------------------------------------
 KERA (0002A8D0) CALLED BY FENA (00017630) AT ISN 20 AT OFFSET 000004F6.
  ARGUMENT LIST AT 0001781C.
    ARG. NO.    ADDRESS            INTEGER           REAL          CHAR    HEXADECIMAL
          1     0001779C :      1032396488     0.130768E-03     '...H'    3D891EC8
          2     000177A8 :      1032396475     0.130768E-03     '....'    3D891EBB
          3     000B30FC :      1091567616     0.100000E+01     '....'    41100000
          4     000B32C8 :               0     0.000000E+00     '....'    00000000
          5     000B32E8 :               0     0.000000E+00     '....'    00000000
```

File 7 Processing

Underflows in the thermal processing are normally of no consequence and can be ignored.

```
   9   000B0568 :      1094518904   0.381457E+01   '....'   413D0878
  10   000AEF18 :      1075515369   0.105712E+00   ' ..Z'   401B0FE9
  11   000AF200 :      1076142985   0.143120E+00   ' ...'   4024A389
  12   000B1448 :      1125273600   0.293000E+03   '....'   43125000
  13   0007FB40 :               3   0.000002E-78   '....'   00000003
  14   000A4FB8 :      1172827904   0.950000E+06   '.X..'   45E7EF00
  15   000A9DD8 :               0   0.000000E+00   '....'   00000000
  16   0007FBDC :            5000   0.002574E-78   '....'   00001388
  17   000AEBF8 :             122   0.000063E-78   '....'   0000007A
  18   000AED88 :               2   0.000001E-78   '....'   00000002
  19   0007FBD8 :             100   0.000051E-78   '....'   00000064
  20   0007F9F0 :               0   0.000000E+00   '....'   00000000
  21   00058E88 :      1102577654   0.115000E+02   '...6'   41B7FFF6
  22   0007FB30 :               0   0.000000E+00   '....'   00000000
  23   0007F938 :              11   0.000006E-78   '....'   0000000B
  24   0007F934 :               1   0.000001E-78   '....'   00000001
  25   0007FA34 :      1122567782   0.233025E+03   '.Z..'   42E90666
  26   0007FA30 :               3   0.000002E-78   '....'   00000003
  27   000B1454 :      1017628076   0.100000E-04   '..E.'   3CA7C5AC
  28   000B156C :      1075093331   0.805561E-01   ' ...'   40149F53
  29   00058F70 :              70   0.000036E-78   '....'   00000046
  30   000B1684 :              13   0.000007E-78   '....'   0000000D
  31   000B16BC :               5   0.000003E-78   '....'   00000005
  32   00058F68 :              14   0.000007E-78   '....'   0000000E
  33   0007FC84 :               1   0.000001E-78   '....'   00000001
  34   0007FAF0 :              14   0.000007E-78   '....'   0000000E
  35   0007FAF4 :              15   0.000008E-78   '....'   0000000F
  36   0007FAEC :              16   0.000008E-78   '....'   00000010
  37   0007FA3C :              18   0.000009E-78   '....'   00000012
  38   8007FA38 :               6   0.000003E-78   '....'   00000006
---------------------------------------------------------------------------
 XLACS (000580C0) CALLED BY ALOCAT (00069FB8) AT OFFSET 0000010C.
  ARGUMENT LIST AT 000050C0.
    ARG. NO.   ADDRESS          INTEGER        REAL      CHAR   HEXADECIMAL
         1   000A4840 :      1017628076   0.100000E-04   '..E.'   3CA7C5AC
         2   800050C8 :          150000   0.077213E-78   '...0'   000249F0
---------------------------------------------------------------------------
 ALOCAT (00069FB8) CALLED BY MAIN (000309F8) AT ISN 57 AT OFFSET 000006D0.
  ARGUMENT LIST AT 00030E24.
    ARG. NO.   ADDRESS          INTEGER        REAL      CHAR   HEXADECIMAL
         1   00030EA4 :          360640   0.185642E-78   '....'   000580C0
         2   8007FBE0 :          150000   0.077213E-78   '...0'   000249F0
---------------------------------------------------------------------------
 MAIN (000309F8) CALLED BY OPERATING SYSTEM.
---------------------------------------------------------------------------

STANDARD CORRECTIVE ACTION TAKEN. EXECUTION CONTINUING.
                             INTEGRATED THERMAL COEFFICIENTS
 PT       ENERGY                P0            P1           P2           P3                P4                P5
  1  3.1623E-05 FINE     2.02405E+01 -9.65554E-01  0.00000E+00  0.00000E+00
                COARSE   2.01449E+01 -9.89472E-01  0.00000E+00  0.00000E+00
  2  2.2361E-04 FINE     1.36308E+01 -2.68960E-01  1.51866E-03  2.72672E-01
                COARSE   1.36185E+01 -2.68808E-01  1.51866E-03  2.72672E-01
  3  6.1237E-04 FINE     1.24989E+01  5.54788E-03  9.82114E-03 -8.56489E-02
                COARSE   1.24963E+01  5.99430E-03  9.82114E-03 -8.56489E-02
  4  8.6603E-04 FINE     1.22127E+01  6.38824E-02  3.21774E-02 -6.28073E-02
                COARSE   1.22117E+01  6.41371E-02  3.21774E-02 -6.28073E-02
  5  1.0954E-03 FINE     1.20664E+01  8.33201E-02  6.82963E-02  1.25793E-03
                COARSE   1.20658E+01  8.34687E-02  6.82963E-02  1.25796E-03
  6  1.3416E-03 FINE     1.19616E+01  9.21557E-02  1.35314E-01 -2.03403E-02
                COARSE   1.19614E+01  9.22371E-02  1.35314E-01 -2.03403E-02
  7  1.7321E-03 FINE     1.18563E+01  9.68552E-02  2.02676E-01  4.32141E-02
                COARSE   1.18562E+01  9.68845E-02  2.02676E-01  4.32140E-02
  8  2.2361E-03 FINE     1.17769E+01  9.85826E-02 -2.67125E-01  6.08975E-02
                COARSE   1.17769E+01  9.85861E-02 -2.67125E-01  6.08973E-02
  9  2.7386E-03 FINE     1.17265E+01  9.88752E-02 -8.64951E-01 -5.36405E-01
                COARSE   1.17265E+01  9.88755E-02 -8.64948E-01 -5.36406E-01
 10  3.4641E-03 FINE     1.16781E+01  9.90140E-02  3.65306E-01  1.38886E-01
                COARSE   1.16781E+01  9.90145E-02  3.65304E-01  1.38885E-01
 11  4.4721E-03 FINE     1.16382E+01  9.84380E-02 -1.31240E-02 -2.14518E-02
                COARSE   1.16382E+01  9.84375E-02 -1.31252E-02 -2.14517E-02
 12  6.1237E-03 FINE     1.15998E+01  9.85436E-02  2.97707E-03 -1.76898E-02
                COARSE   1.15998E+01  9.85429E-02  2.97724E-03 -1.76888E-02
 13  8.6602E-03 FINE     1.15710E+01  9.86589E-02  1.37778E-03 -9.32966E-03
                COARSE   1.15710E+01  9.86581E-02  1.37829E-03 -9.32926E-03
```

A summary table is given
for each temperature at
which thermal matrices are
generated. "Fine" and "Coarse"
values should closely agree.

```
                            RRRRRRRRRRRR    AAAAAAAAA   DDDDDDDDDDDD  EEEEEEEEEEEEE
                            RRRRRRRRRRRRR  AAAAAAAAAAA  DDDDDDDDDDDDD EEEEEEEEEEEEE
                            RR         RR AA         AA DD         DD EE
                            RR         RR AA         AA DD         DD EE
                            RR         RR AA         AA DD         DD EE
                            RRRRRRRRRRRRR AAAAAAAAAAAAA DD         DD EEEEEEEEE
                            RRRRRRRRRRRR  AAAAAAAAAAAAA DD         DD EEEEEEEEE
                            RR      RR    AA         AA DD         DD EE
                            RR       RR   AA         AA DD         DD EE
                            RR        RR  AA         AA DD         DD EE
                            RR         RR AA         AA DDDDDDDDDDDDD EEEEEEEEEEEEE
                            RR         RR AA         AA DDDDDDDDDDDD  EEEEEEEEEEEEE

NN         NN MM         MM  GGGGGGGGGG   UU        UU   2222222222    3333333333   555555555555
NNN        NN MMM       MMM GGGGGGGGGGGG  UU        UU  222222222222  333333333333  555555555555
NNNN       NN MMMM     MMMM GG        GG  UU        UU  22        22  33        33  55
NN NN      NN MM MM   MM MM GG            UU        UU            22            33  55
NN  NN     NN MM  MM MM  MM GG            UU        UU            22            33  55
NN   NN    NN MM   MMM   MM GG   GGGGGGG  UU        UU           22           333    55555555555
NN    NN   NN MM    M    MM GG   GGGGGGG  UU        UU         22             333    555555555555
NN     NN  NN MM         MM GG        GG  UU        UU       22                 33            55
NN      NN NN MM         MM GG        GG  UU        UU     22                   33            55
NN       NNNN MM         MM GG        GG  UU        UU   22          33        33  55        55
NN        NNN MM         MM GGGGGGGGGGGG  UUUUUUUUUUUU  222222222222  333333333333  555555555555
NN         NN MM         MM  GGGGGGGGGG    UUUUUUUUUU   222222222222   3333333333    5555555555

   0000000    555555555555             //      11            11                  //  9999999999        11
  000000000   555555555555            //      111           111                 //  999999999999      111
 00      00   55                     //      1111          1111                //   99        99     1111
00        00  55                    //         11            11               //    99        99       11
00        00  55                   //          11            11              //     99        99       11
00        00  55555555555         //           11            11             //      999999999999       11
00        00  555555555555       //            11            11            //        99999999999       11
00        00            55      //             11            11           //                  99       11
00        00            55     //              11            11          //                   99       11
 00      00   55        55    //               11            11         //                    99       11
  000000000   555555555555   //             11111111      11111111     //           999999999999    11111111
   0000000     5555555555   //              11111111      11111111    //            99999999999     11111111

                 0000000                   3333333333    3333333333                  2222222222    2222222222
                000000000                 333333333333  333333333333                222222222222  222222222222
               00      00                 33        33  33        33                22        22  22        22
              00        00                          33            33                          22            22
              00        00                          33            33                          22            22
              00        00                        333           333                          22            22
              00        00      .....             333           333       .....            22            22
              00        00      .....               33            33      .....          22            22
              00        00      .....               33            33      .....        22            22
               00      00       .....     33        33  33        33      .....      22            22
                000000000                 333333333333  333333333333                222222222222  222222222222
                 0000000                   3333333333    3333333333                 222222222222  222222222222
```

```
CHECKING TOLERANCE= 1.00000E-03 PER CENT

AMPX NUCLIDE       92235 U235
      HAS THE FOLLOWING DATA                    IS THE NUCLIDE SYMBOL        THERE ARE  124 RECORDS
  131 RESOLVED RESONANCES                233.025 MASS(NEUTRON EQUIVALENTS)                  0 BONDARENKO TEMPS
    0 UNRESOLVED RESONANCE POINTS         92235. ZA                                         0 BONDARENKO GROUPS
   22 TEMP IND 1-D NEUT PROCESSES              0 NEUTRON WGTING OPTION                      0 ID(41) NOT USED
   23 2-D NEUT PROCESSES                       0 NEUTRON WGT ID                             0 GAMMA PROD WGT ID
    0 TEMP DEP 1-D NEUT PROCESSES              0 GAMMA WGTING OPTION                        0 ID(43) NOT USED
    0 1-D GAMMA PROCESSES                0.00E+00 POWER/FISSION(WATT-SEC/FIS)               0 GAMMA PROD WGTING OPTION
    0 2-D GAMMA PROCESSES                0.00E+00 ENERGY/CAPTURE(WATT-SEC/CAP)           1395 ENDF MAT OF FAST NEUT DATA
    0 NEUT-TO-GAMMA PROCESSES              28441 MAX 2-D LENGTH                             0 ENDF MAT OF THERMAL NEUT DATA
  111 TOTAL 2-D ARRAYS                         0 BONDARENKO PROCESSES                       0 ENDF MAT OF GAMMA DATA
    5 MAX ORDER OF L                           0 BONDARENKO SIGMA ZEROS                     0 ENDF MAT OF GAMMA PROD DATA

COMMENCE SCAN OF DATA FOR NORDHEIM TREATMENT

MATERIAL       92235 HAS  1 SET(S) OF RESOLVED DATA

  SET  1 HAS 129 L=0 RESONANCES--ABUNDANCE=  1.0000E+00

CAUTION--CAUTION--THE RESONANCE AT EO=   2.900E-01 HAS LIMITS ON ITS NORDHEIM RANGE OF      1.243E-01      3.849E+00
    THE RESOLVED REGION LIMITS ARE      1.000E+00        8.200E+01

CAUTION--CAUTION--THE RESONANCE AT EO=   1.140E+00 HAS LIMITS ON ITS NORDHEIM RANGE OF      4.886E-01      2.814E+00
    THE RESOLVED REGION LIMITS ARE      1.000E+00        8.200E+01

CAUTION--CAUTION--THE RESONANCE AT EO=   7.812E+01 HAS LIMITS ON ITS NORDHEIM RANGE OF      7.312E+01      8.312E+01
    THE RESOLVED REGION LIMITS ARE      1.000E+00        8.200E+01

CAUTION--CAUTION--THE RESONANCE AT EO=   7.967E+01 HAS LIMITS ON ITS NORDHEIM RANGE OF      7.552E+01      8.383E+01
    THE RESOLVED REGION LIMITS ARE      1.000E+00        8.200E+01

CAUTION--CAUTION--THE RESONANCE AT EO=   8.036E+01 HAS LIMITS ON ITS NORDHEIM RANGE OF      7.594E+01      8.477E+01
    THE RESOLVED REGION LIMITS ARE      1.000E+00        8.200E+01

CAUTION--CAUTION--THE RESONANCE AT EO=   8.143E+01 HAS LIMITS ON ITS NORDHEIM RANGE OF      7.718E+01      8.569E+01
    THE RESOLVED REGION LIMITS ARE      1.000E+00        8.200E+01

CAUTION--CAUTION--THE RESONANCE AT EO=   8.359E+01 HAS LIMITS ON ITS NORDHEIM RANGE OF      7.937E+01      8.781E+01
    THE RESOLVED REGION LIMITS ARE      1.000E+00        8.200E+01

CAUTION--CAUTION--THE RESONANCE AT EO=   8.688E+01 HAS LIMITS ON ITS NORDHEIM RANGE OF      8.329E+01      9.047E+01
    THE RESOLVED REGION LIMITS ARE      1.000E+00        8.200E+01

THIS NUCLIDE HAS THE FOLLOWING 1-D NEUTRON PROCESSES
     1.         2.       3002.        4.        16.        17.         18.      3018.       452.       455.
   456.       102.       3102.      251.       252.       253.         27.       101.      1099.      3099.
  1018.      9002.

ESTIMATED RESONANCE INTEGRALS FROM "SHIELDED" VALUES

               N-GAMMA: 1.38951E+02
               FISSION: 2.81587E+02
            SCATTERING: 1.71240E+02
            ABSORPTION: 4.20537E+02
                 TOTAL: 5.97742E+02

ESTIMATED "INFINITE DILUTION" RESONANCE INTEGRALS

               N-GAMMA: 1.38977E+02
               FISSION: 2.81632E+02
            SCATTERING: 1.73404E+02
            ABSORPTION: 4.20609E+02
                 TOTAL: 5.99978E+02

2-D NEUT PROCESSES
       MT     LENGTH        ORDER       TEMPS
 1      2        630            5           0
 2     51        506            5           0
 3     52        535            5           0
 4     53        519            5           0
 5     54        520            5           0
 6     55        523            5           0
 7     56        517            5           0
```

These messages have to do
with the way the Nordheim
Treatment was implemented
in the original Nitawl module
and can now be ignored.

```
  8     57       513          5       0
  9     58       519          5       0
 10     59       514          5       0
 11     60       507          5       0
 12     61       506          5       0
 13     62       490          5       0
 14     63       486          5       0
 15     64       486          5       0
 16     65       485          5       0
 17     66       486          5       0
 18     16      1206          0       0
 19     17       874          0       0
 20   9452     28441          0       0
 21   9452     28441          0       0
 22     91      2508          0       0
 23   1007      1769          3       3
MT=    2 GROUP    1 P0 MATRIX SUM=  3.81452E+00 VERSUS AVERAGE VALUE=  3.81457E+00,FRACT DEV= -1.15004E-05
MT=    2 GROUP    2 P0 MATRIX SUM=  3.56855E+00 VERSUS AVERAGE VALUE=  3.56859E+00,FRACT DEV= -1.12241E-05
MT=    2 GROUP    6 P0 MATRIX SUM=  3.35714E+00 VERSUS AVERAGE VALUE=  3.35718E+00,FRACT DEV= -1.07947E-05
MT=   16 GROUP    2 P0 MATRIX SUM=  1.11834E-01 VERSUS AVERAGE VALUE=  1.11835E-01,FRACT DEV= -1.11924E-05
MT=   16 GROUP    6 P0 MATRIX SUM=  4.50307E-01 VERSUS AVERAGE VALUE=  4.50316E-01,FRACT DEV= -1.83983E-05
MT=   16 GROUP    8 P0 MATRIX SUM=  2.81746E-01 VERSUS AVERAGE VALUE=  2.81750E-01,FRACT DEV= -1.39624E-05
MT=   16 GROUP    9 P0 MATRIX SUM=  3.61870E-02 VERSUS AVERAGE VALUE=  3.61882E-02,FRACT DEV= -3.31474E-05
MT=   17 GROUP    1 P0 MATRIX SUM=  9.04327E-02 VERSUS AVERAGE VALUE=  9.04339E-02,FRACT DEV= -1.31819E-05
MT=   17 GROUP    2 P0 MATRIX SUM=  9.28586E-02 VERSUS AVERAGE VALUE=  9.28612E-02,FRACT DEV= -2.82422E-05
MT=   17 GROUP    3 P0 MATRIX SUM=  6.16316E-02 VERSUS AVERAGE VALUE=  6.16327E-02,FRACT DEV= -1.63802E-05
MT=   17 GROUP    4 P0 MATRIX SUM=  3.70701E-02 VERSUS AVERAGE VALUE=  3.70705E-02,FRACT DEV= -1.30640E-05
MT=   17 GROUP    5 P0 MATRIX SUM=  1.78665E-02 VERSUS AVERAGE VALUE=  1.78669E-02,FRACT DEV= -2.12672E-05
MT=   17 GROUP    6 P0 MATRIX SUM=  8.77790E-04 VERSUS AVERAGE VALUE=  8.78135E-04,FRACT DEV= -3.92410E-04
MT=    4 GROUP    1 P0 MATRIX SUM=  2.11950E-01 VERSUS AVERAGE VALUE=  2.11945E-01,FRACT DEV=  2.02483E-05
MT=    4 GROUP    2 P0 MATRIX SUM=  2.16531E-01 VERSUS AVERAGE VALUE=  2.16519E-01,FRACT DEV=  5.83607E-05
MT=    4 GROUP    3 P0 MATRIX SUM=  2.20609E-01 VERSUS AVERAGE VALUE=  2.20591E-01,FRACT DEV=  8.18720E-05
MT=    4 GROUP    4 P0 MATRIX SUM=  2.24034E-01 VERSUS AVERAGE VALUE=  2.24013E-01,FRACT DEV=  9.52554E-05
MT=    4 GROUP    5 P0 MATRIX SUM=  2.17829E-01 VERSUS AVERAGE VALUE=  2.17813E-01,FRACT DEV=  7.44329E-05
MT=    4 GROUP    6 P0 MATRIX SUM=  1.84975E-01 VERSUS AVERAGE VALUE=  1.84970E-01,FRACT DEV=  2.61014E-05
MT=    4 GROUP    8 P0 MATRIX SUM=  6.59908E-01 VERSUS AVERAGE VALUE=  6.59919E-01,FRACT DEV= -1.73416E-05
MT=    4 GROUP    9 P0 MATRIX SUM=  1.67778E+00 VERSUS AVERAGE VALUE=  1.67781E+00,FRACT DEV= -1.98941E-05
MT=    4 GROUP   10 P0 MATRIX SUM=  1.83037E+00 VERSUS AVERAGE VALUE=  1.83040E+00,FRACT DEV= -1.87567E-05
MT=    4 GROUP   11 P0 MATRIX SUM=  1.81348E+00 VERSUS AVERAGE VALUE=  1.81351E+00,FRACT DEV= -1.73538E-05
MT=1007 P3 COEFFICIENT FOR SCATTER FROM GRP 233 TO GRP 225 IS UNREASONABLE--COEFF=  -5.629E+01
                     P3 VALUE=  -5.165E-04
                     P0 VALUE=   1.311E-06
MT=1007 P3 COEFFICIENT FOR SCATTER FROM GRP 232 TO GRP 225 IS UNREASONABLE--COEFF=  -7.465E+00
                     P3 VALUE=  -6.876E-03
                     P0 VALUE=   1.316E-04
MT=1007 P3 COEFFICIENT FOR SCATTER FROM GRP 231 TO GRP 225 IS UNREASONABLE--COEFF=  -1.740E+00
                     P3 VALUE=  -8.260E-03
                     P0 VALUE=   6.783E-04
MT=1007 P3 COEFFICIENT FOR SCATTER FROM GRP 236 TO GRP 226 IS UNREASONABLE--COEFF=   9.904E+00
                     P3 VALUE=   2.367E-03
                     P0 VALUE=   3.414E-05
MT=1007 P3 COEFFICIENT FOR SCATTER FROM GRP 235 TO GRP 226 IS UNREASONABLE--COEFF=   1.559E+00
                     P3 VALUE=   3.108E-03
                     P0 VALUE=   2.848E-04
MT=1007 P3 COEFFICIENT FOR SCATTER FROM GRP 234 TO GRP 226 IS UNREASONABLE--COEFF=  -2.579E+00
                     P3 VALUE=  -1.399E-02
                     P0 VALUE=   7.749E-04
MT=1007 P3 COEFFICIENT FOR SCATTER FROM GRP 233 TO GRP 226 IS UNREASONABLE--COEFF=  -1.835E+00
                     P3 VALUE=  -2.481E-02
                     P0 VALUE=   1.931E-03
MT=1007 P3 COEFFICIENT FOR SCATTER FROM GRP 232 TO GRP 226 IS UNREASONABLE--COEFF=  -1.013E+00
                     P3 VALUE=  -4.484E-02
                     P0 VALUE=   6.324E-03
MT=1007 P3 COEFFICIENT FOR SCATTER FROM GRP 237 TO GRP 227 IS UNREASONABLE--COEFF=   1.706E+01
                     P3 VALUE=   2.727E-01
                     P0 VALUE=   2.283E-03
MT=1007 P3 COEFFICIENT FOR SCATTER FROM GRP 236 TO GRP 227 IS UNREASONABLE--COEFF=  -1.427E+00
                     P3 VALUE=  -8.756E-02
                     P0 VALUE=   8.769E-03
MT=1007 P3 COEFFICIENT FOR SCATTER FROM GRP 227 TO GRP 236 IS UNREASONABLE--COEFF=   3.023E+00
                     P3 VALUE=   1.629E-03
                     P0 VALUE=   7.696E-05

NUCLIDE       92235 HAS BEEN CHECKED
```

These indicate very consistent processing in transfer matrices

Thermal processing frequently generates poor coefficients for some small valued transfers. These are seldom of any consequence.

The input for the graphite case is given below. In the XLACS run, note that we are combining ENDF/B data from two evaluations: (1) the standard Version V data designated by MAT 1306 and (2) some thermal-scattering law data specifically for graphite (MAT 1065) which dates back to Version III of ENDF/B, or earlier. Note also that we have requested processing of all ten temperature sets in the thermal-scattering law data file. As it is programmed, XLACS will accept requests for processing at any temperature intermediate to those in the file; however, it has been demonstrated several times that the requisite interpolations produce very poor results, such that one should select only temperatures explicitly included in the files and use procedures which interpolate within cross-section values after the data are processed into multigroup form.

```
    AMPX MODULE LOG AND LIST OF CARD INPUT DATA

 MODULE XLACS    HAS BEEN CALLED

SAMPLE PROBLEM
FOR THE XLACS
MODULE OF THE
AMPX77 SYSTEM
+++++++++++++
0$$  11 12 23 1$$    1 238 90  T
T   USE THE STANDARD 238 NEUTRON GROUP STRUCTURE
C-12 (GRAPHITE KERNEL AT THERMAL)
10$$         6000        1306        1065
11$$            2           0           0           0
12$$            5           3           0           0
13$$           11           1          12           1           1
14$$            5           4          15$$ 10
17$$    0   0   3   0   0   0   0   0   0   0
18**  3.00000E+02 1.25000E-01 1.27300E+06 6.74000E+04 0.00000E+00 E
T
22** 296 400 500 600 700 800 1000 1200 1600 2000 T

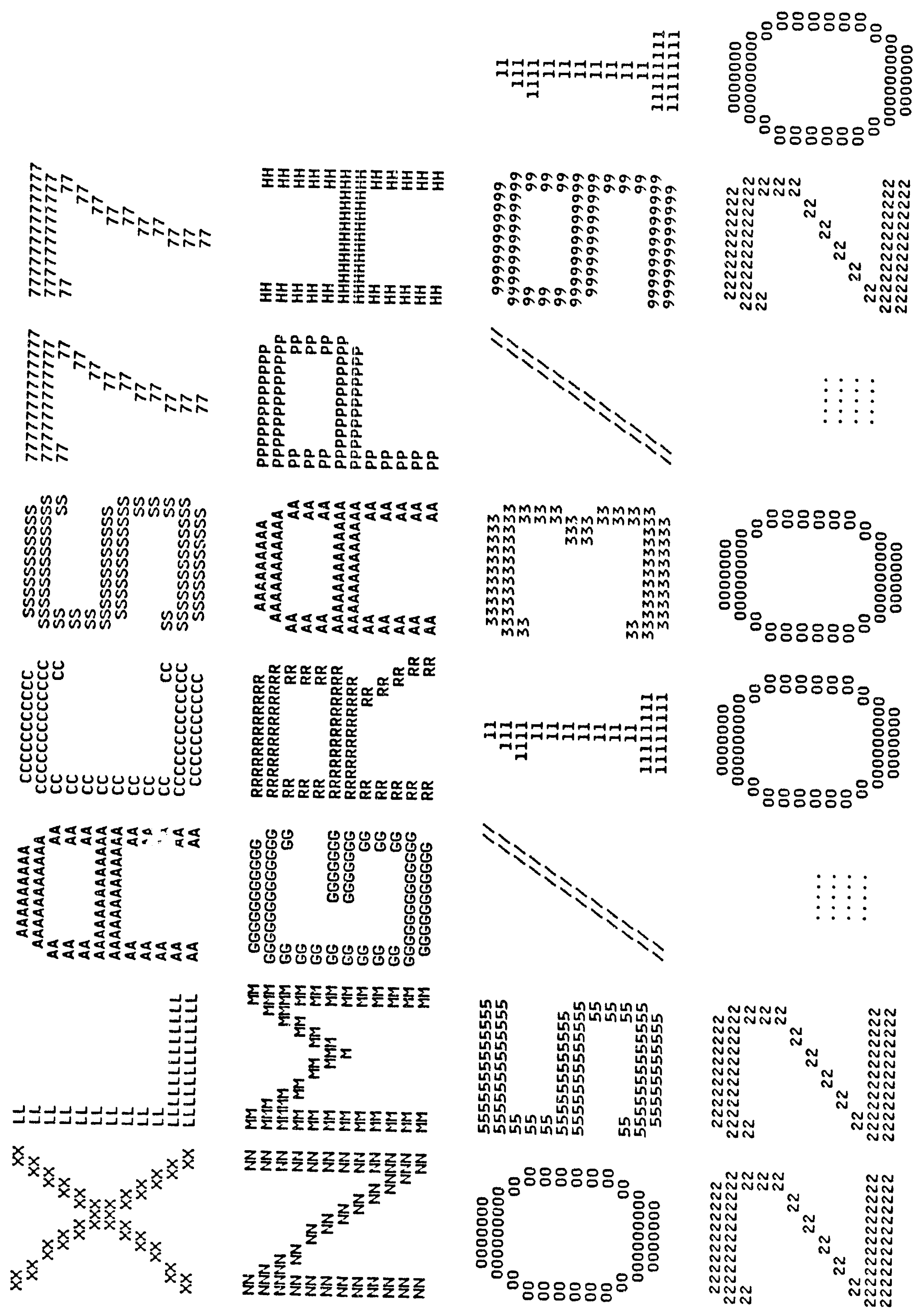
 MODULE XLACS    IS FINISHED.
 CPU TIME   329.19 (SECONDS).  I/O'S       0 USER CODE 0000   SYSTEM CODE 000

 MODULE RADE     HAS BEEN CALLED

1$$ 23 E T

 MODULE RADE     IS FINISHED.
 CPU TIME     2.02 (SECONDS).  I/O'S       0 USER CODE 0000   SYSTEM CODE 000
```

Portions of the output from XLACS and RADE are shown on the following pages. (The complete outputs for the codes used in Task 1 are given in File 65 on the tape discussed in Sect. 5.INSTALLATION of this report.)


XLACS77
NMGRAPH
05/13/91
22:00:20

```
PROCESS C-12 (GRAPHITE KERNEL AT THERMAL)                                         IDENTIFIER:     6000
   FAST DATA MAT: 1306 ON LOGICAL: 11 LIBRARY MODE: 1 VERSION: 5
THERMAL DATA MAT: 1065 ON LOGICAL: 12 LIBRARY MODE: 1
                          LEGENDRE FIT ON FAST DATA TO ORDER:  5
                       LEGENDRE FIT ON THERMAL DATA TO ORDER:  3
            NUMBER OF ATOMS IN PRINCIPAL THERMAL SCATTERER:  1
            THERMAL MATRICES WILL BE PRODUCED AT10 TEMPERATURES
 SIGP FOR UNRESOLVED PROCESSING: 1.00000E+08
R-FACTOR FOR NORDHEIM TREATMENT: 0.00000E+00
S-FACTOR FOR NORDHEIM TREATMENT: 0.00000E+00
       POINT DATA MAT NUMBER (RESONANCE NUCLIDES ONLY):     0
                    LOGICAL UNIT CONTAINING POINT DATA:     0
   NUMBER OF ANGLES TO USE IN PRODUCING ELASTIC MATRICES:     0
 NUMBER OF ANGLES TO USE IN PRODUCING INELASTIC MATRICES:     0
      POINT DATA MAT NUMBER FOR ELASTIC SCATTERING DATA:     0
WEIGHTING OPTION FOR THIS CASE:  2
WEIGHTING SPECTRUM ADJUSTMENT PARAMETERS
                          TEMPERATURE OF MAXWELLIAN SPECTRUM: 3.00000E+02 KELVIN
                 UPPER ENERGY CUTOFF ON MAXWELLIAN SPECTRUM: 1.25000E-01
                  EFFECTIVE TEMPERATURE OF FISSION SPECTRUM: 1.27300E+06
                   LOWER CUTOFF ENERGY FOR FISSION SPECTRUM: 6.74000E+04
                   UPPER CUTOFF ENERGY FOR FISSION SPECTRUM: 1.00000E+07
DIMENSIONAL PARAMETERS:
     MAXIMUM NUMBER OF POINTS ALLOWED IN ANY TAB1 ARRAY:  5000
           MAXIMUM NUMBER OF INTERPOLATION REGIONS USED:   100

PRINTED OUTPUT EDITING OPTIONS
 FILE 1.            HEADER INFORMATION: 0
 FILE 2.          RESONANCE PROCESSING: 0
 FILE 3.          POINT DATA AVERAGING: 3
 FILE 4.     ANGULAR DISTRIBUTION DATA: 0
 FILE 5.              EVAPORATION DATA: 0
 FILE 6.   ENERGY-ANGLE TABULATED DATA: 0
 FILE 7.            S(ALPHA,BETA) DATA: 0
 OPTION 8                   (NOT USED): 0
 OPTION 9                   (NOT USED): 0
 OPTION 10          WEIGHTING SPECTRUM: 0
   22* ARRAY     10 ENTRIES READ
    0T
```

This run combines data from
2 ENDF/B evaluations

```
THE (TAPE) DESCRIPTION OF MATERIAL   1306 IS -
   6-C -    ORNL        EVAL-DEC73 C.Y.FU AND F.G.PEREY
  INDC(F/R)-7/L         DIST-JAN83 REV1-JAN77            821220

  NEW EVALUATION FOR VERSION V:
      1. TOTAL AND ELASTIC SCATTERING FROM THERMAL TO 4.81 MEV.
      2. ELASTIC ANGULAR DISTRIBUTION: THERMAL TO 4.81 MEV.
      3. NEW REPRESENTATION FOR (N,N3A) TO YIELD CORRECT ENERGY-
         ANGULAR KINEMATICS
      4. ACTIVATION FILE FOR (N,P)
      5. GAS PRODUCTION FILE.
      6. UNCERTAINTY FILE.
 ******************************************************************

  THE NORMALIZATION AND STANDARDS SUBCOMMITTEE OF CSWEG RECOMMENDS
  THE CARBON ELASTIC SCATTERING ANGULAR DISTRIBUTION AS A STANDARD
  UP TO 1.8 MEV.

 ******************************************************************
  ADOPTED FROM ENDF/B-IV(BY F.G.PEREY AND C.Y.FU):
      1. (N,A) BELOW 15 MEV AND (N,G) BELOW 1 MEV.
      2. ANGULAR DISTRIBUTIONS OF SECONDARY NEUTRON 4-51.
      3. MULTIPLICITY OF CAPTURE GAMMA-RAYS 12-102.
      4. ALL OTHER CROSS SECTIONS AND DISTRIBUTIONS BELOW 8.5
         MEV EXCEPT (N,G), (N,D), AND (N,T).

  ADOPTED FROM FRENCH EVALUATION (LA75) WHICH IS AN EXTENSIVE REV.
  OF ENDF/B-IV:
      1. (N,G) ABOVE 1 MEV, (N,D), AND (N,T).
      2. ANGULAR DISTRIBUTION OF SECONDARY NEUTRONS 4-52 AND 4-53
         AND GAMMA-RAYS 14-51

 ELAPSED TIME   0.01 MIN.

COMMENCE RESOLVED AND UNRESOLVED RESONANCE PROCESSING

   ENERGY RANGE 1 EXTENDS FROM 1.00000E-05 TO 1.00000E+05 EV

LRF:    0 ABN: 1.00000E+00 AP: 6.14112E-01

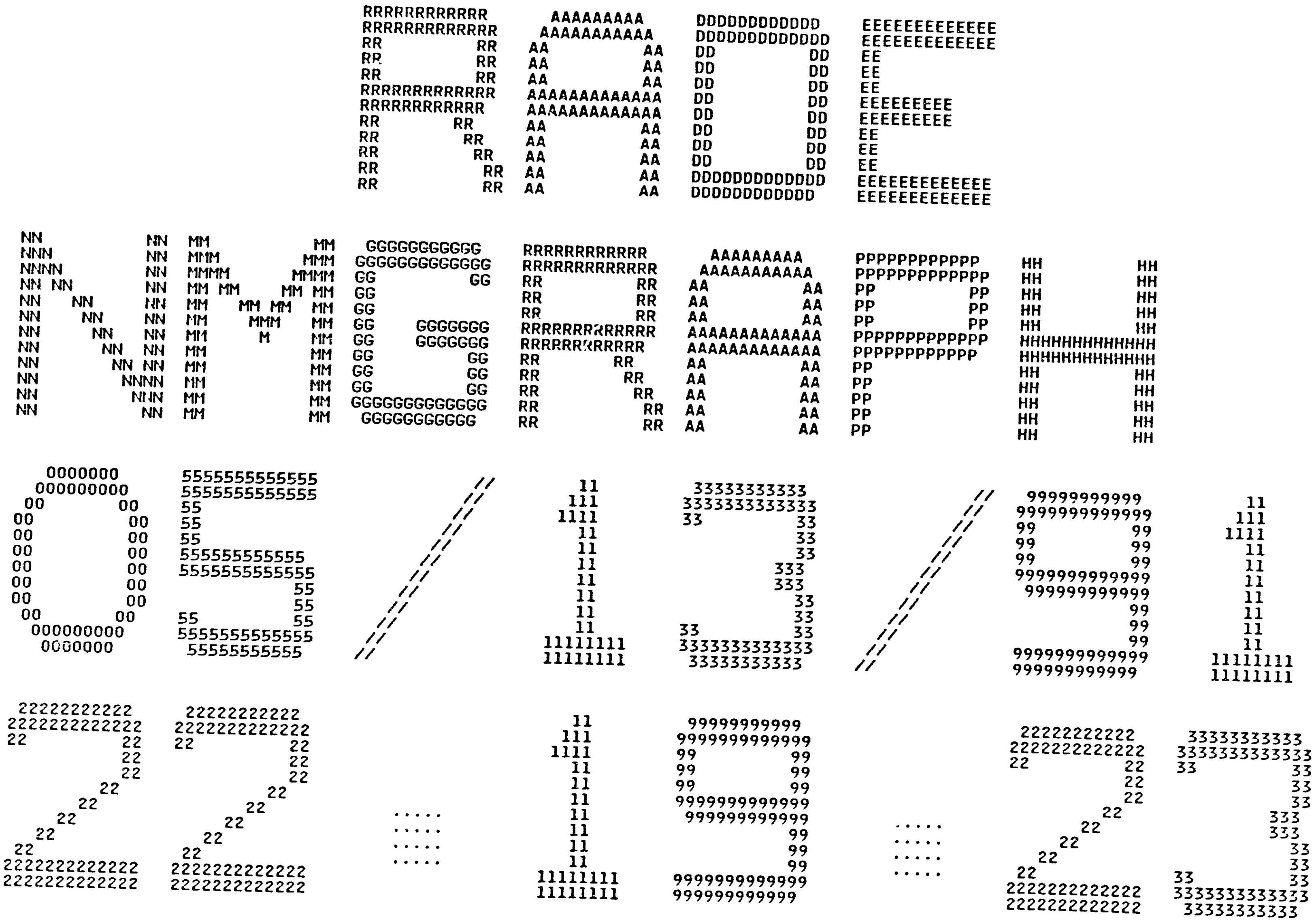
========================TIME FOR THIS BLOCK:****** MIN

PREPARING TO PRODUCE MASTER LIBRARY INFORMATION FOR THE   RESONANCE REGION
```

Carbon requires no resonance processing

```
PROCESSING MAT:    1306
        PROCESS:   1
        PROCESS:   2
        PROCESS:   3
        PROCESS:   4
        PROCESS:  51
        PROCESS:  52
        PROCESS:  53
        PROCESS:  54
        PROCESS:  55
        PROCESS:  56
        PROCESS:  57
        PROCESS:  58
        PROCESS:  59
        PROCESS:  60
        PROCESS:  61
        PROCESS:  62
        PROCESS:  63
        PROCESS:  64
        PROCESS:  65
        PROCESS:  66
        PROCESS:  67
        PROCESS:  68
        PROCESS:  91
        PROCESS: 102
        PROCESS: 103
        PROCESS: 104
        PROCESS: 107
        PROCESS: 203
        PROCESS: 204
        PROCESS: 207
        PROCESS: 251
        PROCESS: 252
        PROCESS: 253
```

These are the File 3 processes
which were group averaged.


RADE
NMGRAPH
05/13/91
22:19:23

```
CHECKING TOLERANCE= 1.00000E-03 ?ER CENT

AMPX NUCLIDE       6000 C-12 (GRAPHITE KERNEL AT THERMAL)
     HAS THE FOLLOWING DATA                           IS THE NUCLIDE SYMBOL          THERE ARE  159 RECORDS
   0 RESOLVED RESONANCES                       11.897 MASS(NEUTRON EQUIVALENTS)                   0 BONDARENKO TEMPS
   0 UNRESOLVED RESONANCE POINTS                6000. ZA                                          0 BONDARENKO GROUPS
  21 TEMP IND 1-D NEUT PROCESSES                    0 NEUTRON WGTING OPTION                       0 ID(41) NOT USED
  21 2-D NEUT PROCESSES                             0 NEUTRON WGT ID                              0 GAMMA PROD WGT ID
   0 TEMP DEP 1-D NEUT PROCESSES                    0 GAMMA WGTING OPTION                         0 ID(43) NOT USED
   0 1-D GAMMA PROCESSES                     0.00E+00 POWER/FISSION(WATT-SEC/FIS)                 0 GAMMA PROD WGTING OPTION
   0 2-D GAMMA PROCESSES                     0.00E+00 ENERGY/CAPTURE(WATT-SEC/CAP)             1306 ENDF MAT OF FAST NEUT DATA
   0 NEUT-TO-GAMMA PROCESSES                     6126 MAX 2-D LENGTH                           1065 ENDF MAT OF THERMAL NEUT DATA
 119 TOTAL 2-D ARRAYS                               0 BONDARENKO PROCESSES                        0 ENDF MAT OF GAMMA DATA
   5 MAX ORDER OF L                                 0 BONDARENKO SIGMA ZEROS                      0 ENDF MAT OF GAMMA PROD DATA

THIS NUCLIDE HAS THE FOLLOWING 1-D NEUTRON PROCESSES
      1.          2.        3002.         3.          4.         102.       3102.        103.        104.        107.
    203.        204.         207.       251.        252.         253.         27.        101.       1099.       3099.
   9002.

ESTIMATED RESONANCE INTEGRALS FROM "SHIELDED" VALUES

             N-GAMMA: 1.68621E-03
             FISSION: 0.00000E+00
          SCATTERING: 7.04219E+01
          ABSORPTION: 1.09614E-01
               TOTAL: 7.09909E+01

ESTIMATED "INFINITE DILUTION" RESONANCE INTEGRALS

             N-GAMMA: 1.68768E-03
             FISSION: 0.00000E+00
          SCATTERING: 7.04739E+01
          ABSORPTION: 1.09615E-01
               TOTAL: 7.10429E+01

2-D NEUT PROCESSES
       MT     LENGTH       ORDER      TEMPS
  1     2      1255           5          0
  2    51       508           5          0
  3    52       503           5          0
  4    53       497           5          0
  5    54       508           5          0
  6    55       522           5          0
  7    56       526           5          0
  8    57       541           5          0
  9    58       528           5          0
 10    59       513           5          0
 11    60       524           5          0
 12    61       509           5          0
 13    62       513           5          0
 14    63       496           5          0
 15    64       500           5          0
 16    65       501           5          0
 17    66       476           5          0
 18    67       476           5          0
 19    68       476           5          0
 20    91      1053           0          0
 21  1007      6126           3         10
MT=    4 GROUP    1 PO MATRIX SUM=  4.19004E-01 VERSUS AVERAGE VALUE=  4.19146E-01,FRACT DEV= -3.39017E-04
MT=    4 GROUP    2 PO MATRIX SUM=  4.95239E-01 VERSUS AVERAGE VALUE=  4.95431E-01,FRACT DEV= -3.86552E-04
MT=    4 GROUP    3 PO MATRIX SUM=  4.68027E-01 VERSUS AVERAGE VALUE=  4.68357E-01,FRACT DEV= -7.04657E-04
MT=    4 GROUP    4 PO MATRIX SUM=  4.23654E-01 VERSUS AVERAGE VALUE=  4.24218E-01,FRACT DEV= -1.32974E-03
MT=    4 GROUP    5 PO MATRIX SUM=  3.99918E-01 VERSUS AVERAGE VALUE=  4.00051E-01,FRACT DEV= -3.30615E-04
MT=    4 GROUP    6 PO MATRIX SUM=  4.22426E-01 VERSUS AVERAGE VALUE=  4.22648E-01,FRACT DEV= -5.24901E-04
MT=    4 GROUP    7 PO MATRIX SUM=  3.08307E-01 VERSUS AVERAGE VALUE=  3.08324E-01,FRACT DEV= -5.58689E-05
MT=    4 GROUP    9 PO MATRIX SUM=  1.22541E-01 VERSUS AVERAGE VALUE=  1.22669E-01,FRACT DEV= -1.04031E-03
P1 TRANSFER FROM 238 TO 204 HAS NO PO MATCH--PROCESS--> 1007
P1 TRANSFER FROM 237 TO 204 HAS NO PO MATCH--PROCESS--> 1007
P1 TRANSFER FROM 236 TO 204 HAS NO PO MATCH--PROCESS--> 1007
P1 TRANSFER FROM 235 TO 204 HAS NO PO MATCH--PROCESS--> 1007
P1 TRANSFER FROM 234 TO 204 HAS NO PO MATCH--PROCESS--> 1007
P1 TRANSFER FROM 233 TO 204 HAS NO PO MATCH--PROCESS--> 1007
P1 TRANSFER FROM 232 TO 204 HAS NO PO MATCH--PROCESS--> 1007
P1 TRANSFER FROM 231 TO 204 HAS NO PO MATCH--PROCESS--> 1007
```

Indicates reasonable transfer
matrix processing

```
                     P3 VALUE=  -8.256E-06
                     P0 VALUE=   1.638E-11
MT=1007 P3 COEFFICIENT FOR SCATTER FROM GRP 193 TO GRP 217 IS UNREASONABLE--COEFF=  -2.599E+01
                     P3 VALUE=  -2.623E-08
                     P0 VALUE=   1.442E-10
P3 TRANSFER FROM 192 TO 217 HAS NO P0 MATCH--PROCESS--> 1007
P3 TRANSFER FROM 191 TO 217 HAS NO P0 MATCH--PROCESS--> 1007
P3 TRANSFER FROM 190 TO 217 HAS NO P0 MATCH--PROCESS--> 1007
P3 TRANSFER FROM 189 TO 217 HAS NO P0 MATCH--PROCESS--> 1007
P3 TRANSFER FROM 188 TO 217 HAS NO P0 MATCH--PROCESS--> 1007
P3 TRANSFER FROM 187 TO 217 HAS NO P0 MATCH--PROCESS--> 1007
P3 TRANSFER FROM 186 TO 217 HAS NO P0 MATCH--PROCESS--> 1007
P3 TRANSFER FROM 195 TO 218 HAS NO P0 MATCH--PROCESS--> 1007
P3 TRANSFER FROM 194 TO 218 HAS NO P0 MATCH--PROCESS--> 1007
P3 TRANSFER FROM 193 TO 218 HAS NO P0 MATCH--PROCESS--> 1007
P3 TRANSFER FROM 192 TO 218 HAS NO P0 MATCH--PROCESS--> 1007
P3 TRANSFER FROM 191 TO 218 HAS NO P0 MATCH--PROCESS--> 1007
P3 TRANSFER FROM 190 TO 218 HAS NO P0 MATCH--PROCESS--> 1007
P3 TRANSFER FROM 189 TO 218 HAS NO P0 MATCH--PROCESS--> 1007
P3 TRANSFER FROM 188 TO 218 HAS NO P0 MATCH--PROCESS--> 1007
P3 TRANSFER FROM 187 TO 218 HAS NO P0 MATCH--PROCESS--> 1007
MT=1007 P3 COEFFICIENT FOR SCATTER FROM GRP 196 TO GRP 219 IS UNREASONABLE--COEFF=  -1.293E+00
                     P3 VALUE=  -6.499E-06
                     P0 VALUE=   7.179E-07
P3 TRANSFER FROM 195 TO 219 HAS NO P0 MATCH--PROCESS--> 1007
P3 TRANSFER FROM 194 TO 219 HAS NO P0 MATCH--PROCESS--> 1007
P3 TRANSFER FROM 193 TO 219 HAS NO P0 MATCH--PROCESS--> 1007
P3 TRANSFER FROM 192 TO 219 HAS NO P0 MATCH--PROCESS--> 1007
MT=1007 P3 COEFFICIENT FOR SCATTER FROM GRP 196 TO GRP 220 IS UNREASONABLE--COEFF=  -2.064E+01
                     P3 VALUE=  -2.242E-06
                     P0 VALUE=   1.552E-08
P3 TRANSFER FROM 195 TO 220 HAS NO P0 MATCH--PROCESS--> 1007
P3 TRANSFER FROM 194 TO 220 HAS NO P0 MATCH--PROCESS--> 1007
P3 TRANSFER FROM 193 TO 220 HAS NO P0 MATCH--PROCESS--> 1007
P3 TRANSFER FROM 192 TO 220 HAS NO P0 MATCH--PROCESS--> 1007
MT=1007 P3 COEFFICIENT FOR SCATTER FROM GRP 196 TO GRP 221 IS UNREASONABLE--COEFF=  -1.187E+01
                     P3 VALUE=  -2.788E-08
                     P0 VALUE=   3.356E-10
P3 TRANSFER FROM 195 TO 221 HAS NO P0 MATCH--PROCESS--> 1007
P3 TRANSFER FROM 194 TO 221 HAS NO P0 MATCH--PROCESS--> 1007
P3 TRANSFER FROM 193 TO 221 HAS NO P0 MATCH--PROCESS--> 1007
MT=1007 P3 COEFFICIENT FOR SCATTER FROM GRP 202 TO GRP 222 IS UNREASONABLE--COEFF=  -1.649E+01
                     P3 VALUE=  -2.934E-05
                     P0 VALUE=   2.541E-07
MT=1007 P3 COEFFICIENT FOR SCATTER FROM GRP 202 TO GRP 223 IS UNREASONABLE--COEFF=  -2.243E+04
                     P3 VALUE=  -1.888E-05
                     P0 VALUE=   1.202E-10
MT=1007 P3 COEFFICIENT FOR SCATTER FROM GRP 202 TO GRP 224 IS UNREASONABLE--COEFF=  -1.357E+07
                     P3 VALUE=  -5.259E-06
                     P0 VALUE=   5.537E-14
MT=1007 P3 COEFFICIENT FOR SCATTER FROM GRP 202 TO GRP 225 IS UNREASONABLE--COEFF=  -3.175E+08
                     P3 VALUE=  -3.642E-06
                     P0 VALUE=   1.639E-15

NUCLIDE       6000 HAS BEEN CHECKED
```

The messages regarding thermal matrices relate to defficiencies in numerical procedures, but are probably of no consequence, since they are for small transfers.

The final parts of Task 1 involve producing Bondarenko factors for ^{235}U, coupling these with the ^{235}U data from XLACS, coupling this ^{235}U file with the carbon file, forcing transfer matrices to properly normalize on this file, and, finally, checking the library. This procedure will involve performing operations shown in Figs. 6.SAMPLE PROBLEMS.2 and 6.SAMPLE PROBLEMS.4. (Note that the modular capabilities of the AMPX system do not require a user to slavishly follow a set procedure, but, rather, allow one to tie together codes in any way that makes sense. In the example on the following pages, we have rearranged several operations previously discussed.) The input for the task is given, followed by portions of the output.

```
    AMPX MODULE LOG AND LIST OF CARD INPUT DATA
 MODULE PRUDE     HAS BEEN CALLED
0$$ 31 1$$ 1 T
2$$ 1395 6 3 11 1 T
3** 1+8 1+5 1+4 1+3 1+2 1+1
4** 300 700 1500 T
```

Make Unresolved Point Functions

```
 MODULE PRUDE     IS FINISHED.
 CPU TIME    142.80 (SECONDS).  I/O'S       0 USER CODE 0000    SYSTEM CODE 000
 MODULE JERGENS  HAS BEEN CALLED
0$$ A2 25 18 1$$ 1 T
3$$ 1 0 4 T
```

Make a Weighting Function

```
 MODULE JERGENS  IS FINISHED.
 CPU TIME       .60 (SECONDS).  I/O'S       0 USER CODE 0000    SYSTEM CODE 000
 MODULE TABU      HAS BEEN CALLED
0$$ 1 31 25 1$$ 1 238 238 2$$ 0 E T
T
U-235 BONDARENKO FACTORS IN THE UNRESOLVED RANGE
10$$ 1395 11$$ 99 3 1 T
```

Make Bondarenko Factors

```
 MODULE TABU      IS FINISHED.
 CPU TIME     42.55 (SECONDS).  I/O'S       0 USER CODE 0000    SYSTEM CODE 000
 MODULE UNITAB   HAS BEEN CALLED
0$$ 65 18 9 8 59 1 0 E 1$$ 1 2 6$$ 500 1000 T
2$$
 92235 59 92235 1111
 92235  1  1395 4444
T
```

Combine Bondarenko Factors with the Library from XLACS

```
 MODULE UNITAB   IS FINISHED.
 CPU TIME      2.40 (SECONDS).  I/O'S       0 USER CODE 0000    SYSTEM CODE 000
 MODULE AJAX      HAS BEEN CALLED
0$$ 70 E 1$$ 2 E T
2$$ 64 0 T
2$$ 65 0 T
```

Combine Carbon and U-235 files

```
 MODULE AJAX      IS FINISHED.
 CPU TIME      1.03 (SECONDS).  I/O'S       0 USER CODE 0000    SYSTEM CODE 000
 MODULE COMET     HAS BEEN CALLED
0$$ 70 71 E 1$$ 0 E 2$$ 2 4 16 17 E 6$$ 800 500 T
```

Force Normalization

```
 MODULE COMET     IS FINISHED.
 CPU TIME     16.48 (SECONDS).  I/O'S       0 USER CODE 0000    SYSTEM CODE 000
 MODULE RADE      HAS BEEN CALLED
1$$ 71 E T
```

Check Final Library

```
 MODULE RADE      IS FINISHED.
 CPU TIME      3.37 (SECONDS).  I/O'S       0 USER CODE 0000    SYSTEM CODE 000
```

```
                PPPPPPPPPPPP    RRRRRRRRRRRR    UU         UU   DDDDDDDDDDDD    EEEEEEEEEEEEE
                PPPPPPPPPPPPP   RRRRRRRRRRRRR   UU         UU   DDDDDDDDDDDDD   EEEEEEEEEEEEE
                PP         PP   RR         RR   UU         UU   DD         DD   EE
                PP         PP   RR         RR   UU         UU   DD         DD   EE
                PP         PP   RR         RR   UU         UU   DD         DD   EE
                PPPPPPPPPPPPP   RRRRRRRRRRRRR   UU         UU   DD         DD   EEEEEEEEE
                PPPPPPPPPPPP    RRRRRRRRRRRR    UU         UU   DD         DD   EEEEEEEEE
                PP              RR      RR      UU         UU   DD         DD   EE
                PP              RR       RR     UU         UU   DD         DD   EE
                PP              RR        RR    UU         UU   DD         DD   EE
                PP              RR         RR   UUUUUUUUUUUUU   DDDDDDDDDDDDD   EEEEEEEEEEEEE
                PP              RR         RR    UUUUUUUUUUU    DDDDDDDDDDDD    EEEEEEEEEEEEE

NN         NN   MM         MM    GGGGGGGGGGG    TTTTTTTTTTTT      AAAAAAAAA      SSSSSSSSSSS    KK         KK         11
NNN        NN   MMM       MMM   GGGGGGGGGGGGG   TTTTTTTTTTTT     AAAAAAAAAAA    SSSSSSSSSSSSS   KK        KK         111
NNNN       NN   MMMM     MMMM   GG         GG        TT         AA         AA   SS         SS   KK       KK         1111
NN NN      NN   MM MM   MM MM   GG                   TT         AA         AA   SS              KK      KK            11
NN  NN     NN   MM  MM MM  MM   GG                   TT         AA         AA   SS              KK     KK             11
NN   NN    NN   MM   MMM   MM   GG    GGGGGGG        TT         AAAAAAAAAAAAA   SSSSSSSSSSSS    KKKKKKKK              11
NN    NN   NN   MM    M    MM   GG    GGGGGGG        TT         AAAAAAAAAAAAA    SSSSSSSSSSSS   KKKKKKKK              11
NN     NN  NN   MM         MM   GG         GG        TT         AA         AA              SS   KK     KK             11
NN      NN NN   MM         MM   GG         GG        TT         AA         AA              SS   KK      KK            11
NN       NNNN   MM         MM   GG         GG        TT         AA         AA   SS         SS   KK       KK           11
NN        NNN   MM         MM   GGGGGGGGGGGGG        TT         AA         AA   SSSSSSSSSSSSS   KK        KK       11111111
NN         NN   MM         MM    GGGGGGGGGGG         TT         AA         AA    SSSSSSSSSSS    KK         KK      11111111

   0000000       88888888888               //      0000000       66666666666               //    99999999999          11
  000000000     8888888888888             //      000000000     6666666666666             //    9999999999999        111
 00       00    88         88            //      00       00    66                       //     99         99       1111
00         00   88         88           //      00         00   66                      //      99         99         11
00         00   88         88          //       00         00   66                     //       99         99         11
00         00    88888888888          //        00         00   666666666666          //        9999999999999         11
00         00    88888888888         //         00         00   6666666666666        //          999999999999         11
00         00   88         88       //          00         00   66         66       //                     99         11
00         00   88         88      //           00         00   66         66      //                      99         11
 00       00    88         88     //             00       00    66         66     //                       99         11
  000000000     8888888888888    //               000000000     6666666666666    //             9999999999999      11111111
   0000000       88888888888    //                 0000000       66666666666    //              999999999999       11111111

      11         22222222222                          11         99999999999                     22222222222    5555555555555
     111        2222222222222                        111        9999999999999                   2222222222222   5555555555555
    1111        22         22                       1111        99         99                   22         22   55
      11                   22                         11        99         99                              22   55
      11                   22                         11        99         99                              22   55
      11                 22                           11        9999999999999                            22     555555555555
      11               22            .....            11         999999999999        .....             22       5555555555555
      11             22              .....            11                   99        .....           22                    55
      11           22                .....            11                   99        .....         22                      55
      11         22                  .....            11                   99        .....       22             55         55
   11111111     2222222222222                      11111111     9999999999999                   2222222222222   5555555555555
   11111111     2222222222222                      11111111     999999999999                    2222222222222    55555555555
```

```
THE PRUDE MODULES HAS BEEN ALLOCATED  50000 WORDS

A BINARY FILE OF POINT DATA FOR THE UNRESOLVED REGION WILL BE OUTPUT ON LOGICAL 31

    2$ ARRAY      5 ENTRIES READ

    0T

    3* ARRAY      6 ENTRIES READ

    4* ARRAY      3 ENTRIES READ

    0T

PROCESSING MAT:1395 NUMBER OF SIGO:    6
NUMBER OF TEMPERATURES:    3
ENDF DATA ON LOGICAL: 11
MODE OF THE ENDF DATA: 1

SIGO: 1.00000E+08 1.00000E+05 1.00000E+04 1.00000E+03 1.00000E+02 1.00000E+0

TEMPERATURES: 3.00000E+02 7.00000E+02 1.50000E+03

    ENERGY RANGE 1 EXTENDS FROM 1.00000E+00 TO 8.20000E+01 EV

LRF:    1 ABN: 1.00000E+00 AP: 9.56630E-01

         BREIT WIGNER PARAMETERS BEING SKIPPED

========================TIME FOR THIS BLOCK:****** MIN

    ENERGY RANGE 2 EXTENDS FROM 8.20000E+01 TO 2.50000E+04 EV

LRF:    2 ABN: 1.00000E+00 AP: 9.56630E-01

         UNRESOLVED SLBW PARAMETERS ARE BEING PROCESSED
```

```
TEMPERATURE: 3.00000E+02 SIGO: 1.00000E+08
POINT      ENERGY     ELASTIC     CAPTURE     FISSION       TOTAL COMPETITIVE   TRANSPORT
    1 8.20000E+01 1.30239E+01 1.98133E+01 3.37990E+01 6.66362E+01 0.00000E+00 6.66758E+01
    2 8.65000E+01 1.26715E+01 1.72380E+01 2.76167E+01 5.75262E+01 0.00000E+00 5.75611E+01
    3 9.10000E+01 1.34756E+01 2.17500E+01 3.48318E+01 7.00574E+01 0.00000E+00 7.01041E+01
    4 9.50000E+01 1.20319E+01 1.17033E+01 1.60869E+01 3.98222E+01 0.00000E+00 3.98457E+01
    5 1.00000E+02 1.20218E+01 1.10386E+01 1.64776E+01 3.95380E+01 0.00000E+00 3.95626E+01
    6 1.10000E+02 1.22057E+01 1.22643E+01 1.80079E+01 4.24779E+01 0.00000E+00 4.25077E+01
    7 1.20000E+02 1.24187E+01 1.27059E+01 2.21456E+01 4.72702E+01 0.00000E+00 4.73078E+01
    8 1.25000E+02 1.26126E+01 1.36617E+01 2.38806E+01 5.01549E+01 0.00000E+00 5.01972E+01
    9 1.30000E+02 1.25012E+01 1.19983E+01 2.55405E+01 5.00399E+01 0.00000E+00 5.00838E+01
   10 1.35000E+02 1.27019E+01 1.36613E+01 2.38811E+01 5.02443E+01 0.00000E+00 5.02901E+01
   11 1.40000E+02 1.25722E+01 1.27048E+01 2.21469E+01 4.74238E+01 0.00000E+00 4.74679E+01
   12 1.55000E+02 1.24577E+01 1.18822E+01 1.82710E+01 4.26108E+01 0.00000E+00 4.26530E+01
   13 1.75000E+02 1.27092E+01 1.13867E+01 2.40740E+01 4.81699E+01 0.00000E+00 4.82261E+01
   14 1.90000E+02 1.22020E+01 8.60655E+00 1.68133E+01 3.76219E+01 0.00000E+00 3.76653E+01
   15 2.05000E+02 1.26190E+01 1.11450E+01 1.73828E+01 4.11468E+01 0.00000E+00 4.12000E+01
   16 2.15000E+02 1.25410E+01 9.50287E+00 2.04790E+01 4.25229E+01 0.00000E+00 4.25812E+01
   17 2.25000E+02 1.34507E+01 1.36039E+01 2.29590E+01 5.00136E+01 0.00000E+00 5.00895E+01
   18 2.35000E+02 1.26378E+01 9.50121E+00 2.04808E+01 4.26198E+01 0.00000E+00 4.26838E+01
   19 2.45000E+02 1.26388E+01 9.31511E+00 2.00821E+01 4.20359E+01 0.00000E+00 4.21014E+01
   20 2.55000E+02 1.21015E+01 5.75641E+00 1.96965E+01 3.75544E+01 0.00000E+00 3.76125E+01
   21 2.60000E+02 1.31713E+01 1.08932E+01 2.34834E+01 4.75479E+01 0.00000E+00 4.76300E+01
   22 2.65000E+02 1.30330E+01 9.33643E+00 2.72053E+01 4.95747E+01 0.00000E+00 4.96630E+01
   23 3.00000E+02 1.19067E+01 5.21968E+00 1.10133E+01 2.81397E+01 0.00000E+00 2.81833E+01
   24 3.35000E+02 1.25925E+01 8.18083E+00 1.55182E+01 3.62914E+01 0.00000E+00 3.63641E+01
   25 3.90000E+02 1.20108E+01 5.23445E+00 1.04177E+01 2.76630E+01 0.00000E+00 2.77180E+01
   26 4.30000E+02 1.20921E+01 4.59798E+00 1.45125E+01 3.12026E+01 0.00000E+00 3.12766E+01
   27 4.60000E+02 1.21043E+01 4.78429E+00 1.26636E+01 2.95522E+01 0.00000E+00 2.96247E+01
   28 4.90000E+02 1.22001E+01 4.85888E+00 1.37870E+01 3.08460E+01 0.00000E+00 3.09288E+01
   29 5.10000E+02 1.23986E+01 4.84090E+00 1.83230E+01 3.55625E+01 0.00000E+00 3.56698E+01
   30 5.50000E+02 1.23663E+01 5.21735E+00 1.37304E+01 3.13140E+01 0.00000E+00 3.14093E+01
   31 6.00000E+02 1.22742E+01 4.63660E+00 1.31406E+01 3.00514E+01 0.00000E+00 3.01487E+01
   32 6.50000E+02 1.21546E+01 4.81355E+00 8.49046E+00 2.54586E+01 0.00000E+00 2.55377E+01
   33 6.65000E+02 1.26134E+01 5.56062E+00 1.31260E+01 3.13000E+01 0.00000E+00 3.14151E+01
   34 6.80000E+02 1.21789E+01 3.97260E+00 1.27233E+01 2.88748E+01 0.00000E+00 2.89780E+01
   35 7.00000E+02 1.19910E+01 3.48176E+00 1.01699E+01 2.56427E+01 0.00000E+00 2.57290E+01
   36 7.15000E+02 1.30183E+01 6.20780E+00 1.46904E+01 3.39165E+01 0.00000E+00 3.40568E+01
   37 7.30000E+02 1.27478E+01 6.11783E+00 1.09637E+01 2.98294E+01 0.00000E+00 2.99463E+01
   38 7.55000E+02 1.22648E+01 4.63280E+00 9.40384E+00 2.63015E+01 0.00000E+00 2.63990E+01
   39 7.70000E+02 1.21980E+01 4.04570E+00 1.07970E+01 2.70407E+01 0.00000E+00 2.71452E+01
   40 8.00000E+02 1.20802E+01 3.78356E+00 8.99641E+00 2.48602E+01 0.00000E+00 2.49534E+01
   41 8.50000E+02 1.20561E+01 3.83140E+00 7.55622E+00 2.34437E+01 0.00000E+00 2.35320E+01
   42 9.00000E+02 1.24148E+01 4.99352E+00 7.88604E+00 2.52943E+01 0.00000E+00 2.54026E+01
   43 9.25000E+02 1.26002E+01 5.46418E+00 8.03836E+00 2.61027E+01 0.00000E+00 2.62206E+01
   44 9.80000E+02 1.22096E+01 4.33429E+00 6.51290E+00 2.30568E+01 0.00000E+00 2.31554E+01
   45 1.00000E+03 1.25946E+01 5.54736E+00 6.65212E+00 2.47941E+01 0.00000E+00 2.49100E+01
   46 1.03000E+03 1.21118E+01 4.04458E+00 5.66691E+00 2.18233E+01 0.00000E+00 2.19157E+01
   47 1.05500E+03 1.23367E+01 4.30617E+00 7.66024E+00 2.43031E+01 0.00000E+00 2.44209E+01
   48 1.08000E+03 1.25610E+01 4.34939E+00 1.03079E+01 2.72183E+01 0.00000E+00 2.73666E+01
   49 1.11500E+03 1.22001E+01 3.82040E+00 7.19071E+00 2.32112E+01 0.00000E+00 2.33249E+01
   50 1.13500E+03 1.21217E+01 3.03147E+00 9.75656E+00 2.49097E+01 0.00000E+00 2.50425E+01
   51 1.15500E+03 1.22112E+01 3.57843E+00 8.16078E+00 2.39504E+01 0.00000E+00 2.40758E+01
   52 1.16500E+03 1.28542E+01 4.03389E+00 1.50912E+01 3.19793E+01 0.00000E+00 3.21883E+01
   53 1.18000E+03 1.20835E+01 2.95980E+00 9.03320E+00 2.40765E+01 0.00000E+00 2.42059E+01
   54 1.21000E+03 1.20908E+01 3.22406E+00 7.38367E+00 2.26985E+01 0.00000E+00 2.28164E+01
   55 1.25000E+03 1.20278E+01 3.07485E+00 6.66838E+00 2.17710E+01 0.00000E+00 2.18826E+01
   56 1.30000E+03 1.18810E+01 2.38139E+00 7.16706E+00 2.14294E+01 0.00000E+00 2.15415E+01
   57 1.34000E+03 1.22000E+01 3.15665E+00 8.47266E+00 2.38293E+01 0.00000E+00 2.39733E+01
   58 1.37000E+03 1.19755E+01 2.50168E+00 8.03163E+00 2.25088E+01 0.00000E+00 2.26401E+01
   59 1.40000E+03 1.20603E+01 2.79143E+00 7.68512E+00 2.25368E+01 0.00000E+00 2.26713E+01
   60 1.45000E+03 1.20784E+01 2.84456E+00 7.36209E+00 2.22851E+01 0.00000E+00 2.24212E+01
   61 1.50000E+03 1.18035E+01 2.34352E+00 4.57482E+00 1.87218E+01 0.00000E+00 1.88153E+01
   62 1.56000E+03 1.19796E+01 2.61206E+00 6.27746E+00 2.08691E+01 0.00000E+00 2.09960E+01
   63 1.67000E+03 1.20462E+01 2.50537E+00 7.45982E+00 2.20113E+01 0.00000E+00 2.21641E+01
   64 1.70000E+03 1.17814E+01 1.81862E+00 6.39509E+00 1.99951E+01 0.00000E+00 2.01203E+01
   65 1.75000E+03 1.19729E+01 2.42709E+00 6.25097E+00 2.06510E+01 0.00000E+00 2.07900E+01
   66 1.90000E+03 1.23970E+01 3.16686E+00 7.34570E+00 2.29096E+01 0.00000E+00 2.30987E+01
   67 2.00000E+03 1.23035E+01 3.11050E+00 6.09246E+00 2.15065E+01 0.00000E+00 2.16806E+01
   68 2.15000E+03 1.20166E+01 2.45739E+00 5.22108E+00 1.96951E+01 0.00000E+00 1.98477E+01
   69 2.30000E+03 1.19091E+01 2.06610E+00 5.32440E+00 1.92996E+01 0.00000E+00 1.94549E+01
   70 2.50000E+03 1.19386E+01 1.96781E+00 5.87681E+00 1.97832E+01 0.00000E+00 1.99628E+01
   71 2.65000E+03 1.17453E+01 1.52084E+00 5.10116E+00 1.83673E+01 0.00000E+00 1.85243E+01
   72 2.90000E+03 1.17571E+01 1.50774E+00 5.00308E+00 1.82679E+01 0.00000E+00 1.84372E+01
   73 3.00000E+03 1.17495E+01 1.48347E+00 4.86985E+00 1.81028E+01 0.00000E+00 1.82736E+01
```

A Table is printed for
each combination of
σ_0 and temperature.

```
 74 3.15000E+03 1.18984E+01 1.91879E+00 4.98438E+00 1.88015E+01 0.00000E+00 1.94398E+01
 75 3.25000E+03 1.19022E+01 1.82493E+00 5.52518E+00 1.92523E+01 0.00000E+00 1.99453E+01
 76 3.50000E+03 1.18581E+01 1.71377E+00 5.12785E+00 1.86998E+01 0.00000E+00 1.93559E+01
 77 3.70000E+03 1.18014E+01 1.59642E+00 4.69371E+00 1.80915E+01 0.00000E+00 1.86920E+01
 78 3.80000E+03 1.19637E+01 1.80350E+00 5.65132E+00 1.94185E+01 0.00000E+00 2.01690E+01
 79 3.90000E+03 1.18655E+01 1.71580E+00 4.61697E+00 1.81983E+01 0.00000E+00 1.88217E+01
 80 4.00000E+03 1.19071E+01 1.72882E+00 5.03076E+00 1.86667E+01 0.00000E+00 1.93521E+01
 81 4.15000E+03 1.18127E+01 1.59466E+00 4.33158E+00 1.77389E+01 0.00000E+00 1.83203E+01
 82 4.25000E+03 1.19521E+01 1.72268E+00 5.38718E+00 1.90619E+01 0.00000E+00 1.98052E+01
 83 4.35000E+03 1.18847E+01 1.67220E+00 4.64663E+00 1.82035E+01 0.00000E+00 1.88537E+01
 84 4.50000E+03 1.18985E+01 1.67907E+00 4.61579E+00 1.81933E+01 0.00000E+00 1.88514E+01
 85 4.80000E+03 1.18625E+01 1.64800E+00 4.01392E+00 1.75244E+01 0.00000E+00 1.81103E+01
 86 5.00000E+03 1.17682E+01 1.42070E+00 4.13553E+00 1.73244E+01 0.00000E+00 1.78951E+01
 87 5.15000E+03 1.18094E+01 1.50225E+00 4.01127E+00 1.73229E+01 0.00000E+00 1.78998E+01
 88 5.35000E+03 1.17685E+01 1.36987E+00 4.30634E+00 1.74447E+01 0.00000E+00 1.80491E+01
 89 5.60000E+03 1.18964E+01 1.55381E+00 4.44499E+00 1.78951E+01 0.00000E+00 1.85712E+01
 90 5.65000E+03 1.18860E+01 1.59910E+00 3.93352E+00 1.74186E+01 0.00000E+00 1.80307E+01
 91 5.80000E+03 1.21687E+01 1.94770E+00 4.39435E+00 1.85108E+01 0.00000E+00 1.92715E+01
 92 6.00000E+03 1.21487E+01 1.99162E+00 3.77742E+00 1.79178E+01 0.00000E+00 1.86115E+01
 93 6.15000E+03 1.18626E+01 1.59324E+00 3.36035E+00 1.68162E+01 0.00000E+00 1.73633E+01
 94 6.40000E+03 1.19448E+01 1.66850E+00 3.58261E+00 1.71959E+01 0.00000E+00 1.78082E+01
 95 6.60000E+03 1.19071E+01 1.62370E+00 3.37000E+00 1.69008E+01 0.00000E+00 1.74780E+01
 96 6.75000E+03 1.18270E+01 1.49388E+00 3.32074E+00 1.66416E+01 0.00000E+00 1.71872E+01
 97 7.00000E+03 1.17768E+01 1.32566E+00 3.85503E+00 1.69574E+01 0.00000E+00 1.75614E+01
 98 7.25000E+03 1.17160E+01 1.27952E+00 3.28355E+00 1.62790E+01 0.00000E+00 1.67892E+01
 99 7.35000E+03 1.19644E+01 1.63022E+00 3.48624E+00 1.70809E+01 0.00000E+00 1.77156E+01
100 7.70000E+03 1.18585E+01 1.48838E+00 3.22965E+00 1.65765E+01 0.00000E+00 1.71479E+01
101 8.00000E+03 1.18309E+01 1.45542E+00 3.06705E+00 1.63534E+01 0.00000E+00 1.69012E+01
102 8.20000E+03 1.19551E+01 1.65963E+00 2.81534E+00 1.64301E+01 0.00000E+00 1.69964E+01
103 8.40000E+03 1.20311E+01 1.68098E+00 3.18129E+00 1.68934E+01 0.00000E+00 1.75406E+01
104 8.70000E+03 1.19182E+01 1.48613E+00 3.41576E+00 1.68201E+01 0.00000E+00 1.74683E+01
105 9.00000E+03 1.16961E+01 1.24001E+00 2.86797E+00 1.58041E+01 0.00000E+00 1.62985E+01
106 9.15000E+03 1.19075E+01 1.44051E+00 3.47912E+00 1.68272E+01 0.00000E+00 1.74938E+01
107 9.60000E+03 1.18122E+01 1.33438E+00 3.24664E+00 1.63932E+01 0.00000E+00 1.70050E+01
108 1.00000E+04 1.16476E+01 1.15650E+00 2.78981E+00 1.55940E+01 0.00000E+00 1.60850E+01
109 1.04000E+04 1.17160E+01 1.23437E+00 2.87181E+00 1.58221E+01 0.00000E+00 1.63643E+01
110 1.06500E+04 1.17400E+01 1.24245E+00 3.01490E+00 1.59973E+01 0.00000E+00 1.65780E+01
111 1.08500E+04 1.17456E+01 1.26718E+00 2.85875E+00 1.58715E+01 0.00000E+00 1.64366E+01
112 1.12000E+04 1.17671E+01 1.25123E+00 3.02826E+00 1.60566E+01 0.00000E+00 1.66660E+01
113 1.16500E+04 1.16653E+01 1.16722E+00 2.70639E+00 1.55389E+01 0.00000E+00 1.60705E+01
114 1.20000E+04 1.17007E+01 1.20276E+00 2.73523E+00 1.56387E+01 0.00000E+00 1.61990E+01
115 1.24000E+04 1.16446E+01 1.15872E+00 2.48723E+00 1.52906E+01 0.00000E+00 1.57994E+01
116 1.28000E+04 1.16431E+01 1.13562E+00 2.63456E+00 1.54133E+01 0.00000E+00 1.59565E+01
117 1.32500E+04 1.16555E+01 1.10765E+00 3.01329E+00 1.57765E+01 0.00000E+00 1.64028E+01
118 1.37000E+04 1.15950E+01 1.06953E+00 2.68047E+00 1.53450E+01 0.00000E+00 1.59021E+01
119 1.43000E+04 1.15874E+01 1.06216E+00 2.63319E+00 1.52827E+01 0.00000E+00 1.58453E+01
120 1.48000E+04 1.14994E+01 9.49668E-01 2.77711E+00 1.52261E+01 0.00000E+00 1.57925E+01
121 1.53000E+04 1.14821E+01 9.61157E-01 2.38341E+00 1.48267E+01 0.00000E+00 1.53261E+01
122 1.60000E+04 1.15242E+01 1.00889E+00 2.45963E+00 1.49928E+01 0.00000E+00 1.55451E+01
123 1.72000E+04 1.15273E+01 1.03123E+00 2.27151E+00 1.48301E+01 0.00000E+00 1.53804E+01
124 1.79000E+04 1.14850E+01 9.72392E-01 2.46364E+00 1.49210E+01 0.00000E+00 1.55108E+01
125 1.84000E+04 1.13985E+01 8.80172E-01 2.50213E+00 1.47808E+01 0.00000E+00 1.53527E+01
126 1.89000E+04 1.13371E+01 8.15506E-01 2.53515E+00 1.46878E+01 0.00000E+00 1.52517E+01
127 1.94000E+04 1.13686E+01 8.68378E-01 2.30719E+00 1.45442E+01 0.00000E+00 1.50876E+01
128 1.98000E+04 1.13249E+01 8.20003E-01 2.38243E+00 1.45274E+01 0.00000E+00 1.50770E+01
129 2.00000E+04 1.14301E+01 9.36578E-01 2.33266E+00 1.46994E+01 0.00000E+00 1.52952E+01
130 2.05000E+04 1.15614E+01 1.08504E+00 2.11542E+00 1.47619E+01 0.00000E+00 1.53864E+01
131 2.10000E+04 1.14128E+01 9.44320E-01 2.10190E+00 1.44591E+01 0.00000E+00 1.50223E+01
132 2.21000E+04 1.13715E+01 8.84853E-01 2.51074E+00 1.47671E+01 0.00000E+00 1.54382E+01
133 2.32000E+04 1.14126E+01 9.61668E-01 2.05701E+00 1.44313E+01 0.00000E+00 1.50436E+01
134 2.37000E+04 1.14161E+01 9.56456E-01 2.19699E+00 1.45696E+01 0.00000E+00 1.52327E+01
135 2.42000E+04 1.13594E+01 9.04046E-01 2.27737E+00 1.45408E+01 0.00000E+00 1.52099E+01
136 2.46000E+04 1.12548E+01 8.11205E-01 2.23251E+00 1.42985E+01 0.00000E+00 1.49104E+01
137 2.50000E+04 1.12372E+01 8.00790E-01 2.16236E+00 1.42003E+01 0.00000E+00 1.47945E+01

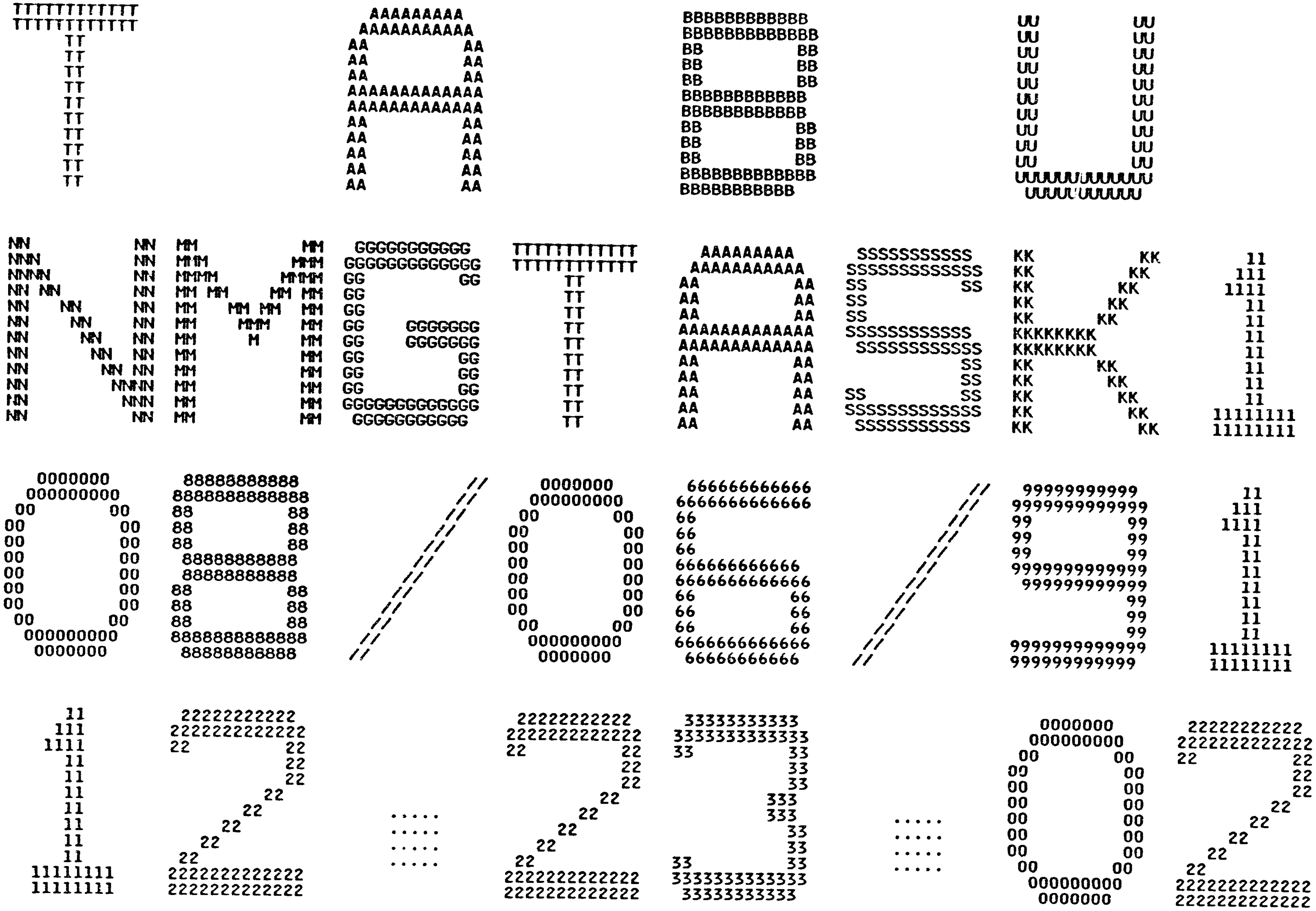
========================TIME FOR THIS BLOCK:  2.34 MIN

           TOTAL RESONANCE PROCESSING TIME:  2.36 MIN

"FLOOR CORRECTIONS" TO ADD TO SHIELDED VALUES
POINT      ENERGY     ELASTIC     CAPTURE     FISSION       TOTAL COMPETITIVE   TRANSPORT
    1 8.20000E+01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
    2 8.65000E+01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
    3 9.10000E+01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
    4 9.50000E+01 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
```

These are extracted
from File 3.

```
JERGENS
NMGTASK1
08/06/91
12:22:57
```



SAMPLE PROBLEMS

```
 TABU CALCULATION FOR MAT: 1395
        FROM LOGICAL UNIT:   31

   WEIGHTING FUNCTION MAT:   99
  WEIGHTING FUNCTION FILE:    3
    WEIGHTING FUNCTION MT:    1
WEIGHTING FUNCTION ON LOG:   25
```

```
SUMMARY OF RECORDS FOUND TO PROCESS
 MAT MF  MT  #INT #POINTS  TEMPERATURE     SIGO     DA RECORD
 ---- -- ---- ---- -------  ----------- ----------- ---------

1395  3    1    1     137    3.000E+02   1.000E+08          1
1395  3    2    1     137    3.000E+02   1.000E+08          3
1395  3   18    1     137    3.000E+02   1.000E+08          5
1395  3  102    1     137    3.000E+02   1.000E+08          7
1395  3 1000    1     137    3.000E+02   1.000E+08          9
1395  3    1    1     137    3.000E+02   1.000E+05         11
1395  3    2    1     137    3.000E+02   1.000E+05         13
1395  3   18    1     137    3.000E+02   1.000E+05         15
1395  3  102    1     137    3.000E+02   1.000E+05         17
1395  3 1000    1     137    3.000E+02   1.000E+05         19
1395  3    1    1     137    3.000E+02   1.000E+04         21
1395  3    2    1     137    3.000E+02   1.000E+04         23
1395  3   18    1     137    3.000E+02   1.000E+04         25
1395  3  102    1     137    3.000E+02   1.000E+04         27
1395  3 1000    1     137    3.000E+02   1.000E+04         29
1395  3    1    1     137    3.000E+02   1.000E+03         31
1395  3    2    1     137    3.000E+02   1.000E+03         33
1395  3   18    1     137    3.000E+02   1.000E+03         35
1395  3  102    1     137    3.000E+02   1.000E+03         37
1395  3 1000    1     137    3.000E+02   1.000E+03         39
1395  3    1    1     137    3.000E+02   1.000E+02         41
1395  3    2    1     137    3.000E+02   1.000E+02         43
1395  3   18    1     137    3.000E+02   1.000E+02         45
1395  3  102    1     137    3.000E+02   1.000E+02         47
1395  3 1000    1     137    3.000E+02   1.000E+02         49
1395  3    1    1     137    3.000E+02   1.000E+01         51
1395  3    2    1     137    3.000E+02   1.000E+01         53
1395  3   18    1     137    3.000E+02   1.000E+01         55
1395  3  102    1     137    3.000E+02   1.000E+01         57
1395  3 1000    1     137    3.000E+02   1.000E+01         59
1395  3    1    1     137    7.000E+02   1.000E+08         61
1395  3    2    1     137    7.000E+02   1.000E+08         63
1395  3   18    1     137    7.000E+02   1.000E+08         65
1395  3  102    1     137    7.000E+02   1.000E+08         67
1395  3 1000    1     137    7.000E+02   1.000E+08         69
1395  3    1    1     137    7.000E+02   1.000E+05         71
1395  3    2    1     137    7.000E+02   1.000E+05         73
1395  3   18    1     137    7.000E+02   1.000E+05         75
1395  3  102    1     137    7.000E+02   1.000E+05         77
1395  3 1000    1     137    7.000E+02   1.000E+05         79
1395  3    1    1     137    7.000E+02   1.000E+04         81
1395  3    2    1     137    7.000E+02   1.000E+04         83
1395  3   18    1     137    7.000E+02   1.000E+04         85
1395  3  102    1     137    7.000E+02   1.000E+04         87
1395  3 1000    1     137    7.000E+02   1.000E+04         89
1395  3    1    1     137    7.000E+02   1.000E+03         91
1395  3    2    1     137    7.000E+02   1.000E+03         93
1395  3   18    1     137    7.000E+02   1.000E+03         95
1395  3  102    1     137    7.000E+02   1.000E+03         97
1395  3 1000    1     137    7.000E+02   1.000E+03         99
1395  3    1    1     137    7.000E+02   1.000E+02        101
1395  3    2    1     137    7.000E+02   1.000E+02        103
1395  3   18    1     137    7.000E+02   1.000E+02        105
1395  3  102    1     137    7.000E+02   1.000E+02        107
1395  3 1000    1     137    7.000E+02   1.000E+02        109
1395  3    1    1     137    7.000E+02   1.000E+01        111
1395  3    2    1     137    7.000E+02   1.000E+01        113
1395  3   18    1     137    7.000E+02   1.000E+01        115
1395  3  102    1     137    7.000E+02   1.000E+01        117
1395  3 1000    1     137    7.000E+02   1.000E+01        119
1395  3    1    1     137    1.500E+03   1.000E+08        121
1395  3    2    1     137    1.500E+03   1.000E+08        123
1395  3   18    1     137    1.500E+03   1.000E+08        125
1395  3  102    1     137    1.500E+03   1.000E+08        127
1395  3 1000    1     137    1.500E+03   1.000E+08        129
1395  3    1    1     137    1.500E+03   1.000E+05        131
1395  3    2    1     137    1.500E+03   1.000E+05        133
1395  3   18    1     137    1.500E+03   1.000E+05        135
1395  3  102    1     137    1.500E+03   1.000E+05        137
1395  3 1000    1     137    1.500E+03   1.000E+05        139
1395  3    1    1     137    1.500E+03   1.000E+04        141
```

The point data from PRUDE are shuttled to a direct access file.

```
INFINITE DILUTE CROSS SECTION AND FLUX FOR REACTION TYPE MT=    1

GROUP    CROSS SECTION      FLUX
  55       1.449E+01      4.341E-05
  56       1.497E+01      3.020E-05
  57       1.550E+01      3.531E-05
  58       1.623E+01      1.892E-05
  59       1.648E+01      3.281E-05
  60       1.745E+01      4.849E-05
  61       1.833E+01      4.716E-06
  62       1.822E+01      2.482E-05
  63       1.835E+01      1.698E-05
  64       1.949E+01      1.342E-05
  65       1.944E+01      4.513E-06
  66       2.131E+01      2.259E-05
  67       2.106E+01      1.683E-05
  68       1.960E+01      3.691E-06
  69       2.267E+01      2.991E-05
  70       2.418E+01      2.151E-05
  71       2.621E+01      3.714E-05
  72       2.942E+01      2.163E-06
  73       2.920E+01      2.222E-05
  74       3.149E+01      6.637E-05
  75       3.097E+01      7.635E-06
  76       4.234E+01      1.934E-05
  77       4.490E+01      1.503E-05
  78       4.166E+01      1.348E-06
  79       3.993E+01      8.447E-06
  80       3.849E+01      3.867E-06
  81       4.646E+01      4.747E-05
  82       4.757E+01      2.803E-06
  83       4.582E+01      3.849E-06
  84       4.323E+01      7.069E-06
  85       4.071E+01      8.663E-06
  86       4.836E+01      1.186E-05
  87       6.207E+01      1.048E-05
```

Bondarenko Factors for
the total cross section

```
BONDARENKO FACTORS FOR MT=    1
                            GROUP  55                                           GROUP  56                                           GROUP  57
       SIGO        300K        700K        1500K          300K        700K        1500K          300K        700K        1500K
   1.000E+08   1.000E+00   1.000E+00   1.000E+00      1.000E+00   1.000E+00   1.000E+00      1.000E+00   1.000E+00   1.000E+00
   1.000E+05   1.000E+00   1.000E+00   1.000E+00      1.000E+00   1.000E+00   1.000E+00      1.000E+00   1.000E+00   1.000E+00
   1.000E+04   1.000E+00   1.000E+00   1.000E+00      1.000E+00   1.000E+00   1.000E+00      1.000E+00   1.000E+00   1.000E+00
   1.000E+03   1.000E+00   1.000E+00   1.000E+00      1.000E+00   1.000E+00   1.000E+00      1.000E+00   1.000E+00   1.000E+00
   1.000E+02   1.002E+00   1.002E+00   1.003E+00      1.002E+00   1.003E+00   1.003E+00      1.003E+00   1.003E+00   1.004E+00
   1.000E+01   1.008E+00   1.009E+00   1.011E+00      1.009E+00   1.011E+00   1.013E+00      1.010E+00   1.013E+00   1.016E+00
                            GROUP  58                                           GROUP  59                                           GROUP  60
       SIGO        300K        700K        1500K          300K        700K        1500K          300K        700K        1500K
   1.000E+08   1.000E+00   1.000E+00   1.000E+00      1.000E+00   1.000E+00   1.000E+00      1.000E+00   1.000E+00   1.000E+00
   1.000E+05   1.000E+00   1.000E+00   1.000E+00      1.000E+00   1.000E+00   1.000E+00      1.000E+00   1.000E+00   1.000E+00
   1.000E+04   1.000E+00   1.000E+00   1.000E+00      1.000E+00   1.000E+00   1.000E+00      1.000E+00   1.000E+00   1.000E+00
   1.000E+03   1.000E+00   1.000E+00   1.001E+00      1.000E+00   1.000E+00   1.001E+00      1.000E+00   1.001E+00   1.001E+00
   1.000E+02   1.003E+00   1.004E+00   1.005E+00      1.003E+00   1.004E+00   1.005E+00      1.003E+00   1.005E+00   1.006E+00
   1.000E+01   1.011E+00   1.017E+00   1.020E+00      1.011E+00   1.017E+00   1.021E+00      1.010E+00   1.019E+00   1.026E+00
                            GROUP  61                                           GROUP  62                                           GROUP  63
       SIGO        300K        700K        1500K          300K        700K        1500K          300K        700K        1500K
   1.000E+08   1.000E+00   1.000E+00   1.000E+00      1.000E+00   1.000E+00   1.000E+00      1.000E+00   1.000E+00   1.000E+00
   1.000E+05   1.000E+00   1.000E+00   1.000E+00      1.000E+00   1.000E+00   1.000E+00      1.000E+00   1.000E+00   1.000E+00
   1.000E+04   1.000E+00   1.000E+00   1.000E+00      9.999E-01   1.000E+00   1.000E+00      9.999E-01   1.000E+00   1.000E+00
   1.000E+03   1.000E+00   1.001E+00   1.001E+00      1.000E+00   1.001E+00   1.001E+00      1.000E+00   1.000E+00   1.001E+00
   1.000E+02   1.003E+00   1.006E+00   1.008E+00      1.003E+00   1.005E+00   1.007E+00      1.002E+00   1.005E+00   1.007E+00
   1.000E+01   1.010E+00   1.022E+00   1.030E+00      1.007E+00   1.020E+00   1.028E+00      1.006E+00   1.018E+00   1.028E+00
                            GROUP  64                                           GROUP  65                                           GROUP  66
       SIGO        300K        700K        1500K          300K        700K        1500K          300K        700K        1500K
   1.000E+08   1.000E+00   1.000E+00   1.000E+00      1.000E+00   1.000E+00   1.000E+00      1.000E+00   1.000E+00   1.000E+00
   1.000E+05   1.000E+00   1.000E+00   1.000E+00      1.000E+00   1.000E+00   1.000E+00      1.000E+00   1.000E+00   1.000E+00
   1.000E+04   9.999E-01   1.000E+00   1.000E+00      9.999E-01   1.000E+00   1.000E+00      9.999E-01   1.000E+00   1.000E+00
   1.000E+03   1.000E+00   1.001E+00   1.001E+00      9.999E-01   1.001E+00   1.001E+00      9.999E-01   1.001E+00   1.001E+00
   1.000E+02   1.002E+00   1.006E+00   1.009E+00      1.001E+00   1.005E+00   1.008E+00      1.000E+00   1.006E+00   1.011E+00
   1.000E+01   1.002E+00   1.019E+00   1.032E+00      9.993E-01   1.017E+00   1.030E+00      9.902E-01   1.014E+00   1.032E+00
                            GROUP  67                                           GROUP  68                                           GROUP  69
       SIGO        300K        700K        1500K          300K        700K        1500K          300K        700K        1500K
   1.000E+08   1.000E+00   1.000E+00   1.000E+00      1.000E+00   1.000E+00   1.000E+00      1.000E+00   1.000E+00   1.000E+00
   1.000E+05   1.000E+00   1.000E+00   1.000E+00      1.000E+00   1.000E+00   1.000E+00      1.000E+00   1.000E+00   1.000E+00
   1.000E+04   9.998E-01   9.999E-01   1.000E+00      9.998E-01   1.000E+00   1.000E+00      9.997E-01   9.999E-01   1.000E+00
   1.000E+03   9.997E-01   1.000E+00   1.001E+00      9.996E-01   1.000E+00   1.001E+00      9.993E-01   1.000E+00   1.001E+00
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INFINITE DILUTE CROSS SECTION AND FLUX FOR REACTION TYPE MT=   2

GROUP   CROSS SECTION     FLUX
  55       1.137E+01    4.341E-05
  56       1.152E+01    3.020E-05
  57       1.166E+01    3.531E-05
  58       1.184E+01    1.892E-05
  59       1.182E+01    3.281E-05
  60       1.185E+01    4.649E-05
  61       1.188E+01    4.716E-06
  62       1.183E+01    2.482E-05
  63       1.176E+01    1.698E-05
  64       1.191E+01    1.342E-05
  65       1.195E+01    4.513E-06
  66       1.222E+01    2.259E-05
  67       1.198E+01    1.683E-05
  68       1.188E+01    3.691E-06
  69       1.207E+01    2.991E-05
  70       1.232E+01    2.151E-05
  71       1.231E+01    3.714E-05
  72       1.229E+01    2.163E-06
  73       1.229E+01    2.222E-05
  74       1.223E+01    6.637E-05
  75       1.209E+01    7.635E-06
  76       1.265E+01    1.934E-05
  77       1.288E+01    1.503E-05
  78       1.259E+01    1.348E-06
  79       1.247E+01    8.447E-06
  80       1.226E+01    3.867E-06
  81       1.256E+01    4.747E-05
  82       1.244E+01    2.803E-06
  83       1.236E+01    3.849E-06
  84       1.224E+01    7.069E-06
  85       1.210E+01    8.663E-06
  86       1.246E+01    1.186E-05
  87       1.290E+01    1.048E-05
BONDARENKO FACTORS FOR MT=   2
                       GROUP  55                                      GROUP  56                                      GROUP  57
     SIGO         300K         700K        1500K         300K         700K        1500K         300K         700K        1500K
  1.000E+08    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00
  1.000E+05    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00
  1.000E+04    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00
  1.000E+03    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00
  1.000E+02    1.000E+00    1.001E+00    1.001E+00    1.000E+00    1.001E+00    1.001E+00    1.000E+00    1.001E+00    1.001E+00
  1.000E+01    1.002E+00    1.003E+00    1.003E+00    1.002E+00    1.002E+00    1.003E+00    1.001E+00    1.003E+00    1.003E+00
                       GROUP  58                                      GROUP  59                                      GROUP  60
     SIGO         300K         700K        1500K         300K         700K        1500K         300K         700K        1500K
  1.000E+08    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00
  1.000E+05    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00
  1.000E+04    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00
  1.000E+03    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00
  1.000E+02    1.000E+00    1.001E+00    1.001E+00    1.000E+00    1.001E+00    1.001E+00    1.000E+00    1.001E+00    1.001E+00
  1.000E+01    1.001E+00    1.003E+00    1.004E+00    1.001E+00    1.003E+00    1.004E+00    9.996E-01    1.002E+00    1.003E+00
                       GROUP  61                                      GROUP  62                                      GROUP  63
     SIGO         300K         700K        1500K         300K         700K        1500K         300K         700K        1500K
  1.000E+08    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00
  1.000E+05    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00
  1.000E+04    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00
  1.000E+03    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    9.999E-01    1.000E+00    1.000E+00
  1.000E+02    9.998E-01    1.000E+00    1.001E+00    9.997E-01    1.000E+00    1.001E+00    9.997E-01    1.000E+00    1.001E+00
  1.000E+01    9.986E-01    1.001E+00    1.003E+00    9.984E-01    1.001E+00    1.003E+00    9.983E-01    1.000E+00    1.002E+00
                       GROUP  64                                      GROUP  65                                      GROUP  66
     SIGO         300K         700K        1500K         300K         700K        1500K         300K         700K        1500K
  1.000E+08    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00
  1.000E+05    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00
  1.000E+04    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00
  1.000E+03    9.999E-01    1.000E+00    1.000E+00    9.999E-01    1.000E+00    1.000E+00    9.998E-01    1.000E+00    1.000E+00
  1.000E+02    9.993E-01    1.000E+00    1.001E+00    9.992E-01    1.000E+00    1.001E+00    9.983E-01    9.998E-01    1.001E+00
  1.000E+01    9.967E-01    9.999E-01    1.002E+00    9.962E-01    9.996E-01    1.002E+00    9.920E-01    9.974E-01    1.002E+00
                       GROUP  67                                      GROUP  68                                      GROUP  69
     SIGO         300K         700K        1500K         300K         700K        1500K         300K         700K        1500K
  1.000E+08    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00
  1.000E+05    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00
  1.000E+04    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    1.000E+00    9.999E-01    1.000E+00    1.000E+00
  1.000E+03    9.998E-01    1.000E+00    1.000E+00    9.998E-01    1.000E+00    1.000E+00    9.997E-01    9.999E-01    1.000E+00
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Bondarenko Factors for elastic scattering

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INFINITE DILUTE CROSS SECTION AND FLUX FOR REACTION TYPE MT=  18

GROUP    CROSS SECTION       FLUX
  55        2.227E+00      4.341E-05
  56        2.482E+00      3.020E-05
  57        2.695E+00      3.531E-05
  58        2.998E+00      1.892E-05
  59        3.225E+00      3.281E-05
  60        4.093E+00      4.849E-05
  61        4.823E+00      4.716E-06
  62        4.782E+00      2.482E-05
  63        5.065E+00      1.698E-05
  64        5.602E+00      1.342E-05
  65        5.287E+00      4.513E-06
  66        6.225E+00      2.259E-05
  67        6.645E+00      1.683E-05
  68        5.237E+00      3.691E-06
  69        7.682E+00      2.991E-05
  70        7.547E+00      2.151E-05
  71        9.342E+00      3.714E-05
  72        1.278E+01      2.163E-06
  73        1.197E+01      2.222E-05
  74        1.358E+01      6.637E-05
  75        1.285E+01      7.635E-06
  76        2.123E+01      1.934E-05
  77        2.113E+01      1.503E-05
  78        1.850E+01      1.348E-06
  79        1.724E+01      8.447E-06
  80        1.733E+01      3.867E-06
  81        2.181E+01      4.747E-05
  82        2.230E+01      2.803E-06
  83        2.085E+01      3.849E-06
  84        1.866E+01      7.069E-06
  85        1.708E+01      8.663E-06
  86        2.140E+01      1.186E-05
  87        3.047E+01      1.048E-05
BONDARENKO FACTORS FOR MT=  18
                           GROUP  55                                       GROUP  56                                       GROUP  57
     SIGO          300K          700K          1500K          300K          700K          1500K          300K          700K          1500K
 1.000E+08     1.000E+00     1.000E+00     1.000E+00      1.000E+00     1.000E+00     1.000E+00      1.000E+00     1.000E+00     1.000E+00
 1.000E+05     1.000E+00     1.000E+00     1.000E+00      1.000E+00     1.000E+00     1.000E+00      1.000E+00     1.000E+00     1.000E+00
 1.000E+04     1.000E+00     1.000E+00     1.000E+00      1.000E+00     1.000E+00     1.000E+00      1.000E+00     1.000E+00     1.000E+00
 1.000E+03     1.001E+00     1.001E+00     1.001E+00      1.001E+00     1.001E+00     1.001E+00      1.001E+00     1.001E+00     1.001E+00
 1.000E+02     1.007E+00     1.009E+00     1.009E+00      1.008E+00     1.010E+00     1.011E+00      1.009E+00     1.011E+00     1.012E+00
 1.000E+01     1.027E+00     1.032E+00     1.036E+00      1.030E+00     1.038E+00     1.044E+00      1.032E+00     1.043E+00     1.050E+00
                           GROUP  58                                       GROUP  59                                       GROUP  60
     SIGO          300K          700K          1500K          300K          700K          1500K          300K          700K          1500K
 1.000E+08     1.000E+00     1.000E+00     1.000E+00      1.000E+00     1.000E+00     1.000E+00      1.000E+00     1.000E+00     1.000E+00
 1.000E+05     1.000E+00     1.000E+00     1.000E+00      1.000E+00     1.000E+00     1.000E+00      1.000E+00     1.000E+00     1.000E+00
 1.000E+04     1.000E+00     1.000E+00     1.000E+00      1.000E+00     1.000E+00     1.000E+00      1.000E+00     1.000E+00     1.000E+00
 1.000E+03     1.001E+00     1.001E+00     1.002E+00      1.001E+00     1.001E+00     1.002E+00      1.001E+00     1.001E+00     1.002E+00
 1.000E+02     1.010E+00     1.013E+00     1.015E+00      1.009E+00     1.013E+00     1.015E+00      1.009E+00     1.014E+00     1.018E+00
 1.000E+01     1.036E+00     1.051E+00     1.061E+00      1.033E+00     1.050E+00     1.061E+00      1.031E+00     1.055E+00     1.071E+00
                           GROUP  61                                       GROUP  62                                       GROUP  63
     SIGO          300K          700K          1500K          300K          700K          1500K          300K          700K          1500K
 1.000E+08     1.000E+00     1.000E+00     1.000E+00      1.000E+00     1.000E+00     1.000E+00      1.000E+00     1.000E+00     1.000E+00
 1.000E+05     1.000E+00     1.000E+00     1.000E+00      1.000E+00     1.000E+00     1.000E+00      1.000E+00     1.000E+00     1.000E+00
 1.000E+04     9.999E-01     1.000E+00     1.000E+00      9.998E-01     1.000E+00     1.000E+00      9.998E-01     1.000E+00     1.000E+00
 1.000E+03     1.001E+00     1.001E+00     1.002E+00      1.000E+00     1.001E+00     1.002E+00      1.000E+00     1.001E+00     1.002E+00
 1.000E+02     1.010E+00     1.016E+00     1.020E+00      1.008E+00     1.014E+00     1.019E+00      1.007E+00     1.013E+00     1.018E+00
 1.000E+01     1.030E+00     1.058E+00     1.079E+00      1.023E+00     1.053E+00     1.074E+00      1.019E+00     1.049E+00     1.071E+00
                           GROUP  64                                       GROUP  65                                       GROUP  66
     SIGO          300K          700K          1500K          300K          700K          1500K          300K          700K          1500K
 1.000E+08     1.000E+00     1.000E+00     1.000E+00      1.000E+00     1.000E+00     1.000E+00      1.000E+00     1.000E+00     1.000E+00
 1.000E+05     1.000E+00     1.000E+00     1.000E+00      1.000E+00     1.000E+00     1.000E+00      1.000E+00     1.000E+00     1.000E+00
 1.000E+04     9.997E-01     1.000E+00     1.000E+00      9.997E-01     1.000E+00     1.000E+00      9.997E-C1     1.000E+00     1.000E+00
 1.000E+03     1.000E+00     1.001E+00     1.002E+00      9.999E-01     1.001E+00     1.002E+00      9.999E-01     1.001E+00     1.002E+00
 1.000E+02     1.006E+00     1.015E+00     1.020E+00      1.004E+00     1.013E+00     1.019E+00      1.003E+00     1.015E+00     1.023E+00
 1.000E+01     1.010E+00     1.047E+00     1.075E+00      1.004E+00     1.042E+00     1.071E+00      9.885E-01     1.036E+00     1.072E+00
                           GROUP  67                                       GROUP  68                                       GROUP  69
     SIGO          300K          700K          1500K          300K          700K          1500K          300K          700K          1500K
 1.000E+08     1.000E+00     1.000E+00     1.000E+00      9.999E-01     9.999E-01     9.999E-01      1.000E+00     1.000E+00     1.000E+00
 1.000E+05     1.000E+00     1.000E+00     1.000E+00      1.000E+00     1.000E+00     1.000E+00      1.000E+00     1.000E+00     1.000E+00
 1.000E+04     9.995E-01     9.998E-01     1.000E+00      9.994E-01     9.999E-01     1.000E+00      9.994E-01     9.998E-01     1.000E+00
 1.000E+03     9.996E-01     1.001E+00     1.002E+00      9.991E-01     1.001E+00     1.002E+00      9.990E-01     1.001E+00     1.002E+00
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Bondarenko Factors
for fission

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INFINITE DILUTE CROSS SECTION AND FLUX FOR REACTION TYPE MT= 102
GROUP    CROSS SECTION      FLUX
  55       8.834E-01      4.341E-05
  56       9.759E-01      3.020E-05
  57       1.143E+00      3.531E-05
  58       1.386E+00      1.892E-05
  59       1.424E+00      3.281E-05
  60       1.508E+00      4.849E-05
  61       1.617E+00      4.716E-06
  62       1.612E+00      2.482E-05
  63       1.528E+00      1.698E-05
  64       1.971E+00      1.342E-05
  65       2.201E+00      4.513E-06
  66       2.857E+00      2.259E-05
  67       2.420E+00      1.683E-05
  68       2.453E+00      3.691E-06
  69       2.892E+00      2.991E-05
  70       4.282E+00      2.151E-05
  71       4.534E+00      3.714E-05
  72       4.333E+00      2.163E-06
  73       4.884E+00      2.222E-05
  74       5.622E+00      6.637E-05
  75       5.778E+00      7.635E-06
  76       8.223E+00      1.934E-05
  77       1.085E+01      1.503E-05
  78       1.049E+01      1.348E-06
  79       1.018E+01      8.447E-06
  80       8.878E+00      3.867E-06
  81       1.204E+01      4.747E-05
  82       1.282E+01      2.803E-06
  83       1.258E+01      3.849E-06
  84       1.231E+01      7.069E-06
  85       1.152E+01      8.663E-06
  86       1.438E+01      1.186E-05
  87       1.867E+01      1.048E-05
BONDARENKO FACTORS FOR MT= 102
                                GROUP  55                                         GROUP  56                                         GROUP  57
      SIGO         300K          700K         1500K          300K          700K         1500K          300K          700K         1500K
 1.000E+08     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00
 1.000E+05     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00
 1.000E+04     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00
 1.000E+03     1.001E+00     1.001E+00     1.001E+00     1.001E+00     1.001E+00     1.001E+00     1.001E+00     1.001E+00     1.002E+00
 1.000E+02     1.009E+00     1.010E+00     1.011E+00     1.009E+00     1.011E+00     1.012E+00     1.010E+00     1.013E+00     1.014E+00
 1.000E+01     1.034E+00     1.041E+00     1.045E+00     1.037E+00     1.046E+00     1.051E+00     1.041E+00     1.053E+00     1.060E+00
                                GROUP  58                                         GROUP  59                                         GROUP  60
      SIGO         300K          700K         1500K          300K          700K         1500K          300K          700K         1500K
 1.000E+08     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00
 1.000E+05     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00
 1.000E+04     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00
 1.000E+03     1.001E+00     1.002E+00     1.002E+00     1.001E+00     1.002E+00     1.002E+00     1.001E+00     1.002E+00     1.002E+00
 1.000E+02     1.011E+00     1.014E+00     1.016E+00     1.011E+00     1.015E+00     1.017E+00     1.010E+00     1.016E+00     1.019E+00
 1.000E+01     1.043E+00     1.059E+00     1.069E+00     1.042E+00     1.061E+00     1.073E+00     1.036E+00     1.062E+00     1.080E+00
                                GROUP  61                                         GROUP  62                                         GROUP  63
      SIGO         300K          700K         1500K          300K          700K         1500K          300K          700K         1500K
 1.000E+08     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00
 1.000E+05     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00
 1.000E+04     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00
 1.000E+03     1.001E+00     1.002E+00     1.002E+00     1.001E+00     1.002E+00     1.002E+00     1.001E+00     1.002E+00     1.002E+00
 1.000E+02     1.010E+00     1.016E+00     1.021E+00     1.008E+00     1.016E+00     1.020E+00     1.007E+00     1.015E+00     1.020E+00
 1.000E+01     1.030E+00     1.061E+00     1.083E+00     1.026E+00     1.059E+00     1.082E+00     1.019E+00     1.055E+00     1.081E+00
                                GROUP  64                                         GROUP  65                                         GROUP  66
      SIGO         300K          700K         1500K          300K          700K         1500K          300K          700K         1500K
 1.000E+08     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00
 1.000E+05     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00
 1.000E+04     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     9.999E-01     1.000E+00     1.000E+00
 1.000E+03     1.000E+00     1.002E+00     1.002E+00     1.000E+00     1.002E+00     1.002E+00     1.000E+00     1.002E+00     1.003E+00
 1.000E+02     1.006E+00     1.016E+00     1.022E+00     1.005E+00     1.015E+00     1.022E+00     1.003E+00     1.016E+00     1.024E+00
 1.000E+01     1.011E+00     1.055E+00     1.086E+00     1.006E+00     1.052E+00     1.084E+00     9.864E-01     1.039E+00     1.078E+00
                                GROUP  67                                         GROUP  68                                         GROUP  69
      SIGO         300K          700K         1500K          300K          700K         1500K          300K          700K         1500K
 1.000E+08     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00
 1.000E+05     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00     1.000E+00
 1.000E+04     9.997E-01     1.000E+00     1.000E+00     9.997E-01     1.000E+00     1.000E+00     9.996E-01     1.000E+00     1.000E+00
 1.000E+03     9.997E-01     1.001E+00     1.003E+00     9.994E-01     1.001E+00     1.002E+00     9.988E-01     1.001E+00     1.002E+00
```

Bondarenko Factors
for $\sigma(n,\gamma)$

```
INFINITE DILUTE CROSS SECTION AND FLUX FOR REACTION TYPE MT=1000

GROUP    CROSS SECTION       FLUX
  55        1.503E+01      4.341E-05
  56        1.542E+01      3.020E-05
  57        1.588E+01      3.531E-05
  58        1.658E+01      1.892E-05
  59        1.677E+01      3.281E-05
  60        1.769E+01      4.849E-05
  61        1.855E+01      4.716E-06
  62        1.841E+01      2.482E-05
  63        1.852E+01      1.698E-05
  64        1.966E+01      1.342E-05
  65        1.960E+01      4.513E-06
  66        2.143E+01      2.259E-05
  67        2.118E+01      1.683E-05
  68        1.969E+01      3.691E-06
  69        2.265E+01      2.991E-05
  70        2.424E+01      2.151E-05
  71        2.613E+01      3.714E-05
  72        2.952E+01      2.163E-06
  73        2.918E+01      2.222E-05
  74        3.142E+01      6.637E-05
  75        3.086E+01      7.635E-06
  76        4.209E+01      1.934E-05
  77        4.482E+01      1.503E-05
  78        4.172E+01      1.348E-06
  79        3.995E+01      8.447E-06
  80        3.852E+01      3.867E-06
  81        4.635E+01      4.747E-05
  82        4.760E+01      2.803E-06
  83        4.585E+01      3.849E-06
  84        4.324E+01      7.069E-06
  85        4.072E+01      8.663E-06
  86        4.626E+01      1.186E-05
  87        6.199E+01      1.048E-05
```

Bondarenko Factors for inverse-weighted total

```
BONDARENKO FACTORS FOR MT=1000
                               GROUP  55                                 GROUP  56                                 GROUP  57
     SIGO          300K         700K         1500K          300K         700K         1500K          300K         700K         1500K
  1.000E+08     1.000E+00    1.000E+00    1.000E+00     1.000E+00    1.000E+00    1.000E+00     1.000E+00    1.000E+00    1.000E+00
  1.000E+05     1.000E+00    1.000E+00    1.000E+00     1.000E+00    1.000E+00    1.000E+00     1.000E+00    1.000E+00    1.000E+00
  1.000E+04     1.000E+00    1.000E+00    1.000E+00     1.000E+00    1.000E+00    1.000E+00     1.000E+00    1.000E+00    1.000E+00
  1.000E+03     1.000E+00    1.000E+00    1.001E+00     1.000E+00    1.001E+00    1.001E+00     1.001E+00    1.001E+00    1.001E+00
  1.000E+02     1.003E+00    1.004E+00    1.004E+00     1.004E+00    1.005E+00    1.006E+00     1.005E+00    1.006E+00    1.007E+00
  1.000E+01     1.008E+00    1.011E+00    1.014E+00     1.011E+00    1.016E+00    1.020E+00     1.014E+00    1.021E+00    1.026E+00
                               GROUP  58                                 GROUP  59                                 GROUP  60
     SIGO          300K         700K         1500K          300K         700K         1500K          300K         700K         1500K
  1.000E+08     1.000E+00    1.000E+00    1.000E+00     1.000E+00    1.000E+00    1.000E+00     1.000E+00    1.000E+00    1.000E+00
  1.000E+05     1.000E+00    1.000E+00    1.000E+00     1.000E+00    1.000E+00    1.000E+00     1.000E+00    1.000E+00    1.000E+00
  1.000E+04     1.000E+00    1.000E+00    1.000E+00     1.000E+00    1.000E+00    1.000E+00     1.000E+00    1.000E+00    1.000E+00
  1.000E+03     1.001E+00    1.001E+00    1.001E+00     1.001E+00    1.001E+00    1.001E+00     1.001E+00    1.001E+00    1.001E+00
  1.000E+02     1.006E+00    1.008E+00    1.009E+00     1.006E+00    1.008E+00    1.010E+00     1.006E+00    1.010E+00    1.012E+00
  1.000E+01     1.017E+00    1.028E+00    1.035E+00     1.016E+00    1.029E+00    1.037E+00     1.016E+00    1.034E+00    1.047E+00
                               GROUP  61                                 GROUP  62                                 GROUP  63
     SIGO          300K         700K         1500K          300K         700K         1500K          300K         700K         1500K
  1.000E+08     1.000E+00    1.000E+00    1.000E+00     1.000E+00    1.000E+00    1.000E+00     1.000E+00    1.000E+00    1.000E+00
  1.000E+05     1.000E+00    1.000E+00    1.000E+00     1.000E+00    1.000E+00    1.000E+00     1.000E+00    1.000E+00    1.000E+00
  1.000E+04     1.000E+00    1.000E+00    1.000E+00     1.000E+00    1.000E+00    1.000E+00     1.000E+00    1.000E+00    1.000E+00
  1.000E+03     1.001E+00    1.001E+00    1.002E+00     1.000E+00    1.001E+00    1.002E+00     1.000E+00    1.001E+00    1.001E+00
  1.000E+02     1.007E+00    1.012E+00    1.015E+00     1.006E+00    1.011E+00    1.014E+00     1.005E+00    1.010E+00    1.014E+00
  1.000E+01     1.014E+00    1.038E+00    1.055E+00     1.011E+00    1.035E+00    1.053E+00     1.008E+00    1.033E+00    1.052E+00
                               GROUP  64                                 GROUP  65                                 GROUP  66
     SIGO          300K         700K         1500K          300K         700K         1500K          300K         700K         1500K
  1.000E+08     1.000E+00    1.000E+00    1.000E+00     1.000E+00    1.000E+00    1.000E+00     1.000E+00    1.000E+00    1.000E+00
  1.000E+05     1.000E+00    1.000E+00    1.000E+00     1.000E+00    1.000E+00    1.000E+00     1.000E+00    1.000E+00    1.000E+00
  1.000E+04     1.000E+00    1.000E+00    1.000E+00     9.999E-01    1.000E+00    1.000E+00     9.999E-01    1.000E+00    1.000E+00
  1.000E+03     1.000E+00    1.001E+00    1.002E+00     1.000E+00    1.001E+00    1.002E+00     1.000E+00    1.001E+00    1.002E+00
  1.000E+02     1.004E+00    1.012E+00    1.017E+00     1.003E+00    1.011E+00    1.017E+00     1.002E+00    1.014E+00    1.022E+00
  1.000E+01     9.999E-01    1.032E+00    1.057E+00     9.953E-01    1.029E+00    1.055E+00     9.760E-01    1.017E+00    1.049E+00
                               GROUP  67                                 GROUP  68                                 GROUP  69
     SIGO          300K         700K         1500K          300K         700K         1500K          300K         700K         1500K
  1.000E+08     1.000E+00    1.000E+00    1.000E+00     1.000E+00    1.000E+00    1.000E+00     1.000E+00    1.000E+00    1.000E+00
  1.000E+05     1.000E+00    1.000E+00    1.000E+00     1.000E+00    1.000E+00    1.000E+00     1.000E+00    1.000E+00    1.000E+00
  1.000E+04     9.998E-01    1.000E+00    1.000E+00     9.998E-01    1.000E+00    1.000E+00     9.997E-01    1.000E+00    1.000E+00
  1.000E+03     9.998E-01    1.001E+00    1.002E+00     9.995E-01    1.001E+00    1.002E+00     9.991E-01    1.001E+00    1.002E+00
```

```
              UU        UU  NN        NN  IIIIIIIIIIII  TTTTTTTTTTTT    AAAAAAAA    BBBBBBBBBBB
              UU        UU  NNN       NN  IIIIIIIIIIII  TTTTTTTTTTTT   AAAAAAAAAA   BBBBBBBBBBBB
              UU        UU  NNNN      NN       II            TT       AA        AA  BB        BB
              UU        UU  NN NN     NN       II            TT       AA        AA  BB        BB
              UU        UU  NN  NN    NN       II            TT       AA        AA  BB        BB
              UU        UU  NN   NN   NN       II            TT       AAAAAAAAAAAA  BBBBBBBBBBB
              UU        UU  NN    NN  NN       II            TT       AAAAAAAAAAAA  BBBBBBBBBBB
              UU        UU  NN     NN NN       II            TT       AA        AA  BB        BB
              UU        UU  NN      NNNN       II            TT       AA        AA  BB        BB
              UU        UU  NN       NNN       II            TT       AA        AA  BB        BB
              UUUUUUUUUUUU  NN        NN  IIIIIIIIIIII       TT       AA        AA  BBBBBBBBBBBB
               UUUUUUUUUU   NN        NN  IIIIIIIIIIII       TT       AA        AA  BBBBBBBBBBB

NN        NN  MM        MM    GGGGGGGG    TTTTTTTTTTTT    AAAAAAAA     SSSSSSSSSS   KK        KK      11
NNN       NN  MMM      MMM   GGGGGGGGGG   TTTTTTTTTTTT   AAAAAAAAAA   SSSSSSSSSSSS  KK       KK      111
NNNN      NN  MMMM    MMMM  GG        GG       TT       AA        AA  SS        SS  KK      KK      1111
NN NN     NN  MM MM  MM MM  GG                 TT       AA        AA  SS            KK     KK         11
NN  NN    NN  MM  MMMM  MM  GG                 TT       AA        AA  SS            KK    KK          11
NN   NN   NN  MM   MM   MM  GG    GGGGGG       TT       AAAAAAAAAAAA  SSSSSSSSSSS   KKKKKKK           11
NN    NN  NN  MM        MM  GG    GGGGGG       TT       AAAAAAAAAAAA   SSSSSSSSSSS  KKKKKKK           11
NN     NN NN  MM        MM  GG        GG       TT       AA        AA            SS  KK    KK          11
NN      NNNN  MM        MM  GG        GG       TT       AA        AA            SS  KK     KK         11
NN       NNN  MM        MM  GG        GG       TT       AA        AA  SS        SS  KK      KK        11
NN        NN  MM        MM   GGGGGGGGGG        TT       AA        AA  SSSSSSSSSSSS  KK       KK     11111111
NN        NN  MM        MM    GGGGGGGG         TT       AA        AA   SSSSSSSSSS   KK        KK    11111111

   000000      8888888888             //     000000      6666666666             //   9999999999       11
  00000000    888888888888           //     00000000    666666666666           //   999999999999     111
 00      00   88        88          //     00      00   66                    //    99        99    1111
00        00  88        88         //     00        00  66                   //     99        99      11
00        00  88        88        //      00        00  66                  //      99        99      11
00        00   8888888888        //       00        00  66666666666        //       999999999999      11
00        00   8888888888       //        00        00  666666666666      //         99999999999      11
00        00  88        88     //         00        00  66        66     //                   99      11
00        00  88        88    //          00        00  66        66    //                    99      11
 00      00   88        88   //            00      00   66        66   //           99        99      11
  00000000    888888888888  //              00000000    666666666666  //            999999999999    11111111
   000000      8888888888   //               000000      6666666666   //             9999999999     11111111

    11         2222222222                  2222222222           44                   3333333333       11
   111        222222222222                222222222222         444                  333333333333     111
  1111        22        22                22        22        4444                  33        33    1111
    11                  22                          22       44 44                            33      11
    11                  22                          22      44  44                            33      11
    11                 22                          22      44   44                          333       11
    11                22       .....              22      44    44       .....              333       11
    11               22        .....             22     444444444444     .....                33      11
    11              22         .....            22      444444444444     .....                33      11
    11             22          .....           22               44       .....      33        33      11
  11111111    222222222222                222222222222          44                  333333333333    11111111
  11111111    222222222222                222222222222          44                   3333333333     11111111
```

```
    0$ ARRAY     16 ENTRIES READ

    1$ ARRAY      2 ENTRIES READ

    6$ ARRAY      2 ENTRIES READ

    0T

=============================================================================
LOGICAL  1 (MASTER LIBRARY DATA SOURCE FOR THIS RUN)
DATASET NAME: SYS91218.T121900.RA000.NMGTASK1.R0000004
      VOLUME: SYSSA1
=============================================================================
```

Bondarenko Factors

```
=============================================================================
LOGICAL 59 (MASTER LIBRARY DATA SOURCE FOR THIS RUN)
DATASET NAME: NMG.AMPX77.N238.U235
      VOLUME: SCSS01
=============================================================================
```

XIACS Library

```
=============================================================================
LOGICAL 65 (OUTPUT MASTER LIBRARY FOR THIS RUN)
DATASET NAME: A.NMG35918.UNITAB.U235
      VOLUME: SCSS01
=============================================================================

    2$ ARRAY      8 ENTRIES READ

    0T
```

Final Library

```
RECORDS FOUND TO USE IN CONSTRUCTING MASTER FILE

RECORD  IDENTIFIER                       DESCRIPTION                         SET ID   LOG NO.   TYPE
   1       92235      U235                                                   92235       59     5555
   2       92235      U235                                                   92235       59     6666
   3       92235      U235                                                   92235       59        2
   4       92235      U235                                                   92235       59        2
   5       92235      U235                                                   92235       59        2
   6       92235      U235                                                   92235       59        2
   7       92235      U235                                                   92235       59        2
   8       92235      U235                                                   92235       59        2
   9       92235      U235                                                   92235       59       51
  10       92235      U235                                                   92235       59       51
  11       92235      U235                                                   92235       59       51
  12       92235      U235                                                   92235       59       51
  13       92235      U235                                                   92235       59       51
  14       92235      U235                                                   92235       59       51
  15       92235      U235                                                   92235       59       52
  16       92235      U235                                                   92235       59       52
  17       92235      U235                                                   92235       59       52
  18       92235      U235                                                   92235       59       52
  19       92235      U235                                                   92235       59       52
  20       92235      U235                                                   92235       59       52
  21       92235      U235                                                   92235       59       53
  22       92235      U235                                                   92235       59       53
  23       92235      U235                                                   92235       59       53
  24       92235      U235                                                   92235       59       53
  25       92235      U235                                                   92235       59       53
  26       92235      U235                                                   92235       59       53
  27       92235      U235                                                   92235       59       54
  28       92235      U235                                                   92235       59       54
  29       92235      U235                                                   92235       59       54
  30       92235      U235                                                   92235       59       54
  31       92235      U235                                                   92235       59       54
  32       92235      U235                                                   92235       59       54
  33       92235      U235                                                   92235       59       55
  34       92235      U235                                                   92235       59       55
  35       92235      U235                                                   92235       59       55
  36       92235      U235                                                   92235       59       55
  37       92235      U235                                                   92235       59       55
  38       92235      U235                                                   92235       59       55
  39       92235      U235                                                   92235       59       56
  40       92235      U235                                                   92235       59       56
  41       92235      U235                                                   92235       59       56
  42       92235      U235                                                   92235       59       56
  43       92235      U235                                                   92235       59       56
  44       92235      U235                                                   92235       59       56
  45       92235      U235                                                   92235       59       57
  46       92235      U235                                                   92235       59       57
  47       92235      U235                                                   92235       59       57
  48       92235      U235                                                   92235       59       57
  49       92235      U235                                                   92235       59       57
  50       92235      U235                                                   92235       59       57
  51       92235      U235                                                   92235       59       58
  52       92235      U235                                                   92235       59       58
  53       92235      U235                                                   92235       59       58
  54       92235      U235                                                   92235       59       58
  55       92235      U235                                                   92235       59       58
  56       92235      U235                                                   92235       59       58
  57       92235      U235                                                   92235       59       59
  58       92235      U235                                                   92235       59       59
  59       92235      U235                                                   92235       59       59
  60       92235      U235                                                   92235       59       59
  61       92235      U235                                                   92235       59       59
  62       92235      U235                                                   92235       59       59
  63       92235      U235                                                   92235       59       60
  64       92235      U235                                                   92235       59       60
  65       92235      U235                                                   92235       59       60
  66       92235      U235                                                   92235       59       60
  67       92235      U235                                                   92235       59       60
  68       92235      U235                                                   92235       59       60
  69       92235      U235                                                   92235       59       61
  70       92235      U235                                                   92235       59       61
  71       92235      U235                                                   92235       59       61
  72       92235      U235                                                   92235       59       61
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DIRECT ACCESS RECORD MAKE-UP

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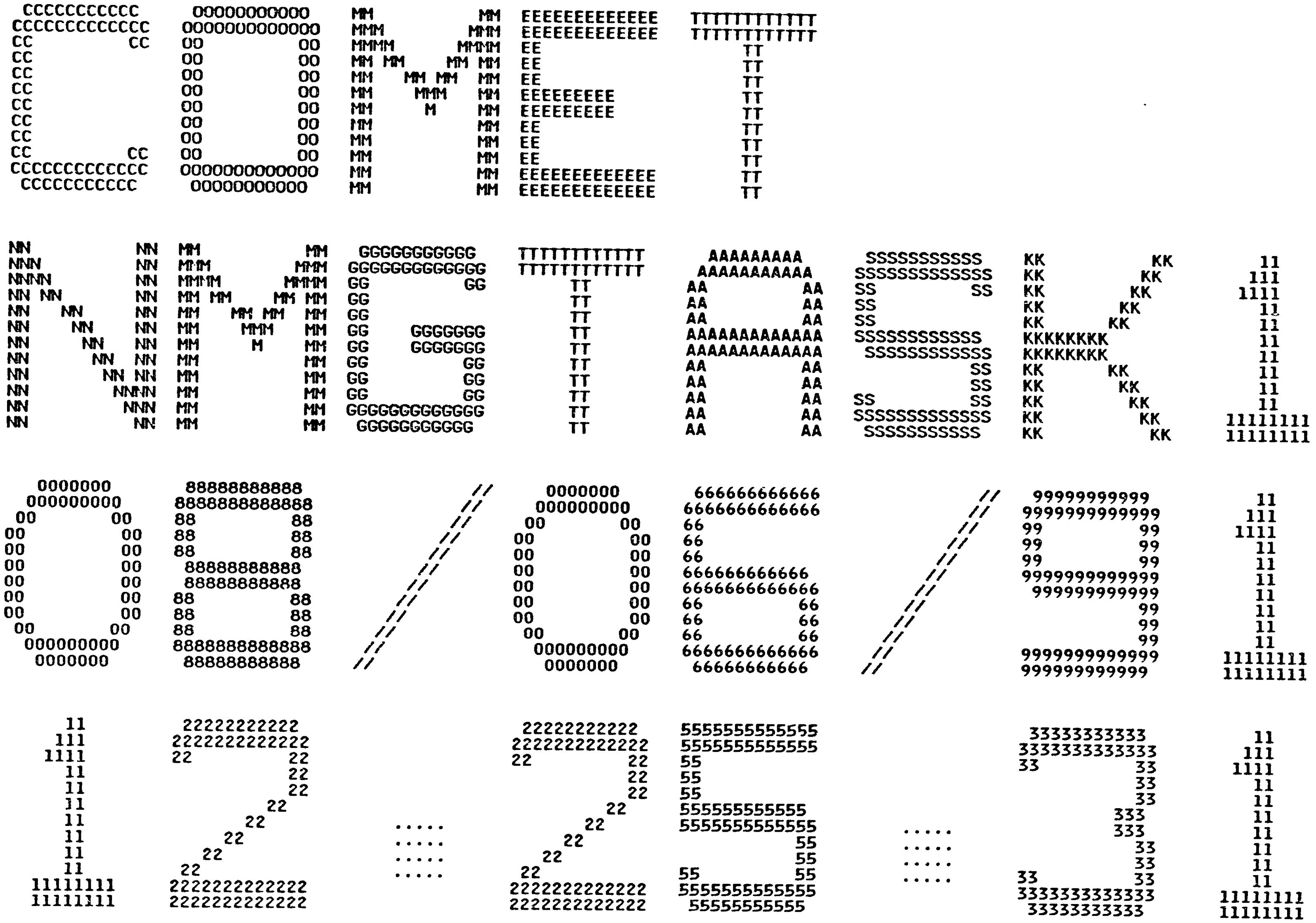
```
                                  AAAAAAAAA                JJ     AAAAAAAAA     XX         XX
                                 AAAAAAAAAAA               JJ    AAAAAAAAAAA     XX       XX
                                AA         AA              JJ   AA         AA     XX     XX
                                AA         AA              JJ   AA         AA      XX   XX
                                AA         AA              JJ   AA         AA       XX XX
                                AAAAAAAAAAAAA              JJ   AAAAAAAAAAAAA        XXX
                                AAAAAAAAAAAAA              JJ   AAAAAAAAAAAAA        XXX
                                AA         AA              JJ   AA         AA       XX XX
                                AA         AA              JJ   AA         AA      XX   XX
                                AA         AA   JJ         JJ   AA         AA     XX     XX
                                AA         AA   JJJJJJJJJJJJJ   AA         AA    XX       XX
                                AA         AA    JJJJJJJJJJJ    AA         AA   XX         XX

NN          NN  MM          MM   GGGGGGGGGGG    TTTTTTTTTTTT      AAAAAAAAA      SSSSSSSSSSS    KK          KK        11
NNN         NN  MMM        MMM  GGGGGGGGGGGGG   TTTTTTTTTTTT     AAAAAAAAAAA    SSSSSSSSSSSSS   KK         KK        111
NNNN        NN  MMMM      MMMM  GG         GG        TT         AA         AA   SS         SS   KK        KK        1111
NN NN       NN  MM MM    MM MM  GG                   TT         AA         AA   SS              KK       KK           11
NN   NN     NN  MM   MM MM  MM  GG                   TT         AA         AA   SS              KK      KK            11
NN    NN    NN  MM    MMM   MM  GG    GGGGGGG        TT         AAAAAAAAAAAAA   SSSSSSSSSSSS    KKKKKKKK              11
NN     NN   NN  MM     M    MM  GG    GGGGGGG        TT         AAAAAAAAAAAAA    SSSSSSSSSSSS   KKKKKKKK              11
NN      NN  NN  MM          MM  GG         GG        TT         AA         AA              SS   KK      KK            11
NN       NN NN  MM          MM  GG         GG        TT         AA         AA              SS   KK       KK           11
NN        NNNN  MM          MM  GG         GG        TT         AA         AA   SS         SS   KK        KK          11
NN         NNN  MM          MM  GGGGGGGGGGGGG        TT         AA         AA   SSSSSSSSSSSSS   KK         KK     11111111
NN          NN  MM          MM   GGGGGGGGGGG         TT         AA         AA    SSSSSSSSSSS    KK          KK    11111111

   0000000       88888888888               //      0000000       66666666666               //    99999999999          11
  000000000     8888888888888             //      000000000     6666666666666             //    9999999999999        111
 00       00    88         88            //      00       00    66                      //     99         99       1111
00         00   88         88           //      00         00   66                     //      99         99         11
00         00   88         88          //       00         00   66                    //       99         99         11
00         00    88888888888          //        00         00   666666666666          //        9999999999999         11
00         00    88888888888         //         00         00   6666666666666        //          999999999999         11
00         00   88         88       //          00         00   66         66       //                    99         11
00         00   88         88      //           00         00   66         66      //                     99         11
 00       00    88         88     //             00       00    66         66     //                      99         11
  000000000     8888888888888    //               000000000     6666666666666    //              9999999999999     11111111
   0000000       88888888888    //                0000000       66666666666    //                999999999999      11111111

      11         22222222222                      22222222222    5555555555555                      0000000       99999999999
     111        2222222222222                   2222222222222   5555555555555                     000000000     9999999999999
    1111        22         22                   22         22   55                              00       00    99         99
      11                   22                              22   55                             00         00   99         99
      11                   22                              22   55                             00         00   99         99
      11                 22                              22     555555555555                    00         00   9999999999999
      11               22            .....             22       5555555555555        .....      00         00    999999999999
      11             22              .....           22                    55        .....      00         00              99
      11           22                .....         22                      55        .....      00         00              99
      11         22                  .....       22             55         55        .....       00       00               99
  11111111      2222222222222                   2222222222222   5555555555555                     000000000     9999999999999
  11111111      2222222222222                   2222222222222    55555555555                       0000000       999999999999
```

```
TABLE OF CONTENTS OF LOGICAL 70

ENTRY     IDENTIFIER                              T I T L E                                        SOURCE
    1           6000     C-12 (GRAPHITE KERNEL AT THERMAL)                                             64
    2          92235     U235                                                                          65

AJAX HAS TERMINATED NORMALLY

    0$ ARRAY      3 ENTRIES READ

    1$ ARRAY      2 ENTRIES READ

    2$ ARRAY    200 ENTRIES READ

    6$ ARRAY      2 ENTRIES READ

    0T
```


COMET
NMGTASK1
08/06/91
12:25:31

```
238 NEUTRON GROUP STRUCTURE
 BDY    ENERGY      BDY    ENERGY      BDY    ENERGY      BDY    ENERGY
   1 2.0000E+07      61 3.9000E+03     121 2.0000E+01     181 1.0900E+00
   2 1.7333E+07      62 3.7400E+03     122 1.9000E+01     182 1.0800E+00
   3 1.5683E+07      63 3.0000E+03     123 1.8500E+01     183 1.0700E+00
   4 1.4550E+07      64 2.5800E+03     124 1.7000E+01     184 1.0600E+00
   5 1.3840E+07      65 2.2900E+03     125 1.6000E+01     185 1.0500E+00
   6 1.2840E+07      66 2.2000E+03     126 1.5100E+01     186 1.0400E+00
   7 1.0000E+07      67 1.8000E+03     127 1.4400E+01     187 1.0300E+00
   8 8.1873E+06      68 1.5500E+03     128 1.3750E+01     188 1.0200E+00
   9 6.4340E+06      69 1.5000E+03     129 1.2900E+01     189 1.0100E+00
  10 4.8000E+06      70 1.1500E+03     130 1.1900E+01     190 1.0000E+00
  11 4.3040E+06      71 9.5000E+02     131 1.1500E+01     191 9.7500E-01
  12 3.0000E+06      72 6.8300E+02     132 1.0000E+01     192 9.5000E-01
  13 2.4790E+06      73 6.7000E+02     133 9.1000E+00     193 9.2500E-01
  14 2.3540E+06      74 5.5000E+02     134 8.1000E+00     194 9.0000E-01
  15 1.8500E+06      75 3.0500E+02     135 7.1500E+00     195 8.5000E-01
  16 1.5000E+06      76 2.8500E+02     136 7.0000E+00     196 8.0000E-01
  17 1.4000E+06      77 2.4000E+02     137 6.7500E+00     197 7.5000E-01
  18 1.3560E+06      78 2.1000E+02     138 6.5000E+00     198 7.0000E-01
  19 1.3170E+06      79 2.0750E+02     139 6.2500E+00     199 6.5000E-01
  20 1.2500E+06      80 1.9250E+02     140 6.0000E+00     200 6.2500E-01
  21 1.2000E+06      81 1.8600E+02     141 5.4000E+00     201 6.0000E-01
  22 1.1000E+06      82 1.2200E+02     142 5.0000E+00     202 5.5000E-01
  23 1.0100E+06      83 1.1900E+02     143 4.7500E+00     203 5.0000E-01
  24 9.2000E+05      84 1.1500E+02     144 4.0000E+00     204 4.5000E-01
  25 9.0000E+05      85 1.0800E+02     145 3.7300E+00     205 4.0000E-01
  26 8.7500E+05      86 1.0000E+02     146 3.5000E+00     206 3.7500E-01
  27 8.6110E+05      87 9.0000E+01     147 3.1500E+00     207 3.5000E-01
  28 8.2000E+05      88 8.2000E+01     148 3.0500E+00     208 3.2500E-01
  29 7.5000E+05      89 8.0000E+01     149 3.0000E+00     209 3.0000E-01
  30 6.7900E+05      90 7.6000E+01     150 2.9700E+00     210 2.7500E-01
  31 6.7000E+05      91 7.2000E+01     151 2.8700E+00     211 2.5000E-01
  32 6.0000E+05      92 6.7500E+01     152 2.7700E+00     212 2.2500E-01
  33 5.7300E+05      93 6.5000E+01     153 2.6700E+00     213 2.0000E-01
  34 5.5000E+05      94 6.1000E+01     154 2.5700E+00     214 1.7500E-01
  35 4.9952E+05      95 5.9000E+01     155 2.4700E+00     215 1.5000E-01
  36 4.7000E+05      96 5.3400E+01     156 2.3800E+00     216 1.2500E-01
  37 4.4000E+05      97 5.2000E+01     157 2.3000E+00     217 1.0000E-01
  38 4.2000E+05      98 5.0600E+01     158 2.2100E+00     218 9.0000E-02
  39 4.0000E+05      99 4.9200E+01     159 2.1200E+00     219 8.0000E-02
  40 3.3000E+05     100 4.8300E+01     160 2.0000E+00     220 7.0000E-02
  41 2.7000E+05     101 4.7000E+01     161 1.9400E+00     221 6.0000E-02
  42 2.0000E+05     102 4.5200E+01     162 1.8600E+00     222 5.0000E-02
  43 1.5000E+05     103 4.4000E+01     163 1.7700E+00     223 4.0000E-02
  44 1.2830E+05     104 4.2400E+01     164 1.6800E+00     224 3.0000E-02
  45 1.0000E+05     105 4.1000E+01     165 1.5900E+00     225 2.5300E-02
  46 8.5000E+04     106 3.9600E+01     166 1.5000E+00     226 1.0000E-02
  47 8.2000E+04     107 3.9100E+01     167 1.4500E+00     227 7.5000E-03
  48 7.5000E+04     108 3.8000E+01     168 1.4000E+00     228 5.0000E-03
  49 7.3000E+04     109 3.7000E+01     169 1.3500E+00     229 4.0000E-03
  50 6.0000E+04     110 3.5500E+01     170 1.3000E+00     230 3.0000E-03
  51 5.2000E+04     111 3.4600E+01     171 1.2500E+00     231 2.5000E-03
  52 5.0000E+04     112 3.3750E+01     172 1.2250E+00     232 2.0000E-03
  53 4.5000E+04     113 3.3250E+01     173 1.2000E+00     233 1.5000E-03
  54 3.0000E+04     114 3.1750E+01     174 1.1750E+00     234 1.2000E-03
  55 2.5000E+04     115 3.1250E+01     175 1.1500E+00     235 1.0000E-03
  56 1.7000E+04     116 3.0000E+01     176 1.1400E+00     236 7.5000E-04
  57 1.3000E+04     117 2.7500E+01     177 1.1300E+00     237 5.0000E-04
  58 9.5000E+03     118 2.5000E+01     178 1.1200E+00     238 1.0000E-04
  59 8.0300E+03     119 2.2500E+01     179 1.1100E+00     239 1.0000E-05
  60 6.0000E+03     120 2.1000E+01     180 1.1000E+00
THE FOLLOWING OPERATIONS WILL BE CARRIED OUT IN RENORMALIZING THE MASTER LIBRARY TO BE WRITTEN ON LOGICAL 71
ENTRY  1 WITH MT=    2 WILL HAVE THE TRANSFER MATRICES NORMALIZED TO THE 1-D SUMS ← elastic
ENTRY  2 WITH MT=    4 WILL HAVE THE TRANSFER MATRICES NORMALIZED TO THE 1-D SUMS ← inelastic
ENTRY  3 WITH MT=   16 WILL HAVE THE TRANSFER MATRICES NORMALIZED TO THE 1-D SUMS ← n,2n
ENTRY  4 WITH MT=   17 WILL HAVE THE TRANSFER MATRICES NORMALIZED TO THE 1-D SUMS ← n,3n
 100000 LOCATIONS HAVE BEEN ALLOCATED TO COMET, PROVIDING A WORKING SPACE OF   99435
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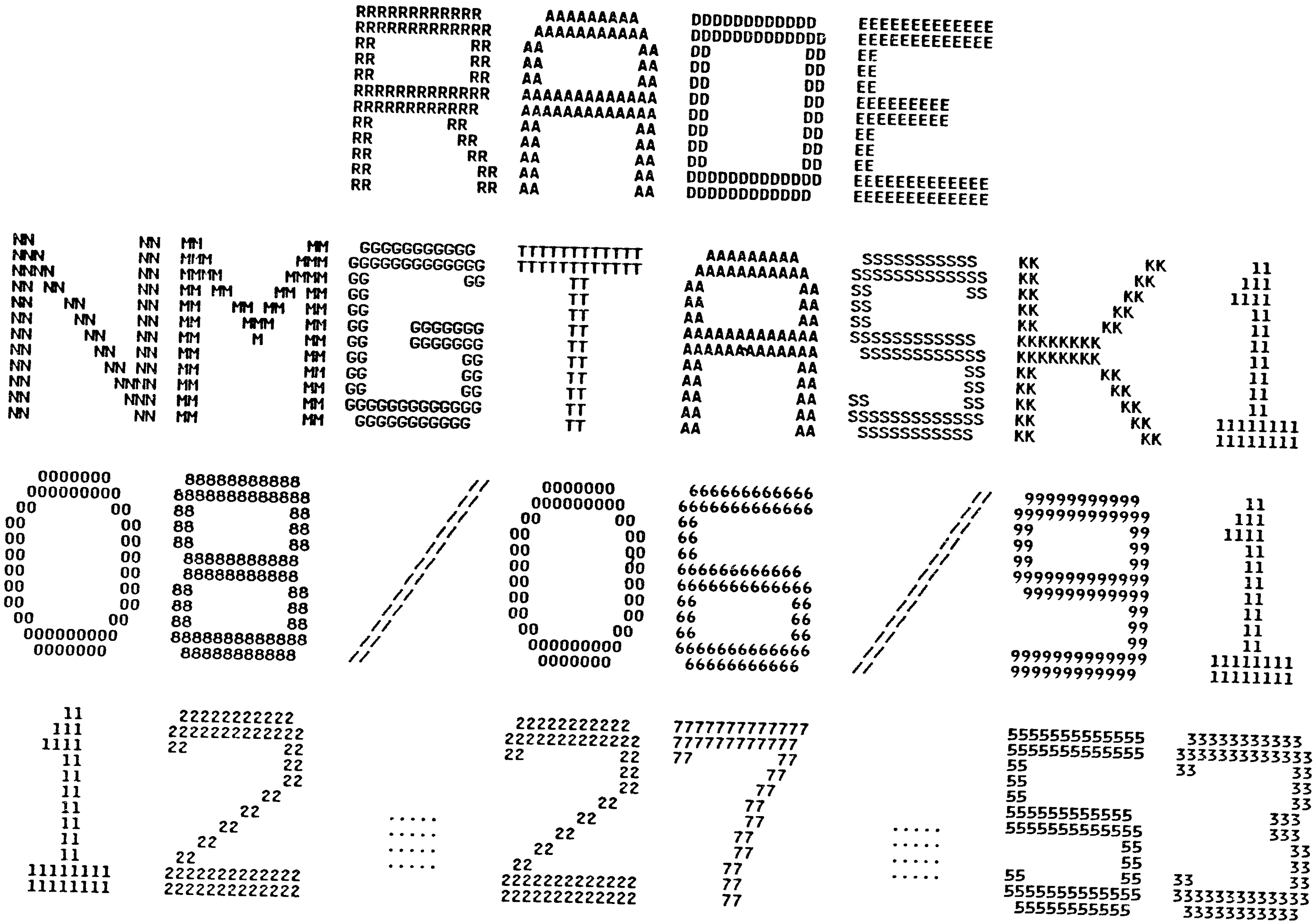

RADE

NMGTASK1

08/06/91

12:27:53

```
 CHECKING TOLERANCE= 1.00000E-03 PER CENT

AMPX NUCLIDE       6000 C-12 (GRAPHITE KERNEL AT THERMAL)
      HAS THE FOLLOWING DATA                          IS THE NUCLIDE SYMBOL       THERE ARE  159 RECORDS
    0 RESOLVED RESONANCES                      11.897 MASS(NEUTRON EQUIVALENTS)                0 BONDARENKO TEMPS
    0 UNRESOLVED RESONANCE POINTS               6000. ZA                                       0 BONDARENKO GROUPS
   41 TEMP IND 1-D NEUT PROCESSES                   0 NEUTRON WGTING OPTION                    0 ID(41) NOT USED
   21 2-D NEUT PROCESSES                            0 NEUTRON WGT ID                           0 GAMMA PROD WGT ID
    0 TEMP DEP 1-D NEUT PROCESSES                   0 GAMMA WGTING OPTION                      0 ID(43) NOT USED
    0 1-D GAMMA PROCESSES                   0.00E+00 POWER/FISSION(WATT-SEC/FIS)               0 GAMMA PROD WGTING OPTION
    0 2-D GAMMA PROCESSES                   0.00E+00 ENERGY/CAPTURE(WATT-SEC/CAP)           1306 ENDF MAT OF FAST NEUT DATA
    0 NEUT-TO-GAMMA PROCESSES                    6126 MAX 2-D LENGTH                        1065 ENDF MAT OF THERMAL NEUT DATA
  119 TOTAL 2-D ARRAYS                              0 BONDARENKO PROCESSES                     0 ENDF MAT OF GAMMA DATA
    5 MAX ORDER OF L                                0 BONDARENKO SIGMA ZEROS                   0 ENDF MAT OF GAMMA PROD DATA

THIS NUCLIDE HAS THE FOLLOWING 1-D NEUTRON PROCESSES
        1.          2.       3002.          3.          4.        102.       3102.        103.        104.        107.
      203.        204.        207.        251.        252.        253.         27.        101.       1099.       3099.
     9002.         51.         52.         53.         54.         55.         56.         57.         58.         59.
       60.         61.         62.         63.         64.         65.         66.         67.         68.         91.
     1007.

ESTIMATED RESONANCE INTEGRALS FROM "SHIELDED" VALUES

               N-GAMMA: 1.68621E-03
               FISSION: 0.00000E+00
            SCATTERING: 7.04219E+01
            ABSORPTION: 1.09614E-01
                 TOTAL: 7.09909E+01

ESTIMATED "INFINITE DILUTION" RESONANCE INTEGRALS

               N-GAMMA: 1.68768E-03
               FISSION: 0.00000E+00
            SCATTERING: 7.04739E+01
            ABSORPTION: 1.09615E-01
                 TOTAL: 7.10429E+01

2-D NEUT PROCESSES
       MT    LENGTH      ORDER      TEMPS
 1      2      1255          5          0
 2     51       508          5          0
 3     52       503          5          0
 4     53       497          5          0
 5     54       508          5          0
 6     55       522          5          0
 7     56       526          5          0
 8     57       541          5          0
 9     58       528          5          0
10     59       513          5          0
11     60       524          5          0
12     61       509          5          0
13     62       513          5          0
14     63       496          5          0
15     64       500          5          0
16     65       501          5          0
17     66       476          5          0
18     67       476          5          0
19     68       476          5          0
20     91      1053          0          0
21   1007      6126          3         10
P1 TRANSFER FROM 238 TO 204 HAS NO P0 MATCH--PROCESS--> 1007
P1 TRANSFER FROM 237 TO 204 HAS NO P0 MATCH--PROCESS--> 1007
P1 TRANSFER FROM 236 TO 204 HAS NO P0 MATCH--PROCESS--> 1007
P1 TRANSFER FROM 235 TO 204 HAS NO P0 MATCH--PROCESS--> 1007
P1 TRANSFER FROM 234 TO 204 HAS NO P0 MATCH--PROCESS--> 1007
P1 TRANSFER FROM 233 TO 204 HAS NO P0 MATCH--PROCESS--> 1007
P1 TRANSFER FROM 232 TO 204 HAS NO P0 MATCH--PROCESS--> 1007
P1 TRANSFER FROM 231 TO 204 HAS NO P0 MATCH--PROCESS--> 1007
P1 TRANSFER FROM 230 TO 204 HAS NO P0 MATCH--PROCESS--> 1007
P1 TRANSFER FROM 229 TO 204 HAS NO P0 MATCH--PROCESS--> 1007
MT=1007 P1 COEFFICIENT FOR SCATTER FROM GRP 171 TO GRP 209 IS UNREASONABLE--COEFF=  -1.345E+00
                      P1 VALUE=  -2.576E-06
                      P0 VALUE=   6.381E-07
MT=1007 P1 COEFFICIENT FOR SCATTER FROM GRP 172 TO GRP 210 IS UNREASONABLE--COEFF=  -1.948E+00
```

Messages regarding imbalances are no longer printed, though other (insignificant) problems are still flagged.

6.SAMPLE PROBLEMS.2 CREATE A MULTIGROUP COUPLED NEUTRON-GAMMA-RAY LIBRARY

In making a coupled library, one has exactly the same problems as for Task 1, discussed earlier, because a neutron library is part of the coupled library. The considerations for making the neutron-to-gamma production cross sections are exactly the same as for the neutron library, since all the "weighting" is in the neutron realm. The additional concern is that of picking a gamma group structure. The major problem is simply that of being able to find evaluations that include gamma production data for all the nuclides of interest. In Table 6.SAMPLE PROBLEMS.1, one notes, for example, that two of the nuclides have no photon production data. Similar considerations are needed to make gamma-ray interaction cross sections. Generally speaking, this is a simpler problem, or at least is treated simpler. The weighting spectrum is frequently taken to be flat, though calculational results suggest a 1/E variation is more reasonable. The group structure is selected by taking uniform bins in an MeV sense with groups added to encompass important gamma source energies for the application. The SMUG program treats only Klein-Nishina scattering, which is for scattering on a free electron. Cross sections for absorption, pair-production, etc., do not vary as a function of the isotope of a nuclide, which greatly simplifies the problem of locating gamma-ray data.

The gamma group structure used in the sample cases is a 44-group structure developed for shipping cask studies.

The procedure selected for this task is shown in Fig. 6.SAMPLE PROBLEMS.5. The neutron path is a combination of any of the procedures discussed in the previous task description. The running of the checking and fix-up modules can (and should be) used on the coupled master library.

For reasons of simple convenience, we split Task 2 into three subtasks:

1. a task to produce a master library containing only the gamma production data,
2. a task to produce a master library containing only the gamma interaction data, and
3. a task to couple the libraries from the two above subtasks with the neutron library from Task 1.

The input for Subtask 1 is shown below, followed by portions of the output.

ORNL-DWG 91Z-14375

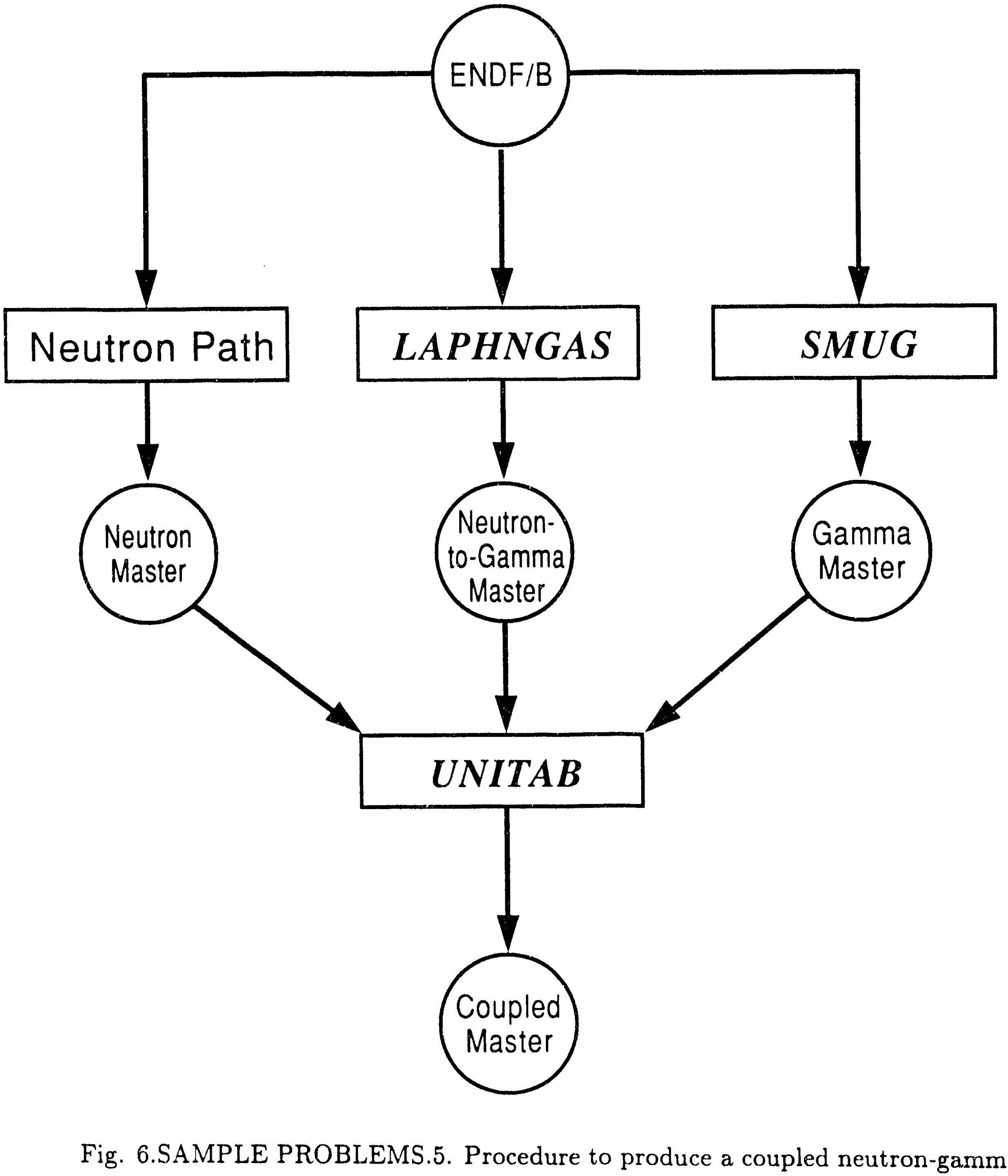

Fig. 6.SAMPLE PROBLEMS.5. Procedure to produce a coupled neutron-gamma library.

```
    AMPX MODULE LOG AND LIST OF CARD INPUT DATA
 MODULE LAPHNGAS HAS BEEN CALLED
SAMPLE PROBLEM FOR AMPX77 RELEASE
1$$ 2 238 44 3 T
T
14$$ 1306 5 E T
14$$ 1395 5 E T
 MODULE LAPHNGAS IS FINISHED.
 CPU TIME   246.25 (SECONDS).  I/O'S      0 USER CODE 0000   SYSTEM CODE 000
```

Default values will be used for most parameters.

```
LAPHNGAS

SAMPLE PROBLEM FOR AMPX77 RELEASE

    1$ ARRAY      4 ENTRIES READ

    0T

INTEGER PARAMETERS (1$ AND 2$ ARRAYS)
MCR    NUMBER OF NUCLIDES                              2
NFG    NO. NEUT FINE GPS.                            238
NGG    NO. GAMMA GPS.                                 44
IM     NON RES WT. FUNCTION 1/2/3/4/5/6 -
       1.0/(1/E)/(1/E-FISS)/EXACT (1/E)/
       (1/E*SIG-T)/ARBITRARY/                          3
LCSM   NO. INTERPOLATION REGIONS                       0
MCSM   NO. PTS. IN ARB. WT. FCTN.                      0
IZM    0/1 CAL SGRPXS/CAL SGREPXS                      0
MS     0/1 NO EFF/MAXWELLIAN THERMAL DIST              1
MM     NO. REACTION TYPES                              1
IWO    1/2/3 MIDPOINT/YIELD FCT/E(BAR) INPUT           1
IOO    0/1 PRINT (Y OR SIG)/DO NOT PRINT              -9
IAM    0/1 NO EFFECT/PUNCH SGRP DATA                   0
ICK    0/1 NO EFFECT/DETAIL CK.                        0
NNBDGP 0/N NO EFFECT/COLLAPSE TO N BROAD GPS.          0
A NEUTRON ENERGY STRUCTURE FOR 238 GROUPS HAS BEEN INSERTED AND WILL BE USED UNLESS YOU OVERRIDE IT--VERSION 0

A   GAMMA ENERGY STRUCTURE FOR  44 GROUPS HAS BEEN INSERTED AND WILL BE USED UNLESS YOU OVERRIDE IT--VERSION 0

    0T

MEAN TEMPERATURE OF MAXWELLIAN DISTRIBUTION (DEG K)    2.93600E+02

UPPER ENERGY FOR THERMAL (N,G) CORRECTION (EV)    1.26390E-01

NON 1/V FACTOR    1.00000E+00
```

```
MATERIAL                                                   1306<——— Graphite
IQA     ORDER P(N)                                            5
NDFB    LOG. UNIT FOR ENDF DATA                              11
MODE    1/2 ENDF BINARY/BCD                                   1
REACTION TYPES
  -1
NDFTYP    ENDF/B VERSION 4/5                                  5

UNDER THE OPTION PROVIDED WHEN INPUT MT=-1 IS USED, THERE WILL BE    2 REACTION TYPES USED AS FOLLOWS -
 102  51
    1      102           102
    2       51             1
    3                      0
FILE  3     6.0000E+03     1.1897E+01     0     0     0     0   1306     3     1
FILE 12     6.0000E+03     1.1897E+01     1     0     3     0   1306    12   102
FILE 13     6.0000E+03     1.1897E+01     0     0     1     0   1306    13    51
FILE 14     6.0000E+03     1.1897E+01     0     1     1     0   1306    14    51
READ/COPY ENDF/B MASTER LIBRARY COMPLETE FILES PROC.     3    12    13    14

FOR MAT  1306 THE FOLLOWING MT NO.S HAD ANISOTROPIC FILE 14 DATA
    51

THE NUMBER OF POINTS FOR SIGT + THE NUMBER OF NEUTRON GROUPS =       2486
THE NUMBER OF POINTS ASSIGNED WAS       7000

  2486 POINT NEUTRON ENERGIES PROCESSED
MATT        0      0      0   2486    119     5      0      0      0   42847   65231   100000   2486
SPOT 3         5     44    238    723     1   42843  61774                                           1
```

Sum of all processes

```
           **********          ***********
  THE PHOTON PRODUCTION MATRIX, MATERIAL  1306 REACTION TYPE   1 P  0 COMPONENT

 G GP    N GP  1       N GP  2       N GP  3       N GP  4       N GP  5       N GP  6       N GP  7       N GP  8
     1   6.38641E-05   6.42281E-05   1.61017E-04   1.22653E-04   5.76224E-05   5.04287E-05   0.00000E+00   0.00000E+00
     2   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   2.71164E-05   0.00000E+00   7.42618E-05   0.00000E+00
     3   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   2.37311E-05   0.00000E+00   5.56577E-05
     4   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   3.49471E-05   2.61917E-05
     5   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
         G GP    6 THRU G GP    11 SAME AS ABOVE
    12   9.45159E-02   1.26746E-01   1.65652E-01   1.83109E-01   2.05101E-01   3.06468E-01   2.97280E-01   2.50287E-01
    13   6.38641E-05   6.42281E-05   5.15256E-05   3.92490E-05   2.71164E-05   2.37311E-05   3.49471E-05   2.61917E-05
    14   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
         G GP   15 THRU G GP    44 SAME AS ABOVE

 G GP    N GP  9       N GP 10       N GP 11       N GP 12       N GP 13       N GP 14       N GP 15       N GP 16
     1   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
     2   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
     3   2.45183E-05   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
     4   0.00000E+00   1.69760E-05   1.22078E-05   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
     5   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
     6   0.00000E+00   0.00000E+00   0.00000E+00   8.13527E-06   6.32305E-06   0.00000E+00   0.00000E+00   0.00000E+00
     7   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   4.31378E-06   0.00000E+00   0.00000E+00
     8   1.15380E-05   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   2.75393E-06   2.09221E-06
     9   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
    10   0.00000E+00   7.98873E-06   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
    11   0.00000E+00   0.00000E+00   5.74480E-06   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
    12   1.22637E-01   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
    13   1.15380E-05   7.98873E-06   5.74480E-06   7.65668E-06   2.97555E-06   2.03002E-06   1.29597E-06   9.84567E-07
    14   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   2.97555E-06   2.03002E-06   0.00000E+00   0.00000E+00
    15   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   1.29597E-06   9.84567E-07
    16   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
         G GP   17 THRU G GP    44 SAME AS ABOVE

 G GP    N GP 17       N GP 18       N GP 19       N GP 20       N GP 21       N GP 22       N GP 23       N GP 24
     1   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
         G GP    2 THRU G GP     7 SAME AS ABOVE
     8   1.87516E-06   1.74961E-06   1.58882E-06   1.41195E-06   1.18421E-06   0.00000E+00   0.00000E+00   0.00000E+00
     9   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   9.24313E-07   8.57741E-07   8.36792E-07
    10   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
         G GP   11 THRU G GP    12 SAME AS ABOVE
    13   8.82428E-07   8.23346E-07   7.47682E-07   6.64449E-07   5.57277E-07   4.34972E-07   4.03643E-07   3.93784E-07
    14   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
    15   8.82428E-07   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
    16   0.00000E+00   8.23346E-07   7.47682E-07   6.64449E-07   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
    17   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   5.57277E-07   4.34972E-07   4.03643E-07   0.00000E+00
    18   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   3.93784E-07
    19   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
         G GP   20 THRU G GP    44 SAME AS ABOVE

 G GP    N GP 25       N GP 26       N GP 27       N GP 28       N GP 29       N GP 30       N GP 31       N GP 32
     1   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
         G GP    2 THRU G GP     8 SAME AS ABOVE
     9   8.28180E-07   8.20764E-07   8.10217E-07   7.88966E-07   7.62010E-07   7.46733E-07   7.31624E-07   0.00000E+00
    10   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   7.13066E-07
    11   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
    12   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
    13   3.89732E-07   3.86242E-07   3.81279E-07   3.71279E-07   3.58593E-07   3.51404E-07   3.44295E-07   3.35560E-07
    14   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
         G GP   15 THRU G GP    17 SAME AS ABOVE
    18   3.89732E-07   3.86242E-07   3.81279E-07   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
    19   0.00000E+00   0.00000E+00   0.00000E+00   3.71279E-07   3.58593E-07   3.51404E-07   3.44295E-07   3.35560E-07
    20   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
         G GP   21 THRU G GP    44 SAME AS ABOVE

 G GP    N GP 33       N GP 34       N GP 35       N GP 36       N GP 37       N GP 38       N GP 39       N GP 40
     1   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
         G GP    2 THRU G GP     9 SAME AS ABOVE
    10   7.03520E-07   6.89475E-07   6.77409E-07   6.72354E-07   6.68095E-07   6.64708E-07   6.57082E-07   6.46039E-07
    11   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
    12   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
    13   3.31068E-07   3.24459E-07   3.18781E-07   3.16402E-07   3.14398E-07   3.12804E-07   3.09216E-07   3.04019E-07
    14   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00
         G GP   15 THRU G GP    19 SAME AS ABOVE
  11  1.05214E-02  1.15651E-02  1.30222E-02  1.46768E-02  2.08014E-02  4.79360E-02
  12  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
  13  4.95124E-03  5.44238E-03  6.12809E-03  6.90672E-03  9.78888E-03  2.25581E-02
  14  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
      G GP   15 THRU G GP   24 SAME AS ABOVE
  25  4.95124E-03  5.44238E-03  6.12809E-03  6.90672E-03  9.78888E-03  2.25581E-02
  26  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
      G GP   27 THRU G GP   44 SAME AS ABOVE

THE PHOTON PRODUCTION MATRIX, MATERIAL  1306 REACTION TYPE   1 P  1 COMPONENT
          ALL ZERO

THE PHOTON PRODUCTION MATRIX, MATERIAL  1306 REACTION TYPE   1 P  2 COMPONENT

G GP  N GP  1      N GP  2      N GP  3      N GP  4      N GP  5      N GP  6      N GP  7      N GP  8
   1  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
      G GP    2 THRU G GP   11 SAME AS ABOVE
  12  5.21263E-02  7.55714E-02  1.06153E-01  1.25061E-01  1.52392E-01  2.60918E-01  2.32297E-01  7.71385E-02
  13  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
      G GP   14 THRU G GP   44 SAME AS ABOVE

G GP  N GP  9      N GP 10      N GP 11      N GP 12      N GP 13      N GP 14      N GP 15      N GP 16
   1  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
      G GP    2 THRU G GP   11 SAME AS ABOVE
  12  1.40904E-01  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
  13  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
      G GP   14 THRU G GP   44 SAME AS ABOVE

G GP  N GP 17      N GP 18      N GP 19      N GP 20      N GP 21      N GP 22      N GP 23      N GP 24
   1  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
      G GP    2 THRU G GP   44 SAME AS ABOVE

G GP  N GP 25      N GP 26      N GP 27      N GP 28      N GP 29      N GP 30      N GP 31      N GP 32
   1  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
      G GP    2 THRU G GP   44 SAME AS ABOVE

G GP  N GP 33      N GP 34      N GP 35      N GP 36      N GP 37      N GP 38      N GP 39      N GP 40
   1  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
      G GP    2 THRU G GP   44 SAME AS ABOVE

G GP  N GP 41      N GP 42      N GP 43      N GP 44      N GP 45      N GP 46      N GP 47      N GP 48
   1  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
      G GP    2 THRU G GP   44 SAME AS ABOVE

G GP  N GP 49      N GP 50      N GP 51      N GP 52      N GP 53      N GP 54      N GP 55      N GP 56
   1  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
      G GP    2 THRU G GP   44 SAME AS ABOVE

G GP  N GP 57      N GP 58      N GP 59      N GP 60      N GP 61      N GP 62      N GP 63      N GP 64
   1  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
      G GP    2 THRU G GP   44 SAME AS ABOVE

G GP  N GP 65      N GP 66      N GP 67      N GP 68      N GP 69      N GP 70      N GP 71      N GP 72
   1  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
      G GP    2 THRU G GP   44 SAME AS ABOVE

G GP  N GP 73      N GP 74      N GP 75      N GP 76      N GP 77      N GP 78      N GP 79      N GP 80
   1  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
      G GP    2 THRU G GP   44 SAME AS ABOVE

G GP  N GP 81      N GP 82      N GP 83      N GP 84      N GP 85      N GP 86      N GP 87      N GP 88
   1  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
      G GP    2 THRU G GP   44 SAME AS ABOVE

G GP  N GP 89      N GP 90      N GP 91      N GP 92      N GP 93      N GP 94      N GP 95      N GP 96
   1  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
      G GP    2 THRU G GP   44 SAME AS ABOVE

G GP  N GP 97      N GP 98      N GP 99      N GP100      N GP101      N GP102      N GP103      N GP104
   1  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
      G GP    2 THRU G GP   44 SAME AS ABOVE

G GP  N GP105      N GP106      N GP107      N GP108      N GP109      N GP110      N GP111      N GP112
   1  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
      G GP    2 THRU G GP   44 SAME AS ABOVE
```

Gamma Production is an "even" function

```
THE PHOTON PRODUCTION MATRIX, MATERIAL  1306 REACTION TYPE 102 P  0 COMPONENT
THE PHOTON PRODUCTION MATRIX, MATERIAL  1306 REACTION TYPE 102 P  1 COMPONENT
THE PHOTON PRODUCTION MATRIX, MATERIAL  1306 REACTION TYPE 102 P  2 COMPONENT
THE PHOTON PRODUCTION MATRIX, MATERIAL  1306 REACTION TYPE 102 P  3 COMPONENT
THE PHOTON PRODUCTION MATRIX, MATERIAL  1306 REACTION TYPE 102 P  4 COMPONENT
THE PHOTON PRODUCTION MATRIX, MATERIAL  1306 REACTION TYPE 102 P  5 COMPONENT
THE PHOTON PRODUCTION MATRIX, MATERIAL  1306 REACTION TYPE  51 P  0 COMPONENT
THE PHOTON PRODUCTION MATRIX, MATERIAL  1306 REACTION TYPE  51 P  1 COMPONENT
THE PHOTON PRODUCTION MATRIX, MATERIAL  1306 REACTION TYPE  51 P  2 COMPONENT
THE PHOTON PRODUCTION MATRIX, MATERIAL  1306 REACTION TYPE  51 P  3 COMPONENT
THE PHOTON PRODUCTION MATRIX, MATERIAL  1306 REACTION TYPE  51 P  4 COMPONENT
THE PHOTON PRODUCTION MATRIX, MATERIAL  1306 REACTION TYPE  51 P  5 COMPONENT

THE FOLLOWING SGR DATA ON IAMPX
MT TYPE,NO. ENTRIES,PN,1/0 SGRPXS/YIELDS
   1     102           803           5          1
   2      51            10           5          1

MATERIAL     1306 REQUIRED       7 SECONDS

PERCENT OF THE ABOVE TIME SPENT IN THE VARIOUS SUBROUTINES
SUBROUTINE  PERCENT

   LAPH      85.714
   ALAN      14.286
   PR15       0.000
   MATT      57.143
   TRC2       0.000
   XSEC      42.857
   NATRIX    14.286
   MUSH       0.000

LAPH CALLS ALAN AND MATT.  ALAN CALLS MUSH AND PR15.  MATT CALLS TRC2, XSEC, AND NATRIX.

MAXIMUM LIMIT REQUIRED   65232 --- LIMIT ALLOCATED  100000
```

Master file contains data for (n,γ) and 1st level inelastic

```
MATERIAL                                            1395 ←— Uranium-235
IQA    ORDER P(N)                                      5
NDFB   LOG. UNIT FOR ENDF DATA                        11
MODE   1/2 ENDF BINARY/BCD                             1
REACTION TYPES
  -1
NDFTYP   ENDF/B VERSION 4/5                            5

 1395  IS A RESONANCE MATERIAL
UNDER THE OPTION PROVIDED WHEN INPUT MT=-1 IS USED, THERE WILL BE    4 REACTION TYPES USED AS FOLLOWS -
   4  18 102   3
    1      4          102
    2     18           18
    3    102            4
    4      3            3
    5                   0
FILE  3      9.2235E+04      2.3302E+02       0       0       0       0    1395       3       1
FILE 12      9.2235E+04      2.3302E+02       1       0      30       0    1395      12       4
FILE 13      9.2235E+04      2.3302E+02       0       0       1       0    1395      13       3
FILE 14      9.2235E+04      2.3302E+02       1       0       1       0    1395      14       3
FILE 15      9.2235E+04      2.3302E+02       0       0       1       0    1395      15       3
READ/COPY ENDF/B MASTER LIBRARY COMPLETE FILES PROC.     3    12    13    14    15

USER REQUESTED P- 5 CALCULATION.  HOWEVER, ALL FILE 14 DATA ARE FOR ISOTROPIC DISTRIBUTIONS.
THUS, IQA IS RESET TO 0 FOR REMAINDER OF LAPHNGAS CALCULATIONS FOR THIS MATERIAL.

THE NUMBER OF POINTS FOR SIGT + THE NUMBER OF NEUTRON GROUPS =       3672
THE NUMBER OF POINTS ASSIGNED WAS        7000

  3672 POINT NEUTRON ENERGIES PROCESSED
SPOT 3          0        44        238       1000        19     42843     59267
```

```
          **********          ***********
THE RESONANCE CAPTURE YIELD MATRIX, MATERIAL  1395 P  0 COMPONENT
        ***************

THE PHOTON PRODUCTION MATRIX, MATERIAL  1395 REACTION TYPE   3 P  0 COMPONENT

THE FOLLOWING SGR DATA ON IAMPX
MT TYPE,NO. ENTRIES,PN,1/0 SGRPXS/YIELDS
   1        4          269          0          1
   2       18         8938          0          0
   3      102         8320          0          0
   4        3          864          0          1

MATERIAL     1395 REQUIRED    237 SECONDS

PERCENT OF THE ABOVE TIME SPENT IN THE VARIOUS SUBROUTINES
SUBROUTINE  PERCENT

   LAPH      98.734
   ALAN      10.549
   PR15       9.705
   MATT      88.186
   TRC2       0.000
   XSEC      85.232
   NATRIX     2.954
   MUSH       0.422

LAPH CALLS ALAN AND MATT.  ALAN CALLS MUSH AND PR15.  MATT CALLS TRC2, XSEC, AND NATRIX.

MAXIMUM LIMIT REQUIRED   65232 --- LIMIT ALLOCATED  100000

PHOTON TIME -   245 SECONDS
```

U-235 has data on inelastic,
fission, (n,γ) and a
"catch-all" (MT=3) category

The input for Subtask 2 is shown on the following pages, followed by portions of the output.

```
    AMPX MODULE LOG AND LIST OF CARD INPUT DATA

 MODULE SMUG     HAS BEEN CALLED

SAMPLE PROBLEM FOR AMPX77 RELEASE
1$$ 44 2 5 2$$ 2 E T
T
10$$     6 0 40 1 -1 T
10$$    92 0 40 1 -1 T

 MODULE SMUG     IS FINISHED.
 CPU TIME    10.74 (SECONDS).  I/O'S       0 USER CODE 0000   SYSTEM CODE 000
```

Gamma Evaluations use "Z" for the MAT

```
                                 SSSSSSSSSSS    MM         MM   UU         UU    GGGGGGGGGGG
                                SSSSSSSSSSSSS   MMM       MMM   UU         UU   GGGGGGGGGGGGG
                                SS         SS   MMMM     MMMM   UU         UU   GG         GG
                                SS              MM MM   MM MM   UU         UU   GG
                                SS              MM  MM MM  MM   UU         UU   GG
                                SSSSSSSSSSSS    MM   MMM   MM   UU         UU   GG     GGGGGG
                                 SSSSSSSSSSSS   MM    M    MM   UU         UU   GG     GGGGGG
                                           SS   MM         MM   UU         UU   GG         GG
                                           SS   MM         MM   UU         UU   GG         GG
                                SS         SS   MM         MM   UU         UU   GG         GG
                                SSSSSSSSSSSSS   MM         MM   UUUUUUUUUUUUU   GGGGGGGGGGGGG
                                 SSSSSSSSSSS    MM         MM    UUUUUUUUUUU     GGGGGGGGGGG

NN         NN   MM         MM    GGGGGGGGGGG    TTTTTTTTTTTT     SSSSSSSSSSS    KK         KK    22222222222    BBBBBBBBBBBB
NNN        NN   MMM       MMM   GGGGGGGGGGGGG   TTTTTTTTTTTT    SSSSSSSSSSSSS   KK        KK    2222222222222   BBBBBBBBBBBBB
NNNN       NN   MMMM     MMMM   GG         GG        TT         SS         SS   KK       KK     22         22   BB         BB
NN NN      NN   MM MM   MM MM   GG                   TT         SS              KK      KK                 22   BB         BB
NN  NN     NN   MM  MM MM  MM   GG                   TT         SS              KK     KK                  22   BB         BB
NN   NN    NN   MM   MMM   MM   GG     GGGGGG        TT         SSSSSSSSSSSS    KKKKKKKK                  22    BBBBBBBBBBBB
NN    NN   NN   MM    M    MM   GG     GGGGGG        TT          SSSSSSSSSSSS   KKKKKKKK                22      BBBBBBBBBBBB
NN     NN  NN   MM         MM   GG         GG        TT                    SS   KK     KK             22        BB         BB
NN      NN NN   MM         MM   GG         GG        TT                    SS   KK      KK          22          BB         BB
NN       NNNN   MM         MM   GG         GG        TT         SS         SS   KK       KK       22            BB         BB
NN        NNN   MM         MM   GGGGGGGGGGGGG        TT         SSSSSSSSSSSSS   KK        KK    2222222222222   BBBBBBBBBBBBB
NN         NN   MM         MM    GGGGGGGGGGG         TT          SSSSSSSSSSS    KK         KK   2222222222222   BBBBBBBBBBBB

   0000000      7777777777777               //   33333333333       0000000                  //   99999999999          11
  000000000     777777777777               //   3333333333333     000000000                //   9999999999999        111
 00       00    77        77              //    33         33    00       00              //    99         99       1111
00         00            77              //                33   00         00            //     99         99         11
00         00           77              //                 33   00         00           //      99         99         11
00         00          77              //                333    00         00          //       9999999999999         11
00         00          77             //                 333    00         00         //         999999999999         11
00         00         77             //                    33   00         00        //                     99         11
00         00         77            //                     33   00         00       //                      99         11
 00       00          77           //           33         33    00       00       //                       99         11
  000000000          77          //            3333333333333     000000000       //            9999999999999      11111111
   0000000           77         //              33333333333       0000000       //             999999999999       11111111

      11        5555555555555                    33333333333    5555555555555                    33333333333          11
     111        5555555555555                   3333333333333   5555555555555                   3333333333333        111
    1111        55                              33         33   55                              33         33       1111
      11        55                                         33   55                                         33         11
      11        55                                         33   55                                         33         11
      11        555555555555                             333    555555555555                             333          11
      11        5555555555555                            333    5555555555555                            333          11
      11                   55                              33              55                              33         11
      11                   55        :::::                 33              55        :::::                 33         11
      11        55         55        :::::      33         33   55         55        :::::      33         33         11
   11111111     5555555555555                   3333333333333   5555555555555                   3333333333333      11111111
   11111111      55555555555                     33333333333     55555555555                     33333333333       11111111
```

```
    1$ ARRAY      3 ENTRIES READ

    2$ ARRAY      8 ENTRIES READ

    OT

================================================================================
LOGICAL 26 (OUTPUT MASTER LIBRARY)
DATASET NAME: SYS91211.T153513.RA000.NMGTSK2B.R0000024
      VOLUME: SYSSA2
================================================================================
SAMPLE PROBLEM FOR AMPX77 RELEASE

NGG     NO. GAMMA GROUPS                                 44
MF      1/2/6 FLAT/1/E/FLUX IN 7*                         2
LMAX    ORDER OF P-N                                      5
NUF     0/1/2 ENERGY/PHOTON NUMBER/1-COMPTON ONLY         1
NSP     NO. INTERVALS IN OUTER INTEGRAL                  31
NPHI    NO. INTERVALS IN INNER INTEGRAL                  51
NNUC    NO. NUCLIDES                                      2
NDS     NO. DOWNSCATTERS REQD                            43
MX      0/2 BINARY/BCD TAPE                               0
NDF     0/1/2 NO EFF/PRINT DOSE FACT/PRINT AND PUN        1

A    GAMMA ENERGY STRUCTURE FOR  44 GROUPS HAS BEEN INSERTED AND WILL BE USED UNLESS YOU OVERRIDE IT--VERSION 0

    OT
```

← SMUG uses double Simpson's Integration

```
                          PHOTON CROSS SECTIONS

E(N)                        ENERGY LEVELS← Group Limits in MeV

    0.9999998E-02    0.2000000E-01    0.3000000E-01    0.4500000E-01
    0.6000000E-01    0.6999999E-01    0.7499999E-01    0.9999996E-01
    0.1500000E+00    0.2000000E+00    0.3000000E+00    0.4000000E+00
    0.4500000E+00    0.5100000E+00    0.5120000E+00    0.6000000E+00
    0.7000000E+00    0.8000000E+00    0.1000000E+01    0.1200000E+01
    0.1330000E+01    0.1440000E+01    0.1500000E+01    0.1570000E+01
    0.1660000E+01    0.1799999E+01    0.2000000E+01    0.2150000E+01
    0.2349999E+01    0.2500000E+01    0.3000000E+01    0.3500000E+01
    0.4000000E+01    0.4500000E+01    0.5000000E+01    0.5500000E+01
    0.6000000E+01    0.6500000E+01    0.7000000E+01    0.7500000E+01
    0.8000000E+01    0.1000000E+02    0.1200000E+02    0.1400000E+02
    0.2000000E+02

                     AVERAGE 1/E FOR ENERGY BAND

    0.7213528E+02    0.4110546E+02    0.2740342E+02    0.1931149E+02
    0.1544565E+02    0.1380410E+02    0.1158692E+02    0.8221055E+01
    0.5793471E+01    0.4110538E+01    0.2896745E+01    0.2358404E+01
    0.2088792E+01    0.1956960E+01    0.1806119E+01    0.1544564E+01
    0.1337301E+01    0.1120357E+01    0.9141391E+00    0.7919109E+00
    0.7227847E+00    0.6804634E+00    0.6516941E+00    0.6195181E+00
    0.5786692E+00    0.5272934E+00    0.4823499E+00    0.4450336E+00
    0.4126367E+00    0.3656562E+00    0.3089146E+00    0.2674618E+00
    0.2358405E+00    0.2109178E+00    0.1907663E+00    0.1741342E+00
    0.1601722E+00    0.1482851E+00    0.1380415E+00    0.1291226E+00
    0.1120359E+00    0.9141371E-01    0.7722822E-01    0.6007893E-01

SG(N)                          COLLISION

    0.6301487E-24    0.6080913E-24    0.5841696E-24    0.5579442E-24
    0.5381962E-24    0.5273030E-24    0.5084973E-24    0.4684422E-24
    0.4250039E-24    0.3798121E-24    0.3348565E-24    0.3092328E-24
    0.2942797E-24    0.2864466E-24    0.2767615E-24    0.2585151E-24
    0.2422624E-24    0.2228989E-24    0.2018658E-24    0.1877406E-24
    0.1790248E-24    0.1734034E-24    0.1694340E-24    0.1648499E-24
    0.1587899E-24    0.1507554E-24    0.1433246E-24    0.1367991E-24
    0.1308678E-24    0.1216821E-24    0.1097148E-24    0.1001750E-24
    0.9235732E-25    0.8581257E-25    0.8023947E-25    0.7542730E-25
    0.7122330E-25    0.6751453E-25    0.6421443E-25    0.6125645E-25
    0.5531651E-25    0.4770832E-25    0.4210172E-25    0.3478516E-25

   10$ ARRAY       5 ENTRIES READ

    0T
```

```
SAMPLE PROBLEM FOR AMPX77 RELEASE

LANO   NUCLIDE ATOMIC NUMBER                        6 ← Carbon
LEMNO  ENDF/B MATERIAL NUMBER                       6
LPUN   0/1 NO EFFECT/PUNCH X-SECTS                 -1
LORDER ORDER PL TO BE PRINTED                       1
```

```
THE KERMA FACTOR AND ITS COMPONENTS PAIR PRODUCTION  PHOTOELECTRIC COMPTON ABSORPTION
  1     4.42955E+00    1.92569E+00    9.66498E-06    2.50385E+00
  2     3.50532E+00    1.20979E+00    9.85975E-06    2.29552E+00
  3     3.06074E+00    8.96717E-01    1.00067E-05    2.16402E+00
  4     2.62075E+00    6.13847E-01    1.02155E-05    2.00689E+00
  5     2.34425E+00    4.51707E-01    1.04020E-05    1.89253E+00
  6     2.23212E+00    3.90887E-01    1.05074E-05    1.84122E+00
  7     2.12098E+00    3.34466E-01    1.06216E-05    1.78650E+00
  8     2.01036E+00    2.82439E-01    1.07459E-05    1.72791E+00
  9     1.89788E+00    2.33005E-01    1.09009E-05    1.66486E+00
 10     1.78359E+00    1.86913E-01    1.10921E-05    1.59666E+00
 11     1.66730E+00    1.44877E-01    1.13300E-05    1.52242E+00
 12     1.54856E+00    1.07561E-01    1.16257E-05    1.44098E+00
 13     1.42569E+00    7.47893E-02    1.20209E-05    1.35089E+00
 14     1.29778E+00    4.76214E-02    1.25472E-05    1.25015E+00
 15     1.16198E+00    2.59201E-02    1.33411E-05    1.13605E+00
 16     1.06873E+00    1.49943E-02    1.40632E-05    1.05373E+00
 17     1.01637E+00    1.08455E-02    1.45196E-05    1.00551E+00
 18     9.62189E-01    7.52009E-03    1.50270E-05    9.54654E-01
 19     9.05028E-01    4.44973E-03    1.57456E-05    9.00563E-01
 20     8.47172E-01    2.27263E-03    1.66527E-05    8.44883E-01
 21     8.06545E-01    1.36054E-03    1.73515E-05    8.05168E-01
 22     7.77399E-01    9.20900E-04    1.78874E-05    7.76460E-01
 23     7.52967E-01    5.02703E-04    1.84518E-05    7.52446E-01
 24     7.20147E-01    1.42454E-04    1.94188E-05    7.19985E-01
 25     6.72244E-01    1.85367E-05    2.09836E-05    6.72204E-01
 26     6.02134E-01    8.13539E-07    2.36730E-05    6.02110E-01
 27     5.09917E-01    0.00000E+00    2.90042E-05    5.09889E-01
 28     4.34950E-01    0.00000E+00    3.61283E-05    4.34914E-01
 29     3.81503E-01    0.00000E+00    4.40510E-05    3.81459E-01
 30     3.28714E-01    0.00000E+00    5.56509E-05    3.28659E-01
 31     3.02605E-01    0.00000E+00    6.34415E-05    3.02541E-01
 32     2.84152E-01    0.00000E+00    7.08924E-05    2.84081E-01
 33     2.50789E-01    0.00000E+00    8.79802E-05    2.50701E-01
 34     2.03740E-01    0.00000E+00    1.29548E-04    2.03611E-01
 35     1.38885E-01    0.00000E+00    2.65544E-04    1.38619E-01
 36     8.95011E-02    0.00000E+00    5.65733E-04    8.89354E-02
 37     5.76854E-02    0.00000E+00    1.24960E-03    5.64358E-02
 38     3.62213E-02    0.00000E+00    2.78051E-03    3.34407E-02
 39     2.91570E-02    0.00000E+00    4.20644E-03    2.49505E-02
 40     2.64488E-02    0.00000E+00    5.46450E-03    2.09843E-02
 41     2.40312E-02    0.00000E+00    9.17765E-03    1.48535E-02
 42     2.91575E-02    0.00000E+00    2.06403E-02    8.51725E-03
 43     5.71759E-02    0.00000E+00    5.27060E-02    4.46999E-03
 44     1.88175E-01    0.00000E+00    1.85319E-01    2.85601E-03


                               PHOTON INTERACTION CROSS SECTIONS
GROUP          GROUP LIMITS (MEV)          SIG ABS        SIG PE         SIG PP       ENERGY DEP

  1       1.40000E+01    2.00000E+01    1.18976E-01    5.81459E-07    1.18975E-01    4.42955E+00
  2       1.20000E+01    1.40000E+01    1.00694E-01    7.61717E-07    1.00693E-01    3.50532E+00
  3       1.00000E+01    1.20000E+01    8.94870E-02    9.15198E-07    8.94861E-02    3.06074E+00
  4       8.00000E+00    1.00000E+01    7.63484E-02    1.14560E-06    7.63472E-02    2.62075E+00
  5       7.50000E+00    8.00000E+00    6.70693E-02    1.34328E-06    6.70680E-02    2.34425E+00
  6       7.00000E+00    7.50000E+00    6.26898E-02    1.45063E-06    6.26884E-02    2.23212E+00
  7       6.50000E+00    7.00000E+00    5.83139E-02    1.57523E-06    5.83123E-02    2.12098E+00
  8       6.00000E+00    6.50000E+00    5.39413E-02    1.72146E-06    5.39396E-02    2.01036E+00
  9       5.50000E+00    6.00000E+00    4.91807E-02    1.89866E-06    4.91788E-02    1.89788E+00
 10       5.00000E+00    5.50000E+00    4.41001E-02    2.11659E-06    4.40979E-02    1.78359E+00
 11       4.50000E+00    5.00000E+00    3.87304E-02    2.39071E-06    3.87280E-02    1.66730E+00
 12       4.00000E+00    4.50000E+00    3.31801E-02    2.74325E-06    3.31774E-02    1.54856E+00
 13       3.50000E+00    4.00000E+00    2.72304E-02    3.21797E-06    2.72272E-02    1.42569E+00
 14       3.00000E+00    3.50000E+00    2.11784E-02    3.88058E-06    2.11745E-02    1.29778E+00
 15       2.50000E+00    3.00000E+00    1.47161E-02    4.88974E-06    1.47112E-02    1.16198E+00
 16       2.35000E+00    2.50000E+00    1.06542E-02    5.80455E-06    1.06483E-02    1.06873E+00
 17       2.15000E+00    2.35000E+00    8.78182E-03    6.46532E-06    8.77536E-03    1.01637E+00
 18       2.00000E+00    2.15000E+00    7.11014E-03    7.25094E-06    7.10289E-03    9.62189E-01
 19       1.80000E+00    2.00000E+00    4.99504E-03    8.31170E-06    4.98673E-03    9.05028E-01
 20       1.66000E+00    1.80000E+00    3.18203E-03    9.64265E-06    3.17239E-03    8.47172E-01
 21       1.57000E+00    1.66000E+00    2.28698E-03    1.07528E-05    2.27623E-03    8.06545E-01
 22       1.50000E+00    1.57000E+00    1.79393E-03    1.16594E-05    1.78227E-03    7.77399E-01
```

These came from the ENDF Evaluation

```
SAMPLE PROBLEM FOR AMPX77 RELEASE

LANO   NUCLIDE ATOMIC NUMBER                               92
LEMNO  ENDF/B MATERIAL NUMBER                              92
LPUN   0/1 NO EFFECT/PUNCH X-SECTS                         -1
LORDER ORDER PL TO BE PRINTED                               1
```

← Uranium

```
GROUP  DOSE FACTORS

                UNITS
  HENDERSON--RADS/HR PER PHOTONS/CM**2/SEC
  SILICON  --RADS/SEC PER PHOTONS/CM**2/SEC
  HCC/DKT  --RADS/HR  PER PHOTONS/CM**2/SEC

        HENDERSON        SILICON        HCC/DKT
****** DATA OUT OF RANGE FOR   2.0000E+01 MEV
****** DATA OUT OF RANGE FOR   2.0000E+01 MEV
****** DATA OUT OF RANGE FOR   1.5031E+01 MEV
****** DATA OUT OF RANGE FOR   1.5031E+01 MEV
****** DATA OUT OF RANGE FOR   1.5125E+01 MEV
****** DATA OUT OF RANGE FOR   1.5125E+01 MEV
****** DATA OUT OF RANGE FOR   1.5219E+01 MEV
****** DATA OUT OF RANGE FOR   1.5219E+01 MEV
****** DATA OUT OF RANGE FOR   1.5313E+01 MEV
****** DATA OUT OF RANGE FOR   1.5313E+01 MEV
****** DATA OUT OF RANGE FOR   1.5406E+01 MEV
****** DATA OUT OF RANGE FOR   1.5406E+01 MEV
****** DATA OUT OF RANGE FOR   1.5500E+01 MEV
****** DATA OUT OF RANGE FOR   1.5500E+01 MEV
****** DATA OUT OF RANGE FOR   1.5594E+01 MEV
****** DATA OUT OF RANGE FOR   1.5594E+01 MEV
****** DATA OUT OF RANGE FOR   1.5688E+01 MEV
****** DATA OUT OF RANGE FOR   1.5688E+01 MEV
****** DATA OUT OF RANGE FOR   1.5781E+01 MEV
****** DATA OUT OF RANGE FOR   1.5781E+01 MEV
****** DATA OUT OF RANGE FOR   1.5875E+01 MEV
****** DATA OUT OF RANGE FOR   1.5875E+01 MEV
****** DATA OUT OF RANGE FOR   1.5969E+01 MEV
****** DATA OUT OF RANGE FOR   1.5969E+01 MEV
****** DATA OUT OF RANGE FOR   1.6063E+01 MEV
****** DATA OUT OF RANGE FOR   1.6063E+01 MEV
****** DATA OUT OF RANGE FOR   1.6156E+01 MEV
****** DATA OUT OF RANGE FOR   1.6156E+01 MEV
****** DATA OUT OF RANGE FOR   1.6250E+01 MEV
****** DATA OUT OF RANGE FOR   1.6250E+01 MEV
****** DATA OUT OF RANGE FOR   1.6344E+01 MEV
****** DATA OUT OF RANGE FOR   1.6344E+01 MEV
****** DATA OUT OF RANGE FOR   1.6438E+01 MEV
```

The built-in tables
for the functions
extend only to 15 MeV
and, therefore, cause
warning messages.

The input for Subtask 3 is shown on the following pages, followed by portions of the output.

```
    AMPX MODULE LOG AND LIST OF CARD INPUT DATA

 MODULE UNITAB   HAS BEEN CALLED

0$$ 26 18 8 9 23 24 25 F0
1$$ 2  6  6$$ 900 1000 T
2$$
    6000 23 6000  1111
   92235 23 92235 1111
    6000 24 1306  2222
   92235 24 1395  2222
    6000 25    6  3333
   92235 25   92  3333

   T


MODULE UNITAB   IS FINISHED.
CPU TIME      5.23 (SECONDS).  I/O'S       0 USER CODE 0000   SYSTEM CODE 000
```

```
                UU         UU   NN          NN  IIIIIIIIIIII    TTTTTTTTTTTT      AAAAAAAAA     BBBBBBBBBBBB
                UU         UU   NNN         NN  IIIIIIIIIIII    TTTTTTTTTTTT     AAAAAAAAAAA    BBBBBBBBBBBBB
                UU         UU   NNNN        NN       II              TT         AA         AA   BB         BB
                UU         UU   NN NN       NN       II              TT         AA         AA   BB         BB
                UU         UU   NN   NN     NN       II              TT         AA         AA   BB         BB
                UU         UU   NN    NN    NN       II              TT         AAAAAAAAAAAAA   BBBBBBBBBBBB
                UU         UU   NN     NN   NN       II              TT         AAAAAAAAAAAAA   BBBBBBBBBBBB
                UU         UU   NN      NN  NN       II              TT         AA         AA   BB         BB
                UU         UU   NN       NN NN       II              TT         AA         AA   BB         BB
                UU         UU   NN        NNNN       II              TT         AA         AA   BB         BB
                UUUUUUUUUUUUU   NN         NNN  IIIIIIIIIIII         TT         AA         AA   BBBBBBBBBBBBB
                 UUUUUUUUUUU    NN          NN  IIIIIIIIIIII         TT         AA         AA   BBBBBBBBBBB



NN          NN  MM          MM   GGGGGGGGGGG    TTTTTTTTTTTT     SSSSSSSSSSS    KK          KK   22222222222     CCCCCCCCCCC
NNN         NN  MMM        MMM  GGGGGGGGGGGGG   TTTTTTTTTTTT    SSSSSSSSSSSSS   KK         KK   2222222222222   CCCCCCCCCCCCC
NNNN        NN  MMMM      MMMM  GG         GG        TT         SS         SS   KK        KK    22         22   CC         CC
NN NN       NN  MM MM    MM MM  GG                   TT         SS              KK       KK                22   CC
NN   NN     NN  MM   MM MM  MM  GG                   TT         SS              KK      KK                 22   CC
NN    NN    NN  MM    MMM   MM  GG    GGGGGGG        TT         SSSSSSSSSSSS    KKKKKKKK                 22     CC
NN     NN   NN  MM     M    MM  GG    GGGGGGG        TT          SSSSSSSSSSSS   KKKKKKKK               22       CC
NN      NN  NN  MM          MM  GG         GG        TT                    SS   KK      KK           22         CC
NN       NN NN  MM          MM  GG         GG        TT                    SS   KK       KK        22           CC
NN        NNNN  MM          MM  GG         GG        TT         SS         SS   KK        KK     22             CC         CC
NN         NNN  MM          MM  GGGGGGGGGGGGG        TT         SSSSSSSSSSSSS   KK         KK   2222222222222   CCCCCCCCCCCCC
NN          NN  MM          MM   GGGGGGGGGGG         TT          SSSSSSSSSSS    KK          KK  2222222222222    CCCCCCCCCCC



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  000000000     8888888888888              //     000000000     9999999999999              //   9999999999999        111
 00       00    88         88             //     00       00    99         99             //    99         99       1111
00         00   88         88            //     00         00   99         99            //     99         99         11
00         00   88         88           //      00         00   99         99           //      99         99         11
00         00    88888888888           //       00         00   9999999999999          //       9999999999999         11
00         00    88888888888          //        00         00    999999999999         //         999999999999         11
00         00   88         88        //         00         00              99        //                    99         11
00         00   88         88       //          00         00              99       //                     99         11
 00       00    88         88      //            00       00               99      //                      99         11
  000000000     8888888888888     //              000000000     9999999999999     //            9999999999999      11111111
   0000000       88888888888     //                0000000      999999999999     //             999999999999       11111111



                 99999999999                     22222222222             44                      22222222222          11
                9999999999999                   2222222222222           444                     2222222222222        111
                99         99                   22         22          4444                     22         22       1111
                99         99                              22         44 44                                22         11
                99         99                              22        44  44                                22         11
                9999999999999                            22         44   44                              22           11
                 999999999999        .....             22          44    44          .....             22             11
                           99        .....           22          444444444444        .....           22               11
                           99        .....         22           4444444444444        .....         22                 11
                           99        .....       22                      44          .....       22                   11
                9999999999999                   2222222222222            44                     2222222222222      11111111
                999999999999                    2222222222222            44                     2222222222222      11111111
```

```
RECORDS FOUND TO USE IN CONSTRUCTING MASTER FILE
RECORD  IDENTIFIER                       DESCRIPTION                                                      SET ID     LOG NO.      TYPE
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     2        6000    C-12 (GRAPHITE KERNEL AT THERMAL)                                                     6000          23         2
     3        :000    C-12 (GRAPHITE KERNEL AT THERMAL)                                                     6000          23         2
     4        6000    C-12 (GRAPHITE KERNEL AT THERMAL)                                                     6000          23         2
     5        6000    C-12 (GRAPHITE KERNEL AT THERMAL)                                                     6000          23         2
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    52        6000    C-12 (GRAPHITE KERNEL AT THERMAL)                                                     6000          23        58
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    55        6000    C-12 (GRAPHITE KERNEL AT THERMAL)                                                     6000          23        58
    56        6000    C-12 (GRAPHITE KERNEL AT THERMAL)                                                     6000          23        59
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    66        6000    C-12 (GRAPHITE KERNEL AT THERMAL)                                                     6000          23        60
    67        6000    C-12 (GRAPHITE KERNEL AT THERMAL)                                                     6000          23        60
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    71        6000    C-12 (GRAPHITE KERNEL AT THERMAL)                                                     6000          23        61
    72        6000    C-12 (GRAPHITE KERNEL AT THERMAL)                                                     6000          23        61
```

6.SAMPLE PROBLEMS.3 PERFORM A RESONANCE SELF-SHIELDING CALCULATION

With the limited palate of nuclides processed in Task 1 (graphite and ^{235}U), we will assume a reactor core consisting of 1-cm-diam. ^{235}U rods inserted in a graphite moderator and arranged in a square lattice with a pitch of 2 cm (see Fig. 6.SAMPLE PROBLEMS.6).

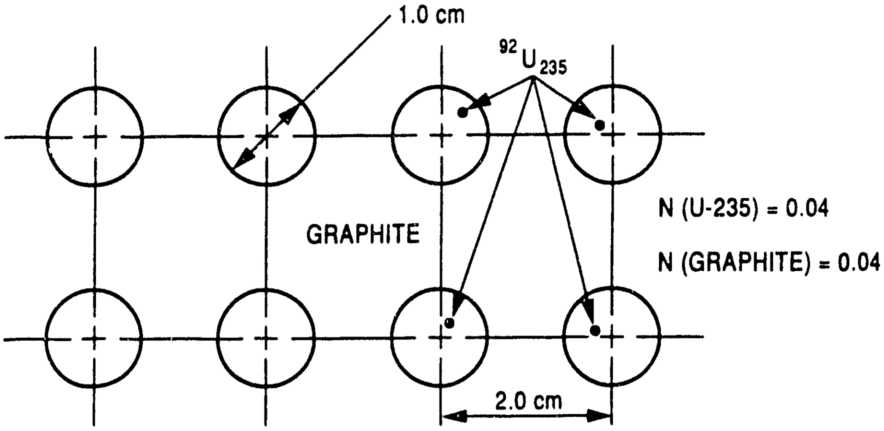


Fig. 6.SAMPLE PROBLEMS.6. Hypothetical reactor lattice.

The first step is to determine a representative "Wigner-Seitz" cell in cylindrical geometry which preserves the volume of a square cell from the lattice above, shown in Fig. 6.SAMPLE PROBLEMS.7 below.

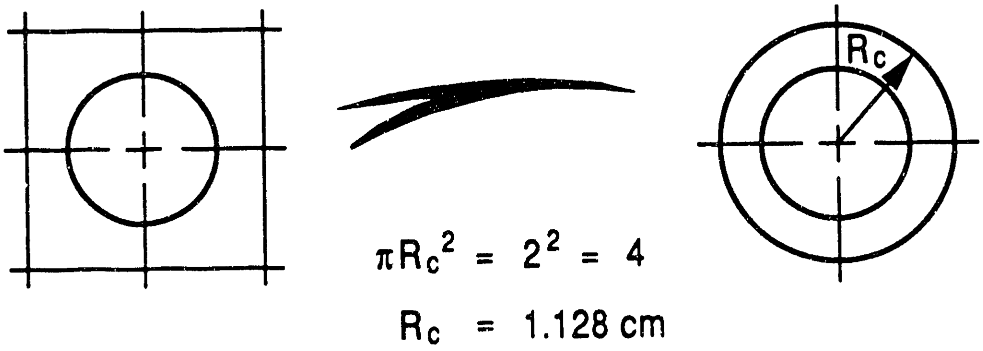


Fig. 6.SAMPLE PROBLEMS.7. Wigner-Seitz cell approximation.

This is the geometry for our resonance calculation.

This section will show how the resonance calculation could be mocked for three situations:

a. the integral transport theory code, ROLAIDS,
b. the integral transport theory code, NITAWL, and
c. the Bondarenko method code, BONAMI.

6.SAMPLE PROBLEMS.3.1 Sample Resonance Calculation by ROLAIDS

To perform this calculation, we need first to obtain a file with point cross sections for carbon and ^{235}U.

A possible procedure is shown in Fig. 6.SAMPLE PROBLEMS.8. Here, POLIDENT is used to generate point cross sections for ^{235}U and to pick up those for carbon. These are input to ROLAIDS, which performs the resonance calculation and group-averages the data to produce self-shielded cross sections on a file that is passed to CLAROL, which corrects the original master library.

6.SAMPLE PROBLEMS.3.2 Sample Resonance Calculation by NITAWL

In this case, all that is required is to prepare the input data for NITAWL. Among other things, this requires that one obtain a value for a Dancoff factor. This can be obtained by accessing tables from ANL-5800 (Fast Reactor Constants), where we find a factor for two isolated 1-cm rods separated by 2 cm in graphite. This value is 0.0035 (based on $\lambda = \frac{1}{0.04(4.8)} = 5.2$, $\rho = 0.5$, d = 2.0). Since each rod sees four rods at this spacing, we multiply the value by 4. There are four rods each rod sees at a spacing of $2\sqrt{2}$ cm. The Dancoff value for this system is essentially zero. Therefore, we use 0.014 for our Dancoff value.

A procedure to use NITAWL is shown in Fig. 6.SAMPLE PROBLEMS.9.

6.SAMPLE PROBLEMS.3.3 Sample Resonance Calculation by BONAMI

In the sample runs for Task 1, Bondarenko factors were produced for ^{235}U for the unresolved resonance range. BONAMI can be used to self-shield these factors. A procedure is shown in Fig. 6.SAMPLE PROBLEMS.10.

ORNL-DWG 91Z-14378

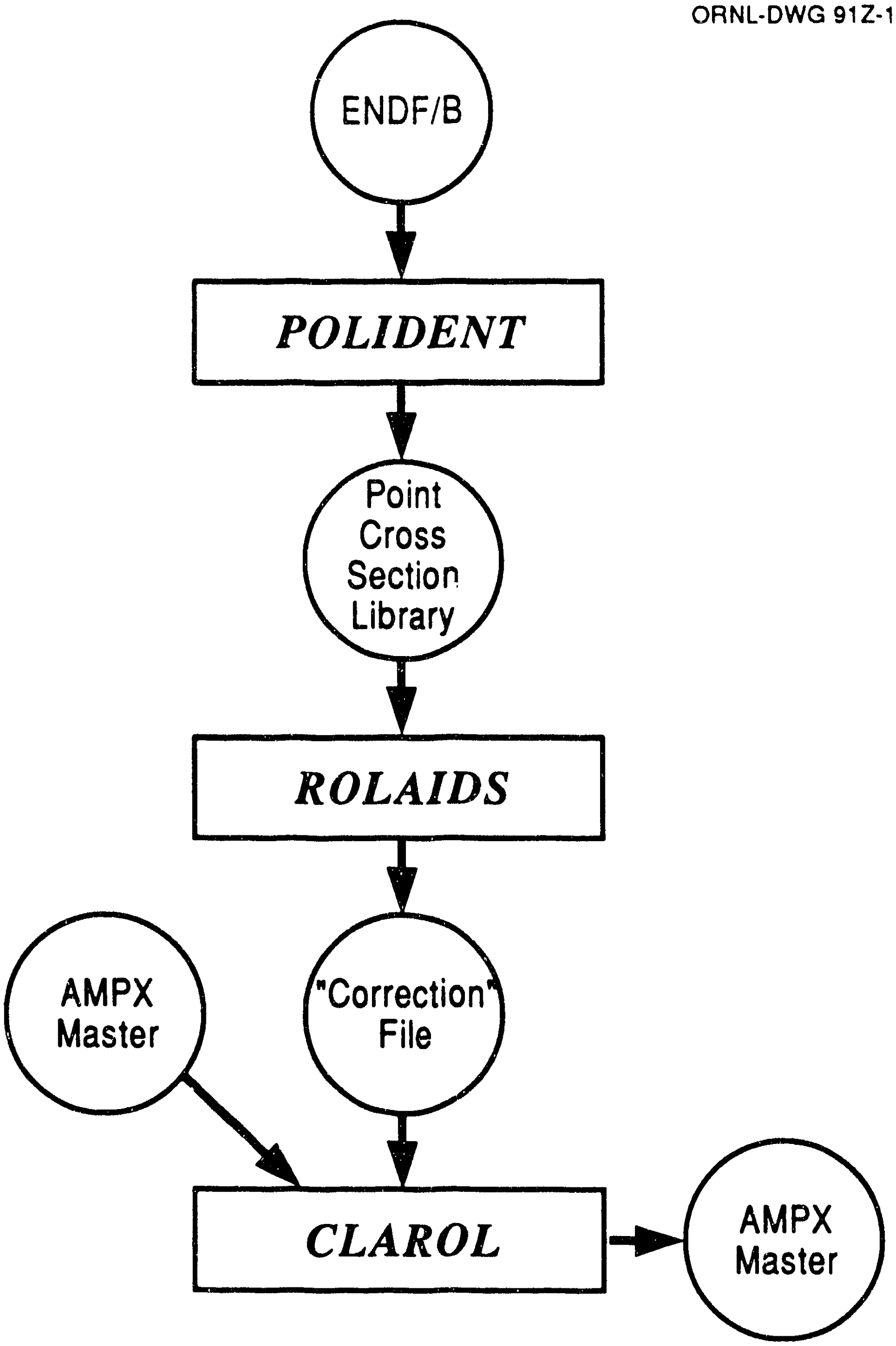
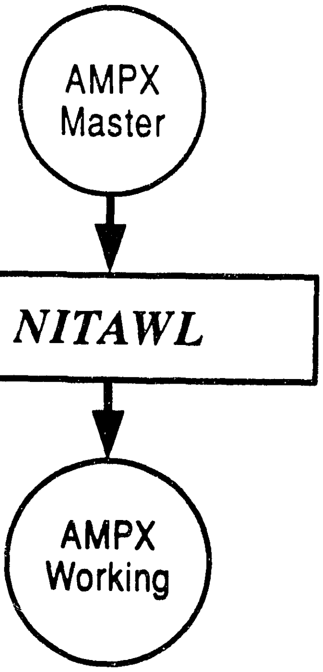
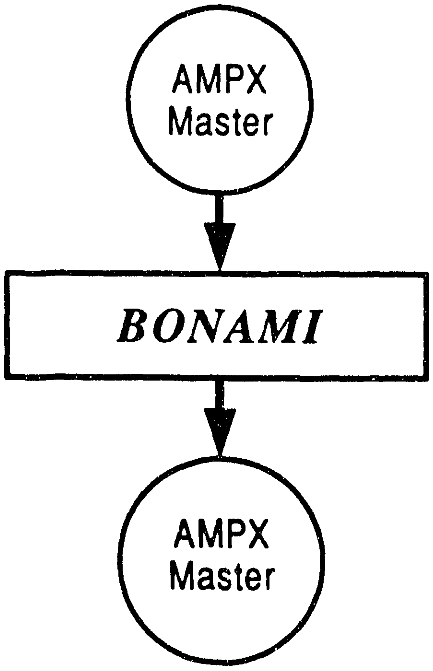


Fig. 6.SAMPLE PROBLEMS.8. Procedure to use ROLAIDS for resonance shielding.



ORNL-DWG 91Z-14379

Fig. 6.SAMPLE PROBLEMS.9. Procedure to use NITAWL for resonance self-shielding.



ORNL-DWG 91Z-14380

Fig. 6.SAMPLE PROBLEMS.10. Procedure to use BONAMI for resonance self-shielding.

The input for the cases is given below, followed by portions of the output from the various modules.

```
   AMPX MODULE LOG AND LIST OF CARD INPUT DATA
 MODULE POLIDENT HAS BEEN CALLED

0$$ 31 1$$ 2 4** 0.001 T                                  00000160
2$$ 1395 11 1 3** 10 300 T     Make Point Library         00000170
2$$ 1306 11 1 T                                           00000180

 MODULE POLIDENT IS FINISHED.
 CPU TIME    38.37 (SECONDS).  I/O'S      0 USER CODE 0000   SYSTEM CODE 000

 MODULE ROLAIDS  HAS BEEN CALLED

0$$ 31 E 1$$ 2 2 4 1 1 1            Integral Transport    00000200
2$$ 1 0 0 1 2 2 0 70                                      00000210
3$$ 3 0 4** 1.0 82.0 1 300 0 T            Calculation     00000220
5**   0.5 2I1.0 1.693 6$$ 2R1 F2 7$$ 1 2                  00000230
9** F300 11$$ 1395  1306 13$$ 1 2 14$$ 1395 1306 15** 0.04 0.04    00000240
         12$$92235  6000                                  00000250
16** 12 17** 4.8 18** 0.0034 T                            00000260

 MODULE ROLAIDS  IS FINISHED.
 CPU TIME    60.99 (SECONDS).  I/O'S      0 USER CODE 0000   SYSTEM CODE 000

 MODULE CLAROL   HAS BEEN CALLED

7$$ 60 E                                                  00000280
0$$ 2 70 26 T         Add ROLAIDS data to                 00000290
                             master library
 MODULE CLAROL   IS FINISHED.
 CPU TIME    13.10 (SECONDS).  I/O'S      0 USER CODE 0000   SYSTEM CODE 000

 MODULE BONAMI   HAS BEEN CALLED

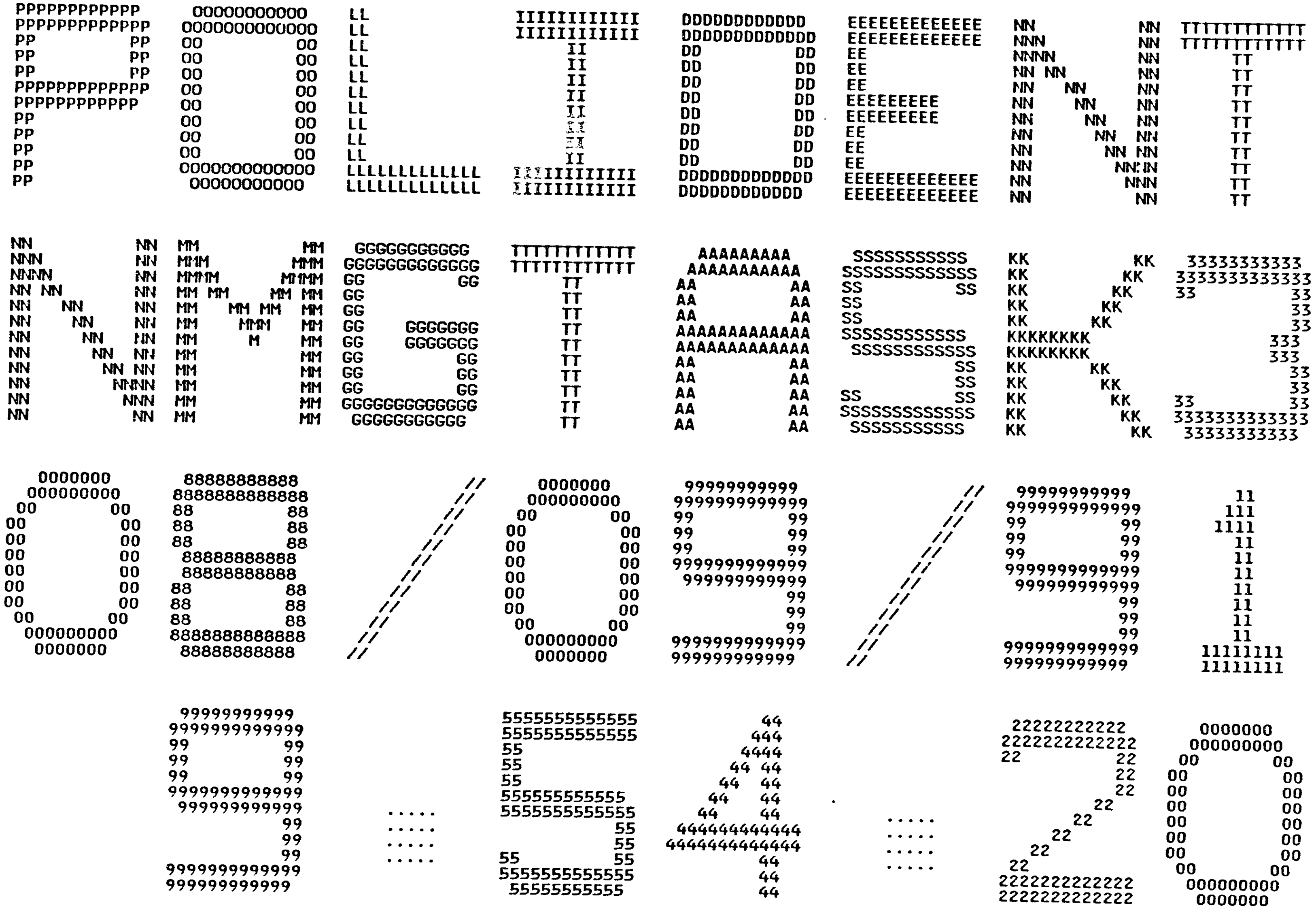
0$$ 70  0 18 25        Bondarenko Calculation             00000310
1$$ 2 2 2 0 0 2 T                                         00000320
3$$ 1 2 4$$ 92235 6000 5** 0.04 0.04 6$$ 1 2 7** 1.0 1.693         00000330
8** 300 300 11$$ 0 1 T                                    00000340

 MODULE BONAMI   IS FINISHED.
 CPU TIME    10.03 (SECONDS).  I/O'S      0 USER CODE 0000   SYSTEM CODE 000

 MODULE NITAWL   HAS BEEN CALLED

0$$ 25 E 1$$ 0 3 A8 1 E T        Nordheim Calculation     00000360
2$$ 9223501 600002 -6000                                  00000370
3** 9223501 300 2 0.5 0.014 0 0.04 1 6Z 1 T               00000380

 MODULE NITAWL   IS FINISHED.
 CPU TIME    15.24 (SECONDS).  I/O'S      0 USER CODE 0000   SYSTEM CODE 000
```


POLIDENT
NMGTASK3
08/09/91
9:54:20

```
POLIDENT HAS BEEN ALLOCATED 100000 WORDS

A BINARY FILE OF POINT DATA WILL BE OUTPUT ON LOGICAL 31

    2$ ARRAY      3 ENTRIES READ

    3* ARRAY      2 ENTRIES READ

    0T

===============================================================================
LOGICAL 11 (INPUT ENDF/B LIBRARY)
DATASET NAME: E.LMP10287.ENDFB.DATA.V5
      VOLUME: PBDE02
===============================================================================

        PROCESSING MAT:         1395
  ENDF DATA ON LOGICAL:           11
 MODE OF THE ENDF DATA:            1
                  SIGO:     1.00E+01
           TEMPERATURE:       300.00

    ENERGY RANGE 1 EXTENDS FROM 1.00000E+00 TO 8.20000E+01 EV

         BREIT WIGNER PARAMETERS BEING PROCESSED

RESOLVED RESONANCE CROSS SECTION VECTORS WITH  3366 POINTS HAVE BEEN CREATED FROM 1.00000E+00 TO 8.20000E+01 EV.

=========================TIME FOR THIS BLOCK:  0.22 MIN

    ENERGY RANGE 2 EXTENDS FROM 8.20000E+01 TO 2.50000E+04 EV

         UNRESOLVED SLBW PARAMETERS ARE BEING PROCESSED
```

Resolved Resonance Region

```
TEMPERATURE: 3.00000E+02 SIGO: 1.00000E+01
POINT       ENERGY     ELASTIC     CAPTURE     FISSION       TOTAL COMPETITIVE   TRANSPORT
    1 8.20000E+01 1.18569E+01 7.20494E+00 1.61840E+01 3.52458E+01 0.00000E+00 2.39368E+01
    2 8.65000E+01 1.18173E+01 7.19630E+00 1.28377E+01 3.18513E+01 0.00000E+00 2.23307E+01
    3 9.10000E+01 1.19499E+01 7.73388E+00 1.41595E+01 3.38433E+01 0.00000E+00 2.12478E+01
    4 9.50000E+01 1.16897E+01 6.21345E+00 9.24749E+00 2.71506E+01 0.00000E+00 2.20136E+01
    5 1.00000E+02 1.16878E+01 5.91991E+00 9.68618E+00 2.72939E+01 0.00000E+00 2.20840E+01
    6 1.10000E+02 1.17471E+01 6.40689E+00 1.02258E+01 2.83798E+01 0.00000E+00 2.23938E+01
    7 1.20000E+02 1.18082E+01 6.39339E+00 1.22173E+01 3.04189E+01 0.00000E+00 2.29727E+01
    8 1.25000E+02 1.18586E+01 6.63179E+00 1.27119E+01 3.12023E+01 0.00000E+00 2.28073E+01
    9 1.30000E+02 1.18229E+01 5.80104E+00 1.61003E+01 3.37242E+01 0.00000E+00 2.59556E+01
   10 1.35000E+02 1.18916E+01 6.68645E+00 1.27694E+01 3.13474E+01 0.00000E+00 2.27697E+01
   11 1.40000E+02 1.18683E+01 6.50736E+00 1.23463E+01 3.07220E+01 0.00000E+00 2.29689E+01
   12 1.55000E+02 1.18612E+01 6.56908E+00 1.08251E+01 2.92554E+01 0.00000E+00 2.29650E+01
   13 1.75000E+02 1.19282E+01 5.95310E+00 1.47142E+01 3.25955E+01 0.00000E+00 2.42628E+01
   14 1.90000E+02 1.18011E+01 5.31175E+00 1.11455E+01 2.82583E+01 0.00000E+00 2.30474E+01
   15 2.05000E+02 1.19587E+01 6.56044E+00 1.10245E+01 2.95437E+01 0.00000E+00 2.35092E+01
   16 2.15000E+02 1.19233E+01 5.59634E+00 1.29982E+01 3.05179E+01 0.00000E+00 2.34112E+01
   17 2.25000E+02 1.21885E+01 7.07049E+00 1.26349E+01 3.18939E+01 0.00000E+00 2.20319E+01
   18 2.35000E+02 1.19694E+01 5.65149E+00 1.30738E+01 3.06947E+01 0.00000E+00 2.33867E+01
   19 2.45000E+02 1.19786E+01 5.62186E+00 1.29760E+01 3.05764E+01 0.00000E+00 2.34363E+01
   20 2.55000E+02 1.17773E+01 3.77888E+00 1.55343E+01 3.10905E+01 0.00000E+00 2.63188E+01
   21 2.60000E+02 1.21387E+01 6.05609E+00 1.39768E+01 3.21717E+01 0.00000E+00 2.24810E+01
   22 2.65000E+02 1.20535E+01 4.98659E+00 1.58053E+01 3.28454E+01 0.00000E+00 2.07039E+01
   23 3.00000E+02 1.17277E+01 3.95342E+00 8.74188E+00 2.44230E+01 0.00000E+00 2.20363E+01
   24 3.35000E+02 1.20412E+01 5.59058E+00 1.10937E+01 2.87254E+01 0.00000E+00 2.36438E+01
   25 3.90000E+02 1.18044E+01 4.12230E+00 8.48983E+00 2.44165E+01 0.00000E+00 2.21889E+01
   26 4.30000E+02 1.18414E+01 3.57115E+00 1.19222E+01 2.73347E+01 0.00000E+00 2.40845E+01
   27 4.60000E+02 1.18626E+01 3.79477E+00 1.05767E+01 2.62340E+01 0.00000E+00 2.36788E+01
   28 4.90000E+02 1.19161E+01 3.82795E+00 1.14731E+01 2.72171E+01 0.00000E+00 2.41815E+01
   29 5.10000E+02 1.19900E+01 3.58690E+00 1.50576E+01 3.06345E+01 0.00000E+00 2.52169E+01
   30 5.50000E+02 1.20214E+01 4.12773E+00 1.14111E+01 2.75602E+01 0.00000E+00 2.42798E+01
   31 6.00000E+02 1.19851E+01 3.78600E+00 1.11615E+01 2.69325E+01 0.00000E+00 2.40710E+01
   32 6.50000E+02 1.19486E+01 4.13216E+00 7.43461E+00 2.35154E+01 0.00000E+00 2.20385E+01
   33 6.65000E+02 1.21953E+01 4.50031E+00 1.09119E+01 2.76076E+01 0.00000E+00 2.41036E+01
   34 6.80000E+02 1.19385E+01 3.29683E+00 1.17643E+01 2.69997E+01 0.00000E+00 2.52041E+01
   35 7.00000E+02 1.18401E+01 3.04917E+00 9.19508E+00 2.40844E+01 0.00000E+00 2.27690E+01
   36 7.15000E+02 1.24160E+01 4.88711E+00 1.18582E+01 2.91614E+01 0.00000E+00 2.42070E+01
   37 7.30000E+02 1.23133E+01 5.06979E+00 9.23762E+00 2.66207E+01 0.00000E+00 2.37313E+01
   38 7.55000E+02 1.20314E+01 4.00932E+00 8.42973E+00 2.44704E+01 0.00000E+00 2.29526E+01
   39 7.70000E+02 1.19780E+01 3.47641E+00 1.00199E+01 2.54743E+01 0.00000E+00 2.40770E+01
   40 8.00000E+02 1.19171E+01 3.36963E+00 8.18559E+00 2.34723E+01 0.00000E+00 2.23122E+01
   41 8.50000E+02 1.19128E+01 3.46311E+00 6.95112E+00 2.23270E+01 0.00000E+00 2.14568E+01
   42 9.00000E+02 1.21675E+01 4.43912E+00 7.15534E+00 2.37619E+01 0.00000E+00 2.24676E+01
   43 9.25000E+02 1.22987E+01 4.85569E+00 7.15824E+00 2.43126E+01 0.00000E+00 2.27075E+01
   44 9.80000E+02 1.20444E+01 3.98219E+00 6.00878E+00 2.20353E+01 0.00000E+00 2.12155E+01
   45 1.00000E+03 1.23232E+01 5.02761E+00 6.01694E+00 2.33677E+01 0.00000E+00 2.21250E+01
   46 1.03000E+03 1.19816E+01 3.76266E+00 5.30772E+00 2.10519E+01 0.00000E+00 2.04678E+01
   47 1.05500E+03 1.21378E+01 3.94724E+00 7.09393E+00 2.31789E+01 0.00000E+00 2.21820E+01
   48 1.08000E+03 1.22748E+01 3.88966E+00 9.48676E+00 2.56512E+01 0.00000E+00 2.39083E+01
   49 1.11500E+03 1.20458E+01 3.54467E+00 6.80218E+00 2.23927E+01 0.00000E+00 2.17099E+01
   50 1.13500E+03 1.19735E+01 2.80897E+00 9.27770E+00 2.40602E+01 0.00000E+00 2.31394E+01
   51 1.15500E+03 1.20502E+01 3.30983E+00 7.81547E+00 2.31755E+01 0.00000E+00 2.24732E+01
   52 1.16500E+03 1.24046E+01 3.39776E+00 1.39026E+01 2.97049E+01 0.00000E+00 2.54442E+01
   53 1.18000E+03 1.19505E+01 2.75188E+00 8.76125E+00 2.34636E+01 0.00000E+00 2.28655E+01
   54 1.21000E+03 1.19690E+01 3.03404E+00 7.09403E+00 2.20971E+01 0.00000E+00 2.15949E+01
   55 1.25000E+03 1.19273E+01 2.93239E+00 6.39455E+00 2.12542E+01 0.00000E+00 2.08408E+01
   56 1.30000E+03 1.18096E+01 2.29145E+00 6.98338E+00 2.10845E+01 0.00000E+00 2.08241E+01
   57 1.34000E+03 1.20566E+01 2.98405E+00 8.15752E+00 2.31982E+01 0.00000E+00 2.25414E+01
   58 1.37000E+03 1.18850E+01 2.40294E+00 7.83283E+00 2.21207E+01 0.00000E+00 2.17578E+01
   59 1.40000E+03 1.19573E+01 2.69161E+00 7.44470E+00 2.20936E+01 0.00000E+00 2.16513E+01
   60 1.45000E+03 1.19751E+01 2.73952E+00 7.15896E+00 2.18736E+01 0.00000E+00 2.15068E+01
   61 1.50000E+03 1.17605E+01 2.29799E+00 4.49110E+00 1.85496E+01 0.00000E+00 1.84797E+01
   62 1.56000E+03 1.19059E+01 2.56088E+00 6.15761E+00 2.06244E+01 0.00000E+00 2.04415E+01
   63 1.67000E+03 1.19597E+01 2.45408E+00 7.34657E+00 2.17603E+01 0.00000E+00 2.15129E+01
   64 1.70000E+03 1.17400E+01 1.80021E+00 6.38530E+00 1.99255E+01 0.00000E+00 1.99361E+01
   65 1.75000E+03 1.19066E+01 2.39535E+00 6.18358E+00 2.04856E+01 0.00000E+00 2.03893E+01
   66 1.90000E+03 1.22628E+01 3.09919E+00 7.24426E+00 2.26062E+01 0.00000E+00 2.22287E+01
   67 2.00000E+03 1.21991E+01 3.07129E+00 6.04822E+00 2.13186E+01 0.00000E+00 2.11631E+01
   68 2.15000E+03 1.19622E+01 2.46477E+00 5.21547E+00 1.96425E+01 0.00000E+00 1.96740E+01
   69 2.30000E+03 1.18689E+01 2.08299E+00 5.35691E+00 1.93088E+01 0.00000E+00 1.94097E+01
   70 2.50000E+03 1.18978E+01 1.99400E+00 5.94970E+00 1.98415E+01 0.00000E+00 1.99767E+01
   71 2.65000E+03 1.17247E+01 1.54815E+00 5.18962E+00 1.84625E+01 0.00000E+00 1.86617E+01
   72 2.90000E+03 1.17382E+01 1.53970E+00 5.10501E+00 1.83829E+01 0.00000E+00 1.86096E+01
   73 3.00000E+03 1.17319E+01 1.51482E+00 4.97506E+00 1.82218E+01 0.00000E+00 1.84571E+01
```

Unresolved
Resonance Region

Total

Combine File 3 and Resolved Data

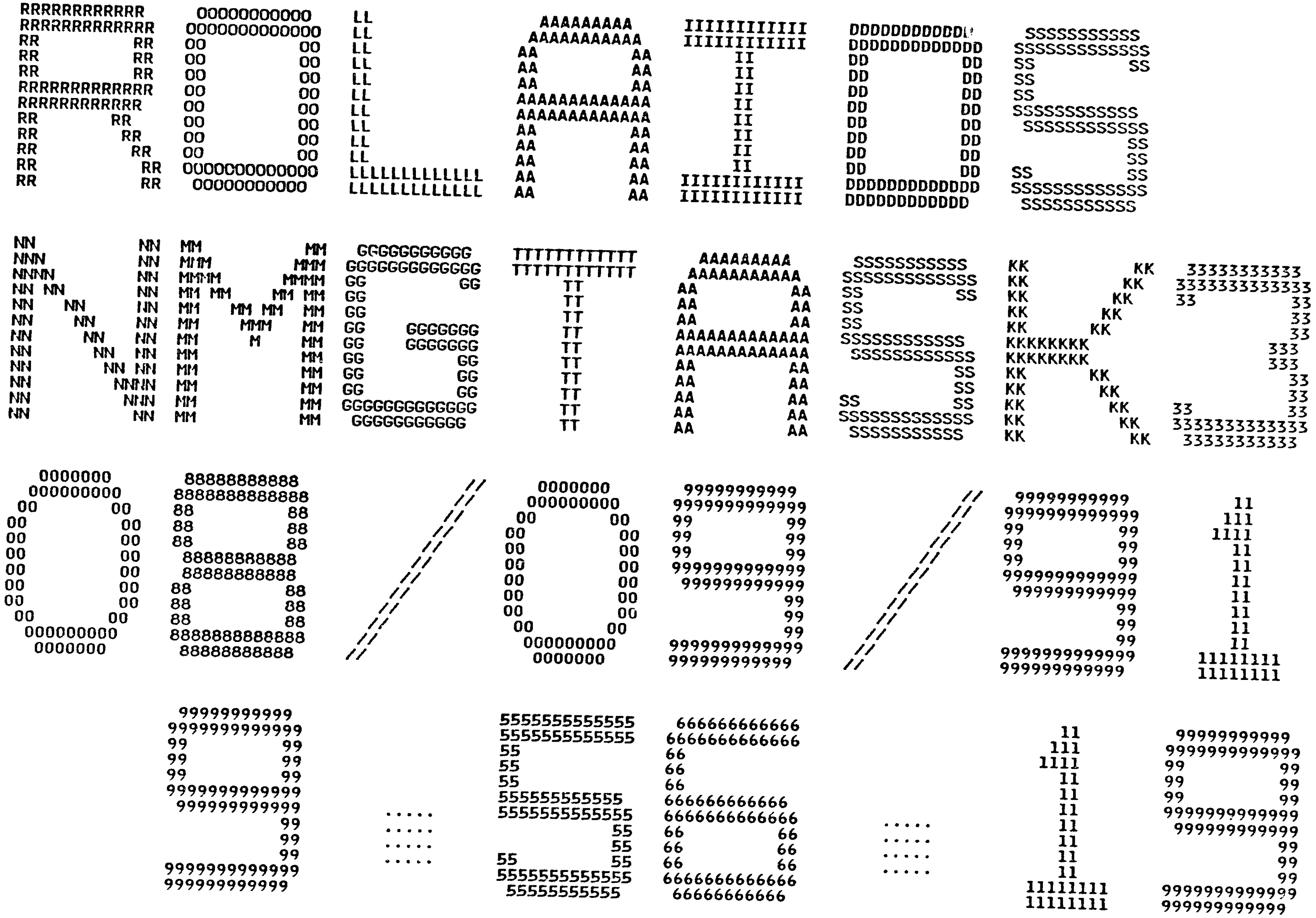
Combine above with unresolved data

Final Function

```
PROCESSING MAT:    1395
======================================================================

       PROCESS:    1
COMBINING PANELS WITH  1399 AND  3366 POINTS
WITH INTERPOLATION TABLES OF     3 AND     1 POINTS
FIRST FUNCTION FROM 1.00000E-05 TO 2.00000E+07
SECOND FUNCTION FROM 1.00000E+00 TO 8.20000E+01
COMBINING RANGE IS 1.00000E-05 TO 2.00000E+07
                          DISCONTINUITY=======KTYPE 0
                          XA1: 1.00000E+00 YA1: 9.07127E+01
                          XA2: 1.00000E+00 YA2: 9.63800E+00
                          XB1: 1.00000E+00 YB1: 0.00000E+00
                          XB2: 1.00000E+00 YB2: 8.16853E+01
                           V2: 9.13233E+01 EL: 1.00000E+00 EH: 1.00000E+00
                          DISCONTINUITY=======KTYPE 0
                          XA1: 8.20000E+01 YA1: 1.04000E+00
                          XA2: 8.20000E+01 YA2: 0.00000E+00
                          XB1: 8.20000E+01 YB1: 1.67135E+01
                          XB2: 8.20000E+01 YB2: 0.00000E+00
                           V2: 0.00000E+00 EL: 8.20000E+01 EH: 8.20000E+01
                          DISCONTINUITY=======KTYPE 1
                          XA1: 2.50000E+04 YA1: 1.29325E-02
                          XA2: 2.50000E+04 YA2: 1.41000E+01
                          XB1: 8.19800E+01 YB1: 1.69557E+01
                          XB2: 8.20000E+01 YB2: 1.67135E+01
                           V2: 1.41000E+01 EL: 2.50000E+04 EH: 2.50000E+04
A FUNCTION WITH  5994 POINTS AND  1 INTERPOLATION REGIONS HAS BEEN PRODUCED
ERROR FLAG IS 0
======================================================================
COMBINING PANELS WITH  5994 AND   137 POINTS
WITH INTERPOLATION TABLES OF     1 AND     1 POINTS
FIRST FUNCTION FROM 1.00000E-05 TO 2.00000E+07
SECOND FUNCTION FROM 8.20000E+01 TO 2.50000E+04
COMBINING RANGE IS 1.00000E-05 TO 2.00000E+07
                          DISCONTINUITY=======KTYPE 1
                          XA1: 1.00000E+00 YA1: 9.07127E+01
                          XA2: 1.00000E+00 YA2: 9.13233E+01
                          XB1: 8.20000E+01 YB1: 3.52458E+01
                          XB2: 8.65000E+01 YB2: 3.18513E+01
                           V2: 9.13233E+01 EL: 1.00000E+00 EH: 1.00000E+00
                          DISCONTINUITY=======KTYPE 0
                          XA1: 8.20000E+01 YA1: 1.77535E+01
                          XA2: 8.20000E+01 YA2: 0.00000E+00
                          XB1: 8.20000E+01 YB1: 0.00000E+00
                          XB2: 8.20000E+01 YB2: 3.52458E+01
                           V2: 3.52458E+01 EL: 8.20000E+01 EH: 8.20000E+01
                          DISCONTINUITY=======KTYPE 0
                          XA1: 2.50000E+04 YA1: 1.29325E-02
                          XA2: 2.50000E+04 YA2: 1.41000E+01
                          XB1: 2.50000E+04 YB1: 1.41695E+01
                          XB2: 2.50000E+04 YB2: 0.00000E+00
                           V2: 1.41000E+01 EL: 2.50000E+04 EH: 2.50000E+04
A FUNCTION WITH  6156 POINTS AND  1 INTERPOLATION REGIONS HAS BEEN PRODUCED
ERROR FLAG IS 0
======================================================================
======================================================================

       PROCESS:    2
COMBINING PANELS WITH  1399 AND  3366 POINTS
WITH INTERPOLATION TABLES OF     3 AND     1 POINTS
FIRST FUNCTION FROM 1.00000E-05 TO 2.00000E+07
SECOND FUNCTION FROM 1.00000E+00 TO 8.20000E+01
COMBINING RANGE IS 1.00000E-05 TO 2.00000E+07
                          DISCONTINUITY=======KTYPE 0
                          XA1: 1.00000E+00 YA1: 1.28956E+01
                          XA2: 1.00000E+00 YA2:-7.23000E-01
                          XB1: 1.00000E+00 YB1: 0.00000E+00
                          XB2: 1.00000E+00 YB2: 1.36183E+01
                           V2: 1.28953E+01 EL: 1.00000E+00 EH: 1.00000E+00
                          DISCONTINUITY=======KTYPE 0
                          XA1: 8.20000E+01 YA1:-1.46000E+00
                          XA2: 8.20000E+01 YA2: 0.00000E+00
                          XB1: 8.20000E+01 YB1: 1.37872E+01
                          XB2: 8.20000E+01 YB2: 0.00000E+00
```



ROLAIDS

NMGTASK3

08/09/91

9:56:19

Replay of Input Data

```
                 ROLAIDS PROBLEM DESCRIPTION

   IGE     0/1/2/3 = INFINITE MEDIUM/PLANAR/CYLINDRICAL/SPHERICAL     2
   IZM     NUMBER OF ZONES                                            2
    IM     NUMBER OF SPATIAL INTERVALS                                4
   IBL     LEFT BOUNDARY CONDITION 0/1/2 VACUUM/WHITE/PERIODIC        1
   IBR     RIGHT BOUNDARY CONDITION 0/1/2 VACUUM/WHITE/PERIODIC       1
  IPRB     PROBLEM NUMBER (NEGATIVE FOR PRECALCULATED DATA TAPE)      1
  NDF1     NUMBER OF NUCLIDES FROM POINTWISE TAPE N1                  1
  NDF2     NUMBER OF NUCLIDES FROM POINTWISE TAPE N2                  0
 NMAST     NUMBER OF NUCLIDES FROM MASTER TAPE                        0
 NFLAT     NUMBER OF NUCLIDES FROM CARD INPUT                         1
   MXX     NUMBER OF MIXTURES                                         2
    MS     MIXING TABLE LENGTH                                        2
  ICON     CROSS SECTION OUTPUT OPTION                                0
  MAXG     NUMBER OF OUTPUT GROUPS                                  102
  ISCT     EXPANSION ORDER OF TRANSFER MATRIX                         3
   ELO     MINIMUM PROBLEM ENERGY (EV)                     1.000000E+00
   EHI     MAXIMUM PROBLEM ENERGY (EV)                     8.200000E+01
   EZP     EXPONENT FOR ASYMPTOTIC SOURCE FROM ABOVL EHI   1.000000E+00
    TK     MAXWELLIAN TEMPERATURE (DEGREES KELVIN)         3.000000E+02
```

```
                                   MIXING TABLE
             MIXTURE   NUCLIDE ID NO.   NUMBER DENSITY (ATOMS/BN-CM)
                1             1395          0.400000E-01
                2             1306          0.400000E-01
                           NFLAT NUCLIDE PARAMETERS

              NUCLIDE NO.   MASS NO.   SIGMA-S (BN)   SIGMA-C (BN)   SIGMA-F (BN)
                    2        12.000    0.480000E+01   0.340000E-02   0.000000E+00
                           CONTAINER STORAGE ALLOCATION
          LIMT (TOTAL PROBLEM ALLOCATION) = 200000

              NPTXS DATA FOUND ON LOGICAL     31
                  MAT     MT     NQ    NQS    NQT    IDF   NDF1  NDF2
                  1395     1   6156   6156     0      0     1     0

         1395       1   6156   6156
                  300.000   300.000
                  1395     2   4886   6156     0      0     1     0

         1395       2   4886   6156
                  300.000   300.000
                  1395    18   6304   6304     0      0     1     0

         1395      18   6304   7025
                  300.000   300.000
                  1395   102   7271   7271   7271    1     1     0

         1395     102   7271   8284
                  300.000   300.000
           LIME (TOTAL ENERGY LATTICE) =   10794

          LMDUM (MAXIMUM SIGMA DATA FOR ANY REACTION TYPE) =    7271


        ELAPSED TIME    0.34 MIN.
              ADDITIONAL POINTWISE ENERGIES

          1.4918251E+07 1.3498582E+07 1.2214031E+07 1.1051712E+07 9.9999980E+06 9.0483730E+06 8.1873050E+06 7.4081800E+06
          6.7031990E+06 6.0653040E+06 5.4881140E+06 4.9658510E+06 4.4932880E+06 4.0656950E+06 3.6787940E+06 3.3287120E+06
          3.0119450E+06 2.7253220E+06 2.4659750E+06 2.2313080E+06 2.0189720E+06 1.8268420E+06 1.6529960E+06 1.4956930E+06
          1.3533600E+06 1.2245720E+06 1.1080390E+06 1.0025960E+06 9.0718681E+05 8.2085725E+05 7.4274237E+05 6.7206144E+05
          6.0810687E+05 5.5023819E+05 4.9787631E+05 4.5049737E+05 4.0762719E+05 3.6883650E+05 3.3373725E+05 3.0197812E+05
          2.7324125E+05 2.4723906E+05 2.2371131E+05 2.0242244E+05 1.8315950E+05 1.6572969E+05 1.4995850E+05 1.3568812E+05
          1.2277575E+05 1.1109212E+05 8.6518625E+04 6.7360812E+04 5.2476227E+04 4.0868520E+04 3.1828441E+04 2.4788016E+04
          1.9304926E+04 1.5034691E+04 1.1709027E+04 9.1190000E+03 7.1018828E+03 5.5309531E+03 4.3075078E+03 3.3546936E+03
          2.6126367E+03 2.0347244E+03 1.5846448E+03 1.2341226E+03 9.6113574E+02 7.4853320E+02 5.8295825E+02 4.5400830E+02
          3.5358203E+02 2.7536987E+02 2.1445840E+02 1.6702032E+02 1.3007558E+02 1.0130296E+02 7.8894821E+01 6.1443344E+01
          4.7852127E+01 3.7267273E+01 2.9023773E+01 2.2603745E+01 1.7603806E+01 1.3709868E+01 1.0677249E+01 8.3154535E+00
          6.4760818E+00 5.0435772E+00 3.9279413E+00 3.0590839E+00 2.3824167E+00 1.8554277E+00 1.4450083E+00 1.1253738E+00
          8.7645161E-01 6.8258089E-01 5.3159469E-01 4.1400635E-01
               1395     3     1           121

        ELAPSED TIME    0.34 MIN.
               1395     3     2          7296

        ELAPSED TIME    0.35 MIN.
               1395     3    18          7296

        ELAPSED TIME    0.35 MIN.
               1395     3   102          7296

        ELAPSED TIME    0.36 MIN.
```

ROLAIDS includes energy group boundaries in its mesh.

```
    ADDITIONAL POINTWISE ENERGIES

 8.0604416E+01 7.9232590E+01 7.7884109E+01 7.6558578E+01 7.5255600E+01 7.3974808E+01 7.2715805E+01 7.1478226E+01
 7.0261719E+01 6.9065918E+01 6.7890457E+01 6.6735001E+01 6.5599213E+01 6.4482758E+01 6.3385300E+01 6.2306519E+01
 6.1246109E+01 6.0203735E+01 5.9179108E+01 5.8171921E+01 5.7181870E+01 5.6208664E+01 5.5252029E+01 5.4311676E+01
 5.3387329E+01 5.2478714E+01 5.1585556E+01 5.0707596E+01 4.9844589E+01 4.8996262E+01 4.8162369E+01 4.7342682E+01
 4.6536942E+01 4.5744919E+01 4.4966370E+01 4.4201065E+01 4.3448792E+01 4.2709320E+01 4.1982437E+01 4.1267929E+01
 4.0565567E+01 3.9875168E+01 3.9196518E+01 3.8529419E+01 3.7873672E+01 3.7229080E+01 3.6595459E+01 3.5972626E+01
 3.5360397E+01 3.4758591E+01 3.4167023E+01 3.3585526E+01 3.3013916E+01 3.2452042E+01 3.1899719E+01 3.1356796E+01
 3.0823120E+01 3.0298523E+01 2.9782852E+01 2.9275970E+01 2.8777710E+01 2.8287933E+01 2.7806488E+01 2.7333237E+01
 2.6868042E+01 2.6410767E+01 2.5961273E+01 2.5519424E+01 2.5085098E+01 2.4658157E+01 2.4238495E+01 2.3825974E+01
 2.3420471E+01 2.3021866E+01 2.2630051E+01 2.2244904E+01 2.1866302E+01 2.1494141E+01 2.1128326E+01 2.0768738E+01
 2.0415268E+01 2.0067810E+01 1.9726257E+01 1.9390518E+01 1.9060501E+01 1.8736099E+01 1.8417221E+01 1.8103760E+01
 1.7795639E+01 1.7492767E+01 1.7195053E+01 1.6902405E+01 1.6614731E+01 1.6331955E+01 1.6053986E+01 1.5780759E+01
 1.5512182E+01 1.5248177E+01 1.4988664E+01 1.4733568E+01 1.4482814E+01 1.4236327E+01 1.3994036E+01 1.3755868E+01
 1.3521753E+01 1.3291623E+01 1.3065410E+01 1.2843046E+01 1.2624467E+01 1.2409608E+01 1.2198405E+01 1.1990798E+01
 1.1786723E+01 1.1586122E+01 1.1388934E+01 1.1195103E+01 1.1004570E+01 1.0817281E+01 1.0633179E+01 1.0452209E+01
 1 0274321E+01 1.0099460E+01 9.9275742E+00 9.7586145E+00 9.5925303E+00 9.4292727E+00 9.2687931E+00 9.1110449E+00
 8.9559813E+00 8.8035574E+00 8.6537275E+00 8.5064478E+00 8.3616743E+00 8.2193651E+00 8.0794773E+00 7.9419708E+00
 7.8068047E+00 7.6739388E+00 7.5433340E+00 7.4149523E+00 7.2887554E+00 7.1647062E+00 7.0427685E+00 6.9229059E+00
 6.8050833E+00 6.6892653E+00 6.5754185E+00 6.4635096E+00 6.3535051E+00 6.2453728E+00 6.1390810E+00 6.0345984E+00
 5.9318933E+00 5.8309364E+00 5.7316980E+00 5.6341486E+00 5.5382595E+00 5.4440022E+00 5.3513489E+00 5.2602730E+00
 5.1707468E+00 5.0827446E+00 4.9962397E+00 4.9112072E+00 4.8276215E+00 4.7454586E+00 4.6646938E+00 4.5853043E+00
 4.5072651E+00 4.4305544E+00 4.3551493E+00 4.2810278E+00 4.2081680E+00 4.1365480E+00 4.0661469E+00 3.9969435E+00
 3.9289179E+00 3.8620501E+00 3.7963209E+00 3.7317104E+00 3.6681995E+00 3.6057692E+00 3.5444012E+00 3.4840775E+00
 3.4247808E+00 3.3664932E+00 3.3091974E+00 3.2528772E+00 3.1975155E+00 3.1430960E+00 3.0896025E+00 3.0370197E+00
 2.9853315E+00 2.9345226E+00 2.8845787E+00 2.8354845E+00 2.7872267E+00 2.7397900E+00 2.6931601E+00 2.6473246E+00
 2.6022692E+00 2.5579805E+00 2.5144453E+00 2.4716511E+00 2.4295855E+00 2.3882351E+00 2.3475885E+00 2.3076344E+00
 2.2683601E+00 2.2297535E+00 2.1918039E+00 2.1545010E+00 2.1178322E+00 2.0817881E+00 2.0463572E+00 2.0115290E+00
 1.9772940E+00 1.9436417E+00 1.9105616E+00 1.8780451E+00 1.8460817E+00 1.8146620E+00 1.7837772E+00 1.7534180E+00
 1.7235756E+00 1.6942415E+00 1.6654062E+00 1.6370621E+00 1.6092005E+00 1.5818129E+00 1.5548916E+00 1.5284281E+00
 1.5024147E+00 1.4768448E+00 1.4517097E+00 1.4270020E+00 1.4027147E+00 1.3788414E+00 1.3553743E+00 1.3323069E+00
 1.3096313E+00 1.2873421E+00 1.2654324E+00 1.2438955E+00 1.2227249E+00 1.2019148E+00 1.1814585E+00 1.1613503E+00
 1.1415844E+00 1.1221552E+00 1.1030569E+00 1.0842829E+00 1.0658283E+00 1.0476885E+00 1.0298576E+00 1.0123301E+00
 9.9510098E-01
   MAXIMUM RECORD SIZE (WORDS) =     858

      MAT NO.    ID NO.    MRP(M)  MCORT(M)

           1      1395       150       123
           2      1306      1615       852
             DATA TAPE COMPLETE.

     NUMBER OF ENERGIES =   7545.

APPROXIMATELY 672K OF CORE UNUSED IN THE D ARRAY AFTER DATA TAPE SETUP.
     SLOWING DOWN SEQUENCE D ARRAY SIZE =      5917

APPROXIMATELY 758K OF CORE UNUSED IN D ARRAY AFTER SLOWING-DOWN CALCULATION.
                              FINE GROUP NUMBER    1

          ROLAIDS PROCESSED   160  ENERGY POINTS BETWEEN   82.0000  EV AND   80.0000  EV.

          INTEGRATED FLUXES BY ZONE

       0.78599E-02 0.99366E-02
          CROSS SECTIONS BY SUPERZONE

             NUCLIDE NUMBER   1, ID NUMBER 92235
 ZONES       TOTAL          CAPTURE        FISSION        SCATTER
 1 -  1    3.1064056E+01  5.3460026E+00  1.3467251E+01  1.2250819E+01
             NUCLIDE NUMBER   2, ID NUMBER  6000
 ZONES       TOTAL          CAPTURE        FISSION        SCATTER
 2 -  2    4.8001204E+00  6.0050908E-05  0.0000000E+00  4.8000612E+00
          CROSS SECTIONS BY ZONE

             NUCLIDE NUMBER   1, ID NUMBER 92235
             TOTAL          CAPTURE        FISSION        SCATTER
ZONE  1    3.1064056E+01  5.3460026E+00  1.3467252E+01  1.2250819E+01
             NUCLIDE NUMBER   2, ID NUMBER  6000
             TOTAL          CAPTURE        FISSION        SCATTER
ZONE  2    4.8001204E+00  6.0050923E-05  0.0000000E+00  4.8000612E+00
```

ROLAIDS includes an equal lethargy mesh in the resolved range based on the α of the heaviest nuclide.

```
             1/E WEIGHTED CROSS SECTIONS

                  NUCLIDE NUMBER   1, ID NUMBER 92235
             TOTAL          CAPTURE         FISSION          SCATTER
           3.6704041E+01  6.7862501E+00  1.7741608E+01  1.2176206E+01
                  NUCLIDE NUMBER   2, ID NUMBER  6000
             TOTAL          CAPTURE         FISSION          SCATTER
           4.8000546E+00  6.0088598E-05  0.0000000E+00  4.7999945E+00
                                FINE GROUP NUMBER    2

             ROLAIDS PROCESSED   288  ENERGY POINTS BETWEEN   80.0000  EV AND   76.0000  EV.

             INTEGRATED FLUXES BY ZONE

           0.93620E-02 0.14750E-01
             CROSS SECTIONS BY SUPERZONE

                  NUCLIDE NUMBER   1, ID NUMBER 92235
 ZONES       TOTAL          CAPTURE         FISSION          SCATTER
 1 - 1     2.8809204E+01  5.0206242E+00  1.1358493E+01  1.2430111E+01
                  NUCLIDE NUMBER   2, ID NUMBER  6000
 ZONES       TOTAL          CAPTURE         FISSION          SCATTER
 2 - 2     4.8001127E+00  6.1235041E-05  0.0000000E+00  4.8000517E+00
             CROSS SECTIONS BY ZONE

                  NUCLIDE NUMBER   1, ID NUMBER 92235
             TOTAL          CAPTURE         FISSION          SCATTER
 ZONE  1   2.8809204E+01  5.0206251E+00  1.1358493E+01  1.2430111E+01
                  NUCLIDE NUMBER   2, ID NUMBER  6000
             TOTAL          CAPTURE         FISSION          SCATTER
 ZONE  2   4.8001127E+00  6.1235041E-05  0.0000000E+00  4.8000517E+00
             1/E WEIGHTED CROSS SECTIONS

                  NUCLIDE NUMBER   1, ID NUMBER 92235
             TOTAL          CAPTURE         FISSION          SCATTER
           3.5198853E+01  7.2381697E+00  1.5538829E+01  1.2421869E+01
                  NUCLIDE NUMBER   2, ID NUMBER  6000
             TOTAL          CAPTURE         FISSION          SCATTER
           4.7999582E+00  6.1240848E-05  0.0000000E+00  4.7998972E+00
                                FINE GROUP NUMBER    3

             ROLAIDS PROCESSED   305  ENERGY POINTS BETWEEN   76.0000  EV AND   72.0000  EV.

             INTEGRATED FLUXES BY ZONE

           0.57570E-02 0.12188E-01
             CROSS SECTIONS BY SUPERZONE

                  NUCLIDE NUMBER   1, ID NUMBER 92235
 ZONES       TOTAL          CAPTURE         FISSION          SCATTER
 1 - 1     4.1229523E+01  6.2731934E+00  2.2419235E+01  1.2537097E+01
                  NUCLIDE NUMBER   2, ID NUMBER  6000
 ZONES       TOTAL          CAPTURE         FISSION          SCATTER
 2 - 2     4.8001862E+00  6.2858089E-05  0.0000000E+00  4.8001242E+00
             CROSS SECTIONS BY ZONE

                  NUCLIDE NUMBER   1, ID NUMBER 92235
             TOTAL          CAPTURE         FISSION          SCATTER
 ZONE  1   4.1229523E+01  6.2731953E+00  2.2419235E+01  1.2537097E+01
                  NUCLIDE NUMBER   2, ID NUMBER  6000
             TOTAL          CAPTURE         FISSION          SCATTER
 ZONE  2   4.8001862E+00  6.2858104E-05  0.0000000E+00  4.8001242E+00
             1/E WEIGHTED CROSS SECTIONS

                  NUCLIDE NUMBER   1, ID NUMBER 92235
             TOTAL          CAPTURE         FISSION          SCATTER
           6.6910736E+01  1.3405929E+01  4.0487564E+01  1.3017260E+01
                  NUCLIDE NUMBER   2, ID NUMBER  6000
             TOTAL          CAPTURE         FISSION          SCATTER
           4.7999487E+00  6.2875391E-05  0.0000000E+00  4.7998867E+00
                                FINE GROUP NUMBER    4
```

Several pages of group
parameters

```
              NUCLIDE NUMBER   1, ID NUMBER 92235
          TOTAL          CAPTURE          FISSION          SCATTER
ZONE  1    9.2859802E+01  1.0356956E+01  6.9614868E+01  1.2887985E+01
              NUCLIDE NUMBER   2, ID NUMBER  6000
          TOTAL          CAPTURE          FISSION          SCATTER
ZONE  2    4.8005381E+00  5.3935940E-04  0.0000000E+00  4.7999992E+00
           1/E WEIGHTED CROSS SECTIONS

              NUCLIDE NUMBER   1, ID NUMBER 92235
          TOTAL          CAPTURE          FISSION          SCATTER
        9.2779495E+01  1.0336607E+01  6.9554352E+01  1.2888564E+01
              NUCLIDE NUMBER   2, ID NUMBER  6000
          TOTAL          CAPTURE          FISSION          SCATTER
        4.8006096E+00  5.3944718E-04  0.0000000E+00  4.8000708E+00
                         RESONANCE INTEGRAL SUMMARY

           EFFECTIVE INTEGRALS BY ZONE

              NUCLIDE NUMBER   1, ID NUMBER 92235
          TOTAL          CAPTURE          FISSION          SCATTER
ZONE  1    1.4282155E+02  2.4940414E+01  6.3773880E+01  5.4107254E+01
              NUCLIDE NUMBER   2, ID NUMBER  6000
          TOTAL          CAPTURE          FISSION          SCATTER
ZONE  2    2.1153076E+01  2.8725876E-04  0.0000000E+00  2.1152802E+01
           DILUTE INTEGRALS BY NUCLIDE

              NUCLIDE NUMBER   1, ID NUMBER 92235
          TOTAL          CAPTURE          FISSION          SCATTER
        3.3021313E+02  1.0537050E+02  1.7194278E+02  5.2899933E+01
              NUCLIDE NUMBER   2, ID NUMBER  6000
          TOTAL          CAPTURE          FISSION          SCATTER
        2.1152802E+01  9.6211233E-04  0.0000000E+00  2.1151840E+01
      NUMBER OF RECORDS IN CLAROL UPDATE FILE =     5162

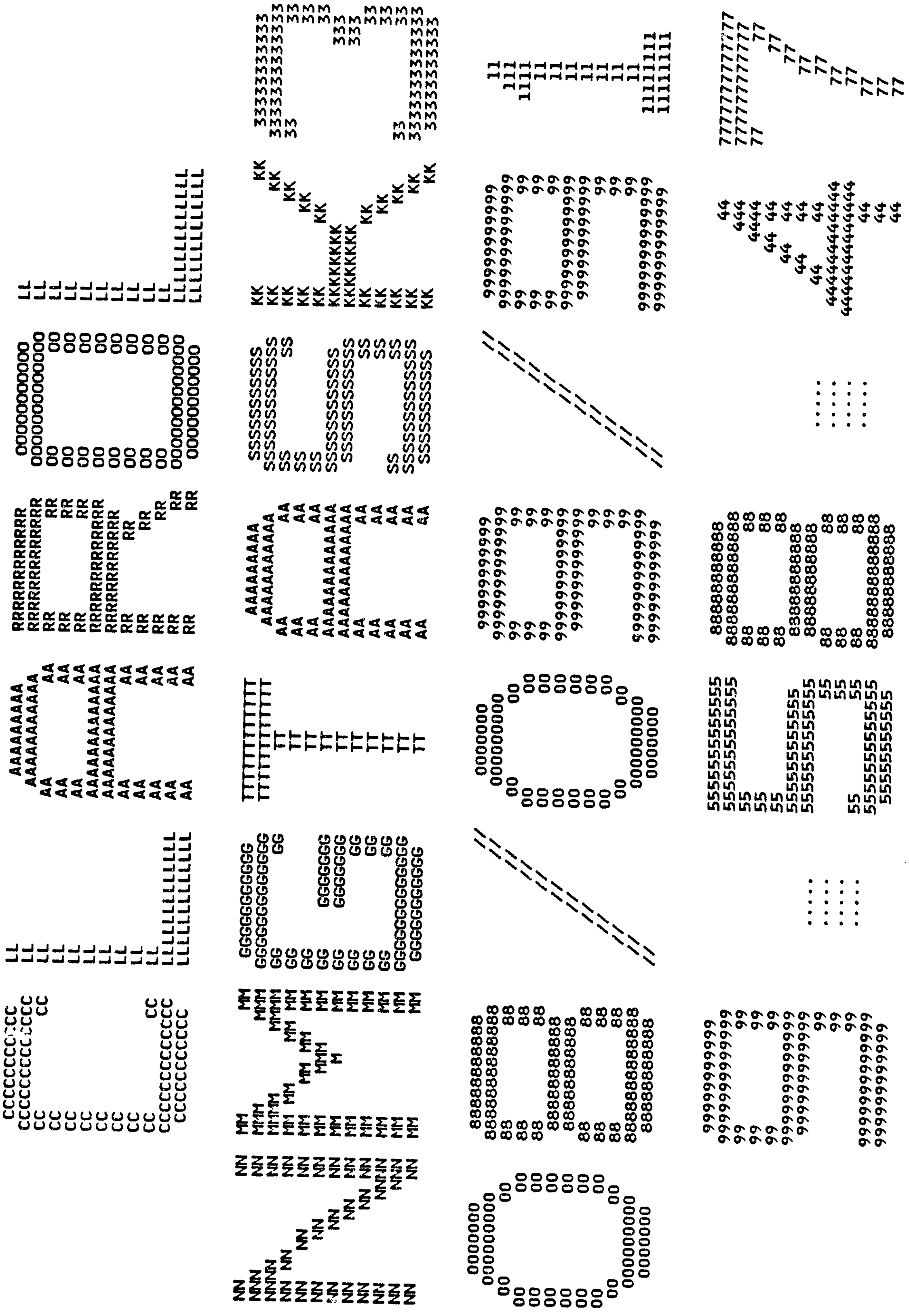
      AVERAGE RECORD LENGTH(WORDS) =        2

      MAXIMUM RECORD LENGTH(WORDS) =      102

APPROXIMATELY 755K OF CORE UNUSED IN D ARRAY AFTER FINAL OUTPUT.

MODULE: ROLAIDS  HAS TERMINATED AFTER A CPU USAGE OF  -3.11  MINUTES
```

Effective Resonance
Integrals for this
problem


CLAROL
NMGTASK3
08/09/91
9:58:47

U-235

```
REQ  ZONE NUCLID  MT  FIRST LAST SINK ORDER TEMP TRACK  _______________NEW INFORMATION_______________

 1    1   92235    2    88  189    0    0     1     1    1.225E+01 1.243E+01 1.254E+01 1.147E+01 1.224E+01 1.274E+01 1.351E+01
                                                        1.316E+01 1.259E+01 1.190E+01 1.108E+01 1.137E+01 1.119E+01 1.092E+01
                                                        1.178E+01 1.185E+01 1.201E+01 1.243E+01 1.322E+01 1.044E+01 1.186E+01
                                                        1.430E+01 2.057E+01 1.074E+01 1.277E+01 1.006E+01 9.274E+00 1.011E+01
                                                        1.077E+01 1.127E+01 1.170E+01 1.212E+01 1.099E+01 1.522E+01 8.218E+00
                                                        9.866E+00 1.106E+01 1.033E+01 1.095E+01 1.152E+01 1.162E+01 1.272E+01
                                                        1.203E+01 9.991E+00 1.159E+01 9.978E+00 1.020E+01 1.108E+01 1.042E+01
                                                        1.134E+01 1.219E+01 9.710E+00 1.029E+01 1.090E+01 1.126E+01 1.085E+01
                                                        1.127E+01 1.157E+01 1.123E+01 1.134E+01 1.120E+01 1.128E+01 1.145E+01
                                                        1.156E+01 1.160E+01 1.164E+01 1.170E+01 1.176E+01 1.182E+01 1.190E+01
                                                        1.202E+01 1.218E+01 1.194E+01 1.203E+01 1.213E+01 1.223E+01 1.233E+01
                                                        1.244E+01 1.253E+01 1.261E+01 1.269E+01 1.280E+01 1.294E+01 1.307E+01
                                                        1.314E+01 1.318E+01 1.311E+01 1.303E+01 1.298E+01 1.294E+01 1.289E+01
                                                        1.285E+01 1.283E+01 1.282E+01 1.282E+01 1.282E+01 1.283E+01 1.284E+01
                                                        1.285E+01 1.286E+01 1.287E+01 1.289E+01
```

Elastic Scattering values for group 88-189

```
 2    1   92235  102    88  189    0    0     1     3    5.346E+00 5.021E+00 6.273E+00 3.818E+00 4.503E+00 6.674E+00 5.196E+00
                                                        1.501E+01 5.686E+00 2.409E+01 2.684E+01 1.668E+01 1.445E+01 5.671E+00
                                                        8.325E+00 1.760E+01 2.255E+01 6.853E+00 5.357E+01 4.788E+00 1.355E+00
                                                        2.640E+00 7.066E+01 3.182E+01 7.235E+01 9.995E+00 5.215E+00 1.120E+01
                                                        6.254E+00 5.412E+00 1.709E+01 5.009E+00 1.988E+01 2.449E+01 1.294E+01
                                                        4.990E+00 1.491E+01 1.369E+01 8.513E+00 6.331E+00 6.285E+00 3.286E+01
                                                        9.347E+01 6.985E+00 9.114E+00 1.937E+01 4.134E+00 8.767E+01 1.064E+01
                                                        1.303E+01 1.580E+02 1.738E+01 4.370E+00 3.853E+00 3.840E+01 3.112E+00
                                                        3.939E+00 2.727E+01 7.324E+00 1.250E+01 6.532E+00 5.041E+00 3.978E+00
                                                        3.809E+00 4.065E+00 2.264E+00 2.072E+00 2.153E+00 2.354E+00 2.837E+00
                                                        4.911E+00 2.739E+01 1.544E+01 5.261E+00 3.592E+00 3.320E+00 3.437E+00
                                                        3.794E+00 4.286E+00 4.837E+00 5.670E+00 7.175E+00 1.036E+01 1.464E+01
                                                        1.854E+01 2.322E+01 2.681E+01 2.883E+01 2.892E+01 2.779E+01 2.671E+01
                                                        2.509E+01 2.297E+01 2.095E+01 1.903E+01 1.726E+01 1.566E+01 1.427E+01
                                                        1.304E+01 1.204E+01 1.113E+01 1.036E+01
```

n,γ values

```
 3    1   92235 1021    88  189    0    0     1     5    0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                                                        0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                                                        0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                                                        0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                                                        0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                                                        0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                                                        0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                                                        0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                                                        0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                                                        0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                                                        0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                                                        0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                                                        0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                                                        0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
                                                        0.000E+00 0.000E+00 0.000E+00 0.000E+00

 4    1   92235   18    88  189    0    0     1     7    1.347E+01 1.136E+01 2.242E+01 1.322E+01 5.452E+00 1.419E+01 2.374E+01
                                                        3.607E+01 3.289E+01 6.772E+01 2.383E+01 3.824E+01 2.826E+01 1.738E+01
                                                        4.287E+01 1.951E+01 3.956E+01 2.504E+01 8.912E+01 1.633E+01 1.010E+01
                                                        1.750E+01 1.901E+02 4.113E+01 5.646E+01 1.187E+01 5.537E+00 1.041E+01
                                                        1.098E+01 3.015E+01 3.663E+01 4.435E+00 2.529E+01 4.903E+01 2.272E+01
                                                        1.395E+01 2.347E+01 1.338E+01 1.290E+01 6.549E+01 2.794E+01 3.551E+01
                                                        2.212E+01 1.490E+01 3.166E+01 4.887E+01 3.989E+00 7.289E+01 9.817E+00
                                                        6.628E+00 6.273E+01 3.741E+01 1.620E+01 7.709E+00 7.933E+00 3.151E+00
                                                        3.171E+00 4.150E+01 2.289E+01 4.547E+01 2.990E+01 2.476E+01 2.070E+01
                                                        1.588E+01 8.258E+00 7.922E+00 9.296E+00 1.016E+01 1.069E+01 1.095E+01
                                                        1.178E+01 1.849E+01 1.589E+01 1.365E+01 1.365E+01 1.421E+01 1.490E+01
                                                        1.579E+01 1.672E+01 1.746E+01 1.876E+01 2.119E+01 2.538E+01 3.444E+01
                                                        4.776E+01 6.858E+01 9.033E+01 1.047E+02 1.091E+02 1.095E+02 1.099E+02
                                                        1.028E+02 1.057E+02 1.012E+02 9.575E+01 9.056E+01 8.578E+01 8.155E+01
                                                        7.768E+01 7.464E+01 7.186E+01 6.961E+01
```

Fission values

```
 REQ  ZONE NUCLIDE  MT  FIRST LAST SINK ORDER TEMP TRACK ______________________NEW INFORMATION______________________
  20    1    92235   2   101  102  102    0     1    25   2.741E+00 8.373E+00
  21    1    92235   2   102  103  103    0     1    26   3.412E+00 9.064E+00
  22    1    92235   2   103  104  104    0     1    27   2.785E+00 8.385E+00
  23    1    92235   2   104  105  105    0     1    28   3.621E+00 9.785E+00
  24    1    92235   2   105  106  106    0     1    29   2.503E+00 4.911E+00
  25    1    92235   2   105  107  107    0     1    30   1.381E-01 8.313E+00 7.612E+00
  26    1    92235   2   107  108  108    0     1    31   2.826E+00 7.726E+00
  27    1    92235   2   108  109  109    0     1    32   4.138E+00 1.275E+01
  28    1    92235   2   109  110  110    0     1    33   1.554E+00 1.631E+01
  29    1    92235   2   110  111  111    0     1    34   4.258E+00 4.947E+00
  30    1    92235   2   111  112  112    0     1    35   5.684E+00 5.972E+00
  31    1    92235   2   111  113  113    0     1    36   1.068E-01 6.796E+00 9.603E+00
  32    1    92235   2   113  114  114    0     1    37   4.500E-01 3.654E+00
  33    1    92235   2   113  115  115    0     1    38   5.133E-03 5.619E+00 6.943E+00
  34    1    92235   2   115  116  116    0     1    39   3.164E+00 1.050E+01
  35    1    92235   2   116  117  117    0     1    40   2.693E-01 1.079E+01
  36    1    92235   2   117  118  118    0     1    41   4.814E-01 1.019E+01
  37    1    92235   2   118  119  119    0     1    42   1.506E+00 1.195E+01
  38    1    92235   2   119  120  120    0     1    43   1.775E-01 8.414E+00
  39    1    92235   2   120  121  121    0     1    44   2.574E+00 1.476E+01
```

$\sigma_0(101 \rightarrow 102)$

$\sigma_0(102-102)$

```
BBBBBBBBBBBB    00000000000   NN         NN                   AAAAAAAAA    MM         MM  IIIIIIIIIIII    22222222222
BBBBBBBBBBBBB  0000000000000  NNN        NN                  AAAAAAAAAAA   MMM       MMM  IIIIIIIIIIII   2222222222222
BB         BB  00         00  NNNN       NN                 AA         AA  MMMM     MMMM       II        22         22
BB         BB  00         00  NN NN      NN                 AA         AA  MM MM   MM MM       II                   22
BB         BB  00         00  NN  NN     NN                 AA         AA  MM  MM MM  MM       II                   22
BBBBBBBBBBBB   00         00  NN   NN    NN  -------------  AAAAAAAAAAAAA  MM   MMM   MM       II                  22
BBBBBBBBBBBB   00         00  NN    NN   NN  -------------  AAAAAAAAAAAAA  MM    M    MM       II                 22
BB         BB  00         00  NN     NN  NN                 AA         AA  MM         MM       II                22
BB         BB  00         00  NN      NN NN                 AA         AA  MM         MM       II               22
BB         BB  00         00  NN       NNNN                 AA         AA  MM         MM       II              22
BBBBBBBBBBBBB  0000000000000  NN        NNN                 AA         AA  MM         MM  IIIIIIIIIIII   2222222222222
BBBBBBBBBBBB    00000000000   NN         NN                 AA         AA  MM         MM  IIIIIIIIIIII   2222222222222

NN         NN  MM         MM   GGGGGGGGGGG   TTTTTTTTTTTT     AAAAAAAAA     SSSSSSSSSSS   KK         KK   33333333333
NNN        NN  MMM       MMM  GGGGGGGGGGGGG  TTTTTTTTTTTT    AAAAAAAAAAA   SSSSSSSSSSSSS  KK        KK   3333333333333
NNNN       NN  MMMM     MMMM  GG         GG       TT        AA         AA  SS         SS  KK       KK    33         33
NN NN      NN  MM MM   MM MM  GG                  TT        AA         AA  SS             KK      KK                33
NN  NN     NN  MM  MM MM  MM  GG                  TT        AA         AA  SS             KK     KK                 33
NN   NN    NN  MM   MMM   MM  GG    GGGGGGG       TT        AAAAAAAAAAAAA  SSSSSSSSSSSS   KKKKKKKK                 333
NN    NN   NN  MM    M    MM  GG    GGGGGGG       TT        AAAAAAAAAAAAA   SSSSSSSSSSSS  KKKKKKKK                 333
NN     NN  NN  MM         MM  GG         GG       TT        AA         AA             SS  KK     KK                 33
NN      NN NN  MM         MM  GG         GG       TT        AA         AA             SS  KK      KK                33
NN       NNNN  MM         MM  GG         GG       TT        AA         AA  SS         SS  KK       KK    33         33
NN        NNN  MM         MM  GGGGGGGGGGGGG       TT        AA         AA  SSSSSSSSSSSSS  KK        KK   3333333333333
NN         NN  MM         MM   GGGGGGGGGGG        TT        AA         AA   SSSSSSSSSSS   KK         KK   33333333333

   0000000      88888888888              //     0000000      99999999999              //   99999999999        11
  000000000    8888888888888            //     000000000    9999999999999            //   9999999999999      111
 00       00   88         88           //     00       00   99         99           //    99         99     1111
00         00  88         88          //     00         00  99         99          //     99         99       11
00         00  88         88         //      00         00  99         99         //      99         99       11
00         00   88888888888         //       00         00  9999999999999        //       9999999999999       11
00         00   88888888888        //        00         00   999999999999       //         999999999999       11
00         00  88         88      //         00         00             99      //                    99       11
00         00  88         88     //          00         00             99     //                     99       11
 00       00   88         88    //            00       00              99    //                      99       11
  000000000    8888888888888   //              000000000    9999999999999   //            9999999999999    11111111
   0000000      88888888888   //                0000000     999999999999   //             999999999999     11111111

     11           0000000                       0000000        0000000                             44     88888888888
    111          000000000                     000000000      000000000                           444    8888888888888
   1111         00       00                   00       00    00       00                         4444    88         88
     11        00         00                 00         00  00         00                       44 44    88         88
     11        00         00                 00         00  00         00                      44  44    88         88
     11        00         00                 00         00  00         00                     44   44     88888888888
     11        00         00      .....      00         00  00         00      .....         44    44     88888888888
     11        00         00      .....      00         00  00         00      .....       444444444444  88         88
     11        00         00      .....      00         00  00         00      .....      4444444444444  88         88
     11         00       00       .....       00       00    00       00       .....               44    88         88
  11111111       000000000                     000000000      000000000                            44    8888888888888
  11111111        0000000                       0000000        0000000                             44     88888888888
```

Replay of Input Data

```
LOGICAL ASSIGNMENTS

MASTER LIBRARY   70
WORKING LIBRARY   0
SCRATCH FILE     18
NEW LIBRARY      25

P R O B L E M   D E S C R I P T I O N

IGR--GEOMETRY (0/1/2/3--INF MED/SLAB/CYL/SPHERE              2

IZM--NUMBER OF ZONES OR MATERIAL REGIONS                     2

MS--MIXING TABLE LENGTH                                      2

IBL--SHIELDED CROSS SECTION EDIT OPTION (0/1--NO/YES)        0

IBR--BONDARENKO FACTOR EDIT OPTION (0/1--NO/YES)             0

ISSOPT--DANCOFF FACTOR OPTION                                2

CONVERGENCE CRITERION    1.00000E-03

GEOMETRY CORRECTION FACTOR FOR WIGNER RATIONAL APPROXIMATION  0.000E+00

    3$ ARRAY      2 ENTRIES READ

    4$ ARRAY      2 ENTRIES READ

    5* ARRAY      2 ENTRIES READ

    6$ ARRAY      2 ENTRIES READ

    7* ARRAY      2 ENTRIES READ

    8* ARRAY      2 ENTRIES READ

   11$ ARRAY      2 ENTRIES READ

    0T

M I X I N G   T A B L E

ENTRY   MIXTURE   ISOTOPE   NUMBER DENSITY   NEW IDENTIFIER
  1        1        92235    4.00000E-02         9223501
  2        2         6000    4.00000E-02          600002

GEOMETRY AND MATERIAL DESCRIPTION

ZONE   MIXTURE   OUTER DIMENSION   TEMPERATURE      EXTRA XS    TYPE (0/1--FUEL/MOD)
  1       1         1.00000E+00    3.00000E+02    0.00000E+00             0
  2       2         1.69300E+00    3.00000E+02    0.00000E+00             1

THIS CALCULATION REQUIRES    30864 LOCATIONS OF    200000 AVAILABLE TO THIS MODULE

POWER FITTING FOR:      92235-- PROCESSES:  5-- SIGO'S: 6-- TEMPERATURES: 3-- MAX GROUPS:  33

ZONE     VOLUME    OUTER RADIUS
  1    3.142E+00    1.000E+00
  2    5.863E+00    1.693E+00

FUEL REGION VOLUME          3.14E+00
MODERATOR REGION VOLUME     5.86E+00
FUEL REGION RADIUS          1.00E+00
MODERATOR REGION RADIUS     1.69E+00

  ELAPSED TIME    0.01 MIN.
```

```
INFINITE DILUTION MACROSCOPIC TOTAL CROSS SECTIONS

ZONE      GROUP   1  GROUP   2  GROUP   3  GROUP   4  GROUP   5  GROUP   6  GROUP   7  GROUP   8  GROUP   9  GROUP  10
   1      2.443E-01  2.409E-01  2.376E-01  2.344E-01  2.319E-01  2.302E-01  2.402E-01  2.632E-01  2.957E-01  3.122E-01
   2      5.823E-02  5.872E-02  5.709E-02  5.217E-02  5.388E-02  5.237E-02  4.745E-02  4.828E-02  4.858E-02  6.660E-02

ZONE      GROUP  11  GROUP  12  GROUP  13  GROUP  14  GROUP  15  GROUP  16  GROUP  17  GROUP  18  GROUP  19  GROUP  20
   1      3.162E-01  3.075E-01  3.003E-01  2.899E-01  2.761E-01  2.706E-01  2.694E-01  2.690E-01  2.686E-01  2.686E-01
   2      8.555E-02  7.774E-02  6.339E-02  7.102E-02  7.583E-02  8.315E-02  8.586E-02  8.750E-02  8.970E-02  9.222E-02

ZONE      GROUP  21  GROUP  22  GROUP  23  GROUP  24  GROUP  25  GROUP  26  GROUP  27  GROUP  28  GROUP  29  GROUP  30
   1      2.694E-01  2.717E-01  2.756E-01  2.788E-01  2.803E-01  2.817E-01  2.838E-01  2.886E-01  2.959E-01  3.007E-01
   2      9.565E-02  1.003E-01  1.050E-01  1.080E-01  1.093E-01  1.105E-01  1.121E-01  1.156E-01  1.202E-01  1.229E-01

ZONE      GROUP  31  GROUP  32  GROUP  33  GROUP  34  GROUP  35  GROUP  36  GROUP  37  GROUP  38  GROUP  39  GROUP  40
   1      3.063E-01  3.140E-01  3.185E-01  3.254E-01  3.320E-01  3.380E-01  3.429E-01  3.469E-01  3.572E-01  3.742E-01
   2      1.257E-01  1.293E-01  1.312E-01  1.341E-01  1.374E-01  1.399E-01  1.421E-01  1.438E-01  1.479E-01  1.542E-01

ZONE      GROUP  41  GROUP  42  GROUP  43  GROUP  44  GROUP  45  GROUP  46  GROUP  47  GROUP  48  GROUP  49  GROUP  50
   1      3.955E-01  4.213E-01  4.410E-01  4.584E-01  4.766E-01  4.855E-01  4.905E-01  4.951E-01  5.036E-01  5.163E-01
   2      1.609E-01  1.675E-01  1.716E-01  1.746E-01  1.773E-01  1.784E-01  1.790E-01  1.796E-01  1.805E-01  1.819E-01

ZONE      GROUP  51  GROUP  52  GROUP  53  GROUP  54  GROUP  55  GROUP  56  GROUP  57  GROUP  58  GROUP  59  GROUP  60
   1      5.225E-01  5.270E-01  5.429E-01  5.595E-01  5.797E-01  5.990E-01  6.201E-01  6.490E-01  6.589E-01  6.979E-01
   2      1.825E-01  1.830E-01  1.844E-01  1.856E-01  1.865E-01  1.873E-01  1.878E-01  1.881E-01  1.884E-01  1.887E-01

ZONE      GROUP  61  GROUP  62  GROUP  63  GROUP  64  GROUP  65  GROUP  66  GROUP  67  GROUP  68  GROUP  69  GROUP  70
   1      7.327E-01  7.288E-01  7.340E-01  7.795E-01  7.774E-01  8.519E-01  8.417E-01  7.827E-01  9.056E-01  9.660E-01
   2      1.889E-01  1.889E-01  1.891E-01  1.891E-01  1.892E-01  1.892E-01  1.893E-01  1.893E-01  1.893E-01  1.894E-01

ZONE      GROUP  71  GROUP  72  GROUP  73  GROUP  74  GROUP  75  GROUP  76  GROUP  77  GROUP  78  GROUP  79  GROUP  80
   1      1.047E+00  1.176E+00  1.166E+00  1.257E+00  1.229E+00  1.684E+00  1.794E+00  1.663E+00  1.596E+00  1.539E+00
   2      1.894E-01  1.894E-01  1.895E-01  1.895E-01  1.895E-01  1.895E-01  1.895E-01  1.895E-01  1.895E-01  1.895E-01

ZONE      GROUP  81  GROUP  82  GROUP  83  GROUP  84  GROUP  85  GROUP  86  GROUP  87  GROUP  88  GROUP  89  GROUP  90
   1      1.857E+00  1.903E+00  1.831E+00  1.728E+00  1.628E+00  1.929E+00  2.482E+00  1.465E+00  1.408E+00  2.677E+00
   2      1.895E-01  1.896E-01  1.895E-01  1.895E-01  1.895E-01  1.896E-01  1.896E-01  1.896E-01  1.896E-01  1.896E-01

ZONE      GROUP  91  GROUP  92  GROUP  93  GROUP  94  GROUP  95  GROUP  96  GROUP  97  GROUP  98  GROUP  99  GROUP 100
   1      2.080E+00  1.020E+00  1.620E+00  1.893E+00  4.520E+00  2.966E+00  5.516E+00  3.215E+00  2.955E+00  3.044E+00
   2      1.896E-01  1.896E-01  1.896E-01  1.896E-01  1.896E-01  1.896E-01  1.896E-01  1.896E-01  1.896E-01  1.896E-01

ZONE      GROUP 101  GROUP 102  GROUP 103  GROUP 104  GROUP 105  GROUP 106  GROUP 107  GROUP 108  GROUP 109  GROUP 110
   1      1.957E+00  2.785E+00  2.365E+00  3.772E+00  1.953E+00  9.464E+00  1.329E+00  9.275E-01  1.793E+00  1.417E+01
   2      1.896E-01  1.896E-01  1.896E-01  1.896E-01  1.896E-01  1.896E-01  1.896E-01  1.896E-01  1.896E-01  1.896E-01

ZONE      GROUP 111  GROUP 112  GROUP 113  GROUP 114  GROUP 115  GROUP 116  GROUP 117  GROUP 118  GROUP 119  GROUP 120
   1      7.214E+00  9.089E+00  3.568E+00  8.358E-01  2.084E+00  1.820E+00  2.416E+00  4.171E+00  3.541E+00  3.053E+00
   2      1.896E-01  1.896E-01  1.896E-01  1.896E-01  1.896E-01  1.896E-01  1.896E-01  1.896E-01  1.896E-01  1.896E-01

ZONE      GROUP 121  GROUP 122  GROUP 123  GROUP 124  GROUP 125  GROUP 126  GROUP 127  GROUP 128  GROUP 129  GROUP 130
   1      1.379E+01  2.157E+00  1.740E+00  3.356E+00  2.260E+00  1.909E+00  3.568E+00  1.926E+00  9.226E+00  1.103E+01
   2      1.896E-01  1.896E-01  1.896E-01  1.896E-01  1.896E-01  1.896E-01  1.896E-01  1.896E-01  1.896E-01  1.896E-01
```

Initial Total Values

```
                                 BONDARENKO ITERATION STATISTICS
ITERATION      MT      MAX CHANGE      GROUP      ZONE      NEW VALUE      NUCLIDE          SIGO       FIRST  LAST  TIME(SEC)
    1           1      -4.666E-01        87         1       3.309E+01      9223501        1.00000E+01    55     87 4.00E-02
    2      ALL GROUPS FOR NUCLIDE        9223501 ARE CONVERGED TO LESS THAN EPS=  1.00E-03
    3      ALL GROUPS FOR NUCLIDE        9223501 ARE CONVERGED TO LESS THAN EPS=  1.00E-03

  ELAPSED TIME    0.01 MIN.
```

The total cross section in group 87
of U-235 changed by 47% on iteration 1.

```
SHIELDED MACROSCOPIC TOTAL CROSS SECTIONS

ZONE     GROUP    1  GROUP    2  GROUP    3  GROUP    4  GROUP    5  GROUP    6  GROUP    7  GROUP    8  GROUP    9  GROUP   10
   1     2.443E-01   2.409E-01   2.376E-01   2.344E-01   2.319E-01   2.302E-01   2.402E-01   2.632E-01   2.957E-01   3.122E-01
   2     5.823E-02   5.872E-02   5.709E-02   5.217E-02   5.388E-02   5.237E-02   4.745E-02   4.828E-02   4.858E-02   6.660E-02

ZONE     GROUP   11  GROUP   12  GROUP   13  GROUP   14  GROUP   15  GROUP   16  GROUP   17  GROUP   18  GROUP   19  GROUP   20
   1     3.162E-01   3.075E-01   3.003E-01   2.899E-01   2.761E-01   2.706E-01   2.694E-01   2.690E-01   2.686E-01   2.686E-01
   2     8.555E-02   7.774E-02   6.339E-02   7.102E-02   7.583E-02   8.315E-02   8.586E-02   8.750E-02   8.970E-02   9.222E-02

ZONE     GROUP   21  GROUP   22  GROUP   23  GROUP   24  GROUP   25  GROUP   26  GROUP   27  GROUP   28  GROUP   29  GROUP   30
   1     2.694E-01   2.717E-01   2.756E-01   2.788E-01   2.803E-01   2.817E-01   2.838E-01   2.886E-01   2.959E-01   3.007E-01
   2     9.565E-02   1.003E-01   1.050E-01   1.080E-01   1.093E-01   1.105E-01   1.121E-01   1.156E-01   1.202E-01   1.229E-01

ZONE     GROUP   31  GROUP   32  GROUP   33  GROUP   34  GROUP   35  GROUP   36  GROUP   37  GROUP   38  GROUP   39  GROUP   40
   1     3.063E-01   3.140E-01   3.185E-01   3.254E-01   3.320E-01   3.380E-01   3.429E-01   3.469E-01   3.572E-01   3.742E-01
   2     1.257E-01   1.293E-01   1.312E-01   1.341E-01   1.374E-01   1.399E-01   1.421E-01   1.438E-01   1.479E-01   1.542E-01

ZONE     GROUP   41  GROUP   42  GROUP   43  GROUP   44  GROUP   45  GROUP   46  GROUP   47  GROUP   48  GROUP   49  GROUP   50
   1     3.955E-01   4.213E-01   4.410E-01   4.584E-01   4.766E-01   4.855E-01   4.905E-01   4.951E-01   5.036E-01   5.163E-01
   2     1.609E-01   1.675E-01   1.716E-01   1.746E-01   1.773E-01   1.784E-01   1.790E-01   1.796E-01   1.805E-01   1.819E-01

ZONE     GROUP   51  GROUP   52  GROUP   53  GROUP   54  GROUP   55  GROUP   56  GROUP   57  GROUP   58  GROUP   59  GROUP   60
   1     5.225E-01   5.270E-01   5.429E-01   5.595E-01   5.841E-01   6.042E-01   6.262E-01   6.565E-01   6.660E-01   7.051E-01
   2     1.825E-01   1.830E-01   1.844E-01   1.856E-01   1.865E-01   1.873E-01   1.878E-01   1.881E-01   1.884E-01   1.887E-01

ZONE     GROUP   61  GROUP   62  GROUP   63  GROUP   64  GROUP   65  GROUP   66  GROUP   67  GROUP   68  GROUP   69  GROUP   70
   1     7.401E-01   7.343E-01   7.383E-01   7.813E-01   7.772E-01   8.440E-01   8.339E-01   7.755E-01   8.820E-01   9.217E-01
   2     1.889E-01   1.889E-01   1.891E-01   1.891E-01   1.892E-01   1.892E-01   1.893E-01   1.893E-01   1.893E-01   1.894E-01

ZONE     GROUP   71  GROUP   72  GROUP   73  GROUP   74  GROUP   75  GROUP   76  GROUP   77  GROUP   78  GROUP   79  GROUP   80
   1     9.727E-01   1.084E+00   1.047E+00   1.078E+00   1.026E+00   1.230E+00   1.239E+00   1.196E+00   1.164E+00   1.145E+00
   2     1.894E-01   1.894E-01   1.895E-01   1.895E-01   1.895E-01   1.895E-01   1.895E-01   1.895E-01   1.895E-01   1.895E-01

ZONE     GROUP   81  GROUP   82  GROUP   83  GROUP   84  GROUP   85  GROUP   86  GROUP   87  GROUP   88  GROUP   89  GROUP   90
   1     1.238E+00   1.220E+00   1.192E+00   1.148E+00   1.109E+00   1.161E+00   1.324E+00   1.465E+00   1.408E+00   2.677E+00
   2     1.895E-01   1.896E-01   1.895E-01   1.895E-01   1.895E-01   1.896E-01   1.896E-01   1.896E-01   1.896E-01   1.896E-01

ZONE     GROUP   91  GROUP   92  GROUP   93  GROUP   94  GROUP   95  GROUP   96  GROUP   97  GROUP   98  GROUP   99  GROUP  100
   1     2.080E+00   1.020E+00   1.620E+00   1.893E+00   4.520E+00   2.966E+00   5.516E+00   3.215E+00   2.955E+00   3.044E+00
   2     1.896E-01   1.896E-01   1.896E-01   1.896E-01   1.896E-01   1.896E-01   1.896E-01   1.896E-01   1.896E-01   1.896E-01

ZONE     GROUP  101  GROUP  102  GROUP  103  GROUP  104  GROUP  105  GROUP  106  GROUP  107  GROUP  108  GROUP  109  GROUP  110
   1     1.957E+00   2.785E+00   2.365E+00   3.772E+00   1.953E+00   9.464E+00   1.329E+00   9.275E-01   1.793E+00   1.417E+01
   2     1.896E-01   1.896E-01   1.896E-01   1.896E-01   1.896E-01   1.896E-01   1.896E-01   1.896E-01   1.896E-01   1.896E-01

ZONE     GROUP  111  GROUP  112  GROUP  113  GROUP  114  GROUP  115  GROUP  116  GROUP  117  GROUP  118  GROUP  119  GROUP  120
   1     7.214E+00   9.089E+00   3.568E+00   8.358E-01   2.084E+00   1.820E+00   2.416E+00   4.171E+00   3.541E+00   3.053E+00
   2     1.896E-01   1.896E-01   1.896E-01   1.896E-01   1.896E-01   1.896E-01   1.896E-01   1.896E-01   1.896E-01   1.896E-01

ZONE     GROUP  121  GROUP  122  GROUP  123  GROUP  124  GROUP  125  GROUP  126  GROUP  127  GROUP  128  GROUP  129  GROUP  130
   1     1.379E+01   2.157E+00   1.740E+00   3.356E+00   2.260E+00   1.909E+00   3.568E+00   1.926E+00   9.226E+00   1.103E+01
   2     1.896E-01   1.896E-01   1.896E-01   1.896E-01   1.896E-01   1.896E-01   1.896E-01   1.896E-01   1.896E-01   1.896E-01
```

Final Total Cross Sections

```
MACROSCOPIC ESCAPE CROSS SECTIONS

ZONE  GROUP    1  GROUP    2  GROUP    3  GROUP    4  GROUP    5  GROUP    6  GROUP    7  GROUP    8  GROUP    9  GROUP   10
  1   9.822E-02   9.896E-02   9.648E-02   8.890E-02   9.155E-02   8.921E-02   8.150E-02   8.278E-02   8.322E-02   1.107E-01
  2   1.056E-01   1.044E-01   1.033E-01   1.022E-01   1.013E-01   1.007E-01   1.042E-01   1.121E-01   1.227E-01   1.278E-01

ZONE  GROUP   11  GROUP   12  GROUP   13  GROUP   14  GROUP   15  GROUP   16  GROUP   17  GROUP   18  GROUP   19  GROUP   20
  1   1.378E-01   1.269E-01   1.059E-01   1.172E-01   1.242E-01   1.346E-01   1.384E-01   1.407E-01   1.437E-01   1.471E-01
  2   1.290E-01   1.263E-01   1.241E-01   1.208E-01   1.163E-01   1.145E-01   1.141E-01   1.139E-01   1.138E-01   1.138E-01

ZONE  GROUP   21  GROUP   22  GROUP   23  GROUP   24  GROUP   25  GROUP   26  GROUP   27  GROUP   28  GROUP   29  GROUP   30
  1   1.518E-01   1.580E-01   1.642E-01   1.681E-01   1.698E-01   1.712E-01   1.734E-01   1.777E-01   1.835E-01   1.868E-01
  2   1.140E-01   1.148E-01   1.161E-01   1.171E-01   1.176E-01   1.180E-01   1.187E-01   1.203E-01   1.226E-01   1.241E-01

ZONE  GROUP   31  GROUP   32  GROUP   33  GROUP   34  GROUP   35  GROUP   36  GROUP   37  GROUP   38  GROUP   39  GROUP   40
  1   1.903E-01   1.946E-01   1.969E-01   2.003E-01   2.041E-01   2.070E-01   2.095E-01   2.116E-01   2.162E-01   2.231E-01
  2   1.258E-01   1.282E-01   1.295E-01   1.316E-01   1.336E-01   1.354E-01   1.368E-01   1.380E-01   1.409E-01   1.456E-01

ZONE  GROUP   41  GROUP   42  GROUP   43  GROUP   44  GROUP   45  GROUP   46  GROUP   47  GROUP   48  GROUP   49  GROUP   50
  1   2.303E-01   2.372E-01   2.415E-01   2.444E-01   2.470E-01   2.481E-01   2.487E-01   2.492E-01   2.501E-01   2.513E-01
  2   1.514E-01   1.581E-01   1.630E-01   1.672E-01   1.715E-01   1.736E-01   1.747E-01   1.757E-01   1.776E-01   1.804E-01

ZONE  GROUP   51  GROUP   52  GROUP   53  GROUP   54  GROUP   55  GROUP   56  GROUP   57  GROUP   58  GROUP   59  GROUP   60
  1   2.519E-01   2.523E-01   2.535E-01   2.546E-01   2.551E-01   2.557E-01   2.559E-01   2.558E-01   2.559E-01   2.557E-01
  2   1.817E-01   1.827E-01   1.860E-01   1.894E-01   1.942E-01   1.980E-01   2.021E-01   2.073E-01   2.089E-01   2.152E-01

ZONE  GROUP   61  GROUP   62  GROUP   63  GROUP   64  GROUP   65  GROUP   66  GROUP   67  GROUP   68  GROUP   69  GROUP   70
  1   2.554E-01   2.555E-01   2.556E-01   2.550E-01   2.551E-01   2.542E-01   2.544E-01   2.553E-01   2.537E-01   2.531E-01
  2   2.205E-01   2.197E-01   2.202E-01   2.263E-01   2.257E-01   2.343E-01   2.331E-01   2.255E-01   2.387E-01   2.429E-01

ZONE  GROUP   71  GROUP   72  GROUP   73  GROUP   74  GROUP   75  GROUP   76  GROUP   77  GROUP   78  GROUP   79  GROUP   80
  1   2.524E-01   2.517E-01   2.521E-01   2.518E-01   2.523E-01   2.501E-01   2.500E-01   2.505E-01   2.509E-01   2.511E-01
  2   2.479E-01   2.592E-01   2.559E-01   2.586E-01   2.539E-01   2.701E-01   2.707E-01   2.678E-01   2.656E-01   2.641E-01

ZONE  GROUP   81  GROUP   82  GROUP   83  GROUP   84  GROUP   85  GROUP   86  GROUP   87  GROUP   88  GROUP   89  GROUP   90
  1   2.500E-01   2.503E-01   2.506E-01   2.511E-01   2.515E-01   2.509E-01   2.490E-01   2.475E-01   2.481E-01   2.382E-01
  2   2.706E-01   2.694E-01   2.675E-01   2.644E-01   2.613E-01   2.653E-01   2.756E-01   2.825E-01   2.799E-01   3.069E-01

ZONE  GROUP   91  GROUP   92  GROUP   93  GROUP   94  GROUP   95  GROUP   96  GROUP   97  GROUP   98  GROUP   99  GROUP  100
  1   2.418E-01   2.524E-01   2.458E-01   2.433E-01   2.322E-01   2.368E-01   2.304E-01   2.358E-01   2.369E-01   2.365E-01
  2   2.995E-01   2.533E-01   2.883E-01   2.958E-01   3.148E-01   3.091E-01   3.163E-01   3.106E-01   3.090E-01   3.096E-01

ZONE  GROUP  101  GROUP  102  GROUP  103  GROUP  104  GROUP  105  GROUP  106  GROUP  107  GROUP  108  GROUP  109  GROUP  110
  1   2.428E-01   2.376E-01   2.399E-01   2.340E-01   2.428E-01   2.271E-01   2.490E-01   2.532E-01   2.442E-01   2.254E-01
  2   2.972E-01   3.078E-01   3.037E-01   3.129E-01   2.971E-01   3.183E-01   2.759E-01   2.435E-01   2.934E-01   3.189E-01

ZONE  GROUP  111  GROUP  112  GROUP  113  GROUP  114  GROUP  115  GROUP  116  GROUP  117  GROUP  118  GROUP  119  GROUP  120
  1   2.286E-01   2.273E-01   2.346E-01   2.546E-01   2.418E-01   2.439E-01   2.396E-01   2.329E-01   2.347E-01   2.364E-01
  2   3.176E-01   3.182E-01   3.122E-01   2.333E-01   2.996E-01   2.941E-01   3.043E-01   3.141E-01   3.121E-01   3.097E-01

ZONE  GROUP  121  GROUP  122  GROUP  123  GROUP  124  GROUP  125  GROUP  126  GROUP  127  GROUP  128  GROUP  129  GROUP  130
  1   2.255E-01   2.413E-01   2.447E-01   2.353E-01   2.406E-01   2.432E-01   2.346E-01   2.430E-01   2.272E-01   2.264E-01
  2   3.189E-01   3.008E-01   2.920E-01   3.113E-01   3.023E-01   2.961E-01   3.122E-01   2.965E-01   3.183E-01   3.186E-01
```

"Escape" Cross Sections $\left(\frac{1}{\ell}\right)$

```
                NN          NN  IIIIIIIIIIII    TTTTTTTTTTTT      AAAAAAAAA     WW          WW  LL
                NNN         NN  IIIIIIIIIIII    TTTTTTTTTTTT     AAAAAAAAAAA    WW          WW  LL
                NNNN        NN       II              TT         AA         AA   WW          WW  LL
                NN NN       NN       II              TT         AA         AA   WW          WW  LL
                NN   NN     NN       II              TT         AA         AA   WW          WW  LL
                NN    NN    NN       II              TT         AAAAAAAAAAAAA   WW     W    WW  LL
                NN     NN   NN       II              TT         AAAAAAAAAAAAA   WW    WWW   WW  LL
                NN      NN  NN       II              TT         AA         AA   WW   WW WW  WW  LL
                NN       NN NN       II              TT         AA         AA   WW WW    WW WW  LL
                NN        NNNN       II              TT         AA         AA   WWWW      WWWW  LL
                NN         NNN  IIIIIIIIIIII         TT         AA         AA   WWW        WWW  LLLLLLLLLLLLL
                NN          NN  IIIIIIIIIIII         TT         AA         AA   WW          WW  LLLLLLLLLLLLL



NN          NN  MM          MM   GGGGGGGGGGG    TTTTTTTTTTTT      AAAAAAAAA      SSSSSSSSSSS    KK          KK   33333333333
NNN         NN  MMM        MMM  GGGGGGGGGGGGG   TTTTTTTTTTTT     AAAAAAAAAAA    SSSSSSSSSSSSS   KK         KK   3333333333333
NNNN        NN  MMMM      MMMM  GG         GG        TT         AA         AA   SS         SS   KK        KK    33         33
NN NN       NN  MM MM    MM MM  GG                   TT         AA         AA   SS              KK       KK                33
NN   NN     NN  MM   MM MM  MM  GG                   TT         AA         AA   SS              KK      KK                 33
NN    NN    NN  MM    MMM   MM  GG    GGGGGGG        TT         AAAAAAAAAAAAA   SSSSSSSSSSSS    KKKKKKKK                  333
NN     NN   NN  MM     M    MM  GG    GGGGGGG        TT         AAAAAAAAAAAAA    SSSSSSSSSSSS   KKKKKKKK                  333
NN      NN  NN  MM          MM  GG         GG        TT         AA         AA              SS   KK      KK                 33
NN       NN NN  MM          MM  GG         GG        TT         AA         AA              SS   KK       KK                33
NN        NNNN  MM          MM  GG         GG        TT         AA         AA   SS         SS   KK        KK    33         33
NN         NNN  MM          MM  GGGGGGGGGGGGG        TT         AA         AA   SSSSSSSSSSSSS   KK         KK   3333333333333
NN          NN  MM          MM   GGGGGGGGGGG         TT         AA         AA    SSSSSSSSSSS    KK          KK   33333333333



   0000000       88888888888               //      0000000       99999999999               //    99999999999          11
  000000000     8888888888888             //      000000000     9999999999999             //    9999999999999        111
 00       00    88         88            //      00       00    99         99            //     99         99       1111
00         00   88         88           //      00         00   99         99           //      99         99         11
00         00   88         88          //       00         00   99         99          //       99         99         11
00         00    88888888888          //        00         00   9999999999999         //        9999999999999         11
00         00    88888888888         //         00         00    999999999999        //          999999999999         11
00         00   88         88       //          00         00              99       //                     99         11
00         00   88         88      //           00         00              99      //                      99         11
 00       00    88         88     //             00       00               99     //                       99         11
  000000000     8888888888888    //               000000000     9999999999999    //             9999999999999      11111111
   0000000       88888888888    //                 0000000      999999999999    //              999999999999       11111111



      11           0000000                         0000000            11                         33333333333       0000000
     111          000000000                       000000000          111                        3333333333333     000000000
    1111         00       00                     00       00        1111                        33         33    00       00
      11        00         00                   00         00         11                                   33   00         00
      11        00         00                   00         00         11                                   33   00         00
      11        00         00                   00         00         11                                  333   00         00
      11        00         00        .....      00         00         11             .....                333   00         00
      11        00         00        .....      00         00         11             .....                 33   00         00
      11        00         00        .....      00         00         11             .....                 33   00         00
      11         00       00         .....       00       00          11             .....      33         33    00       00
   11111111       000000000                       000000000        11111111                     3333333333333     000000000
   11111111        0000000                         0000000         11111111                      33333333333       0000000
```

Oops!

Blank Page

```
     0$ ARRAY      9 ENTRIES READ

     1$ ARRAY     12 ENTRIES READ

     0T

 SELECT  3 NUCLIDES FROM THE MASTER  LIBRARY ON LOGICAL 25
         0 NUCLIDES FROM THE WORKING LIBRARY ON LOGICAL  2
         0 NUCLIDES FROM THE WORKING LIBRARY ON LOGICAL  3
           TO CREATE THE NEW WORKING LIBRARY ON LOGICAL  4

         1 RESONANCE CALCULATIONS HAVE BEEN REQUESTED
         0 OUTPUT OPTION FOR AMPX FORMATTED CROSS SECTION DATA

 THE STORAGE ALLOCATED FOR THIS CASE IS 200000 WORDS

     2$ ARRAY      3 ENTRIES READ

     3* ARRAY     15 ENTRIES READ

     0T

 GENERAL INFORMATION CONCERNING CROSS SECTION LIBRARY
   TAPE IDENTIFICATION NUMBER                 4321
   NUMBER OF NUCLIDES ON TAPE                    2
   NUMBER OF NEUTRON ENERGY GROUPS             238
   FIRST THERMAL NEUTRON ENERGY GROUP          149
   NUMBER OF GAMMA ENERGY GROUPS                 0

   DIRECT ACCESS UNIT NUMBER  9 REQUIRES 144 BLOCKS OF LENGTH  8172 WORDS


 XSDRN TAPE   4321
                        SAMPLE PROBLEM
                        FOR THE XLACS
                        MODULE OF THE
                        AMPX77 SYSTEM
                        +++++++++++++

 NUCLIDES FROM XSDRN TAPE
    1    C-12 (GRAPHITE KERNEL AT THERMAL)                                      600002
    2    C-12 (GRAPHITE KERNEL AT THERMAL)                                        6000
    3    U235                                                                  9223501

C-12 (GRAPHITE KERNEL AT THERMAL)                                  600002    TEMPERATURE=      0.00
                        THERMAL SCATTERING MATRIX NUMBER   1 AT A TEMPERATURE OF   296.01 WAS SELECTED.
C-12 (GRAPHITE KERNEL AT THERMAL)                                    6000    TEMPERATURE=      0.00
                        THERMAL SCATTERING MATRIX NUMBER   1 AT A TEMPERATURE OF   296.01 WAS SELECTED.
U235
                                                                  9223501    TEMPERATURE=      0.00
RESONANCE DATA FOR THIS NUCLIDE

MASS NUMBER (A)          =   233.025         TEMPERATURE(KELVIN)       =   300.000

POTENTIAL SCATTER SIGMA  =    11.500         LUMPED NUCLEAR DENSITY    = 3.9999999E-02

SPIN FACTOR (G)          =     0.000         LUMP DIMENSION (A-BAR)    = 5.0000000E-01

INNER RADIUS             = 0.0000000E+00     DANCOFF CORRECTION (C)    = 1.3999999E-02

THE ABSORBER WILL BE TREATED BY THE NORDHEIM INTEGRAL METHOD.

THIS RESONANCE MATERIAL WILL BE TREATED AS A 2-DIMENSIONAL OBJECT.

VOLUME FRACTION OF LUMP IN CELL USED TO ACCOUNT FOR SPATIAL SELF-SHIELDING=1.00000

GROUP        RES ABS        RES FISS        RES SCAT
 87      -1.322264E-04  -9.164021E-05  -4.719150E-05
 88      -6.166785E+00  -4.443350E+00  -3.758390E-02
 89      -6.891645E+00  -4.577898E+00  -3.994286E-02
 90      -2.618823E+01  -1.891270E+01  -4.781390E-01
```

← Difference in "Shielded" versus infinite dilution values.

6.SAMPLE PROBLEMS.4 HOMOGENIZE AND COLLAPSE CROSS SECTIONS

In this task, we assume our simple reactor lattice discussed in the previous task is located in a cylindrical region that is 50 cm in radius and surrounded by an annular shell of 200-cm-thick graphite. See Fig. 6.SAMPLE PROBLEMS.11.

ORNL-DWG 91Z-14381

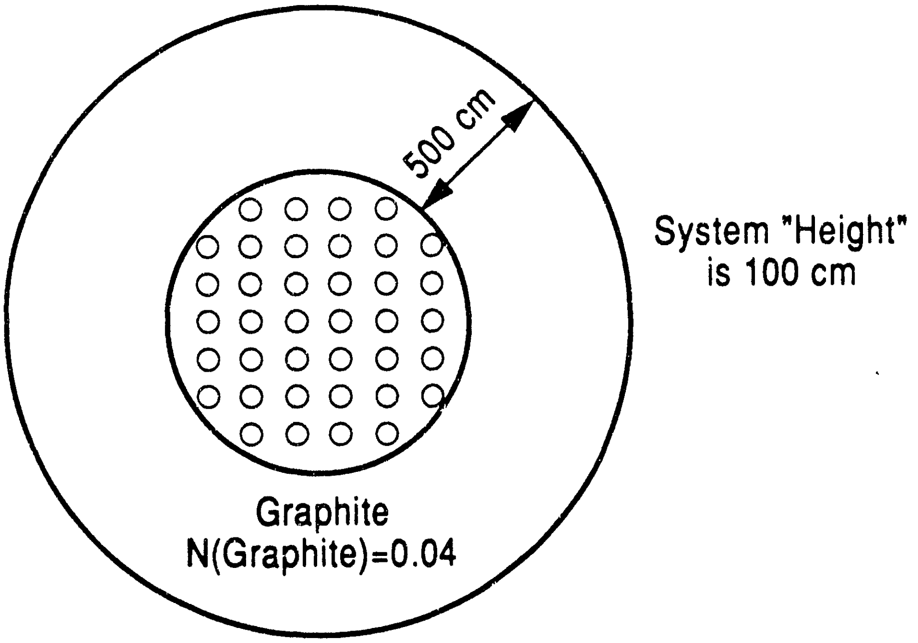


Fig. 6.SAMPLE PROBLEMS.11. Hypothetical system for demonstrating Task 4.

It was decided to produce cross sections in a 25-group energy structure, which are collapsed consistent with using them in a homogeneous representation of the core region. This collapsing will be made in two stages:

1. The first stage will produce homogenized cross sections for the representative cell shown for Task 3.
2. The second stage will use the homogenized cross sections, along with those for graphite, in a one-dimensional cylindrical mock-up of the reactor to collapse to 25 groups.

6.SAMPLE PROBLEMS.4.1 Homogenization of Cross Sections

This case will use the cross sections from the resonance self-shielding calculations from the BONAMI/NITAWL segment discussed in Sect. 6.SAMPLE PROBLEMS.4.3 for ^{235}U in conjunction with those for graphite to homogenize the cell shown in Fig. 6.SAMPLE PROBLEMS.7. The procedure is shown in Fig. 6.SAMPLE PROBLEMS.12.

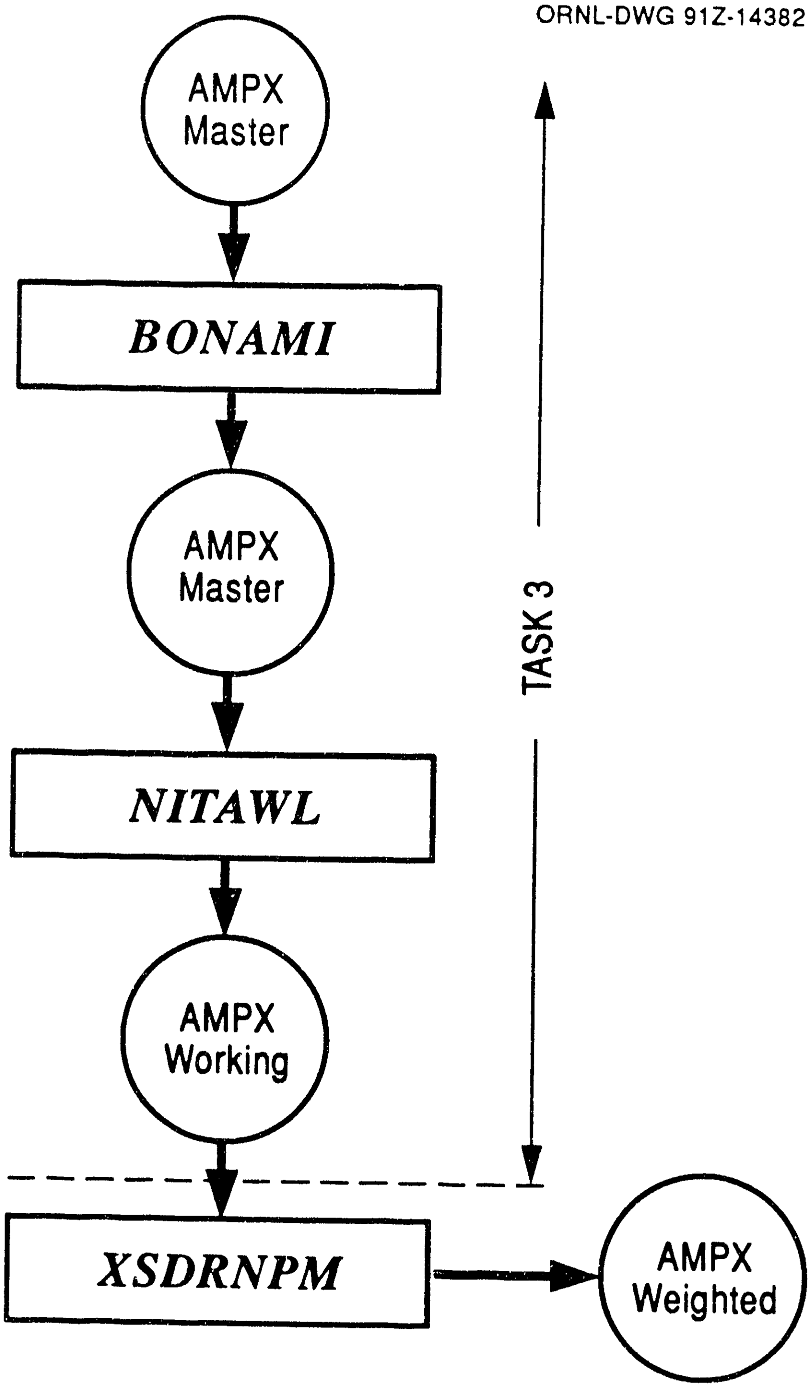


Fig. 6.SAMPLE PROBLEMS.12. Procedure for homogenizing cross sections.

6.SAMPLE PROBLEMS.4.2 Collapsing the 238-Group Library to 25 Groups

The "weighted" library discussed above is combined with a set of graphite data from the master library and used in a one-dimensional mock-up of the reactor to collapse to 25 groups. The procedure is shown in Fig. 6.SAMPLE PROBLEMS.13.

The input for the combination of the two XSDRNPM cases is shown below. Note that in the NITAWL calculation discussed in Task 3 we used a special option that allows one to make one or more copies of a nuclide when it creates a working library. In this case we have made two sets for carbon because when we homogenize the lattice cell we want a set that accounts for the flux peaking and dipping in this area; however, in the large region surrounding the core region, we need a set of data without these effects. In the first "cell-weighting" XSDRNPM case, we pick up both of the carbon sets, identified by 600002 and 6000, and mix one into the moderator region of the cell with its real number density, while we mix the other into both regions with an equal but insignificant number density. This step cancels any cell weighting on the second set and conveniently allow it to be written on the output weighted library, along with the cell-weighted set, ready for use in the second XSDRNPM case.

Portions of the output follow the input shown on the following pages.

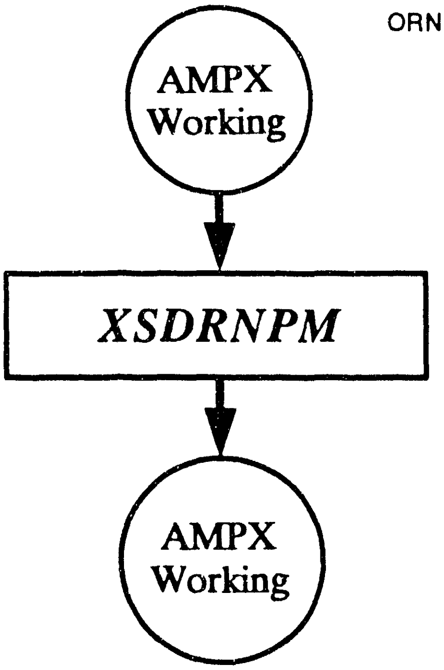


Fig. 6.SAMPLE PROBLEMS.13. Procedure to collapse cross sections.

```
    AMPX MODULE LOG AND LIST OF CARD INPUT DATA

 MODULE XSDRNPM  HAS BEEN CALLED

CASE TO CELL WEIGHT CROSS SECTIONS FOR REACTOR CORE
1$$ 2 2 5 1 3 2 4 4 3 1 10 20 0 0 0
3$$ 1 E
4$$ -1 238 E T
13$$ 1 2 1 2 14$$ 9223501 600002 2R6000 15** 0.04 0.04 2R1.0E-20 T
33## F1 T
35** 110.0 210.5 1.128 36$$ 2R1 F2 39$$ 1 2 40$$ F3 51$$ 236I1 238 T

 MODULE XSDRNPM  IS FINISHED.
 CPU TIME    22.56 (SECONDS).  I/O'S       0 USER CODE 0000   SYSTEM CODE 000
```

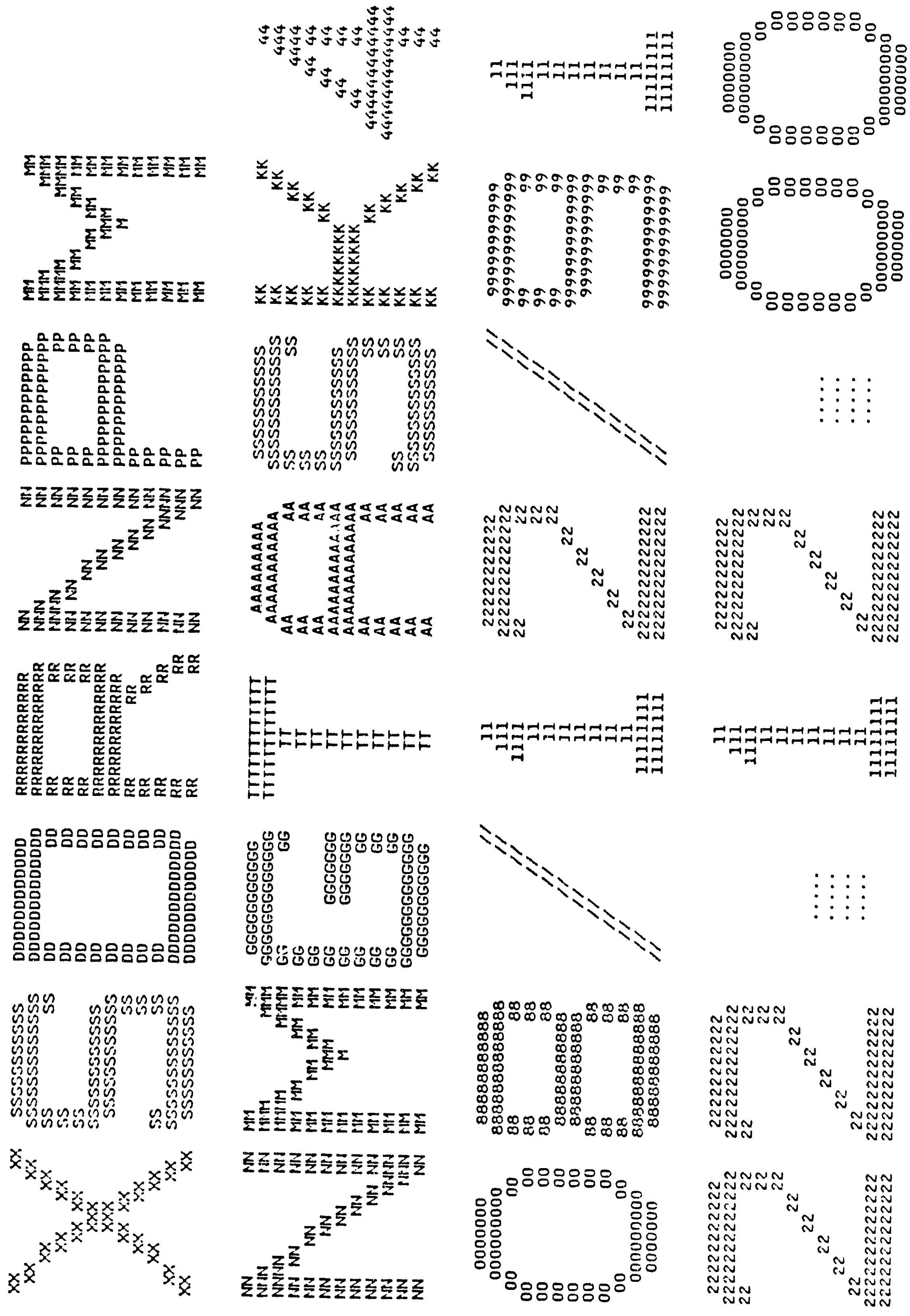
This run "cell weights"
without reducing the
number of groups.

```
 MODULE XSDRNPM  HAS BEEN CALLED

CASE TO COLLAPSE TO 25 ENERGY GROUPS
0$$ A3 3 A5 2 E
1$$ 2 2 50 1 0 2 3 4 3 1 25 25 0 0 0  2$$ A7 -3 E
3$$ 1 E 4$$ 0 25 E T
13$$ 1 1 2 14$$ 9223501 600002 6000
15** 7.8592-3 3.214-4 0.04 T
33## F1 T
35** 19I0 29I50 250 36$$ 20R1 F2 39$$ 1 2 40$$ F3
51$$  5R1 10R2 10R3 10R4 10R5 10R6 10R7 10R8 10R9 10R10
10R11 10R12 10R13 10R14 10R15 10R16 10R17 10R18 10R19 10R20
10R21 10R22 10R23 10R24 F 25 T
```

This run "zone weights"
to collapse 238 groups
to 25 groups.

```
MODULE XSDRNPM  IS FINISHED.
CPU TIME   357.53 (SECONDS).  I/O'S       0 USER CODE 0000   SYSTEM CODE 000
```



XSDRNPM
NMGTASK4
08/12/91
22:12:00

```
                       CASE TO CELL WEIGHT CROSS SECTIONS FOR REACTOR CORE
  GENERAL PROBLEM DESCRIPTION DATA BLOCK

                                    GENERAL PROBLEM DATA

IGE   1/2/3 = PLANE/CYLINDER/SPHERE        2       ISN  QUADRATURE ORDER                     4
IZM   NUMBER OF ZONES                      2       ISCT ORDER OF SCATTERING                  3
IM    NUMBER OF SPACIAL INTERVALS          5       IEVT 0/1/2/3/4/5/6=Q/K/ALPHA/C/Z/R/H      1
IBL   0/1/2/3 = VACUUM/REFL/PER/WHITE      1       IIM  INNER ITERATION MAXIMUM             10
IBR   RIGHT BOUNDARY CONDITION             3       ICM  OUTER ITERATION MAXIMUM             20
MXX   NUMBER OF MIXTURES                   2       ICLC -1/0/N--FLAT RES/SN/OPT              0
MS    MIXING TABLE LENGTH                  4       ITH  0/1 = FORWARD/ADJOINT                0
IGM   NUMBER OF ENERGY GROUPS            238       IFLU NOT USED(ALWAYS WGTD)                0
NNG   NUMBER OF NEUTRON GROUPS           238       IPRT -2/-1/0/N=MIXTURE XSEC PRINT        -1
NGG   NUMBER OF GAMMA GROUPS               0       ID1  0/1/2/3=NO/PRT ND/PCH N/BOTH         0
IFTG  NUMBER OF FIRST THERMAL GROUP      149       IPBT -1/0/1=NONE/FINE/ALL BAL. PRT        0

                                      SPECIAL OPTIONS

IFG   0/1 = NONE/WEIGHTING CALCULATION     1       IPN  0/1/2 DIFF. COEF. PARAM              3
IQM   VOLUMETRIC SOURCES (0/N=NO/YES)      0       IDFM 0/1 = NONE/DENSITY FACTORS 38*       0
IPM   BOUNDARY SOURCES (0/N=NO/YES)        0       IAZ  0/N = NONE/N ACTIVITIES BY ZONE      0
IFN   0/1/2 = INPUT 33*/34*/USE LAST       0       IAI  0/1=NONE/ACTIVITIES BY INTERVAL      0
ITMX  MAXIMUM TIME (MINUTES)               0       IFCT 0/1=NO/YES UPSCATTER SCALING         0
IDT1  0/1/2/3=NO/XSECT/SRCE/FLUX--OUT      0       IPVT 0/1/2=NO/K/ALPHA PARAMETRIC SRCH     0
ISX   BROAD GROUP FLUXES                   0       ISEN OUTER ITERATION ACCELERATION         0
IBLN  ACTIVITY DATA UNIT                   0       NBND BAND REBALN PARAMETER                0
JBKL  0/1/2 BUCKLING GEOMETRY              0

                                    WEIGHTING DATA (IFG=1)

ICON  -1/0/1=CELL/ZONE/REGION WEIGHT      -1       IHTF TOTAL XSECT PSN IN BRD GP TABLES     3
IGMF  NUMBER OF BROAD GROUPS             238       NDSF PSN G-G OR FILE NUMBER               4
ITP   0/10/20/30/40 0/C/E/AC/A             0       NUSF TABLE LENGTH OR MAX ORDER          241
IPP   -2/-1/0/N=WGTED XSECT PRINT         -1       MSCM EXTRA 1-D X-SECT POSITIONS           0
IAP   -1/N ANISN XSECT PRINT              -1

                                  FLOATING POINT PARAMETERS

EPS   OVERALL CONVERGENCE          1.00000E-04     DY   CYL/PLA HT FOR BUCKLING      0.00000E+00
PTC   POINT CONVERGENCE            1.00000E-04     DZ   PLANE DEPTH FOR BUCKLING     0.00000E+00
XNF   NORMALIZATION FACTOR         1.00000E+00     VSC  VOID STREAMING CORRECTION    0.00000E+00
EV    EIGENVALUE GUESS             0.00000E+00     PV   IPVT=1/2--K/ALPHA            0.00000E+00
EVM   EIGENVALUE MODIFIER          0.00000E+00     EQL  EV CHANGE EPS FOR SEARCH     1.00000E-03
BF    BUCKLING FACTOR=1.420892     1.42089E+00     XNPM NEW PARAM MOD FOR SEARCH     7.50000E-01
    THIS CASE WILL REQUIRE         49595 LOCATIONS FOR MIXING
    THIS CASE HAS BEEN ALLOCATED 200000 LOCATIONS
```

Primary Calculational Options

```
                         CASE TO CELL WEIGHT CROSS SECTIONS FOR REACTOR CORE
     13$ ARRAY       4 ENTRIES READ
     14$ ARRAY       4 ENTRIES READ
     15* ARRAY       4 ENTRIES READ
      0T
                                          DATA BLOCK 2 (MIXING TABLE, ETC.)
                                                          MIXING TABLE
     NUCLIDES        CCCC                       MIXTURE   COMPONENT    ATOM DENSITY             EXTRA
      ON TAPE    IDENTIFICATION                    1      9223501      4.00000E-02           XSECT ID'S
    1  600002                                      2       600002      4.00000E-02
    2    6000                                      1         6000      1.00000E-20
    3 9223501                                      2         6000      1.00000E-20
    4
  MACROSCOPIC 1-D CROSS SECTIONS FOR MIXTURE    1

         GRP.   1     GRP.   2     GRP.   3     GRP.   4     GRP.   5     GRP.   6     GRP.   7     GRP.   8
    1 3.16873E+00 2.98199E+00 2.82719E+00 2.77604E+00 2.81244E+00 2.72896E+00 2.77361E+00 2.56761E+00
    2 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
    3 9.49982E-04 4.47339E-03 8.09600E-03 1.11854E-02 1.44759E-02 1.60126E-02 1.66098E-02 1.12700E-02
    4 2.59836E-06 8.64001E-06 1.96282E-05 2.43271E-05 6.68350E-05 1.10113E-03 3.86252E-03 1.40155E-02
    5 7.86199E-02 8.12062E-02 8.39124E-02 8.31358E-02 7.87520E-02 7.03107E-02 7.09291E-02 6.31736E-02
    6 7.86696E-02 8.12688E-02 8.39913E-02 8.32270E-02 7.88524E-02 7.04492E-02 7.12062E-02 6.36624E-02
    7 3.97670E-01 3.85878E-01 3.82323E-01 3.67975E-01 3.39024E-01 2.83043E-01 2.60573E-01 2.16640E-01
    8 2.44297E-01 2.40861E-01 2.37576E-01 2.34382E-01 2.31887E-01 2.30183E-01 2.40230E-01 2.63188E-01

         GRP.   9     GRP.  10     GRP.  11     GRP.  12     GRP.  13     GRP.  14     GRP.  15     GRP.  16
    1 2.27315E+00 2.11456E+00 2.00547E+00 1.88707E+00 1.83724E+00 1.80255E+00 1.77590E+00 1.76600E+00
    2 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
    3 1.44753E-03 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
    4 4.38980E-02 2.65147E-02 1.26053E-01 8.51930E-02 2.41076E-02 1.14749E-01 9.64280E-02 3.01484E-02
    5 4.34470E-02 4.42587E-02 4.68322E-02 4.98682E-02 5.10549E-02 5.17246E-02 5.09078E-02 4.98082E-02
    6 4.41305E-02 4.51276E-02 4.79909E-02 5.14132E-02 5.28210E-02 5.38100E-02 5.35480E-02 5.28916E-02
    7 1.36488E-01 1.32180E-01 1.33379E-01 1.36166E-01 1.37172E-01 1.36636E-01 1.32161E-01 1.28247E-01
    8 2.95732E-01 3.12224E-01 3.16152E-01 3.07488E-01 3.00291E-01 2.89875E-01 2.76096E-01 2.70567E-01

         GRP.  17     GRP.  18     GRP.  19     GRP.  20     GRP.  21     GRP.  22     GRP.  23     GRP.  24
    1 1.76428E+00 1.76110E+00 1.74897E+00 1.73926E+00 1.71665E+00 1.68656E+00 1.65104E+00 1.64909E+00
    2 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
    3 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
    4 1.35514E-02 1.21673E-02 2.12634E-02 1.61826E-02 3.31732E-02 3.04210E-02 3.09141E-02 6.94189E-03
    5 4.94658E-02 4.92889E-02 4.90623E-02 4.88598E-02 4.86694E-02 4.86359E-02 4.82590E-02 4.69897E-02
    6 5.27464E-02 5.26732E-02 5.25888E-02 5.25613E-02 5.26533E-02 5.30444E-02 5.30408E-02 5.18790E-02
    7 1.27023E-01 1.26371E-01 1.25538E-01 1.24744E-01 1.23903E-01 1.23370E-01 1.21994E-01 1.18534E-01
    8 2.69423E-01 2.68951E-01 2.68602E-01 2.68592E-01 2.69357E-01 2.71660E-01 2.75551E-01 2.78759E-01

         GRP.  25     GRP.  26     GRP.  27     GRP.  28     GRP.  29     GRP.  30     GRP.  31     GRP.  32
    1 1.63163E+00 1.64112E+00 1.59698E+00 1.55774E+00 1.50903E+00 1.51755E+00 1.45212E+00 1.42340E+00
    2 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
    3 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
    4 8.71691E-03 4.86574E-03 1.44148E-02 2.45568E-02 2.49153E-02 3.15861E-03 2.44999E-02 9.36383E-03
    5 4.65098E-02 4.61832E-02 4.58027E-02 4.55255E-02 4.54874E-02 4.55412E-02 4.56646E-02 4.59080E-02
    6 5.14486E-02 5.11820E-02 5.08914E-02 5.08203E-02 5.10672E-02 5.13132E-02 5.16707E-02 5.22345E-02
    7 1.17222E-01 1.16312E-01 1.15231E-01 1.14289E-01 1.13882E-01 1.13840E-01 1.13973E-01 1.14364E-01
    8 2.80289E-01 2.81691E-01 2.83820E-01 2.88624E-01 2.95912E-01 3.00733E-01 3.06339E-01 3.14039E-01

         GRP.  33     GRP.  34     GRP.  35     GRP.  36     GRP.  37     GRP.  38     GRP.  39     GRP.  40
    1 1.40271E+00 1.35550E+00 1.32610E+00 1.29444E+00 1.27680E+00 1.25694E+00 1.19530E+00 1.12414E+00
    2 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
    3 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
    4 7.93274E-03 1.72625E-02 9.98675E-03 1.00141E-02 6.59293E-03 6.52350E-03 2.22096E-02 1.80047E-02
    5 4.61079E-02 4.64339E-02 4.68525E-02 4.72849E-02 4.77448E-02 4.81517E-02 4.90731E-02 5.04829E-02
    6 5.26193E-02 5.32318E-02 5.39870E-02 5.46986E-02 5.54103E-02 5.60255E-02 5.74501E-02 6.00061E-02
    7 1.14751E-01 1.15396E-01 1.16255E-01 1.17191E-01 1.18215E-01 1.19128E-01 1.21194E-01 1.24358E-01
    8 3.18471E-01 3.25402E-01 3.31975E-01 3.37969E-01 3.42865E-01 3.46907E-01 3.57170E-01 3.74192E-01

         GRP.  41     GRP.  42     GRP.  43     GRP.  44     GRP.  45     GRP.  46     GRP.  47     GRP.  48
    1 1.04524E+00 9.47216E-01 8.75068E-01 8.16953E-01 7.72357E-01 7.84663E-01 7.46969E-01 7.76552E-01
    2 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
    3 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00
```

13$

14$

15*

D

Σ_{up}

Σ_{n2n}

χ

Σ_f

Σ_a

$\nu\Sigma_f$

Σ_t

```
                    CASE TO CELL WEIGHT CROSS SECTIONS FOR REACTOR CORE
                    NEUTRON GROUP PARAMETERS
GP    ENERGY         LETHARGY       MID PT       BROAD GP     CALC      GROUP      RIGHT         LEFT
    BOUNDARIES      BOUNDARIES    VELOCITIES     NUMBERS      TYPE      BAND       ALBEDO        ALBEDO
 1  2.00000E+07 -6.93147E-01  5.97878E+09        1           0          1     1.00000E+00
 2  1.73330E+07 -5.50027E-01  5.62676E+09        2           0          2     1.00000E+00
 3  1.56830E+07 -4.49992E-01  5.38610E+09        3           0          3     1.00000E+00
 4  1.45500E+07 -3.75006E-01  5.22054E+09        4           0          4     1.00000E+00
 5  1.38400E+07 -3.24978E-01  5.05973E+09        5           0          5     1.00000E+00
 6  1.28400E+07 -2.49980E-01  4.66218E+09        6           0          6     1.00000E+00
 7  1.00000E+07       0       4.16711E+09        7           0          7     1.00000E+00
 8  8.18730E+06  2.00000E-01  3.73142E+09        8           0          8     1.00000E+00
 9  6.43400E+06  4.40988E-01  3.26417E+09        9           0          9     1.00000E+00
10  4.80000E+06  7.33969E-01  2.95431E+09       10           0         10     1.00000E+00
11  4.30400E+06  8.43040E-01  2.62356E+09       11           0         11     1.00000E+00
12  3.00000E+06  1.20397E+00  2.28779E+09       12           0         12     1.00000E+00
13  2.47900E+06  1.39473E+00  2.15398E+09       13           0         13     1.00000E+00
14  2.35400E+06  1.44647E+00  2.00084E+09       14           0         14     1.00000E+00
15  1.85000E+06  1.68740E+00  1.78792E+09       15           0         15     1.00000E+00
16  1.50000E+06  1.89712E+00  1.66826E+09       16           0         16     1.00000E+00
17  1.40000E+06  1.96611E+00  1.62669E+09       17           0         17     1.00000E+00
18  1.35600E+06  1.99805E+00  1.60210E+09       18           0         18     1.00000E+00
19  1.31700E+06  2.02723E+00  1.56979E+09       19           0         19     1.00000E+00
20  1.25000E+06  2.07944E+00  1.53369E+09       20           0         20     1.00000E+00
21  1.20000E+06  2.12026E+00  1.48538E+09       21           0         21     1.00000E+00
22  1.10000E+06  2.20727E+00  1.42273E+09       22           0         22     1.00000E+00
23  1.01000E+06  2.29263E+00  1.36057E+09       23           0         23     1.00000E+00
24  9.20000E+05  2.38597E+00  1.32198E+09       24           0         24     1.00000E+00
25  9.00000E+05  2.40795E+00  1.30552E+09       25           0         25     1.00000E+00
26  8.75000E+05  2.43612E+00  1.29118E+09       26           0         26     1.00000E+00
27  8.61100E+05  2.45213E+00  1.27038E+09       27           0         27     1.00000E+00
28  8.20000E+05  2.50104E+00  1.22719E+09       28           0         28     1.00000E+00
29  7.50000E+05  2.59027E+00  1.17063E+09       29           0         29     1.00000E+00
30  6.79000E+05  2.68972E+00  1.13813E+09       30           0         30     1.00000E+00
31  6.70000E+05  2.70306E+00  1.10340E+09       31           0         31     1.00000E+00
32  6.00000E+05  2.81341E+00  1.06117E+09       32           0         32     1.00000E+00
33  5.73000E+05  2.85945E+00  1.03839E+09       33           0         33     1.00000E+00
34  5.50000E+05  2.90042E+00  1.00326E+09       34           0         34     1.00000E+00
35  4.99520E+05  2.99669E+00  9.64673E+08       35           0         35     1.00000E+00
36  4.70000E+05  3.05761E+00  9.34551E+08       36           0         36     1.00000E+00
37  4.40000E+05  3.12357E+00  9.08623E+08       37           0         37     1.00000E+00
38  4.20000E+05  3.17008E+00  8.87242E+08       38           0         38     1.00000E+00
39  4.00000E+05  3.21888E+00  8.35040E+08       39           0         39     1.00000E+00
40  3.30000E+05  3.41125E+00  7.56864E+08       40           0         40     1.00000E+00
41  2.70000E+05  3.61192E+00  6.67455E+08       41           0         41     1.00000E+00
42  2.00000E+05  3.91202E+00  5.76285E+08       42           0         42     1.00000E+00
43  1.50000E+05  4.19971E+00  5.16058E+08       43           0         43     1.00000E+00
44  1.28300E+05  4.35597E+00  4.66131E+08       44           0         44     1.00000E+00
45  1.00000E+05  4.60517E+00  4.20695E+08       45           0         45     1.00000E+00
46  8.50000E+04  4.76769E+00  4.00430E+08       46           0         46     1.00000E+00
47  8.20000E+04  4.80362E+00  3.88073E+08       47           0         47     1 00000E+00
48  7.50000E+04  4.89285E+00  3.76974E+08       48           0         48     1.00000E+00
49  7.30000E+04  4.91988E+00  3.56390E+08       49           0         49     1.00000E+00
50  6.00000E+04  5.11600E+00  3.27473E+08       50           0         50     1.00000E+00
51  5.20000E+04  5.25910E+00  3.12938E+08       51           0         51     1.00000E+00
52  5.00000E+04  5.29832E+00  3.01805E+08       52           0         52     1.00000E+00
53  4.50000E+04  5.40368E+00  2.65199E+08       53           0         53     1.00000E+00
54  3.00000E+04  5.80914E+00  2.29269E+08       54           0         54     1.00000E+00
55  2.50000E+04  5.99146E+00  1.98681E+08       55           0         55     1.00000E+00
56  1.70000E+04  6.37713E+00  1.68851E+08       56           0         56     1.00000E+00
57  1.30000E+04  6.64539E+00  1.45950E+08       57           0         57     1.00000E+00
58  9.50000E+03  6.95905E+00  1.29483E+08       58           0         58     1.00000E+00
59  8.03000E+03  7.12716E+00  1.15362E+08       59           0         59     1.00000E+00
60  6.00000E+03  7.41858E+00  9.62048E+07       60           0         60     1.00000E+00
61  3.90000E+03  7.84936E+00  8.56434E+07       61           0         61     1.00000E+00
62  3.74000E+03  7.89125E+00  8.01695E+07       62           0         62     1.00000E+00
63  3.00000E+03  8.11173E+00  7.30825E+07       63           0         63     1.00000E+00
64  2.58000E+03  8.26255E+00  6.83174E+07       64           0         64     1.00000E+00
65  2.29000E+03  8.38179E+00  6.56558E+07       65           0         65     1.00000E+00
66  2.20000E+03  8.42183E+00  6.17978E+07       66           0         66     1.00000E+00
67  1.80000E+03  8.62255E+00  5.66280E+07       67           0         67     1.00000E+00
68  1.55000E+03  8.77209E+00  5.41159E+07       68           0         68     1.00000E+00
69  1.50000E+03  8.80487E+00  5.01890E+07       69           0         69     1.00000E+00
70  1.15000E+03  9.07058E+00  4.47889E+07       70           0         70     1.00000E+00
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                                   ASE TO CELL WEIGHT CROSS SECTIONS FOR REACTOR CORE
          MIXTURE      ORDER P(L)      ACTIVITY TABLE                       QUADRATURE CONSTANTS
          BY ZONE       BY ZONE    MATL NO.      REACTION       WEIGHTS      DIRECTIONS    REFL DIREC     WT X COS
     1       1             3                                       0        -5.08374E-01       3             0
     2       2             3                                 1.73927E-01 -3.59475E-01       3        -6.25225E-02
     3                                                       1.73927E-01  3.59475E-01       2         6.25225E-02
     4                                                            0       -9.40432E-01       8             0
     5                                                       1.63036E-01 -8.68846E-01       8        -1.41653E-01
     6                                                       1.63036E-01 -3.59888E-01       7        -5.86748E-02
     7                                                       1.63036E-01  3.59888E-01       6         5.86748E-02
     8                                                       1.63036E-01  8.68846E-01       5         1.41653E-01
 CONSTANTS FOR P( 3) SCATTERING

 ANGL     SET  1         SET  2         SET  3         SET  4         SET  5
     1 -5.08374E-01  6.12333E-01  2.23819E-01 -8.42969E-01 -1.03870E-01
     2 -3.59475E-01  6.12333E-01  0.00000E+00 -5.96069E-01  7.34471E-02
     3  3.59475E-01  6.12333E-01  0.00000E+00  5.96069E-01 -7.34471E-02
     4 -9.40432E-01 -3.26619E-01  7.65924E-01  2.43065E-01 -6.57540E-01
     5 -8.68846E-01 -3.26619E-01  5.41590E-01  2.24562E-01 -2.51630E-01
     6 -3.59888E-01 -3.26619E-01 -5.41589E-01  9.30170E-02  6.07489E-01
     7  3.59888E-01 -3.26619E-01 -5.41589E-01 -9.30169E-02 -6.07488E-01
     8  8.68846E-01 -3.26619E-01  5.41590E-01 -2.24562E-01  2.51630E-01
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Automatically supplied

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INT     RADII       MID PTS    ZONE NO.       AREAS       VOLUMES     DENS FACT    RADIUS MOD      SPEC(INT)
 1        0       1.25000E-01      1            0       1.96350E-01                  0
 2  2.50000E-01  3.75000E-01       1      1.57080E+00  5.89048E-01                   0
 3  5.00000E-01  6.04666E-01       2      3.14159E+00  7.95306E-01
 4  7.09333E-01  8.14000E-01       2      4.45687E+00  1.07064E+00
 5  9.18667E-01  1.02333E+00       2      5.77215E+00  1.34597E+00
 6  1.12800E+00                           7.08743E+00

ELAPSED TIME   0.03 MIN.
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Iteration Statistics

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OUTER INNER  1 - BALANCE   EIGENVALUE  1 - SOURCE   1 - SCATTER  1 - UPSCAT      SEARCH          TIME
ITER ITERS                                RATIO         RATIO        RATIO      PARAMETER        (MIN)
   1  1713 -1.72691E-05  2.13930E+00 -1.13926E+00  1.00000E+00  9.73090E-01  0.00000E+00     0.1008
   2  2560  1.10624E-05  2.13907E+00  7.80988E-07  7.21869E-05 -6.51675E-01  0.00000E+00     0.1527
   3  3231 -3.16345E-07  2.13925E+00  6.78477E-08 -6.56918E-07 -2.88398E-03  0.00000E+00     0.2002
   4  3732 -2.46062E-07  2.13924E+00 -1.58750E-09  1.80979E-08 -1.74760E-04  0.00000E+00     0.2453
                                                                GRP TO GRP INNER   MFD    MAX. FLUX    MSF   MAX. SCALE COARSE
                                                                           ITERS  INT.   DIFFERENCE   INT.     FACTOR    MESH
                                                                  1     1     1     1  1.92015E-08     5  1.00000E+00      1
                                                                  2     2     1     1  1.71998E-08     5  1.00000E+00      1
                                                                  3     3     1     1  1.48496E-08     5  1.00000E+00      1
                                                                  4     4     1     1  1.25487E-08     5  1.00000E+00      1
                                                                  5     5     1     1  1.24652E-08     5  1.00000E+00      1
                                                                  6     6     1     1  1.21758E-08     5  1.00000E+00      1
                                                                  7     7     1     1  1.30377E-08     5  1.00000E+00      1
                                                                  8     8     1     1  1.57021E-08     5  1.00000E+00      1
                                                                  9     9     1     1  2.04151E-08     5  1.00000E+00      1
                                                                 10    10     1     1  2.27511E-08     5  1.00000E+00      1
                                                                 11    11     1     1  2.38599E-08     5  1.00000E+00      1
                                                                 12    12     1     1  1.37768E-08     5  1.00000E+00      1
                                                                 13    13     1     1  8.36776E-09     5  1.00000E+00      1
                                                                 14    14     1     1  7.00888E-09     5  1.00000E+00      1
                                                                 15    15     1     1  4.20019E-09     5  1.00000E+00      1
                                                                 16    16     1     1  2.89202E-09     5  1.00000E+00      1
                                                                 17    17     1     1  2.36350E-09     5  1.00000E+00      1
                                                                 18    18     1     5  2.26217E-09     5  1.00000E+00      1
                                                                 19    19     1     1  2.33958E-09     5  1.00000E+00      1
                                                                 20    20     1     5  2.23071E-09     5  1.00000E+00      1
                                                                 21    21     1     1  2.21284E-09     5  1.00000E+00      1
                                                                 22    22     1     5  2.16035E-09     5  1.00000E+00      1
                                                                 23    23     1     5  2.17465E-09     5  1.00000E+00      1
                                                                 24    24     1     1  1.24942E-09     5  1.00000E+00      1
                                                                 25    25     1     1  1.32047E-09     5  1.00000E+00      1
                                                                 26    26     1     1  9.75881E-10     5  1.00000E+00      1
                                                                 27    27     1     1  1.45616E-09     5  1.00000E+00      1
                                                                 28    28     1     1  1.51871E-09     5  1.00000E+00      1
                                                                 29    29     1     1  1.42651E-09     5  1.00000E+00      1
                                                                 30    30     1     1  7.38651E-10     5  1.00000E+00      1
                                                                 31    31     1     1  1.34851E-09     5  1.00000E+00      1
                                                                 32    32     1     1  1.25236E-09     5  1.00000E+00      1
                                                                 33    33     1     1  1.22449E-09     5  1.00000E+00      1
                                                                 34    34     1     1  1.16900E-09     5  1.00000E+00      1
                                                                 35    35     1     1  1.1[illegible]0E-09     5  1.00000E+00      1
                                                                 36    36     1     1  1.06533E-09     5  1.00000E+00      1
                                                                 37    37     1     1  1.07546E-09     5  1.00000E+00      1
                                                                 38    38     1     1  1.05364E-09     5  1.00000E+00      1
                                                                 39    39     1     5  8.19991E-10     5  1.00000E+00      1
                                                                 40    40     1     5  6.44379E-10     5  1.00000E+00      1
                                                                 41    41     1     1  1.01552E-10     5  1.00000E+00      1
                                                                 42    42     1     5  2.33159E-10     5  1.00000E+00      1
                                                                 43    43     1     1  1.24876E-09     5  1.00000E+00      1
                                                                 44    44     1     1  7.63373E-10     5  1.00000E+00      1
                                                                 45    45     1     1  2.43986E-09     5  1.00000E+00      1
                                                                 46    46     1     1  2.52263E-09     5  1.00000E+00      1
                                                                 47    47     1     1  3.40997E-09     5  1.00000E+00      1
                                                                 48    48     1     1  2.15161E-09     5  1.00000E+00      1
                                                                 49    49     1     1  3.62328E-09     5  1.00000E+00      1
                                                                 50    50     1     1  4.60405E-09     5  1.00000E+00      1
                                                                 51    51     1     1  2.88245E-09     5  1.00000E+00      1
                                                                 52    52     1     1  5.38395E-09     5  1.00000E+00      1
                                                                 53    53     1     1  9.26562E-09     5  1.00000E+00      1
                                                                 54    54     1     5  8.89480E-09     5  1.00000E+00      1
                                                                 55    55     1     1  1.18220E-08     5  1.00000E+00      1
                                                                 56    56     1     5  1.21467E-08     5  1.00000E+00      1
                                                                 57    57     1     5  1.20682E-08     5  1.00000E+00      1
                                                                 58    58     1     5  1.92294E-08     5  1.00000E+00      1
                                                                 59    59     1     5  1.61968E-08     5  1.00000E+00      1
                                                                 60    60     1     5  1.07278E-08     5  1.00000E+00      1
                                                                 61    61     1     5  3.33228E-08     5  1.00000E+00      1
                                                                 62    62     1     5  2.7116[illegible]08     5  1.00000E+00      1
                                                                 63    63     1     5  2.952[illegible]     5  1.00000E+00      1
                                                                 64    64     1     5  3.0553[illegible]     5  1.00000E+00      1
                                                                 65    65     1     5  3.45583E-08     5  1.0000[illegible]00      1
                                                                 66    66     1     5  2.73534E-08     5  1.000[illegible]0      1
                                                                 67    67     1     5  2.87389E-08     5  1.000[illegible]0      1
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                    CASE TO CELL WEIGHT CROSS SECTIONS FOR REACTOR CORE

INT. ZONE NUMBER      RADIUS    INT. MIDPOINT     AREA         VOLUME     PROD DENSITY
  1        1       0.00000E+00  1.25000E-01  0.00000E+00  1.96350E-01  5.33589E-01
  2        1       2.50000E-01  3.75000E-01  1.57080E+00  5.89048E-01  1.60565E+00
  3        2       5.00000E-01  6.04666E-01  3.14159E+00  7.95306E-01  0.00000E+00
  4        2       7.09333E-01  8.14000E-01  4.45687E+00  1.07064E+00  0.00000E+00
  5        2       9.18667E-01  1.02333E+00  5.77215E+00  1.34597E+00  0.00000E+00
  6                1.12800E+00               7.08743E+00
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                         CASE TO CELL WEIGHT CROSS SECTIONS FOR REACTOR CORE
TOTAL FLUX

INT.   GRP.  1       GRP.  2       GRP.  3       GRP.  4       GRP.  5       GRP.  6       GRP.  7       GRP.  8
  1  1.58558E-05  4.85727E-05  1.09134E-04  1.39726E-04  3.90885E-04  6.96577E-03  2.34751E-02  9.27629E-02
  2  1.55596E-05  4.75735E-05  1.06936E-04  1.37106E-04  3.83660E-04  6.84736E-03  2.30511E-02  9.14065E-02
  3  1.51293E-05  4.61222E-05  1.03746E-04  1.33308E-04  3.73184E-04  6.67570E-03  2.24372E-02  8.94459E-02
  4  1.49087E-05  4.53784E-05  1.02115E-04  1.31371E-04  3.67838E-04  6.58803E-03  2.21245E-02  8.84517E-02
  5  1.48631E-05  4.52247E-05  1.01779E-04  1.30972E-04  3.66736E-04  6.56996E-03  2.20601E-02  8.82475E-02

INT.   GRP.  9       GRP. 10       GRP. 11       GRP. 12       GRP. 13       GRP. 14       GRP. 15       GRP. 16
  1  2.87920E-01  1.69000E-01  7.64899E-01  6.48311E-01  2.15294E-01  1.12979E+00  1.10691E+00  3.71925E-01
  2  2.84109E-01  1.66700E-01  7.52309E-01  6.41466E-01  2.13821E-01  1.12320E+00  1.10153E+00  3.70149E-01
  3  2.78603E-01  1.63372E-01  7.34045E-01  6.31492E-01  2.11674E-01  1.11360E+00  1.09373E+00  3.67575E-01
  4  2.75822E-01  1.61687E-01  7.24755E-01  6.26364E-01  2.10565E-01  1.10868E+00  1.08976E+00  3.66263E-01
  5  2.75249E-01  1.61339E-01  7.22819E-01  6.25270E-01  2.10326E-01  1.10762E+00  1.08892E+00  3.65984E-01

INT.   GRP. 17       GRP. 18       GRP. 19       GRP. 20       GRP. 21       GRP. 22       GRP. 23       GRP. 24
  1  1.70743E-01  1.56340E-01  2.79599E-01  2.18998E-01  4.66482E-01  4.53499E-01  4.89855E-01  1.14204E-01
  2  1.69886E-01  1.55574E-01  2.78241E-01  2.17896E-01  4.64173E-01  4.51445E-01  4.87817E-01  1.13746E-01
  3  1.68645E-01  1.54465E-01  2.76275E-01  2.16301E-01  4.60832E-01  4.48472E-01  4.84866E-01  1.13083E-01
  4  1.68013E-01  1.53900E-01  2.75273E-01  2.15489E-01  4.59128E-01  4.46953E-01  4.83356E-01  1.12744E-01
  5  1.67879E-01  1.53780E-01  2.75061E-01  2.15316E-01  4.58766E-01  4.46629E-01  4.83033E-01  1.12671E-01

INT.   GRP. 25       GRP. 26       GRP. 27       GRP. 28       GRP. 29       GRP. 30       GRP. 31       GRP. 32
  1  1.46572E-01  8.31374E-02  2.53247E-01  4.57285E-01  5.02233E-01  6.63813E-02  5.50825E-01  2.27349E-01
  2  1.45961E-01  8.27883E-02  2.52184E-01  4.55496E-01  5.00417E-01  6.61624E-02  5.48848E-01  2.26527E-01
  3  1.45075E-01  8.22827E-02  2.50646E-01  4.52911E-01  4.97796E-01  6.58465E-02  5.45994E-01  2.25342E-01
  4  1.44621E-01  8.20239E-02  2.49858E-01  4.51589E-01  4.96455E-01  6.56849E-02  5.44535E-01  2.24737E-01
  5  1.44524E-01  8.19682E-02  2.49689E-01  4.51304E-01  4.96166E-01  6.56499E-02  5.44219E-01  2.24606E-01

INT.   GRP. 33       GRP. 34       GRP. 35       GRP. 36       GRP. 37       GRP. 38       GRP. 39       GRP. 40
  1  2.00737E-01  4.66934E-01  2.90651E-01  3.09907E-01  2.15656E-01  2.23998E-01  8.63432E-01  8.47108E-01
  2  2.00029E-01  4.65485E-01  2.89874E-01  3.09210E-01  2.15264E-01  2.23629E-01  8.62931E-01  8.48145E-01
  3  1.99008E-01  4.63399E-01  2.88757E-01  3.08207E-01  2.14701E-01  2.23099E-01  8.62214E-01  8.49642E-01
  4  1.98488E-01  4.62336E-01  2.88187E-01  3.07693E-01  2.14411E-01  2.22826E-01  8.61832E-01  8.50377E-01
  5  1.98375E-01  4.62106E-01  2.88062E-01  3.07580E-01  2.14346E-01  2.22764E-01  8.61739E-01  8.50525E-01

INT.   GRP. 41       GRP. 42       GRP. 43       GRP. 44       GRP. 45       GRP. 46       GRP. 47       GRP. 48
  1  1.16750E+00  9.69817E-01  4.64340E-01  6.64403E-01  3.86423E-01  7.91702E-02  1.90300E-01  5.51366E-02
  2  1.17139E+00  9.75436E-01  4.67715E-01  6.70314E-01  3.90167E-01  7.99977E-02  1.92288E-01  5.58054E-02
  3  1.17698E+00  9.83481E-01  4.72531E-01  6.78702E-01  3.95466E-01  8.11678E-02  1.95092E-01  5.67506E-02
  4  1.17976E+00  9.87487E-01  4.74925E-01  6.82836E-01  3.98074E-01  8.17419E-02  1.96462E-01  5.72126E-02
  5  1.18035E+00  9.88349E-01  4.75445E-01  6.83730E-01  3.98643E-01  8.18668E-02  1.96761E-01  5.73128E-02

INT.   GRP. 49       GRP. 50       GRP. 51       GRP. 52       GRP. 53       GRP. 54       GRP. 55       GRP. 56
  1  3.76133E-01  2.45224E-01  6.42736E-02  1.64673E-01  5.04734E-01  1.90436E-01  3.03369E-01  1.61880E-01
  2  3.80714E-01  2.48538E-01  6.50993E-02  1.66882E-01  5.12948E-01  1.94054E-01  3.10313E-01  1.66154E-01
  3  3.87155E-01  2.53190E-01  6.62553E-02  1.69977E-01  5.24433E-01  1.99101E-01  3.19976E-01  1.72093E-01
  4  3.90289E-01  2.55447E-01  6.68152E-02  1.71476E-01  5.29960E-01  2.01514E-01  3.24572E-01  1.74903E-01
  5  3.90970E-01  2.55930E-01  6.69374E-02  1.71803E-01  5.31163E-01  2.02038E-01  3.25570E-01  1.75514E-01

INT.   GRP. 57       GRP. 58       GRP. 59       GRP. 60       GRP. 61       GRP. 62       GRP. 63       GRP. 64
  1  1.38627E-01  5.69956E-02  7.39868E-02  6.29023E-02  4.67768E-03  2.05406E-02  1.05358E-02  6.52390E-03
  2  1.42817E-01  5.89980E-02  7.68059E-02  6.58216E-02  4.91098E-03  2.16576E-02  1.11141E-02  6.94164E-03
  3  1.48630E-01  6.17683E-02  8.07112E-02  6.98595E-02  5.23178E-03  2.32025E-02  1.19139E-02  7.51896E-03
  4  1.51369E-01  6.30609E-02  8.25362E-02  7.17292E-02  5.37832E-03  2.39139E-02  1.22824E-02  7.78245E-03
  5  1.51964E-01  6.33405E-02  8.29330E-02  7.21346E-02  5.40985E-03  2.40680E-02  1.23625E-02  7.83950E-03

INT.   GRP. 65       GRP. 66       GRP. 67       GRP. 68       GRP. 69       GRP. 70       GRP. 71       GRP. 72
  1  1.94999E-03  7.10434E-03  3.82387E-03  7.67500E-04  3.99328E-03  1.74426E-03  1.58065E-03  5.94578E-05
  2  2.07134E-03  7.65765E-03  4.11570E-03  8.15208E-04  4.34746E-03  1.91192E-03  1.75598E-03  6.66098E-05
  3  2.23873E-03  8.42066E-03  4.51838E-03  8.80882E-04  4.83801E-03  2.14319E-03  1.99905E-03  7.63188E-05
  4  2.31517E-03  8.76348E-03  4.70038E-03  9.11045E-04  5.05836E-03  2.24572E-03  2.10640E-03  8.04178E-05
  5  2.33174E-03  8.83712E-03  4.73982E-03  9.17724E-04  5.10611E-03  2.26782E-03  2.12963E-03  8.12822E-05

INT.   GRP. 73       GRP. 74       GRP. 75       GRP. 76       GRP. 77       GRP. 78       GRP. 79       GRP. 80
  1  4.75418E-04  4.91939E-04  3.67631E-05  5.92626E-05  2.96815E-05  2.26761E-06  1.25142E-05  5.12549E-06
  2  5.38578E-04  5.60938E-04  4.12532E-05  7.02615E-05  3.52624E-05  2.64725E-06  1.45951E-05  5.94698E-06
  3  6.26247E-04  6.57030E-04  4.74303E-05  8.56388E-05  4.30580E-05  3.16994E-06  1.75023E-05  7.09644E-06
  4  6.64259E-04  6.98837E-04  5.01067E-05  9.21168E-05  4.63433E-05  3.39012E-06  1.87514E-05  7.59515E-06
  5  6.72405E-04  7.07904E-04  5.06820E-05  9.34983E-05  4.70447E-05  3.43772E-06  1.90241E-05  7.70493E-06

INT.   GRP. 81       GRP. 82       GRP. 83       GRP. 84       GRP. 85       GRP. 86       GRP. 87       GRP. 88
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Flux per unit volume
integrated over
energy

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 223  0.00000E+00  1.24551E-12  8.40268E-15  1.96828E-14  7.36751E-15  1.33527E-12 -8.87190E-14  9.99997E-01
 224  0.00000E+00  5.20559E-13  4.30971E-15  5.14563E-15  4.67163E-15  5.53115E-13 -3.29242E-14  1.00000E+00
 225  0.00000E+00  1.34341E-12  3.19292E-15  1.75313E-14  1.85044E-15  1.41785E-12 -7.31018E-14  1.00000E+00
 226  0.00000E+00  1.55695E-13  9.00872E-16  7.84228E-16  7.70377E-16  1.62596E-13 -6.77064E-15  1.00000E+00
 227  0.00000E+00  1.31477E-13  5.25163E-16  6.15168E-16  4.85656E-16  1.36722E-13 -5.20601E-15  1.00000E+00
 228  0.00000E+00  4.46729E-14  2.20377E-16  1.03509E-16  2.12173E-16  4.62651E-14 -1.58428E-15  1.00000E+00
 229  0.00000E+00  3.93831E-14  1.62812E-16  8.83474E-17  1.56615E-16  4.06650E-14 -1.27581E-15  1.00000E+00
 230  0.00000E+00  1.74662E-14  7.68160E-17  2.15621E-17  7.46679E-17  1.79863E-14 -5.18056E-16  1.00000E+00
 231  0.00000E+00  1.57959E-14  6.13659E-17  1.91709E-17  5.96322E-17  1.62326E-14 -4.34981E-16  1.00000E+00
 232  0.00000E+00  1.39260E-14  4.63198E-17  1.65208E-17  4.49481E-17  1.42757E-14 -3.48371E-16  1.00000E+00
 233  0.00000E+00  7.34107E-15  2.37375E-17  5.48462E-18  2.31229E-17  7.50738E-15 -1.65716E-16  1.00000E+00
 234  0.00000E+00  4.41833E-15  1.37037E-17  2.26073E-18  1.33762E-17  4.50999E-15 -9.13425E-17  1.00000E+00
 235  0.00000E+00  4.92332E-15  1.29880E-17  3.04016E-18  1.26561E-17  5.01580E-15 -9.21622E-17  1.00000E+00
 236  0.00000E+00  4.15748E-15  9.17708E-18  2.50806E-18  8.92699E-18  4.22409E-15 -6.63709E-17  1.00000E+00
 237  0.00000E+00  4.52224E-15  6.12790E-18  3.73247E-18  5.78554E-18  4.57275E-15 -5.01723E-17  1.00000E+00
 238  0.00000E+00  4.30178E-16  5.38155E-19  8.45882E-20  4.94514E-19  4.32058E-16 -1.83689E-18  1.00000E+00
 239  0.00000E+00  9.99997E-01  7.70780E-01  3.74205E+00  7.70776E-01  1.00060E+00  9.33653E-04  1.00000E+00

GRP.  RT BDY FLUX   RT LEAKAGE LFT BDY FLUX  LFT LEAKAGE    N2N RATE     FISS RATE    FLUX*DB**2   TOTAL FLUX
   1  1.53028E-05  1.47552E-06  1.58941E-05  0.00000E+00  1.16645E-08  9.65345E-07  0.00000E+00  1.22786E-05
   2  4.67068E-05  4.96392E-06  4.87014E-05  0.00000E+00  1.68022E-07  3.05013E-06  0.00000E+00  3.75603E-0[illegible]
   3  1.05027E-04  1.08902E-05  1.09416E-04  0.00000E+00  6.83454E-07  7.08377E-06  0.00000E+00  8.44187E-05
   4  1.34831E-04  1.29634E-05  1.40062E-04  0.00000E+00  1.21023E-06  8.99507E-06  0.00000E+00  1.08197E-04
   5  3.77386E-04  3.57678E-05  3.91810E-04  0.00000E+00  4.38250E-06  2.38417E-05  0.00000E+00  3.02744E-04
   6  6.74461E-03  5.86815E-04  6.98097E-03  0.00000E+00  9.72890E-05  3.79758E-04  0.00000E+00  5.40115E-03
   7  2.26831E-02  2.09279E-03  2.35296E-02  0.00000E+00  3.02090E-04  1.29002E-03  0.00000E+00  1.81875E-02
   8  9.02278E-02  6.66551E-03  9.29356E-02  0.00000E+00  8.12080E-04  4.55208E-03  0.00000E+00  7.20568E-02
   9  2.80791E-01  1.85972E-02  2.88400E-01  0.00000E+00  3.24082E-04  9.72719E-03  0.00000E+00  2.23887E-01
  10  1.64695E-01  1.11878E-02  1.69287E-01  0.00000E+00  0.00000E+00  5.81459E-03  0.00000E+00  1.31378E-01
  11  7.41335E-01  6.10317E-02  7.66470E-01  0.00000E+00  0.00000E+00  2.77871E-02  0.00000E+00  5.93334E-01
  12  6.35499E-01  3.29064E-02  6.49164E-01  0.00000E+00  0.00000E+00  2.51909E-02  0.00000E+00  5.05150E-01
  13  2.12538E-01  7.03672E-03  2.15478E-01  0.00000E+00  0.00000E+00  8.58866E-03  0.00000E+00  1.68224E-01
  14  1.11745E+00  3.15566E-02  1.13061E+00  0.00000E+00  0.00000E+00  4.56961E-02  0.00000E+00  8.83451E-01
  15  1.09684E+00  2.57565E-02  1.10758E+00  0.00000E+00  0.00000E+00  4.40961E-02  0.00000E+00  8.66196E-01
  16  3.68602E-01  8.48671E-03  3.72147E-01  0.00000E+00  0.00000E+00  1.44973E-02  0.00000E+00  2.91063E-01
  17  1.69139E-01  4.09682E-03  1.70851E-01  0.00000E+00  0.00000E+00  6.60845E-03  0.00000E+00  1.33596E-01
  18  1.54907E-01  3.65998E-03  1.56436E-01  0.00000E+00  0.00000E+00  6.02989E-03  0.00000E+00  1.22338E-01
  19  2.77058E-01  6.48535E-03  2.79770E-01  0.00000E+00  0.00000E+00  1.07347E-02  0.00000E+00  2.18796E-01
  20  2.16937E-01  5.25706E-03  2.19137E-01  0.00000E+00  0.00000E+00  8.37220E-03  0.00000E+00  1.71352E-01
  21  4.62164E-01  1.10037E-02  4.66773E-01  0.00000E+00  0.00000E+00  1.77650E-02  0.00000E+00  3.65014E-01
  22  4.49658E-01  9.77199E-03  4.53759E-01  0.00000E+00  0.00000E+00  1.72641E-02  0.00000E+00  3.54967E-01
  23  4.86045E-01  9.67282E-03  4.90113E-01  0.00000E+00  0.00000E+00  1.85088E-02  0.00000E+00  3.83530E-01
  24  1.13348E-01  2.16928E-03  1.14262E-01  0.00000E+00  0.00000E+00  4.20211E-03  0.00000E+00  8.94260E-02
  25  1.45429E-01  2.89447E-03  1.46649E-01  0.00000E+00  0.00000E+00  5.33733E-03  0.00000E+00  1.14757E-01
  26  8.24848E-02  1.65087E-03  8.31816E-02  0.00000E+00  0.00000E+00  3.00608E-03  0.00000E+00  6.50902E-02
  27  2.51260E-01  5.01809E-03  2.53381E-01  0.00000E+00  0.00000E+00  9.08145E-03  0.00000E+00  1.98273E-01
  28  4.53943E-01  8.41615E-03  4.57512E-01  0.00000E+00  0.00000E+00  1.63025E-02  0.00000E+00  3.58097E-01
  29  4.98841E-01  8.50960E-03  5.02464E-01  0.00000E+00  0.00000E+00  1.78940E-02  0.00000E+00  3.93383E-01
  30  6.59724E-02  1.02306E-03  6.64094E-02  0.00000E+00  0.00000E+00  2.36845E-03  0.00000E+00  5.20068E-02
  31  5.47131E-01  9.22063E-03  5.51077E-01  0.00000E+00  0.00000E+00  1.97021E-02  0.00000E+00  4.31452E-01
  32  2.25813E-01  3.81894E-03  2.27454E-01  0.00000E+00  0.00000E+00  8.17508E-03  0.00000E+00  1.78075E-01
  33  1.99414E-01  3.28298E-03  2.00828E-01  0.00000E+00  0.00000E+00  7.25007E-03  0.00000E+00  1.57241E-01
  34  4.64227E-01  6.68980E-03  4.67120E-01  0.00000E+00  0.00000E+00  1.69890E-02  0.00000E+00  3.65875E-01
  35  2.89201E-01  3.57147E-03  2.90751E-01  0.00000E+00  0.00000E+00  1.06739E-02  0.00000E+00  2.27819E-01
  36  3.08606E-01  3.19377E-03  3.09998E-01  0.00000E+00  0.00000E+00  1.14897E-02  0.00000E+00  2.42989E-01
  37  2.14925E-01  1.78594E-03  2.15707E-01  0.00000E+00  0.00000E+00  8.07576E-03  0.00000E+00  1.69145E-01
  38  2.23310E-01  1.67635E-03  2.24046E-01  0.00000E+00  0.00000E+00  8.46073E-03  0.00000E+00  1.75710E-01
  39  8.62505E-01  2.21863E-03  8.63505E-01  0.00000E+00  0.00000E+00  3.32639E-02  0.00000E+00  6.77843E-01
  40  8.49061E-01 -4.77354E-03  8.46991E-01  0.00000E+00  0.00000E+00  3.36179E-02  0.00000E+00  6.65928E-01
  41  1.17480E+00 -1.75685E-02  1.16703E+00  0.00000E+00  0.00000E+00  4.86540E-02  0.00000E+00  9.19242E-01
  42  9.80352E-01 -2.49289E-02  9.69134E-01  0.00000E+00  0.00000E+00  4.33180E-02  0.00000E+00  7.65002E-01
  43  4.70666E-01 -1.47491E-02  4.63927E-01  0.00000E+00  0.00000E+00  2.16830E-02  0.00000E+00  3.66680E-01
  44  6.75479E-01 -2.55197E-02  6.63680E-01  0.00000E+00  0.00000E+00  3.23216E-02  0.00000E+00  5.25303E-01
  45  3.93436E-01 -1.59691E-02  3.85962E-01  0.00000E+00  0.00000E+00  1.91118E-02  0.00000E+00  3.05701E-01
  46  8.07208E-02 -3.51480E-03  7.90688E-02  0.00000E+00  0.00000E+00  4.05231E-03  0.00000E+00  6.26675E-02
  47  1.94025E-01 -8.40236E-03  1.90054E-01  0.00000E+00  0.00000E+00  1.00214E-02  0.00000E+00  1.50632E-01
  48  5.63906E-02 -2.83199E-03  5.50556E-02  0.00000E+00  0.00000E+00  3.09170E-03  0.00000E+00  4.36981E-02
  49  3.84714E-01 -1.92028E-02  3.75570E-01  0.00000E+00  0.00000E+00  2.08204E-02  0.00000E+00  2.98112E-01
  50  2.51433E-01 -1.38011E-02  2.44818E-01  0.00000E+00  0.00000E+00  1.42773E-02  0.00000E+00  1.94550E-01
  51  6.58198E-02 -3.41684E-03  6.41715E-02  0.00000E+00  0.00000E+00  3.55817E-03  0.00000E+00  5.09667E-02
  52  1.68811E-01 -9.13947E-03  1.64401E-01  0.00000E+00  0.00000E+00  9.23102E-03  0.00000E+00  1.30635E-01
  53  5.20130E-01 -3.37026E-02  5.03731E-01  0.00000E+00  0.00000E+00  3.09273E-02  0.00000E+00  4.01256E-01
  54  1.97221E-01 -1.47292E-02  1.89997E-01  0.00000E+00  0.00000E+00  1.25981E-02  0.00000E+00  1.51699E-01
  55  3.16398E-01 -2.79793E-02  3.02535E-01  0.00000E+00  0.00000E+00  2.24163E-02  0.00000E+00  2.42356E-01
  56  1.69905E-01 -1.70875E-02  1.61371E-01  0.00000E+00  0.00000E+00  1.34093E-02  0.00000E+00  1.29658E-01
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Integrated over
volume and energy

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 TRANSPORT CROSS SECTION WEIGHTING FUNCTION

ZONE   GRP.  1      GRP.  2      GRP.  3      GRP.  4      GRP.  5      GRP.  6      GRP.  7      GRP.  8
   1  2.91751E-07  9.81208E-07  2.15193E-06  2.56122E-06  7.06765E-06  1.15994E-04  4.13635E-04  1.31680E-03
   2  1.70286E-07  5.72675E-07  1.25652E-06  1.49616E-06  4.12817E-06  6.77443E-05  2.41553E-04  7.69872E-04
   3  1.94151E-07  6.52945E-07  1.43246E-06  1.70543E-06  4.70573E-06  7.72244E-05  2.75364E-04  8.77334E-04

ZONE   GRP.  9      GRP. 10      GRP. 11      GRP. 12      GRP. 13      GRP. 14      GRP. 15      GRP. 16
   1  3.67097E-03  2.20793E-03  1.20519E-02  6.49941E-03  1.38997E-03  6.23283E-03  5.08921E-03  1.67785E-03
   2  2.14844E-03  1.29221E-03  7.04454E-03  3.80988E-03  8.17499E-04  3.65942E-03  2.98249E-03  9.82171E-04
   3  2.44759E-03  1.47213E-03  8.02840E-03  4.33832E-03  9.29978E-04  4.16505E-03  3.39642E-03  1.11886E-03

ZONE   GRP. 17      GRP. 18      GRP. 19      GRP. 20      GRP. 21      GRP. 22      GRP. 23      GRP. 24
   1  8.10121E-04  7.23895E-04  1.28295E-03  1.04008E-03  2.17772E-03  1.93474E-03  1.91589E-03  4.29793E-04
   2  4.73814E-04  4.23349E-04  7.50184E-04  6.07914E-04  1.27270E-03  1.13115E-03  1.12033E-03  2.51282E-04
   3  5.39892E-04  4.82400E-04  8.54864E-04  6.92827E-04  1.45052E-03  1.28904E-03  1.27664E-03  2.86356E-04

ZONE   GRP. 25      GRP. 26      GRP. 27      GRP. 28      GRP. 29      GRP. 30      GRP. 31      GRP. 32
   1  5.73458E-04  3.27130E-04  9.94529E-04  1.66876E-03  1.68813E-03  2.03089E-04  1.82998E-03  7.58151E-04
   2  3.35062E-04  1.91075E-04  5.80716E-04  9.74443E-04  9.85712E-04  1.18620E-04  1.06743E-03  4.41890E-04
   3  3.81903E-04  2.17808E-04  6.62023E-04  1.11086E-03  1.12372E-03  1.35217E-04  1.21725E-03  5.04030E-04

ZONE   GRP. 33      GRP. 34      GRP. 35      GRP. 36      GRP. 37      GRP. 38      GRP. 39      GRP. 40
   1  6.51893E-04  1.32923E-03  7.10085E-04  6.35495E-04  3.55811E-04  3.34053E-04  4.46732E-04  9.39320E-04
   2  3.79956E-04  7.75369E-04  4.14631E-04  3.71486E-04  2.08300E-04  1.95532E-04  2.64202E-04  5.43085E-04
   3  4.33386E-04  8.84192E-04  4.72683E-04  4.23359E-04  2.37284E-04  2.22749E-04  3.00066E-04  6.20938E-04

ZONE   GRP. 41      GRP. 42      GRP. 43      GRP. 44      GRP. 45      GRP. 46      GRP. 47      GRP. 48
   1  3.47407E-03  4.93394E-03  2.91999E-03  5.05206E-03  3.16207E-03  6.95702E-04  1.66390E-03  5.60048E-04
   2  2.02213E-03  2.87617E-03  1.70408E-03  2.95029E-03  1.84855E-03  4.06665E-04  9.72804E-04  3.27238E-04
   3  2.30741E-03  3.28049E-03  1.94298E-03  3.36325E-03  2.10663E-03  4.63455E-04  1.10859E-03  3.72981E-04

ZONE   GRP. 49      GRP. 50      GRP. 51      GRP. 52      GRP. 53      GRP. 54      GRP. 55      GRP. 56
   1  3.80128E-03  2.73090E-03  6.76601E-04  1.80897E-03  6.66558E-03  2.91104E-03  5.52415E-03  3.37054E-03
   2  2.22223E-03  1.59755E-03  3.96227E-04  1.05933E-03  3.90326E-03  1.70560E-03  3.24175E-03  1.98103E-03
   3  2.53248E-03  1.82023E-03  4.51316E-04  1.20662E-03  4.44601E-03  1.94245E-03  3.69020E-03  2.25405E-03

ZONE   GRP. 57      GRP. 58      GRP. 59      GRP. 60      GRP. 61      GRP. 62      GRP. 63      GRP. 64
   1  3.27365E-03  1.54680E-03  2.17077E-03  2.21792E-03  1.74584E-04  8.41290E-04  4.34553E-04  3.09628E-04
   2  1.92713E-03  9.11864E-04  1.28172E-03  1.31340E-03  1.03642E-04  4.99491E-04  2.58455E-04  1.84446E-04
   3  2.19170E-03  1.03662E-03  1.45640E-03  1.49112E-03  1.17580E-04  5.66649E-04  2.93055E-04  2.09042E-04

ZONE   GRP. 65      GRP. 66      GRP. 67      GRP. 68      GRP. 69      GRP. 70      GRP. 71      GRP. 72
   1  8.97957E-05  4.02212E-04  2.12630E-04  3.52165E-05  2.54998E-04  1.19153E-04  1.22955E-04  4.77379E-06
   2  5.35001E-05  2.40564E-04  1.27447E-04  2.10716E-05  1.53333E-04  7.19056E-05  7.45333E-05  2.91172E-06
   3  6.06315E-05  2.72325E-04  1.44183E-04  2.38508E-05  1.73308E-04  8.11889E-05  8.40473E-05  3.27759E-06

ZONE   GRP. 73      GRP. 74      GRP. 75      GRP. 76      GRP. 77      GRP. 78      GRP. 79      GRP. 80
   1  4.35999E-05  4.71303E-05  3.09454E-06  7.26561E-06  3.66015E-06  2.48708E-07  1.39409E-06  5.51851E-07
   2  2.66165E-05  2.88939E-05  1.89237E-06  4.50486E-06  2.27394E-06  1.53831E-07  8.64517E-07  3.41654E-07
   3  2.99535E-05  3.24771E-05  2.12858E-06  5.04729E-06  2.54630E-06  1.72473E-07  9.68569E-07  3.82953E-07

ZONE   GRP. 81      GRP. 82      GRP. 83      GRP. 84      GRP. 85      GRP. 86      GRP. 87      GRP. 88
   1  3.44461E-06  1.11597E-07  1.52712E-07  2.52837E-07  2.63558E-07  2.94503E-07  1.99341E-07  4.33774E-08
   2  2.14592E-06  6.92054E-08  9.50164E-08  1.56772E-07  1.62902E-07  1.82425E-07  1.24746E-07  2.68973E-08
   3  2.40109E-06  7.75345E-08  1.06353E-07  1.75647E-07  1.82679E-07  2.04446E-07  1.39403E-07  3.01354E-08

ZONE   GRP. 89      GRP. 90      GRP. 91      GRP. 92      GRP. 93      GRP. 94      GRP. 95      GRP. 96
   1  7.64677E-08  8.22874E-08  7.75626E-08  2.88774E-08  5.35168E-08  2.67241E-08  6.82438E-08  1.47090E-08
   2  4.72189E-08  5.27673E-08  4.86822E-08  1.76586E-08  3.35112E-08  1.70753E-08  4.58592E-08  9.90459E-09
   3  5.29657E-08  5.85675E-08  5.43567E-08  1.98628E-08  3.74419E-08  1.89711E-08  5.02574E-08  1.08486E-08

ZONE   GRP. 97      GRP. 98      GRP. 99      GRP.100      GRP.101      GRP.102      GRP.103      GRP.104
   1  1.32028E-08  1.31013E-08  7.78573E-09  1.05620E-08  1.22683E-08  7.88000E-09  9.30301E-09  7.50029E-09
   2  1.05559E-08  8.87493E-09  5.40940E-09  7.13098E-09  7.83931E-09  5.51052E-09  6.11098E-09  5.31428E-09
   3  1.10759E-08  9.70534E-09  5.87631E-09  7.80512E-09  8.70953E-09  5.97608E-09  6.73815E-09  5.74379E-09

ZONE   GRP.105      GRP.106      GRP.107      GRP.108      GRP.109      GRP.110      GRP.111      GRP.112
   1  6.88980E-09  1.53111E-09  4.33452E-09  2.67134E-09  5.37107E-09  2.07718E-09  2.84639E-09  1.14288E-09
   2  4.48859E-09  1.83066E-09  2.73737E-09  1.66756E-09  3.46489E-09  2.70455E-09  2.34826E-09  1.26722E-09
   3  4.96039E-09  1.77180E-09  3.05118E-09  1.86479E-09  3.83942E-09  2.58128E-09  2.44613E-09  1.24279E-09

ZONE   GRP.113      GRP.114      GRP.115      GRP.116      GRP.117      GRP.118      GRP.119      GRP.120
   1  4.36697E-09  7.77865E-10  2.93705E-09  5.18327E-09  4.90768E-09  4.70415E-09  1.44659E-09  1.43447E-09
   2  2.80127E-09  4.82704E-10  1.88629E-09  3.25507E-09  3.22873E-09  3.20329E-09  8.93693E-10  9.49788E-10
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Definition depends
on ITP (See 4$
array)

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              CASE TO CELL WEIGHT CROSS SECTIONS FOR REACTOR CORE
              C-12 (GRAPHITE KERNEL AT THERMAL)
                 CELL WEIGHTED CROSS SECTIONS FOR XSDRN MATERIAL    600002

XSEC ID      1            2           3002           3            4            102          3102         103
GRP.
   1    1.44272E+00  9.05580E-01  9.05578E-01  5.37139E-01  4.15381E-01  1.98780E-04  1.98780E-04  1.70024E-02
   2    1.45341E+00  8.61243E-01  8.61243E-01  5.92165E-01  4.90506E-01  2.00173E-04  2.00173E-04  1.06677E-02
   3    1.41331E+00  8.68440E-01  8.68440E-01  5.44871E-01  4.63810E-01  1.62523E-04  1.62523E-04  2.09591E-03
   4    1.29261E+00  7.91823E-01  7.91822E-01  5.00794E-01  4.20405E-01  1.22765E-04  1.22765E-04  3.40757E-06
   5    1.33503E+00  8.51955E-01  8.51954E-01  4.83079E-01  3.96508E-01  8.60393E-05  8.60393E-05  0.00000E+00
   6    1.29869E+00  7.78616E-01  7.78617E-01  5.20076E-01  4.19220E-01  6.97788E-05  6.97787E-05  0.00000E+00
   7    1.17609E+00  7.20900E-01  7.02281E-01  4.55191E-01  3.05664E-01  1.08258E-04  1.05750E-04  0.00000E+00
   8    1.19862E+00  9.17649E-01  1.00824E+00  2.80974E-01  2.48576E-01  8.12900E-05  8.64237E-05  0.00000E+00
   9    1.20686E+00  1.08486E+00  1.07308E+00  1.22004E-01  1.21907E-01  3.58338E-05  3.77872E-05  0.00000E+00
  10    1.65438E+00  1.65435E+00  1.63840E+00  2.48045E-05  0.00000E+00  2.48045E-05  2.48740E-05  0.00000E+00
  11    2.12207E+00  2.12206E+00  2.13208E+00  1.78118E-05  0.00000E+00  1.78118E-05  1.81831E-05  0.00000E+00
  12    1.93372E+00  1.93371E+00  1.94543E+00  1.19036E-05  0.00000E+00  1.19036E-05  1.19455E-05  0.00000E+00
  13    1.57961E+00  1.57960E+00  1.57962E+00  9.26894E-06  0.00000E+00  9.26894E-06  9.27107E-06  0.00000E+00
  14    1.77059E+00  1.77059E+00  1.76968E+00  6.32616E-06  0.00000E+00  6.32616E-06  6.33861E-06  0.00000E+00
  15    1.89160E+00  1.89160E+00  1.89250E+00  4.04097E-06  0.00000E+00  4.04097E-06  4.03592E-06  0.00000E+00
  16    2.07408E+00  2.07408E+00  2.07428E+00  3.07003E-06  0.00000E+00  3.07003E-06  3.06911E-06  0.00000E+00
  17    2.14147E+00  2.14147E+00  2.14156E+00  2.75121E-06  0.00000E+00  2.75121E-06  2.75104E-06  0.00000E+00
  18    2.18265E+00  2.18264E+00  2.18270E+00  2.56710E-06  0.00000E+00  2.56710E-06  2.56692E-06  0.00000E+00
  19    2.23747E+00  2.23747E+00  2.23765E+00  2.33130E-06  0.00000E+00  2.33130E-06  2.33068E-06  0.00000E+00
  20    2.30009E+00  2.30008E+00  2.30022E+00  2.07157E-06  0.00000E+00  2.07157E-06  2.07120E-06  0.00000E+00
  21    2.38583E+00  2.38583E+00  2.38634E+00  1.73757E-06  0.00000E+00  1.73757E-06  1.73564E-06  0.00000E+00
  22    2.50162E+00  2.50162E+00  2.50216E+00  1.35645E-06  0.00000E+00  1.35645E-06  1.35535E-06  0.00000E+00
  23    2.62003E+00  2.62003E+00  2.62075E+00  1.25899E-06  0.00000E+00  1.25899E-06  1.25870E-06  0.00000E+00
  24    2.69618E+00  2.69617E+00  2.69629E+00  1.22830E-06  0.00000E+00  1.22830E-06  1.22832E-06  0.00000E+00
  25    2.72830E+00  2.72830E+00  2.72840E+00  1.21557E-06  0.00000E+00  1.21557E-06  1.21556E-06  0.00000E+00
  26    2.75666E+00  2.75666E+00  2.75673E+00  1.20464E-06  0.00000E+00  1.20464E-06  1.20465E-06  0.00000E+00
  27    2.79780E+00  2.79780E+00  2.79804E+00  1.18920E-06  0.00000E+00  1.18920E-06  1.18914E-06  0.00000E+00
  28    2.88429E+00  2.88429E+00  2.88503E+00  1.15816E-06  0.00000E+00  1.15816E-06  1.15790E-06  0.00000E+00
  29    2.99987E+00  2.99986E+00  3.00081E+00  1.11875E-06  0.00000E+00  1.11875E-06  1.11845E-06  0.00000E+00
  30    3.06846E+00  3.06846E+00  3.06855E+00  1.09647E-06  0.00000E+00  1.09647E-06  1.09649E-06  0.00000E+00
  31    3.13853E+00  3.13853E+00  3.13970E+00  1.07415E-06  0.00000E+00  1.07415E-06  1.07379E-06  0.00000E+00
  32    3.22778E+00  3.22778E+00  3.22800E+00  1.04691E-06  0.00000E+00  1.04691E-06  1.04686E-06  0.00000E+00
  33    3.27567E+00  3.27567E+00  3.27587E+00  1.03292E-06  0.00000E+00  1.03292E-06  1.03288E-06  0.00000E+00
  34    3.34863E+00  3.34863E+00  3.34954E+00  1.01251E-06  0.00000E+00  1.01251E-06  1.01227E-06  0.00000E+00
  35    3.43068E+00  3.43068E+00  3.43104E+00  9.94978E-07  0.00000E+00  9.94978E-07  9.94944E-07  0.00000E+00
  36    3.49402E+00  3.49402E+00  3.49446E+00  9.87740E-07  0.00000E+00  9.87740E-07  9.87703E-07  0.00000E+00
  37    3.54878E+00  3.54878E+00  3.54898E+00  9.81689E-07  0.00000E+00  9.81689E-07  9.81669E-07  0.00000E+00
  38    3.59323E+00  3.59322E+00  3.59349E+00  9.76769E-07  0.00000E+00  9.76769E-07  9.76759E-07  0.00000E+00
  39    3.69757E+00  3.69757E+00  3.70075E+00  9.66053E-07  0.00000E+00  9.66053E-07  9.65712E-07  0.00000E+00
  40    3.85709E+00  3.85709E+00  3.86026E+00  9.50588E-07  0.00000E+00  9.50588E-07  9.50273E-07  0.00000E+00
  41    4.02762E+00  4.02762E+00  4.03374E+00  9.35274E-07  0.00000E+00  9.35274E-07  9.34701E-07  0.00000E+00
  42    4.19708E+00  4.19708E+00  4.20170E+00  9.21211E-07  0.00000E+00  9.21211E-07  9.20803E-07  0.00000E+00
  43    4.30425E+00  4.30425E+00  4.30542E+00  9.12717E-07  0.00000E+00  9.12717E-07  9.12622E-07  0.00000E+00
  44    4.38164E+00  4.38164E+00  4.38414E+00  9.07090E-07  0.00000E+00  9.07090E-07  9.06878E-07  0.00000E+00
  45    4.45004E+00  4.45004E+00  4.45094E+00  9.12044E-07  0.00000E+00  9.12044E-07  9.12366E-07  0.00000E+00
  46    4.47990E+00  4.47990E+00  4.47990E+00  9.22481E-07  0.00000E+00  9.22481E-07  9.22488E-07  0.00000E+00
  47    4.49531E+00  4.49531E+00  4.49553E+00  9.28006E-07  0.00000E+00  9.28006E-07  9.28088E-07  0.00000E+00
  48    4.51273E+00  4.51273E+00  4.51274E+00  9.33716E-07  0.00000E+00  9.33716E-07  9.33720E-07  0.00000E+00
  49    4.53713E+00  4.53713E+00  4.53748E+00  9.42193E-07  0.00000E+00  9.42193E-07  9.42319E-07  0.00000E+00
  50    4.57333E+00  4.57333E+00  4.57333E+00  9.54426E-07  0.00000E+00  9.54426E-07  9.54426E-07  0.00000E+00
  51    4.58781E+00  4.58781E+00  4.58781E+00  9.59637E-07  0.00000E+00  9.59637E-07  9.59636E-07  0.00000E+00
  52    4.60044E+00  4.60044E+00  4.60044E+00  9.63817E-07  0.00000E+00  9.63817E-07  9.63816E-07  0.00000E+00
  53    4.64019E+00  4.64019E+00  4.64019E+00  9.76606E-07  0.00000E+00  9.76606E-07  9.76606E-07  0.00000E+00
  54    4.67700E+00  4.67700E+00  4.67700E+00  9.88352E-07  0.00000E+00  9.88352E-07  9.88352E-07  0.00000E+00
  55    4.70645E+00  4.70645E+00  4.70645E+00  9.97306E-07  0.00000E+00  9.97306E-07  9.97305E-07  0.00000E+00
  56    4.73242E+00  4.73242E+00  4.73241E+00  1.00516E-06  0.00000E+00  1.00516E-06  1.00516E-06  0.00000E+00
  57    4.75189E+00  4.75189E+00  4.75189E+00  1.08540E-06  0.00000E+00  1.08540E-06  1.08539E-06  0.00000E+00
  58    4.76837E+00  4.76837E+00  4.76836E+00  3.29124E-06  0.00000E+00  3.29124E-06  3.29124E-06  0.00000E+00
  59    4.77964E+00  4.77963E+00  4.77963E+00  6.52442E-06  0.00000E+00  6.52442E-06  6.52442E-06  0.00000E+00
  60    4.80072E+00  4.80071E+00  4.80070E+00  1.03501E-05  0.00000E+00  1.03501E-05  1.03501E-05  0.00000E+00
  61    4.81037E+00  4.81035E+00  4.81035E+00  1.22845E-05  0.00000E+00  1.22845E-05  1.22845E-05  0.00000E+00
  62    4.82018E+00  4.82017E+00  4.82016E+00  1.31493E-05  0.00000E+00  1.31493E-05  1.31493E-05  0.00000E+00
  63    4.82369E+00  4.82367E+00  4.82367E+00  1.41953E-05  0.00000E+00  1.41953E-05  1.41953E-05  0.00000E+00
  64    4.83902E+00  4.83900E+00  4.83900E+00  1.48812E-05  0.00000E+00  1.48812E-05  1.48812E-05  0.00000E+00
  65    4.83708E+00  4.83706E+00  4.83706E+00  1.52155E-05  0.00000E+00  1.52155E-05  1.52155E-05  0.00000E+00
  66    4.86054E+00  4.86053E+00  4.86052E+00  1.57477E-05  0.00000E+00  1.57477E-05  1.57477E-05  0.00000E+00
  67    4.86010E+00  4.86009E+00  4.86008E+00  1.63320E-05  0.00000E+00  1.63320E-05  1.63320E-05  0.00000E+00
  68    4.84044E+00  4.84042E+00  4.84042E+00  1.65327E-05  0.00000E+00  1.65327E-05  1.65327E-05  0.00000E+00
  69    4.87912E+00  4.87910E+00  4.87910E+00  1.70443E-05  0.00000E+00  1.70443E-05  1.70443E-05  0.00000E+00
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Cell weighted
values for
Carbon

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                    CASE TO CELL WEIGHT CROSS SECTIONS FOR REACTOR CORE
                    C-12 (GRAPHITE KERNEL AT THERMAL)
                       CELL WEIGHTED CROSS SECTIONS FOR XSDRN MATERIAL      6000

XSEC ID       1             2            3002            3             4             102           3102          103
GRP.
   1     1.45579E+00   9.13789E-01   9.13787E-01   5.42008E-01   4.19146E-01   2.00582E-04   2.00582E-04   1.71565E-02
   2     1.46800E+00   8.69890E-01   8.69890E-01   5.98111E-01   4.95431E-01   2.02183E-04   2.02183E-04   1.07748E-02
   3     1.42716E+00   8.76952E-01   8.76952E-01   5.50212E-01   4.68357E-01   1.64116E-04   1.64116E-04   2.11645E-03
   4     1.30434E+00   7.99003E-01   7.99003E-01   5.05336E-01   4.24218E-01   1.23879E-04   1.23878E-04   3.43848E-06
   5     1.34696E+00   8.59567E-01   8.59566E-01   4.87396E-01   4.00050E-01   8.68080E-05   8.68081E-05   0.00000E+00
   6     1.30931E+00   7.84984E-01   7.84985E-01   5.24329E-01   4.22648E-01   7.03495E-05   7.03494E-05   0.00000E+00
   7     1.18633E+00   7.27174E-01   7.08392E-01   4.59152E-01   3.08324E-01   1.09200E-04   1.06670E-04   0.00000E+00
   8     1.20695E+00   9.24025E-01   1.01524E+00   2.82926E-01   2.50303E-01   8.18548E-05   8.70241E-05   0.00000E+00
   9     1.21441E+00   1.09164E+00   1.07979E+00   1.22767E-01   1.22669E-01   3.60578E-05   3.80234E-05   0.00000E+00
  10     1.66505E+00   1.66502E+00   1.64896E+00   2.49645E-05   0.00000E+00   2.49645E-05   2.50345E-05   0.00000E+00
  11     2.13885E+00   2.13883E+00   2.14893E+00   1.79526E-05   0.00000E+00   1.79526E-05   1.83268E-05   0.00000E+00
  12     1.94341E+00   1.94340E+00   1.95518E+00   1.19633E-05   0.00000E+00   1.19633E-05   1.20054E-05   0.00000E+00
  13     1.58469E+00   1.58468E+00   1.58470E+00   9.29876E-06   0.00000E+00   9.29876E-06   9.30090E-06   0.00000E+00
  14     1.77542E+00   1.77542E+00   1.77450E+00   6.34341E-06   0.00000E+00   6.34341E-06   6.35589E-06   0.00000E+00
  15     1.89586E+00   1.89586E+00   1.89675E+00   4.05006E-06   0.00000E+00   4.05006E-06   4.04500E-06   0.00000E+00
  16     2.07866E+00   2.07866E+00   2.07886E+00   3.07682E-06   0.00000E+00   3.07682E-06   3.07589E-06   0.00000E+00
  17     2.14645E+00   2.14644E+00   2.14653E+00   2.75759E-06   0.00000E+00   2.75759E-06   2.75742E-06   0.00000E+00
  18     2.18759E+00   2.18759E+00   2.18765E+00   2.57292E-06   0.00000E+00   2.57292E-06   2.57274E-06   0.00000E+00
  19     2.24249E+00   2.24249E+00   2.24267E+00   2.33654E-06   0.00000E+00   2.33654E-06   2.33591E-06   0.00000E+00
  20     2.30544E+00   2.30544E+00   2.30557E+00   2.07639E-06   0.00000E+00   2.07639E-06   2.07602E-06   0.00000E+00
  21     2.39129E+00   2.39129E+00   2.39180E+00   1.74154E-06   0.00000E+00   1.74154E-06   1.73962E-06   0.00000E+00
  22     2.50685E+00   2.50685E+00   2.50740E+00   1.35929E-06   0.00000E+00   1.35929E-06   1.35819E-06   0.00000E+00
  23     2.62507E+00   2.62507E+00   2.62579E+00   1.26141E-06   0.00000E+00   1.26141E-06   1.26112E-06   0.00000E+00
  24     2.70117E+00   2.70117E+00   2.70129E+00   1.23057E-06   0.00000E+00   1.23057E-06   1.23059E-06   0.00000E+00
  25     2.73356E+00   2.73356E+00   2.73366E+00   1.21792E-06   0.00000E+00   1.21792E-06   1.21790E-06   0.00000E+00
  26     2.76202E+00   2.76202E+00   2.76208E+00   1.20698E-06   0.00000E+00   1.20698E-06   1.20699E-06   0.00000E+00
  27     2.80322E+00   2.80322E+00   2.80347E+00   1.19151E-06   0.00000E+00   1.19151E-06   1.19144E-06   0.00000E+00
  28     2.88950E+00   2.88950E+00   2.89023E+00   1.16025E-06   0.00000E+00   1.16025E-06   1.15999E-06   0.00000E+00
  29     3.00486E+00   3.00486E+00   3.00580E+00   1.12061E-06   0.00000E+00   1.12061E-06   1.12031E-06   0.00000E+00
  30     3.07312E+00   3.07312E+00   3.07321E+00   1.09814E-06   0.00000E+00   1.09814E-06   1.09816E-06   0.00000E+00
  31     3.14371E+00   3.14371E+00   3.14489E+00   1.07592E-06   0.00000E+00   1.07592E-06   1.07557E-06   0.00000E+00
  32     3.23314E+00   3.23314E+00   3.23336E+00   1.04865E-06   0.00000E+00   1.04865E-06   1.04860E-06   0.00000E+00
  33     3.28097E+00   3.28097E+00   3.28117E+00   1.03459E-06   0.00000E+00   1.03459E-06   1.03455E-06   0.00000E+00
  34     3.35338E+00   3.35338E+00   3.35430E+00   1.01395E-06   0.00000E+00   1.01395E-06   1.01371E-06   0.00000E+00
  35     3.43487E+00   3.43486E+00   3.43524E+00   9.96194E-07   0.00000E+00   9.96194E-07   9.96160E-07   0.00000E+00
  36     3.49761E+00   3.49761E+00   3.49805E+00   9.88756E-07   0.00000E+00   9.88756E-07   9.88719E-07   0.00000E+00
  37     3.55172E+00   3.55172E+00   3.55193E+00   9.82503E-07   0.00000E+00   9.82503E-07   9.82484E-07   0.00000E+00
  38     3.59593E+00   3.59592E+00   3.59619E+00   9.77504E-07   0.00000E+00   9.77504E-07   9.77494E-07   0.00000E+00
  39     3.69856E+00   3.69856E+00   3.70173E+00   9.66310E-07   0.00000E+00   9.66310E-07   9.65970E-07   0.00000E+00
  40     3.85498E+00   3.85498E+00   3.85815E+00   9.50067E-07   0.00000E+00   9.50067E-07   9.49753E-07   0.00000E+00
  41     4.02164E+00   4.02164E+00   4.02775E+00   9.33886E-07   0.00000E+00   9.33886E-07   9.33314E-07   0.00000E+00
  42     4.18637E+00   4.18637E+00   4.19097E+00   9.18859E-07   0.00000E+00   9.18859E-07   9.18452E-07   0.00000E+00
  43     4.29056E+00   4.29056E+00   4.29174E+00   9.09816E-07   0.00000E+00   9.09816E-07   9.09721E-07   0.00000E+00
  44     4.36480E+00   4.36480E+00   4.36729E+00   9.03603E-07   0.00000E+00   9.03603E-07   9.03391E-07   0.00000E+00
  45     4.43149E+00   4.43149E+00   4.43239E+00   9.08242E-07   0.00000E+00   9.08242E-07   9.08563E-07   0.00000E+00
  46     4.45983E+00   4.45983E+00   4.45984E+00   9.18349E-07   0.00000E+00   9.18349E-07   9.18356E-07   0.00000E+00
  47     4.47525E+00   4.47525E+00   4.47547E+00   9.23865E-07   0.00000E+00   9.23865E-07   9.23947E-07   0.00000E+00
  48     4.48943E+00   4.48943E+00   4.48943E+00   9.28894E-07   0.00000E+00   9.28894E-07   9.28898E-07   0.00000E+00
  49     4.51373E+00   4.51373E+00   4.51409E+00   9.37334E-07   0.00000E+00   9.37334E-07   9.37460E-07   0.00000E+00
  50     4.54732E+00   4.54732E+00   4.54732E+00   9.48998E-07   0.00000E+00   9.48998E-07   9.48997E-07   0.00000E+00
  51     4.56303E+00   4.56303E+00   4.56303E+00   9.54452E-07   0.00000E+00   9.54452E-07   9.54451E-07   0.00000E+00
  52     4.57451E+00   4.57451E+00   4.57451E+00   9.58385E-07   0.00000E+00   9.58385E-07   9.58385E-07   0.00000E+00
  53     4.60884E+00   4.60884E+00   4.60883E+00   9.70005E-07   0.00000E+00   9.70005E-07   9.70005E-07   0.00000E+00
  54     4.64051E+00   4.64051E+00   4.64051E+00   9.80641E-07   0.00000E+00   9.80641E-07   9.80641E-07   0.00000E+00
  55     4.66283E+00   4.66283E+00   4.66283E+00   9.88064E-07   0.00000E+00   9.88064E-07   9.88063E-07   0.00000E+00
  56     4.68243E+00   4.68243E+00   4.68243E+00   9.94546E-07   0.00000E+00   9.94546E-07   9.94546E-07   0.00000E+00
  57     4.69516E+00   4.69516E+00   4.69516E+00   1.07244E-06   0.00000E+00   1.07244E-06   1.07244E-06   0.00000E+00
  58     4.70338E+00   4.70337E+00   4.70337E+00   3.24638E-06   0.00000E+00   3.24638E-06   3.24638E-06   0.00000E+00
  59     4.70943E+00   4.70942E+00   4.70941E+00   6.42858E-06   0.00000E+00   6.42858E-06   6.42857E-06   0.00000E+00
  60     4.71695E+00   4.71694E+00   4.71694E+00   1.01695E-05   0.00000E+00   1.01695E-05   1.01695E-05   0.00000E+00
  61     4.72166E+00   4.72165E+00   4.72165E+00   1.20579E-05   0.00000E+00   1.20579E-05   1.20579E-05   0.00000E+00
  62     4.72373E+00   4.72372E+00   4.72371E+00   1.28862E-05   0.00000E+00   1.28862E-05   1.28861E-05   0.00000E+00
  63     4.72637E+00   4.72636E+00   4.72636E+00   1.39090E-05   0.00000E+00   1.39090E-05   1.39090E-05   0.00000E+00
  64     4.72800E+00   4.72798E+00   4.72798E+00   1.45398E-05   0.00000E+00   1.45398E-05   1.45398E-05   0.00000E+00
  65     4.72889E+00   4.72888E+00   4.72888E+00   1.48752E-05   0.00000E+00   1.48752E-05   1.48752E-05   0.00000E+00
  66     4.73004E+00   4.73002E+00   4.73002E+00   1.53249E-05   0.00000E+00   1.53249E-05   1.53249E-05   0.00000E+00
  67     4.73151E+00   4.73150E+00   4.73149E+00   1.58999E-05   0.00000E+00   1.58999E-05   1.58999E-05   0.00000E+00
  68     4.73226E+00   4.73224E+00   4.73224E+00   1.61632E-05   0.00000E+00   1.61632E-05   1.61632E-05   0.00000E+00
  69     4.73316E+00   4.73315E+00   4.73314E+00   1.65344E-05   0.00000E+00   1.65344E-05   1.65344E-05   0.00000E+00
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Unweighted
values for
Carbon

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                    CASE TO CELL WEIGHT CROSS SECTIONS FOR REACTOR CORE
                    U235
                       CELL WEIGHTED CROSS SECTIONS FOR XSDRN MATERIAL   9223501

XSEC ID      1            2           3002            4            16           17           18          3018
GRP.
   1    6.33181E+00  3.95471E+00  3.95471E+00  2.19732E-01  2.46221E-02  9.37562E-02  2.03771E+00  2.03771E+00
   2    6.26632E+00  3.71367E+00  3.71367E+00  2.25321E-01  1.16381E-01  9.66364E-02  2.11269E+00  2.11269E+00
   3    6.17518E+00  3.48818E+00  3.48818E+00  2.29347E-01  2.10435E-01  6.40792E-02  2.18108E+00  2.18108E+00
   4    6.07492E+00  3.35717E+00  3.35717E+00  2.32247E-01  2.89913E-01  3.84331E-02  2.15479E+00  2.15479E+00
   5    6.00712E+00  3.34520E+00  3.34520E+00  2.25701E-01  3.75004E-01  1.85139E-02  2.04010E+00  2.04010E+00
   6    5.94547E+00  3.46854E+00  3.46855E+00  1.91106E-01  4.65254E-01  9.07265E-04  1.81608E+00  1.81608E+00
   7    6.21762E+00  3.71803E+00  3.69199E+00  2.26734E-01  4.29894E-01  0.00000E+00  1.83579E+00  1.83243E+00
   8    6.76535E+00  4.16064E+00  4.11068E+00  6.78539E-01  2.89700E-01  0.00000E+00  1.62390E+00  1.66506E+00
   9    7.58115E+00  4.69231E+00  4.65736E+00  1.72044E+00  3.71077E-02  0.00000E+00  1.11377E+00  1.12603E+00
  10    8.01017E+00  4.97404E+00  4.97155E+00  1.87838E+00  0.00000E+00  0.00000E+00  1.13547E+00  1.13465E+00
  11    8.15727E+00  5.04735E+00  5.05472E+00  1.87167E+00  0.00000E+00  0.00000E+00  1.20835E+00  1.20409E+00
  12    7.84401E+00  4.71905E+00  4.72176E+00  1.81341E+00  0.00000E+00  0.00000E+00  1.27214E+00  1.27160E+00
  13    7.60572E+00  4.49493E+00  4.49514E+00  1.77295E+00  0.00000E+00  0.00000E+00  1.29311E+00  1.29310E+00
  14    7.32746E+00  4.20533E+00  4.20664E+00  1.76192E+00  0.00000E+00  0.00000E+00  1.30749E+00  1.30745E+00
  15    6.96578E+00  3.94862E+00  3.94825E+00  1.66617E+00  0.00000E+00  0.00000E+00  1.28438E+00  1.28424E+00
  16    6.82516E+00  3.89988E+00  3.89991E+00  1.59106E+00  0.00000E+00  0.00000E+00  1.25643E+00  1.25641E+00
  17    6.79941E+00  3.90976E+00  3.90983E+00  1.55849E+00  0.00000E+00  0.00000E+00  1.24836E+00  1.24838E+00
  18    6.78593E+00  3.91805E+00  3.91808E+00  1.53888E+00  0.00000E+00  0.00000E+00  1.24361E+00  1.24362E+00
  19    6.77658E+00  3.93569E+00  3.93579E+00  1.51412E+00  0.00000E+00  0.00000E+00  1.23780E+00  1.23779E+00
  20    6.77855E+00  3.96455E+00  3.96466E+00  1.48749E+00  0.00000E+00  0.00000E+00  1.23309E+00  1.23311E+00
  21    6.79683E+00  4.01585E+00  4.01619E+00  1.45236E+00  0.00000E+00  0.00000E+00  1.22810E+00  1.22808E+00
  22    6.84953E+00  4.10490E+00  4.10541E+00  1.40718E+00  0.00000E+00  0.00000E+00  1.22628E+00  1.22631E+00
  23    6.94283E+00  4.24299E+00  4.24412E+00  1.36342E+00  0.00000E+00  0.00000E+00  1.21594E+00  1.21570E+00
  24    7.02167E+00  4.35671E+00  4.35690E+00  1.35818E+00  0.00000E+00  0.00000E+00  1.18363E+00  1.18364E+00
  25    7.06239E+00  4.41046E+00  4.41062E+00  1.35559E+00  0.00000E+00  0.00000E+00  1.17190E+00  1.17189E+00
  26    7.09808E+00  4.46058E+00  4.46069E+00  1.34782E+00  0.00000E+00  0.00000E+00  1.16373E+00  1.16374E+00
  27    7.15167E+00  4.52598E+00  4.52633E+00  1.34334E+00  0.00000E+00  0.00000E+00  1.15413E+00  1.15411E+00
  28    7.26873E+00  4.64679E+00  4.64799E+00  1.34207E+00  0.00000E+00  0.00000E+00  1.14651E+00  1.14649E+00
  29    7.44806E+00  4.84966E+00  4.85152E+00  1.31305E+00  0.00000E+00  0.00000E+00  1.14491E+00  1.14493E+00
  30    7.56487E+00  4.99377E+00  4.99393E+00  1.28032E+00  0.00000E+00  0.00000E+00  1.14558E+00  1.14561E+00
  31    7.71012E+00  5.19077E+00  5.19428E+00  1.21887E+00  0.00000E+00  0.00000E+00  1.14931E+00  1.14938E+00
  32    7.90424E+00  5.44858E+00  5.44910E+00  1.14093E+00  0.00000E+00  0.00000E+00  1.15548E+00  1.15551E+00
  33    8.01441E+00  5.56207E+00  5.56252E+00  1.12816E+00  0.00000E+00  0.00000E+00  1.16032E+00  1.16035E+00
  34    8.18224E+00  5.72986E+00  5.73185E+00  1.11387E+00  0.00000E+00  0.00000E+00  1.16758E+00  1.16770E+00
  35    8.34079E+00  5.89570E+00  5.89662E+00  1.08868E+00  0.00000E+00  0.00000E+00  1.17716E+00  1.17721E+00
  36    8.48471E+00  6.05789E+00  6.05902E+00  1.05362E+00  0.00000E+00  0.00000E+00  1.18709E+00  1.18718E+00
  37    8.60069E+00  6.20028E+00  6.20085E+00  1.01045E+00  0.00000E+00  0.00000E+00  1.19767E+00  1.19771E+00
  38    8.69935E+00  6.32238E+00  6.32309E+00  9.72028E-01  0.00000E+00  0.00000E+00  1.20749E+00  1.20756E+00
  39    8.93898E+00  6.59593E+00  6.60478E+00  9.05236E-01  0.00000E+00  0.00000E+00  1.22816E+00  1.22890E+00
  40    9.33383E+00  7.02880E+00  7.03823E+00  8.08234E-01  0.00000E+00  0.00000E+00  1.25924E+00  1.25994E+00
  41    9.82790E+00  7.54637E+00  7.56786E+00  6.85380E-01  0.00000E+00  0.00000E+00  1.31517E+00  1.31832E+00
  42    1.04218E+01  8.13527E+00  8.15539E+00  5.60327E-01  0.00000E+00  0.00000E+00  1.40080E+00  1.40336E+00
  43    1.08812E+01  8.58819E+00  8.59383E+00  4.68672E-01  0.00000E+00  0.00000E+00  1.45905E+00  1.45986E+00
  44    1.12784E+01  8.95250E+00  8.96645E+00  4.09446E-01  0.00000E+00  0.00000E+00  1.51395E+00  1.51630E+00
  45    1.17102E+01  9.45986E+00  9.47103E+00  2.83971E-01  0.00000E+00  0.00000E+00  1.53620E+00  1.53482E+00
  46    1.19137E+01  9.67960E+00  9.67946E+00  1.90262E-01  0.00000E+00  0.00000E+00  1.58685E+00  1.58717E+00
  47    1.20367E+01  9.75802E+00  9.75811E+00  1.67044E-01  0.00000E+00  0.00000E+00  1.63274E+00  1.63424E+00
  48    1.21148E+01  9.72133E+00  9.72153E+00  1.46486E-01  0.00000E+00  0.00000E+00  1.73123E+00  1.73119E+00
  49    1.23225E+01  9.97858E+00  9.98105E+00  1.12757E-01  0.00000E+00  0.00000E+00  1.70901E+00  1.70972E+00
  50    1.26054E+01  1.01798E+01  1.01798E+01  6.60151E-02  0.00000E+00  0.00000E+00  1.79173E+00  1.79173E+00
  51    1.27730E+01  1.04700E+01  1.04700E+01  4.43190E-02  0.00000E+00  0.00000E+00  1.70656E+00  1.70656E+00
  52    1.28686E+01  1.05385E+01  1.05385E+01  3.63968E-02  0.00000E+00  0.00000E+00  1.72562E+00  1.72562E+00
  53    1.31948E+01  1.06425E+01  1.06425E+01  2.51977E-02  0.00000E+00  0.00000E+00  1.87328E+00  1.87328E+00
  54    1.35368E+01  1.07797E+01  1.07797E+01  1.50568E-02  0.00000E+00  0.00000E+00  2.00941E+00  2.00940E+00
  55    1.40432E+01  1.09294E+01  1.09096E+01  8.00561E-03  0.00000E+00  0.00000E+00  2.22388E+00  2.16665E+00
  56    1.44447E+01  1.09989E+01  1.09820E+01  1.92159E-03  0.00000E+00  0.00000E+00  2.47264E+00  2.40057E+00
  57    1.48787E+01  1.10690E+01  1.10534E+01  0.00000E+00  0.00000E+00  0.00000E+00  2.67491E+00  2.59166E+00
  58    1.54821E+01  1.11468E+01  1.11331E+01  0.00000E+00  0.00000E+00  0.00000E+00  2.96463E+00  2.86143E+00
  59    1.56318E+01  1.10716E+01  1.10645E+01  0.00000E+00  0.00000E+00  0.00000E+00  3.16224E+00  3.06152E+00
  60    1.63443E+01  1.09402E+01  1.09450E+01  0.00000E+00  0.00000E+00  0.00000E+00  3.95313E+00  3.83431E+00
  61    1.70712E+01  1.09061E+01  1.09213E+01  0.00000E+00  0.00000E+00  0.00000E+00  4.62784E+00  4.49611E+00
  62    1.68226E+01  1.07834E+01  1.08002E+01  0.00000E+00  0.00000E+00  0.00000E+00  4.52581E+00  4.42311E+00
  63    1.69009E+01  1.07149E+01  1.07336E+01  0.00000E+00  0.00000E+00  0.00000E+00  4.76506E+00  4.67831E+00
  64    1.76524E+01  1.06905E+01  1.07260E+01  0.00000E+00  0.00000E+00  0.00000E+00  5.16137E+00  5.10973E+00
  65    1.76055E+01  1.07450E+01  1.07861E+01  0.00000E+00  0.00000E+00  0.00000E+00  4.85221E+00  4.83540E+00
  66    1.87102E+01  1.06922E+01  1.07792E+01  0.00000E+00  0.00000E+00  0.00000E+00  5.51227E+00  5.57560E+00
  67    1.85197E+01  1.05360E+01  1.06009E+01  0.00000E+00  0.00000E+00  0.00000E+00  5.87558E+00  5.95670E+00
  68    1.75477E+01  1.06777E+01  1.07288E+01  0.00000E+00  0.00000E+00  0.00000E+00  4.69134E+00  4.78592E+00
  69    1.92474E+01  1.03867E+01  1.04931E+01  0.00000E+00  0.00000E+00  0.00000E+00  6.47789E+00  6.76959E+00
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Cell Weighted
values for
Uranium-235

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                    CASE TO CELL WEIGHT CROSS SECTIONS FOR REACTOR CORE
CELL AVERAGED FLUXES

ZONE   GRP.  1      GRP.  2      GRP.  3      GRP.  4      GRP.  5      GRP.  6      GRP.  7      GRP.  8
   1 1.56337E-05  4.78233E-05  1.07485E-04  1.37761E-04  3.85466E-04  6.87696E-03  2.31571E-02  9.17456E-02
   2 1.49442E-05  4.54982E-05  1.02378E-04  1.31683E-04  3.68700E-04  6.60216E-03  2.21750E-02  8.86123E-02
   3 1.50797E-05  4.59550E-05  1.03381E-04  1.32877E-04  3.71994E-04  6.65615E-03  2.23679E-02  8.92279E-02
ZONE   GRP.  9      GRP. 10      GRP. 11      GRP. 12      GRP. 13      GRP. 14      GRP. 15      GRP. 16
   1 2.85062E-01  1.67275E-01  7.55457E-01  6.43177E-01  2.14190E-01  1.12485E+00  1.10288E+00  3.70592E-01
   2 2.76271E-01  1.61958E-01  7.26244E-01  6.27175E-01  2.10740E-01  1.10945E+00  1.09039E+00  3.66471E-01
   3 2.77998E-01  1.63003E-01  7.31984E-01  6.30319E-01  2.11417E-01  1.11248E+00  1.09284E+00  3.67281E-01
ZONE   GRP. 17      GRP. 18      GRP. 19      GRP. 20      GRP. 21      GRP. 22      GRP. 23      GRP. 24
   1 1.70100E-01  1.55765E-01  2.78580E-01  2.18172E-01  4.64750E-01  4.51958E-01  4.88326E-01  1.13861E-01
   2 1.68113E-01  1.53990E-01  2.75432E-01  2.15618E-01  4.59398E-01  4.47193E-01  4.83594E-01  1.12797E-01
   3 1.68504E-01  1.54339E-01  2.76051E-01  2.16119E-01  4.60450E-01  4.48129E-01  4.84524E-01  1.13006E-01
ZONE   GRP. 25      GRP. 26      GRP. 27      GRP. 28      GRP. 29      GRP. 30      GRP. 31      GRP. 32
   1 1.46113E-01  8.28755E-02  2.52450E-01  4.55943E-01  5.00871E-01  6.62171E-02  5.49342E-01  2.26733E-01
   2 1.44693E-01  8.20646E-02  2.49983E-01  4.51797E-01  4.96666E-01  6.57102E-02  5.44764E-01  2.24832E-01
   3 1.44972E-01  8.22240E-02  2.50467E-01  4.52611E-01  4.97492E-01  6.58098E-02  5.45663E-01  2.25205E-01
ZONE   GRP. 33      GRP. 34      GRP. 35      GRP. 36      GRP. 37      GRP. 38      GRP. 39      GRP. 40
   1 2.00206E-01  4.65847E-01  2.90068E-01  3.09384E-01  2.15362E-01  2.23721E-01  8.63056E-01  8.47886E-01
   2 1.98570E-01  4.62503E-01  2.88276E-01  3.07773E-01  2.14456E-01  2.22867E-01  8.61888E-01  8.50257E-01
   3 1.98891E-01  4.63160E-01  2.88628E-01  3.08090E-01  2.14634E-01  2.23035E-01  8.62117E-01  8.49791E-01
ZONE   GRP. 41      GRP. 42      GRP. 43      GRP. 44      GRP. 45      GRP. 46      GRP. 47      GRP. 48
   1 1.17042E+00  9.74031E-01  4.66871E-01  6.68836E-01  3.89231E-01  7.97907E-02  1.91791E-01  5.56382E-02
   2 1.17932E+00  9.86856E-01  4.74550E-01  6.82187E-01  3.97667E-01  8.16520E-02  1.96248E-01  5.71402E-02
   3 1.17757E+00  9.84336E-01  4.73041E-01  6.79563E-01  3.96009E-01  8.12864E-02  1.95372E-01  5.68451E-02
ZONE   GRP. 49      GRP. 50      GRP. 51      GRP. 52      GRP. 53      GRP. 54      GRP. 55      GRP. 56
   1 3.79568E-01  2.47709E-01  6.48928E-02  1.66330E-01  5.10895E-01  1.93150E-01  3.08577E-01  1.65086E-01
   2 3.89798E-01  2.55094E-01  6.67278E-02  1.71242E-01  5.29095E-01  2.01136E-01  3.23852E-01  1.74463E-01
   3 3.87788E-01  2.53643E-01  6.63673E-02  1.70277E-01  5.25519E-01  1.99567E-01  3.20851E-01  1.72621E-01
ZONE   GRP. 57      GRP. 58      GRP. 59      GRP. 60      GRP. 61      GRP. 62      GRP. 63      GRP. 64
   1 1.41769E-01  5.84974E-02  7.61011E-02  6.50917E-02  4.85266E-03  2.13783E-02  1.09695E-02  6.83720E-03
   2 1.50940E-01  6.28580E-02  8.22506E-02  7.14361E-02  5.35525E-03  2.38023E-02  1.22247E-02  7.74111E-03
   3 1.49139E-01  6.20012E-02  8.10423E-02  7.01896E-02  5.25650E-03  2.33261E-02  1.19781E-02  7.56351E-03
ZONE   GRP. 65      GRP. 66      GRP. 67      GRP. 68      GRP. 69      GRP. 70      GRP. 71      GRP. 72
   1 2.04100E-03  7.51932E-03  4.04274E-03  8.03281E-04  4.25892E-03  1.87001E-03  1.71215E-03  6.48218E-05
   2 2.30318E-03  8.70946E-03  4.67185E-03  9.06375E-04  5.02381E-03  2.22959E-03  2.08955E-03  7.97650E-05
   3 2.25167E-03  8.47562E-03  4.54824E-03  8.86119E-04  4.87352E-03  2.15894E-03  2.01540E-03  7.68289E-05
ZONE   GRP. 73      GRP. 74      GRP. 75      GRP. 76      GRP. 77      GRP. 78      GRP. 79      GRP. 80
   1 5.22788E-04  5.43688E-04  4.01307E-05  6.75118E-05  3.38671E-05  2.55234E-06  1.40748E-05  5.74161E-06
   2 6.58261E-04  6.92285E-04  4.96851E-05  9.10917E-05  4.58237E-05  3.35555E-06  1.85564E-05  7.51766E-06
   3 6.31643E-04  6.63088E-04  4.78078E-05  8.64587E-05  4.34745E-05  3.19773E-06  1.76758E-05  7.16870E-06
ZONE   GRP. 81      GRP. 82      GRP. 83      GRP. 84      GRP. 85      GRP. 86      GRP. 87      GRP. 88
   1 3.19955E-05  1.19260E-06  1.50636E-06  2.62137E-06  2.89947E-06  3.03760E-06  1.73067E-06  4.28973E-07
   2 4.33064E-05  1.55343E-06  1.99571E-06  3.42749E-06  3.73864E-06  3.99234E-06  2.39417E-06  5.69928E-07
   3 4.10840E-05  1.48253E-06  1.89956E-06  3.26910E-06  3.57376E-06  3.80475E-06  2.26381E-06  5.42233E-07
ZONE   GRP. 89      GRP. 90      GRP. 91      GRP. 92      GRP. 93      GRP. 94      GRP. 95      GRP. 96
   1 8.58657E-07  5.74323E-07  6.48925E-07  4.62692E-07  5.10935E-07  1.97448E-07  3.61183E-07  7.68673E-08
   2 1.10274E-06  8.64474E-07  9.08533E-07  5.51430E-07  6.88685E-07  2.91638E-07  6.25062E-07  1.33638E-07
   3 1.05478E-06  8.07465E-07  8.57525E-07  5.33995E-07  6.53761E-07  2.73131E-07  5.73214E-07  1.22483E-07
ZONE   GRP. 97      GRP. 98      GRP. 99      GRP.100      GRP.101      GRP.102      GRP.103      GRP.104
   1 4.65037E-08  6.44317E-08  3.64084E-08  5.50429E-08  9.37089E-08  3.88637E-08  5.99156E-08  3.55385E-08
   2 1.11728E-07  1.14912E-07  6.78215E-08  9.53788E-08  1.35724E-07  7.10085E-08  9.38484E-08  6.69972E-08
   3 9.89126E-08  1.04994E-07  6.16494E-08  8.74535E-08  1.27469E-07  6.46926E-08  8.71812E-08  6.08161E-08
ZONE   GRP.105      GRP.106      GRP.107      GRP.108      GRP.109      GRP.110      GRP.111      GRP.112
   1 4.72350E-08  4.61128E-09  3.98398E-08  4.73664E-08  4.64929E-08  6.15195E-09  9.71941E-09  3.13374E-09
   2 7.20527E-08  1.71132E-08  5.43336E-08  5.58359E-08  6.56364E-08  2.50335E-08  2.43002E-08  1.15926E-08
   3 6.71765E-08  1.46568E-08  5.14858E-08  5.41718E-08  6.18751E-08  2.13236E-08  2.14354E-08  9.93060E-09
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Flux per unit
volume integrated
over energy.

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ZONE   GRP.233      GRP.234      GRP.235      GRP.236      GRP.237      GRP.238
   1 7.61272E-17  4.12500E-17  4.09102E-17  2.91216E-17  2.22266E-17  9.10704E-19
   2 2.85906E-16  1.57289E-16  1.58358E-16  1.14229E-16  8.77037E-17  3.43121E-18
   3 2.44689E-16  1.34490E-16  1.35282E-16  9.75070E-17  7.48386E-17  2.93598E-18

FLUX DISADVANTAGE FACTORS (ZONE AVERAGE/CELL AVERAGE-FLUX)

ZONE   GRP.  1      GRP.  2      GRP.  3      GRP.  4      GRP.  5      GRP.  6      GRP.  7      GRP.  8
   1 1.03674E+00  1.04065E+00  1.03970E+00  1.03675E+00  1.03621E+00  1.03317E+00  1.03528E+00  1.02822E+00
   2 9.91016E-01  9.90059E-01  9.90293E-01  9.91013E-01  9.91144E-01  9.91888E-01  9.91373E-01  9.93101E-01
   3 1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00

ZONE   GRP.  9      GRP. 10      GRP. 11      GRP. 12      GRP. 13      GRP. 14      GRP. 15      GRP. 16
   1 1.02541E+00  1.02621E+00  1.03207E+00  1.02040E+00  1.01311E+00  1.01112E+00  1.00918E+00  1.00902E+00
   2 9.93787E-01  9.93591E-01  9.92159E-01  9.95012E-01  9.96793E-01  9.97281E-01  9.97755E-01  9.97794E-01
   3 1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00

ZONE   GRP. 17      GRP. 18      GRP. 19      GRP. 20      GRP. 21      GRP. 22      GRP. 23      GRP. 24
   1 1.00947E+00  1.00924E+00  1.00916E+00  1.00949E+00  1.00934E+00  1.00854E+00  1.00785E+00  1.00756E+00
   2 9.97683E-01  9.97739E-01  9.97760E-01  9.97678E-01  9.97716E-01  9.97911E-01  9.98081E-01  9.98151E-01
   3 1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00

ZONE   GRP. 25      GRP. 26      GRP. 27      GRP. 28      GRP. 29      GRP. 30      GRP. 31      GRP. 32
   1 1.00787E+00  1.00792E+00  1.00791E+00  1.00736E+00  1.00679E+00  1.00619E+00  1.00674E+00  1.00678E+00
   2 9.98075E-01  9.98062E-01  9.98065E-01  9.98200E-01  9.98340E-01  9.98486E-01  9.98352E-01  9.98341E-01
   3 1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00

ZONE   GRP. 33      GRP. 34      GRP. 35      GRP. 36      GRP. 37      GRP. 38      GRP. 39      GRP. 40
   1 1.00661E+00  1.00580E+00  1.00499E+00  1.00420E+00  1.00339E+00  1.00307E+00  1.00109E+00  9.97759E-01
   2 9.98383E-01  9.98582E-01  9.98780E-01  9.98973E-01  9.99171E-01  9.99248E-01  9.99734E-01  1.00055E+00
   3 1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00

ZONE   GRP. 41      GRP. 42      GRP. 43      GRP. 44      GRP. 45      GRP. 46      GRP. 47      GRP. 48
   1 9.93924E-01  9.89531E-01  9.86957E-01  9.84215E-01  9.82884E-01  9.81600E-01  9.81670E-01  9.78769E-01
   2 1.00148E+00  1.00256E+00  1.00319E+00  1.00386E+00  1.00419E+00  1.00450E+00  1.00448E+00  1.00519E+00
   3 1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00

ZONE   GRP. 49      GRP. 50      GRP. 51      GRP. 52      GRP. 53      GRP. 54      GRP. 55      GRP. 56
   1 9.78804E-01  9.76606E-01  9.77784E-01  9.76821E-01  9.72171E-01  9.67844E-01  9.61746E-01  9.56348E-01
   2 1.00518E+00  1.00572E+00  1.00543E+00  1.00567E+00  1.00680E+00  1.00786E+00  1.00935E+00  1.01067E+00
   3 1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00

ZONE   GRP. 57      GRP. 58      GRP. 59      GRP. 60      GRP. 61      GRP. 62      GRP. 63      GRP. 64
   1 9.50589E-01  9.43487E-01  9.39029E-01  9.27370E-01  9.23173E-01  9.16499E-01  9.15801E-01  9.03971E-01
   2 1.01208E+00  1.01382E+00  1.01491E+00  1.01776E+00  1.01879E+00  1.02042E+00  1.02059E+00  1.02348E+00
   3 1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00

ZONE   GRP. 65      GRP. 66      GRP. 67      GRP. 68      GRP. 69      GRP. 70      GRP. 71      GRP. 72
   1 9.06439E-01  8.87171E-01  8.88860E-01  9.06516E-01  8.73889E-01  8.66169E-01  8.49533E-01  8.43715E-01
   2 1.02288E+00  1.02759E+00  1.02718E+00  1.02286E+00  1.03084E+00  1.03272E+00  1.03679E+00  1.03822E+00
   3 1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00

ZONE   GRP. 73      GRP. 74      GRP. 75      GRP. 76      GRP. 77      GRP. 78      GRP. 79      GRP. 80
   1 8.27663E-01  8.19933E-01  8.39417E-01  7.80856E-01  7.79012E-01  7.98172E-01  7.96276E-01  8.00927E-01
   2 1.04214E+00  1.04403E+00  1.03927E+00  1.05359E+00  1.05404E+00  1.04935E+00  1.04982E+00  1.04868E+00
   3 1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00

ZONE   GRP. 81      GRP. 82      GRP. 83      GRP. 84      GRP. 85      GRP. 86      GRP. 87      GRP. 88
   1 7.78782E-01  8.04436E-01  7.93005E-01  8.01862E-01  8.11322E-01  7.98371E-01  7.64496E-01  7.91123E-01
   2 1.05409E+00  1.04782E+00  1.05062E+00  1.04845E+00  1.04614E+00  1.04930E+00  1.05759E+00  1.05107E+00
   3 1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00

ZONE   GRP. 89      GRP. 90      GRP. 91      GRP. 92      GRP. 93      GRP. 94      GRP. 95      GRP. 96
   1 8.14064E-01  7.11267E-01  7.56742E-01  8.66473E-01  7.81532E-01  7.22904E-01  6.30100E-01  6.27574E-01
   2 1.04547E+00  1.07060E+00  1.05948E+00  1.03265E+00  1.05342E+00  1.06776E+00  1.09045E+00  1.09107E+00
   3 1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00

ZONE   GRP. 97      GRP. 98      GRP. 99      GRP.100      GRP.101      GRP.102      GRP.103      GRP.104
   1 4.70149E-01  6.13672E-01  5.90572E-01  6.29396E-01  7.35151E-01  6.00744E-01  6.87253E-01  5.84359E-01
   2 1.12956E+00  1.09447E+00  1.10012E+00  1.09062E+00  1.06476E+00  1.09763E+00  1.07647E+00  1.10163E+00
   3 1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00  1.00000E+00

ZONE   GRP.105      GRP.106      GRP.107      GRP.108      GRP.109      GRP.110      GRP.111      GRP.112
   1 7.03148E-01  3.14618E-01  7.73801E-01  8.74374E-01  7.51399E-01  2.88504E-01  4.53429E-01  3.15564E-01
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Indication of
relative flux
"peaking" by zone

```
XX         XX   SSSSSSSSSSS   DDDDDDDDDDDD   RRRRRRRRRRRR   NN         NN  PPPPPPPPPPPP   MM         MM
 XX       XX   SSSSSSSSSSSSS  DDDDDDDDDDDDD  RRRRRRRRRRRRR  NNN        NN  PPPPPPPPPPPPP  MMM       MMM
  XX     XX    SS         SS  DD         DD  RR         RR  NNNN       NN  PP         PP  MMMM     MMMM
   XX   XX     SS             DD         DD  RR         RR  NN NN      NN  PP         PP  MM MM   MM MM
    XX XX      SS             DD         DD  RR         RR  NN  NN     NN  PP         PP  MM  MM MM  MM
     XXX       SSSSSSSSSSSS   DD         DD  RRRRRRRRRRRRR  NN   NN    NN  PPPPPPPPPPPPP  MM   MMM   MM
     XXX        SSSSSSSSSSSS  DD         DD  RRRRRRRRRRRR   NN    NN   NN  PPPPPPPPPPPP   MM    M    MM
    XX XX                 SS  DD         DD  RR      RR     NN     NN  NN  PP             MM         MM
   XX   XX                SS  DD         DD  RR       RR    NN      NN NN  PP             MM         MM
  XX     XX    SS         SS  DD         DD  RR        RR   NN       NNNN  PP             MM         MM
 XX       XX   SSSSSSSSSSSSS  DDDDDDDDDDDDD  RR         RR  NN        NNN  PP             MM         MM
XX         XX   SSSSSSSSSSS   DDDDDDDDDDDD   RR         RR  NN         NN  PP             MM         MM

NN         NN  MM         MM   GGGGGGGGGGG   TTTTTTTTTTTTT    AAAAAAAAA     SSSSSSSSSSS   KK         KK           44
NNN        NN  MMM       MMM  GGGGGGGGGGGGG  TTTTTTTTTTTTT   AAAAAAAAAAA   SSSSSSSSSSSSS  KK        KK           444
NNNN       NN  MMMM     MMMM  GG         GG       TT        AA         AA  SS         SS  KK       KK           4444
NN NN      NN  MM MM   MM MM  GG                  TT        AA         AA  SS             KK      KK           44 44
NN  NN     NN  MM  MM MM  MM  GG                  TT        AA         AA  SS             KK     KK           44  44
NN   NN    NN  MM   MMM   MM  GG    GGGGGGG       TT        AAAAAAAAAAAAA  SSSSSSSSSSSS   KKKKKKK            44   44
NN    NN   NN  MM    M    MM  GG    GGGGGGG       TT        AAAAAAAAAAAAA   SSSSSSSSSSSS  KKKKKKK           44    44
NN     NN  NN  MM         MM  GG         GG       TT        AA         AA             SS  KK     KK      444444444444
NN      NN NN  MM         MM  GG         GG       TT        AA         AA             SS  KK      KK     4444444444444
NN       NNNN  MM         MM  GG         GG       TT        AA         AA  SS         SS  KK       KK             44
NN        NNN  MM         MM  GGGGGGGGGGGGG       TT        AA         AA  SSSSSSSSSSSSS  KK        KK            44
NN         NN  MM         MM   GGGGGGGGGGG        TT        AA         AA   SSSSSSSSSSS   KK         KK           44

   0000000      88888888888              //       11        22222222222              //   99999999999        11
  000000000    8888888888888            //       111        2222222222222            //   9999999999999      111
 00       00   88         88           //       1111        22         22           //    99         99     1111
00         00  88         88          //          11                   22          //     99         99       11
00         00  88         88         //           11                   22         //      99         99       11
00         00   88888888888         //            11                 22          //       9999999999999       11
00         00   88888888888        //             11               22           //         999999999999       11
00         00  88         88      //              11             22            //                    99       11
00         00  88         88     //               11           22             //                     99       11
 00       00   88         88    //                11         22              //                      99       11
  000000000    8888888888888   //             11111111    2222222222222   //            9999999999999     11111111
   0000000      88888888888   //              11111111    2222222222222  //              99999999999      11111111

 22222222222    22222222222                       11        33333333333                   22222222222      0000000
2222222222222  2222222222222                     111        3333333333333                 2222222222222    000000000
22         22  22         22                    1111        33         33                 22         22   00       00
           22             22                      11                   33                            22  00         00
           22             22                      11                   33                            22  00         00
         22             22                        11                  333                          22    00         00
       22             22          .....           11                  333      .....             22      00         00
     22             22            .....           11                   33      .....           22        00         00
   22             22              .....           11                   33      .....         22          00         00
 22             22                .....           11        33         33      .....       22            00       00
2222222222222  2222222222222                    11111111    3333333333333                 2222222222222    000000000
2222222222222  2222222222222                    11111111     33333333333                  2222222222222     0000000
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                       CASE TO COLLAPSE TO 25 ENERGY GROUPS
GENERAL PROBLEM DESCRIPTION DATA BLOCK
                          GENERAL PROBLEM DATA
IGE  1/2/3 = PLANE/CYLINDER/SPHERE        2      ISN  QUADRATURE ORDER                   4
IZM  NUMBER OF ZONES                      2      ISCT ORDER OF SCATTERING                3
IM   NUMBER OF SPACIAL INTERVALS         50      IEVT 0/1/2/3/4/5/6=Q/K/ALPHA/C/Z/R/H    1
IBL  0/1/2/3 = VACUUM/REFL/PER/WHITE      1      IIM  INNER ITERATION MAXIMUM           25
IBR  RIGHT BOUNDARY CONDITION             0      ICM  OUTER ITERATION MAXIMUM           25
MXX  NUMBER OF MIXTURES                   2      ICLC -1/0/N--FLAT RES/SN/OPT            0
MS   MIXING TABLE LENGTH                  3      ITH  0/1 = FORWARD/ADJOINT              0
IGM  NUMBER OF ENERGY GROUPS            238      IFLU NOT USED(ALWAYS WGTD)              0
NNG  NUMBER OF NEUTRON GROUPS           238      IPRT -2/-1/0/N=MIXTURE XSEC PRINT      -1
NGG  NUMBER OF GAMMA GROUPS               0      ID1  0/1/2/3=NO/PRT ND/PCH N/BOTH       0
IFTG NUMBER OF FIRST THERMAL GROUP      149      IPBT -1/0/1=NONE/FINE/ALL BAL. PRT      0
                            SPECIAL OPTIONS
IFG  0/1 = NONE/WEIGHTING CALCULATION     1      IPN  0/1/2 DIFF. COEF. PARAM            3
IQM  VOLUMETRIC SOURCES (0/N=NO/YES)      0      IDFM 0/1 = NONE/DENSITY FACTORS 38*     0
IPM  BOUNDARY SOURCES (0/N=NO/YES)        0      IAZ  0/N = NONE/N ACTIVITIES BY ZONE    0
IFN  0/1/2 = INPUT 33*/34*/USE LAST       0      IAI  0/1=NONE/ACTIVITIES BY INTERVAL    0
ITMX MAXIMUM TIME (MINUTES)               0      IFCT 0/1=NO/YES UPSCATTER SCALING       0
IDT1 0/1/2/3=NO/XSECT/SRCE/FLUX--OUT      0      IPVT 0/1/2=NO/K/ALPHA PARAMETRIC SRCH   0
ISX  BROAD GROUP FLUXES                   0      ISEN OUTER ITERATION ACCELERATION       0
IBLN ACTIVITY DATA UNIT                   0      NBND BAND REBALN PARAMETER             -3
JBKL 0/1/2 BUCKLING GEOMETRY              0
                             WEIGHTING DATA ~~(IFG=1)~~ Zone Weighting
ICON -1/0/1=CELL/ZONE/REGION WEIGHT       0      IHTF TOTAL XSECT PSN IN BRD GP TABLES   3
IGMF NUMBER OF BROAD GROUPS              25      NDSF PSN G-G OR FILE NUMBER             4
ITP  0/10/20/30/40 0/C/E/AC/A             0      NUSF TABLE LENGTH OR MAX ORDER         28
IPP  -2/-1/0/N=WGTED XSECT PRINT         -1      MSCM EXTRA 1-D X-SECT POSITIONS         0
IAP  -1/N ANISN XSECT PRINT              -1
                         FLOATING POINT PARAMETERS
EPS  OVERALL CONVERGENCE          1.00000E-04    DY   CYL/PLA HT FOR BUCKLING    0.00000E+00
PTC  POINT CONVERGENCE            1.00000E-04    DZ   PLANE DEPTH FOR BUCKLING   0.00000E+00
XNF  NORMALIZATION FACTOR         1.00000E+00    VSC  VOID STREAMING CORRECTION  0.00000E+00
EV   EIGENVALUE GUESS             0.00000E+00    PV   IPVT=1/2--K/ALPHA          0.00000E+00
EVM  EIGENVALUE MODIFIER          0.00000E+00    EQL  EV CHANGE EPS FOR SEARCH   1.00000E-03
BF   BUCKLING FACTOR=1.420892     1.42089E+00    XNPM NEW PARAM MOD FOR SEARCH   7.50000E-01
    THIS CASE WILL REQUIRE        49593 LOCATIONS FOR MIXING
    THIS CASE HAS BEEN ALLOCATED 200000 LOCATIONS
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                          CASE TO COLLAPSE TO 25 ENERGY GROUPS
                          NEUTRON GROUP PARAMETERS

 GP    ENERGY       LETHARGY       MID PT      BROAD GP      CALC       GROUP        RIGHT      LEFT
     BOUNDARIES    BOUNDARIES    VELOCITIES    NUMBERS       TYPE        BAND        ALBEDO     ALBEDO
  1  2.00000E+07 -6.93147E-01  5.97878E+09        1            0           1
  2  1.73330E+07 -5.50027E-01  5.62676E+09        1            0           2
  3  1.56830E+07 -4.49992E-01  5.38610E+09        1            0           3
  4  1.45500E+07 -3.75006E-01  5.22054E+09        1            0           4
  5  1.38400E+07 -3.24978E-01  5.05973E+09        1            0           5
  6  1.28400E+07 -2.49980E-01  4.66218E+09        2            0           6
  7  1.00000E+07       0       4.16711E+09        2            0           7
  8  8.18730E+06  2.00000E-01  3.73142E+09        2            0           8
  9  6.43400E+06  4.40988E-01  3.26417E+09        2            0           9
 10  4.80000E+06  7.33969E-01  2.95431E+09        2            0          10
 11  4.30400E+06  8.43040E-01  2.62356E+09        2            0          11
 12  3.00000E+06  1.20397E+00  2.28779E+09        2            0          12
 13  2.47900E+06  1.39473E+00  2.15398E+09        2            0          13
 14  2.35400E+06  1.44647E+00  2.00084E+09        2            0          14
 15  1.85000E+06  1.68740E+00  1.78792E+09        2            0          15
 16  1.50000E+06  1.89712E+00  1.66826E+09        3            0          16
 17  1.40000E+06  1.96611E+00  1.62669E+09        3            0          17
 18  1.35600E+06  1.99805E+00  1.60210E+09        3            0          18
 19  1.31700E+06  2.02723E+00  1.56979E+09        3            0          19
 20  1.25000E+06  2.07944E+00  1.53369E+09        3            0          20
 21  1.20000E+06  2.12026E+00  1.48538E+09        3            0          21
 22  1.10000E+06  2.20727E+00  1.42273E+09        3            0          22
 23  1.01000E+06  2.29263E+00  1.36057E+09        3            0          23
 24  9.20000E+05  2.38597E+00  1.32198E+09        3            0          24
 25  9.00000E+05  2.40795E+00  1.30552E+09        3            0          25
 26  8.75000E+05  2.43612E+00  1.29118E+09        4            0          26
 27  8.61100E+05  2.45213E+00  1.27038E+09        4            0          27
 28  8.20000E+05  2.50104E+00  1.22719E+09        4            0          28
 29  7.50000E+05  2.59027E+00  1.17063E+09        4            0          29
 30  6.79000E+05  2.68972E+00  1.13813E+09        4            0          30
 31  6.70000E+05  2.70306E+00  1.10340E+09        4            0          31
 32  6.00000E+05  2.81341E+00  1.06117E+09        4            0          32
 33  5.73000E+05  2.85945E+00  1.03839E+09        4            0          33
 34  5.50000E+05  2.90042E+00  1.00326E+09        4            0          34
 35  4.99520E+05  2.99669E+00  9.64673E+08        4            0          35
 36  4.70000E+05  3.05761E+00  9.34551E+08        5            0          36
 37  4.40000E+05  3.12357E+00  9.08623E+08        5            0          37
 38  4.20000E+05  3.17008E+00  8.87242E+08        5            0          38
 39  4.00000E+05  3.21888E+00  8.35040E+08        5            0          39
 40  3.30000E+05  3.41125E+00  7.56864E+08        5            0          40
 41  2.70000E+05  3.61192E+00  6.67455E+08        5            0          41
 42  2.00000E+05  3.91202E+00  5.76285E+08        5            0          42
 43  1.50000E+05  4.19971E+00  5.16058E+08        5            0          43
 44  1.28300E+05  4.35597E+00  4.66131E+08        5            0          44
 45  1.00000E+05  4.60517E+00  4.20695E+08        5            0          45
 46  8.50000E+04  4.76769E+00  4.00430E+08        6            0          46
 47  8.20000E+04  4.80362E+00  3.88073E+08        6            0          47
 48  7.50000E+04  4.89285E+00  3.76974E+08        6            0          48
 49  7.30000E+04  4.91988E+00  3.56390E+08        6            0          49
 50  6.00000E+04  5.11600E+00  3.27473E+08        6            0          50
 51  5.20000E+04  5.25910E+00  3.12938E+08        6            0          51
 52  5.00000E+04  5.29832E+00  3.01805E+08        6            0          52
 53  4.50000E+04  5.40368E+00  2.65199E+08        6            0          53
 54  3.00000E+04  5.80914E+00  2.29269E+08        6            0          54
 55  2.50000E+04  5.99146E+00  1.98681E+08        6            0          55
 56  1.70000E+04  6.37713E+00  1.68851E+08        7            0          56
 57  1.30000E+04  6.64539E+00  1.45950E+08        7            0          57
 58  9.50000E+03  6.95905E+00  1.29483E+08        7            0          58
 59  8.03000E+03  7.12716E+00  1.15362E+08        7            0          59
 60  6.00000E+03  7.41858E+00  9.62048E+07        7            0          60
 61  3.90000E+03  7.84936E+00  8.56434E+07        7            0          61
 62  3.74000E+03  7.89125E+00  8.01695E+07        7            0          62
 63  3.00000E+03  8.11173E+00  7.30825E+07        7            0          63
 64  2.58000E+03  8.26255E+00  6.83174E+07        7            0          64
 65  2.29000E+03  8.38179E+00  6.56558E+07        7            0          65
 66  2.20000E+03  8.42188E+00  6.17978E+07        8            0          66
 67  1.80000E+03  8.62255E+00  5.66280E+07        8            0          67
 68  1.55000E+03  8.77209E+00  5.41159E+07        8            0          68
 69  1.50000E+03  8.80487E+00  5.01890E+07        8            0          69
 70  1.15000E+03  9.07058E+00  4.47889E+07        8            0          70
```

1st 5 groups make 1 group

next 10 go to output group 2

next 10 go to group 3

Iteration Statistics

```
OUTER INNER  1 - BALANCE   EIGENVALUE  1 - SOURCE   1 - SCATTER  1 - UPSCAT     SEARCH        TIME
 ITER ITERS                                RATIO        RATIO        RATIO     PARAMETER      (MIN)
    1  2742  3.59253E-03  1.89438E+00 -9.59225E-01  1.00000E+00 -2.49032E-02  0.00000E+00     1.2527
    2  5056  7.47958E-04  1.90996E+00  2.05322E-03 -1.82802E-01 -3.76118E-03  0.00000E+00     2.3062
    3  7147 -5.93292E-05  1.92933E+00  1.02875E-02 -2.15288E-02  5.34511E-04  0.00000E+00     3.2730
    4  8903 -4.24737E-05  1.93303E+00  1.42683E-03  8.75380E-03  2.92656E-04  0.00000E+00     4.1270
    5 10409 -6.08976E-06  1.93301E+00 -1.61715E-04  2.67683E-03  3.73189E-05  0.00000E+00     4.8915
    6 11706 -2.64646E-07  1.93287E+00 -7.46305E-05  1.09457E-04 -4.63364E-06  0.00000E+00     5.5598
                                                               GRP TO GRP INNER  MFD    MAX. FLUX   MSF  MAX. SCALE COARSE
                                                                          ITERS  INT.   DIFFERENCE  INT.    FACTOR    MESH
                                                                 1      1   25    31  3.43746E-04   50  1.00004E+00   13
                                                                 2      2    2    10  2.44192E-05    9  1.00000E+00   13
                                                                 3      3    2    10  2.39749E-05    9  1.00000E+00   13
                                                                 4      4    2    10  2.30238E-05    9  1.00000E+00   12
                                                                 5      5    2    10  2.35013E-05    9  1.00000E+00   12
                                                                 6      6    2    10  2.44337E-05    9  1.00000E+00   12
                                                                 7      7    2    10  2.51124E-05    9  1.00000E+00   10
                                                                 8      8    2    16  2.78194E-05    8  1.00000E+00   10
                                                                 9      9    2    15  2.90630E-05   50  1.00001E+00   11
                                                                10     10    2    15  2.88234E-05   21  9.99997E-01   13
                                                                11     11    2    15  3.31866E-05   27  1.00000E+00   18
                                                                12     12    2     8  2.74727E-05   33  1.00000E+00   18
                                                                13     13    2    14  2.36044E-05    7  1.00000E+00   13
                                                                14     14    2     8  2.60852E-05   36  1.00000E+00   13
                                                                15     15    2    16  2.56639E-05   37  1.00000E+00   18
                                                                16     16    2    16  2.36384E-05   16  1.00000E+00   18
                                                                17     17    2    16  2.18866E-05   16  1.00000E+00   18
                                                                18     18    2    16  2.14443E-05   16  1.00000E+00   18
                                                                19     19    2    16  2.26641E-05   16  1.00000E+00   18
                                                                20     20    2    16  2.18451E-05   16  1.00000E+00   18
                                                                21     21    2    16  2.30178E-05   16  1.00000E+00   18
                                                                22     22    2    16  2.27655E-05   16  1.00000E+00   18
                                                                23     23    2    16  2.27819E-05   16  1.00000E+00   18
                                                                24     24    2    16  1.90676E-05   16  1.00000E+00   18
                                                                25     25    2    16  1.99459E-05   16  1.00000E+00   18
                                                                26     26    2    16  1.69944E-05   16  1.00000E+00   18
                                                                27     27    2    16  2.12949E-05   16  1.00000E+00   18
                                                                28     28    2     8  2.11587E-05    7  9.99998E-01   18
                                                                29     29    2     8  2.19225E-05    7  9.99997E-01   18
                                                                30     30    2    14  1.34012E-05    7  1.00000E+00   18
                                                                31     31    2 [illegible]  2.26280E-05    7  9.99996E-01   18
                                                                32     32    2     8  1.91884E-05    7  9.99998E-01   18
                                                                33     33    2     8  1.86813E-05    7  9.99998E-01   18
                                                                34     34    1     1  9.92550E-05    7  9.99938E-01   18
                                                                35     35    1     1  9.73044E-05    7  9.99941E-01   18
                                                                36     36    1     1  9.06113E-05    6  9.99932E-01   19
                                                                37     37    1     1  9.13134E-05    6  9.99935E-01   19
                                                                38     38    1     1  8.88988E-05    6  9.99935E-01   19
                                                                39     39    1     1  7.70406E-05    6  9.99932E-01   19
                                                                40     40    1     1  7.20684E-05    6  9.99935E-01   33
                                                                41     41    1     1  6.58888E-05    6  9.99940E-01   33
                                                                42     42    1     1  5.79151E-05    5  9.99936E-01   34
                                                                43     43    1     1  5.76573E-05    5  9.99939E-01   34
                                                                44     44    1     1  5.59691E-05    5  9.99942E-01   34
                                                                45     45    1     1  5.46193E-05    5  9.99946E-01   34
                                                                46     46    1    36  6.53197E-05    5  9.99955E-01   34
                                                                47     47    1    36  5.83861E-05    5  9.99951E-01   34
                                                                48     48    1    36  6.60623E-05    5  9.99961E-01   34
                                                                49     49    1     1  5.43484E-05    5  9.99952E-01   34
                                                                50     50    1    36  5.18968E-05    4  9.99944E-01   35
                                                                51     51    1    36  6.41672E-05    4  9.99954E-01   35
                                                                52     52    1    36  5.60781E-05    4  9.99950E-01   35
                                                                53     53    1     1  4.75185E-05    4  9.99952E-01   35
                                                                54     54    1     1  4.72661E-05    4  9.99962E-01   35
                                                                55     55    1     1  5.06105E-05   38  1.00004E+00   35
                                                                56     56    1     1  4.99858E-05   20  1.00004E+00   35
                                                                57     57    1     1  5.05060E-05   20  1.00004E+00   35
                                                                58     58    1     1  5.15371E-05   16  1.00004E+00   35
                                                                59     59    1     1  5.07843E-05   16  1.00004E+00   35
                                                                60     60    1     1  5.35083E-05   16  1.00004E+00   35
                                                                61     61    1    40  6.08366E-05   15  1.00003E+00   36
                                                                62     62    1    40  4.15373E-05   15  1.00003E+00   36
                                                                63     63    1    41  4.89542E-05   12  1.00004E+00   36
                                                                64     64    1    41  5.21608E-05   12  1.00003E+00   36
                                                                65     65    1    41  6.07983E-05   12  1.00003E+00   36
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                    CASE TO COLLAPSE TO 25 ENERGY GROUPS
                    C-12 (GRAPHITE KERNEL AT THERMAL)
                       ZONE WEIGHTED CROSS SECTIONS FOR XSDRN MATERIAL  1600002
XSEC ID      1             2             3002          3             4             102           3102          103
GRP.
   1    1.35019E+00   8.44641E-01   8.44641E-01   5.05548E-01   4.19183E-01   1.16290E-04   1.16290E-04   1.49286E-03
   2    1.82552E+00   1.80773E+00   1.81198E+00   1.77872E-02   1.59895E-02   1.41287E-05   1.44385E-05   0.00000E+00
   3    2.38707E+00   2.38707E+00   2.38743E+00   1.90942E-06   0.00000E+00   1.90942E-06   1.90865E-06   0.00000E+00
   4    3.11275E+00   3.11274E+00   3.11344E+00   1.08598E-06   0.00000E+00   1.08598E-06   1.08578E-06   0.00000E+00
   5    3.95069E+00   3.95069E+00   3.95391E+00   9.44139E-07   0.00000E+00   9.44139E-07   9.43850E-07   0.00000E+00
   6    4.59350E+00   4.59350E+00   4.59359E+00   9.60810E-07   0.00000E+00   9.60810E-07   9.60843E-07   0.00000E+00
   7    4.77290E+00   4.77290E+00   4.77289E+00   5.64228E-06   0.00000E+00   5.64228E-06   5.64228E-06   0.00000E+00
   8    4.89838E+00   4.89836E+00   4.89835E+00   2.03010E-05   0.00000E+00   2.03010E-05   2.03010E-05   0.00000E+00
   9    4.98599E+00   4.98595E+00   4.98595E+00   4.40201E-05   0.00000E+00   4.40201E-05   4.40202E-05   0.00000E+00
  10    5.00931E+00   5.00925E+00   5.00924E+00   6.64360E-05   0.00000E+00   6.64360E-05   6.64361E-05   0.00000E+00
  11    5.15481E+00   5.15472E+00   5.15472E+00   8.69102E-05   0.00000E+00   8.69102E-05   8.69103E-05   0.00000E+00
  12    5.05816E+00   5.05806E+00   5.05806E+00   9.83065E-05   0.00000E+00   9.83065E-05   9.83066E-05   0.00000E+00
  13    5.01999E+00   5.01986E+00   5.01986E+00   1.24093E-04   0.00000E+00   1.24093E-04   1.24093E-04   0.00000E+00
  14    5.02408E+00   5.02390E+00   5.02389E+00   1.83604E-04   0.00000E+00   1.83604E-04   1.83604E-04   0.00000E+00
  15    4.90711E+00   4.90686E+00   4.90685E+00   2.58248E-04   0.00000E+00   2.58248E-04   2.58248E-04   0.00000E+00
  16    4.95671E+00   4.95637E+00   4.95630E+00   3.38123E-04   0.00000E+00   3.38123E-04   3.38123E-04   0.00000E+00
  17    4.97153E+00   4.97112E+00   4.97098E+00   4.12737E-04   0.00000E+00   4.12737E-04   4.12737E-04   0.00000E+00
  18    5.12100E+00   5.12050E+00   5.12031E+00   5.06777E-04   0.00000E+00   5.06777E-04   5.06777E-04   0.00000E+00
  19    5.50670E+00   5.50610E+00   5.50588E+00   6.02286E-04   0.00000E+00   6.02286E-04   6.02286E-04   0.00000E+00
  20    5.29249E+00   5.29185E+00   5.32299E+00   6.37894E-04   0.00000E+00   6.37894E-04   6.37894E-04   0.00000E+00
  21    5.32747E+00   5.32664E+00   5.37828E+00   8.23788E-04   0.00000E+00   8.23788E-04   8.23787E-04   0.00000E+00
  22    5.36114E+00   5.35974E+00   5.42895E+00   1.39086E-03   0.00000E+00   1.39086E-03   1.39099E-03   0.00000E+00
  23    5.40066E+00   5.39792E+00   5.31967E+00   2.73947E-03   0.00000E+00   2.73947E-03   2.73947E-03   0.00000E+00
  24    4.97733E+00   4.96949E+00   5.45731E+00   7.84109E-03   0.00000E+00   7.84109E-03   7.84110E-03   0.00000E+00
  25    9.17704E+00   9.14848E+00   5.55247E+00   2.85534E-02   0.00000E+00   2.85534E-02   2.85529E-02   0.00000E+00

XSEC ID     104           107           203           204           207           251           252           253
GRP.
   1    3.74333E-03   8.10129E-02   1.49286E-03   3.74333E-03   7.89887E-01   6.21629E-01   6.24607E-02   9.58849E-02
   2    0.00000E+00   1.78365E-03   0.00000E+00   0.00000E+00   2.68685E-03   1.03880E-01   1.50290E-01   1.13967E-01
   3    0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   1.19153E-01   1.48123E-01   1.05790E-01
   4    0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   1.10347E-01   1.49693E-01   1.06042E-01
   5    0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   8.58002E-02   1.54301E-01   1.07606E-01
   6    0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   6.34349E-02   1.58915E-01   1.09387E-01
   7    0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   5.83987E-02   1.61192E-01   1.10620E-01
   8    0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   5.84464E-02   1.64546E-01   1.12857E-01
   9    0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   5.93067E-02   1.67365E-01   1.14782E-01
  10    0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   5.95626E-02   1.68132E-01   1.15308E-01
  11    0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   6.12862E-02   1.73011E-01   1.18653E-01
  12    0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   6.01346E-02   1.69765E-01   1.16427E-01
  13    0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   5.96777E-02   1.68481E-01   1.15546E-01
  14    0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   5.97232E-02   1.68615E-01   1.15638E-01
  15    0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   5.83305E-02   1.64685E-01   1.12943E-01
  16    0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   5.89178E-02   1.66344E-01   1.14081E-01
  17    0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   5.90921E-02   1.66837E-01   1.14418E-01
  18    0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   6.08671E-02   1.71848E-01   1.17855E-01
  19    0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   6.54503E-02   1.84789E-01   1.26730E-01
  20    0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   6.32762E-02   1.78651E-01   1.22520E-01
  21    0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   6.39334E-02   1.80506E-01   1.23793E-01
  22    0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   6.45356E-02   1.82207E-01   1.24959E-01
  23    0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   6.32365E-02   1.78539E-01   1.22444E-01
  24    0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   6.48728E-02   1.83159E-01   1.25612E-01
  25    0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   0.00000E+00   6.60042E-02   1.86353E-01   1.27803E-01

XSEC ID      27            101           1099          3099          9002          11000         11001         1000
GRP.
   1    8.63654E-02   8.63654E-02   1.71914E-08   7.27687E-02   0.00000E+00   6.74808E-01   7.47087E-01   7.62326E-01
   2    1.79777E-03   1.79777E-03   9.38217E-05   2.37814E-01   0.00000E+00   1.46053E+00   1.50830E+00   1.62123E+00
   3    1.90942E-06   1.90942E-06   5.52105E-05   6.64127E-02   0.00000E+00   1.84923E+00   1.84007E+00   2.09611E+00
   4    1.08598E-06   1.08598E-06   5.96527E-05   7.97192E-02   0.00000E+00   2.43407E+00   2.44962E+00   2.76137E+00
   5    9.44139E-07   9.44139E-07   8.72989E-05   2.07190E-01   0.00000E+00   3.16787E+00   3.41700E+00   3.54838E+00
   6    9.60810E-07   9.60810E-07   1.61086E-05   2.23920E-01   0.00000E+00   3.75591E+00   3.77143E+00   4.33331E+00
   7    5.64228E-06   5.64228E-06   4.75208E-06   2.83556E-01   0.00000E+00   3.90221E+00   4.05894E+00   4.50518E+00
   8    2.03010E-05   2.03010E-05   1.39131E-06   3.04714E-01   0.00000E+00   3.95996E+00   4.46533E+00   4.62552E+00
   9    4.40201E-05   4.40201E-05   3.77622E-07   2.38919E-01   0.00000E+00   3.99419E+00   4.88312E+00   4.70660E+00
  10    6.64360E-05   6.64360E-05   1.82484E-07   7.74223E-02   0.00000E+00   4.00848E+00   4.99649E+00   4.73198E+00
  11    8.69102E-05   8.69102E-05   5.61655E-08   3.41821E-02   0.00000E+00   4.09124E+00   5.13584E+00   4.86717E+00
  12    9.83065E-05   9.83065E-05   5.82558E-08   3.48984E-02   0.00000E+00   4.09753E+00   5.95222E+00   4.78347E+00
  13    1.24093E-04   1.24093E-04   1.29616E-07   8.14943E-02   0.00000E+00   4.04368E+00   5.04320E+00   4.74415E+00
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Carbon
weighted over
the 1st zone

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                  CASE TO COLLAPSE TO 25 ENERGY GROUPS
                  C-12 (GRAPHITE KERNEL AT THERMAL)
                     ZONE WEIGHTED CROSS SECTIONS FOR XSDRN MATERIAL     26000
XSEC ID      1            2            3002          3             4             102           3102          103
GRP.
   1    1.36112E+00  8.52090E-01  8.52089E-01  5.09031E-01  4.21905E-01  1.16090E-04  1.16090E-04  1.43237E-03
   2    1.82076E+00  1.80379E+00  1.80734E+00  1.69695E-02  1.54018E-02  1.32055E-05  1.34979E-05  0.00000E+00
   3    2.39534E+00  2.39534E+00  2.39571E+00  1.90436E-06  0.00000E+00  1.90436E-06  1.90366E-06  0.00000E+00
   4    3.12074E+00  3.12074E+00  3.12144E+00  1.08684E-06  0.00000E+00  1.08684E-06  1.08664E-06  0.00000E+00
   5    4.04347E+00  4.04347E+00  4.04668E+00  9.34147E-07  0.00000E+00  9.34147E-07  9.33883E-07  0.00000E+00
   6    4.58918E+00  4.58918E+00  4.58923E+00  9.63115E-07  0.00000E+00  9.63115E-07  9.63136E-07  0.00000E+00
   7    4.70879E+00  4.70879E+00  4.70878E+00  7.25424E-06  0.00000E+00  7.25424E-06  7.25424E-06  0.00000E+00
   8    4.73484E+00  4.73482E+00  4.73481E+00  2.07326E-05  0.00000E+00  2.07326E-05  2.07326E-05  0.00000E+00
   9    4.73840E+00  4.73836E+00  4.73836E+00  4.20397E-05  0.00000E+00  4.20397E-05  4.20398E-05  0.00000E+00
  10    4.73890E+00  4.73884E+00  4.73884E+00  6.34937E-05  0.00000E+00  6.34937E-05  6.34937E-05  0.00000E+00
  11    4.73909E+00  4.73901E+00  4.73901E+00  7.98181E-05  0.00000E+00  7.98181E-05  7.98182E-05  0.00000E+00
  12    4.73914E+00  4.73905E+00  4.73904E+00  9.21843E-05  0.00000E+00  9.21843E-05  9.21844E-05  0.00000E+00
  13    4.73920E+00  4.73908E+00  4.73908E+00  1.17742E-04  0.00000E+00  1.17742E-04  1.17742E-04  0.00000E+00
  14    4.73930E+00  4.73913E+00  4.73912E+00  1.69604E-04  0.00000E+00  1.69604E-04  1.69605E-04  0.00000E+00
  15    4.73941E+00  4.73917E+00  4.73917E+00  2.44197E-04  0.00000E+00  2.44197E-04  2.44197E-04  0.00000E+00
  16    4.73961E+00  4.73929E+00  4.73923E+00  3.19197E-04  0.00000E+00  3.19197E-04  3.19197E-04  0.00000E+00
  17    4.73974E+00  4.73935E+00  4.73921E+00  3.94451E-04  0.00000E+00  3.94451E-04  3.94451E-04  0.00000E+00
  18    4.73989E+00  4.73942E+00  4.73924E+00  4.73525E-04  0.00000E+00  4.73525E-04  4.73525E-04  0.00000E+00
  19    4.74015E+00  4.73963E+00  4.73945E+00  5.18383E-04  0.00000E+00  5.18383E-04  5.18383E-04  0.00000E+00
  20    4.71243E+00  4.71187E+00  4.73925E+00  5.66804E-04  0.00000E+00  5.66804E-04  5.66803E-04  0.00000E+00
  21    4.69356E+00  4.69282E+00  4.73921E+00  7.39369E-04  0.00000E+00  7.39369E-04  7.39369E-04  0.00000E+00
  22    4.68212E+00  4.68081E+00  4.73921E+00  1.30580E-03  0.00000E+00  1.30580E-03  1.30600E-03  0.00000E+00
  23    4.82623E+00  4.82351E+00  4.73919E+00  2.72417E-03  0.00000E+00  2.72417E-03  2.72416E-03  0.00000E+00
  24    4.44732E+00  4.44014E+00  4.73919E+00  7.18059E-03  0.00000E+00  7.18059E-03  7.18060E-03  0.00000E+00
  25    7.84778E+00  7.82254E+00  4.73919E+00  2.52441E-02  0.00000E+00  2.52441E-02  2.52437E-02  0.00000E+00

XSEC ID     104          107           203           204           207           251           252           253
GRP.
   1    3.61857E-03  8.19587E-02  1.43237E-03  3.61857E-03  7.91674E-01  6.26415E-01  6.31889E-02  9.68776E-02
   2    0.00000E+00  1.55454E-03  0.00000E+00  0.00000E+00  2.31399E-03  1.06275E-01  1.50649E-01  1.13457E-01
   3    0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  1.19416E-01  1.48440E-01  1.06015E-01
   4    0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  1.10458E-01  1.49948E-01  1.06218E-01
   5    0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  8.22688E-02  1.54692E-01  1.07660E-01
   6    0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  6.20829E-02  1.58090E-01  1.08761E-01
   7    0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  5.73555E-02  1.58885E-01  1.09026E-01
   8    0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  5.64691E-02  1.59035E-01  1.09076E-01
   9    0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  5.63612E-02  1.59053E-01  1.09082E-01
  10    0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  5.63470E-02  1.59056E-01  1.09083E-01
  11    0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  5.63436E-02  1.59058E-01  1.09084E-01
  12    0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  5.63419E-02  1.59058E-01  1.09084E-01
  13    0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  5.63397E-02  1.59057E-01  1.09083E-01
  14    0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  5.63380E-02  1.59057E-01  1.09083E-01
  GRPS    15 THRU   18 ARE THE SAME AS ABOVE
  19    0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  5.63395E-02  1.59066E-01  1.09089E-01
  20    0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  5.63372E-02  1.59059E-01  1.09084E-01
  GRPS    21 THRU   25 ARE THE SAME AS ABOVE

XSEC ID      27           101          1099          3099          9002          11000         11001         1000
GRP.
   1    8.71257E-02  8.71257E-02  8.29912E-09  7.32772E-02  0.00000E+00  7.68979E-01  8.50483E-01  7.69009E-01
   2    1.56774E-03  1.56774E-03  5.90304E-05  2.33276E-01  0.00000E+00  1.64657E+00  1.73793E+00  1.59880E+00
   3    1.90436E-06  1.90436E-06  4.36693E-05  6.66506E-02  0.00000E+00  2.11007E+00  2.09953E+00  2.09395E+00
   4    1.08684E-06  1.08684E-06  4.93610E-05  7.98944E-02  0.00000E+00  2.77822E+00  2.79586E+00  2.76237E+00
   5    9.34147E-07  9.34147E-07  1.20469E-04  2.16952E-01  0.00000E+00  3.71506E+00  3.86577E+00  3.64727E+00
   6    9.63115E-07  9.63115E-07  8.80297E-05  2.61089E-01  0.00000E+00  4.30586E+00  4.33407E+00  4.30400E+00
   7    7.25424E-06  7.25424E-06  9.75837E-05  2.73684E-01  0.00000E+00  4.44015E+00  4.64369E+00  4.43980E+00
   8    2.07326E-05  2.07326E-05  8.82473E-05  3.25217E-01  0.00000E+00  4.46889E+00  5.07740E+00  4.46882E+00
   9    4.20397E-05  4.20397E-05  4.27591E-05  2.32377E-01  0.00000E+00  4.47276E+00  5.47377E+00  4.47276E+00
  10    6.34937E-05  6.34937E-05  2.49827E-05  7.43340E-02  0.00000E+00  4.47331E+00  5.55547E+00  4.47331E+00
  11    7.98181E-05  7.98181E-05  1.17402E-05  3.10254E-02  0.00000E+00  4.47350E+00  5.63178E+00  4.47352E+00
  12    9.21843E-05  9.21843E-05  1.08125E-05  3.22278E-02  0.00000E+00  4.47356E+00  6.38517E+00  4.47357E+00
  13    1.17742E-04  1.17742E-04  2.63845E-05  7.64193E-02  0.00000E+00  4.47362E+00  5.52341E+00  4.47363E+00
  14    1.69604E-04  1.69604E-04  2.89893E-05  9.63178E-02  0.00000E+00  4.47372E+00  5.24908E+00  4.47373E+00
  15    2.44197E-04  2.44197E-04  2.56874E-05  9.23510E-02  0.00000E+00  4.47384E+00  5.08272E+00  4.47385E+00
  16    3.19197E-04  3.19197E-04  1.46608E-05  5.30581E-02  2.91033E+00  4.55134E+00  4.36590E+00  4.55005E+00
  17    3.94451E-04  3.94451E-04  1.74691E-05  4.80687E-02  4.73935E+00  4.65678E+00  5.29023E+00  4.65666E+00
  18    4.73525E-04  4.73525E-04  1.07003E-05  3.08295E-02  4.73942E+00  4.71192E+00  5.91958E+00  4.71193E+00
  19    5.18383E-04  5.18383E-04  3.69121E-06  9.18773E-03  4.73963E+00  4.76045E+00  5.65396E+00  4.76040E+00
  20    5.66804E-04  5.66804E-04  1.08285E-05  3.86213E-02  4.71187E+00  4.79871E+00  4.88984E+00  4.79870E+00
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Carbon weighted
over zone 2

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                         CASE TO COLLAPSE TO 25 ENERGY GROUPS
                         U235
                            ZONE WEIGHTED CROSS SECTIONS FOR XSDRN MATERIAL  19223501

XSEC ID       1              2            3002             4              16             17             18            3018
GRP.
   1     6.07340E+00    3.41087E+00    3.41087E+00    2.27400E-01    3.05331E-01    3.70662E-02    2.09037E+00    2.09037E+00
   2     7.52695E+00    4.46583E+00    4.46432E+00    1.73708E+00    1.21383E-02    1.58214E-06    1.26779E+00    1.26847E+00
   3     6.85236E+00    4.06400E+00    4.06437E+00    1.45898E+00    0.00000E+00    0.00000E+00    1.22813E+00    1.22809E+00
   4     7.70022E+00    5.16586E+00    5.16745E+00    1.22789E+00    0.00000E+00    0.00000E+00    1.15538E+00    1.15541E+00
   5     9.73302E+00    7.41402E+00    7.42599E+00    7.27387E-01    0.00000E+00    0.00000E+00    1.31733E+00    1.31872E+00
   6     1.28459E+01    1.03351E+01    1.03332E+01    7.05191E-02    0.00000E+00    0.00000E+00    1.82794E+00    1.82131E+00
   7     1.55421E+01    1.09883E+01    1.09833E+01    4.33960E-04    0.00000E+00    0.00000E+00    3.27240E+00    3.18109E+00
   8     2.01631E+01    1.02333E+01    1.04019E+01    0.00000E+00    0.00000E+00    0.00000E+00    6.99599E+00    7.90012E+00
   9     2.37550E+01    9.26446E+00    9.77565E+00    0.00000E+00    0.00000E+00    0.00000E+00    9.82047E+00    1.62147E+01
  10     2.53093E+01    9.28543E+00    9.67810E+00    0.00000E+00    0.00000E+00    0.00000E+00    1.12305E+01    2.06174E+01
  11     3.14573E+01    7.50001E+00    7.64790E+00    0.00000E+00    0.00000E+00    0.00000E+00    1.67262E+01    2.46062E+01
  12     2.85158E+01    8.36651E+00    8.66722E+00    0.00000E+00    0.00000E+00    0.00000E+00    1.34494E+01    2.19714E+01
  13     2.94869E+01    8.53976E+00    8.91384E+00    0.00000E+00    0.00000E+00    0.00000E+00    1.39762E+01    2.87444E+01
  14     2.95066E+01    8.06765E+00    8.29594E+00    0.00000E+00    0.00000E+00    0.00000E+00    1.38991E+01    2.49667E+01
  15     2.18655E+01    9.30903E+00    9.30664E+00    0.00000E+00    0.00000E+00    0.00000E+00    6.57162E+00    7.17893E+00
  16     2.45648E+01    9.38627E+00    9.38507E+00    0.00000E+00    0.00000E+00    0.00000E+00    1.19076E+01    1.25608E+01
  17     2.52094E+01    9.69783E+00    9.69618E+00    0.00000E+00    0.00000E+00    0.00000E+00    1.09926E+01    1.10857E+01
  18     3.12273E+01    8.56703E+00    8.56716E+00    0.00000E+00    0.00000E+00    0.00000E+00    1.70368E+01    1.71049E+01
  19     4.48785E+01    4.35403E+00    4.35408E+00    0.00000E+00    0.00000E+00    0.00000E+00    3.33484E+01    3.33697E+01
  20     3.92595E+01    5.78914E+00    6.48670E+00    0.00000E+00    0.00000E+00    0.00000E+00    2.97197E+01    2.97216E+01
  21     4.32541E+01    5.15851E+00    6.09624E+00    0.00000E+00    0.00000E+00    0.00000E+00    3.36694E+01    3.36694E+01
  22     9.62840E+01    4.65666E+00    5.73892E+00    0.00000E+00    0.00000E+00    0.00000E+00    7.61170E+01    7.61267E+01
  23     2.34057E+02    5.74631E+00    7.27564E+00    0.00000E+00    0.00000E+03    0.00000E+00    1.95253E+02    1.95253E+02
  24     5.46781E+02    4.41276E+00    5.62098E+00    0.00000E+00    0.00000E+00    0.00000E+00    4.63624E+02    4.63625E+02
  25     1.55737E+03    3.83200E+00    4.41335E+00    0.00000E+00    0.00000E+00    0.00000E+00    1.32739E+03    1.32738E+03

XSEC ID      452            455             456            102            3102            251            252            253
GRP.
   1     4.42073E+00    9.33488E-03    4.57351E+00    2.36674E-03    2.36674E-03    9.24048E-01    1.01274E-03    3.22344E-03
   2     2.76191E+00    1.64569E-02    2.79652E+00    4.41072E-02    4.39602E-02    6.93678E-01    2.79081E-03    4.23284E-03
   3     2.54720E+00    1.68464E-02    2.55237E+00    1.01247E-01    1.01273E-01    4.72712E-01    4.60147E-03    4.69475E-03
   4     2.49777E+00    1.68110E-02    2.49760E+00    1.51088E-01    1.51144E-01    3.71463E-01    5.45186E-03    4.80454E-03
   5     2.45965E+00    1.66177E-02    2.43181E+00    2.74270E-01    2.75126E-01    2.43091E-01    6.45430E-03    5.02724E-03
   6     2.43908E+00    1.62733E-02    2.36065E+00    6.12368E-01    6.08985E-01    5.16981E-02    7.91987E-03    5.43239E-03
   7     2.43670E+00    1.56943E-02    2.27426E+00    1.28097E+00    1.23743E+00    4.29152E-03    8.02913E-03    5.36516E-03
   8     2.43670E+00    1.43320E-02    2.07686E+00    2.93384E+00    3.39992E+00    2.45564E-03    7.34476E-03    4.90352E-03
   9     2.43671E+00    1.31313E-02    1.90286E+00    4.67010E+00    8.58301E+00    2.24990E-03    6.72942E-03    4.49270E-03
  10     2.43671E+00    1.28029E-02    1.85527E+00    4.79346E+00    1.01574E+01    2.19363E-03    6.56112E-03    4.38034E-03
  11     2.43674E+00    1.07092E-02    1.55187E+00    7.23115E+00    1.22573E+01    1.83491E-03    5.48817E-03    3.66402E-03
  12     2.43673E+00    1.21028E-02    1.75381E+00    6.69997E+00    1.27589E+01    2.07368E-03    6.20232E-03    4.14080E-03
  13     2.43672E+00    1.26537E-02    1.83365E+00    6.97096E+00    1.89813E+01    2.16807E-03    6.48466E-03    4.32929E-03
  14     2.43671E+00    1.25963E-02    1.82533E+00    7.53982E+00    1.56605E+01    2.15824E-03    6.45525E-03    4.30966E-03
  15     2.43671E+00    1.42836E-02    2.06983E+00    5.98486E+00    7.52022E+00    2.44733E-03    7.31993E-03    4.88693E-03
  16     2.43673E+00    1.35721E-02    1.96674E+00    3.27094E+00    3.50202E+00    2.32544E-03    6.95533E-03    4.64353E-03
  17     2.43672E+00    1.33602E-02    1.93603E+00    4.51900E+00    4.84785E+00    2.28913E-03    6.84674E-03    4.57104E-03
  18     2.43673E+00    1.12087E-02    1.62425E+00    5.62349E+00    5.64374E+00    1.92049E-03    5.74414E-03    3.83491E-03
  19     2.43683E+00    5.65604E-03    8.19618E-01    7.17604E+00    7.18237E+00    9.69100E-04    2.89856E-03    1.93514E-03
  20     2.43672E+00    8.28807E-03    1.20103E+00    3.75071E+00    3.75129E+00    1.42008E-03    4.24742E-03    2.83567E-03
  21     2.43666E+00    7.49036E-03    1.08543E+00    4.42621E+00    4.42621E+00    1.28342E-03    3.83868E-03    2.56279E-03
  22     2.43667E+00    6.76037E-03    9.79647E-01    1.55104E+01    1.55115E+01    1.15833E-03    3.46455E-03    2.31301E-03
  23     2.43670E+00    8.33493E-03    1.20782E+00    3.30577E+01    3.30576E+01    1.42809E-03    4.27140E-03    2.85168E-03
  24     2.43669E+00    6.35164E-03    9.20417E-01    7.87445E+01    7.87446E+01    1.08830E-03    3.25507E-03    2.17316E-03
  25     2.43668E+00    4.97989E-03    7.21639E-01    2.26149E+02    2.26146E+02    8.53259E-04    2.55208E-03    1.70383E-03

XSEC ID       27            101            1099           3099            1018           9002           2001          11000
GRP.
   1     2.09273E+00    2.36674E-03    1.71914E-08    7.61792E-02    1.22030E-04    0.00000E+00    6.07340E+00    4.21670E+00
   2     1.31190E+00    4.41072E-02    9.38217E-05    2.43811E-01    5.35927E-01    0.00000E+00    7.52695E+00    6.55863E+00
   3     1.32938E+00    1.01247E-01    5.52105E-05    6.71349E-02    2.03482E-01    0.00000E+00    6.85236E+00    7.36438E+00
   4     1.30647E+00    1.51088E-01    5.96527E-05    8.03773E-02    1.40958E-01    0.00000E+00    7.70022E+00    8.66339E+00
   5     1.59160E+00    2.74270E-01    8.72989E-05    2.05557E-01    1.08873E-01    0.00000E+00    9.73302E+00    1.20617E+01
   6     2.44031E+00    6.12368E-01    1.61086E-05    2.16121E-01    9.67633E-03    0.00000E+00    1.28460E+01    1.89515E+01
   7     4.55336E+00    1.28097E+00    4.75208E-06    2.62897E-01    9.32422E-04    0.00000E+00    1.55423E+01    2.46001E+01
   8     9.92983E+00    2.93384E+00    1.39131E-06    2.48801E-01    4.36632E-05    0.00000E+00    2.01551E+01    3.44582E+01
   9     1.44906E+01    4.67010E+00    3.77622E-07    1.77105E-01    1.69290E-06    0.00000E+00    2.37314E+01    4.33994E+01
  10     1.60239E+01    4.79346E+00    1.82484E-07    5.55670E-02    2.70865E-07    0.00000E+00    3.40618E+01    4.76272E+01
  11     2.39573E+01    7.23115E+00    5.61655E-08    2.04791E-02    6.26442E-08    0.00000E+00    4.44990E+01    6.72574E+01
  12     2.01493E+01    6.69997E+00    5.82558E-08    2.41251E-02    3.77040E-08    0.00000E+00    4.33868E+01    5.83036E+01
  13     2.09471E+01    6.97096E+00    1.29616E-07    5.83266E-02    4.69265E-08    0.00000E+00    5.66272E+01    5.59306E+01
```

U-235 weighted
over zone 1

6.SAMPLE PROBLEMS.5 MOVE MULTIGROUP LIBRARIES TO ANOTHER COMPUTING SYSTEM

A very common task for a user of multigroup libraries is that of moving them from one computing system to another. Because the binary formats vary from system to system, a BCD transmittal file is typically employed.

AMPX libraries can be transmitted by using the AIM module. This module reads a master library in binary format and generates a BCD-formatted library that it can also read to recreate the master library. The procedure is shown in Fig. 6.SAMPLE PROBLEMS.14.

The input for the AIM module is trivial (unless the user elects to generate the BCD input to create a master file). It generally consists of data that identify where the files are to be located and one parameter that specifies which way the format conversion will be made.

The input for a case to convert the library produced by Task 2 to a BCD file is shown below. In this case, we start with a master library on logical unit 70 containing just the ^{235}U data, convert this to a BCD file on logical unit 71 using an AIM run, then take logical 71 and pass it back through AIM to recreate a binary master file on logical unit 2, after which we run ALE to demonstrate that the file is readable and structured properly.

Portions of the output follow the input data.

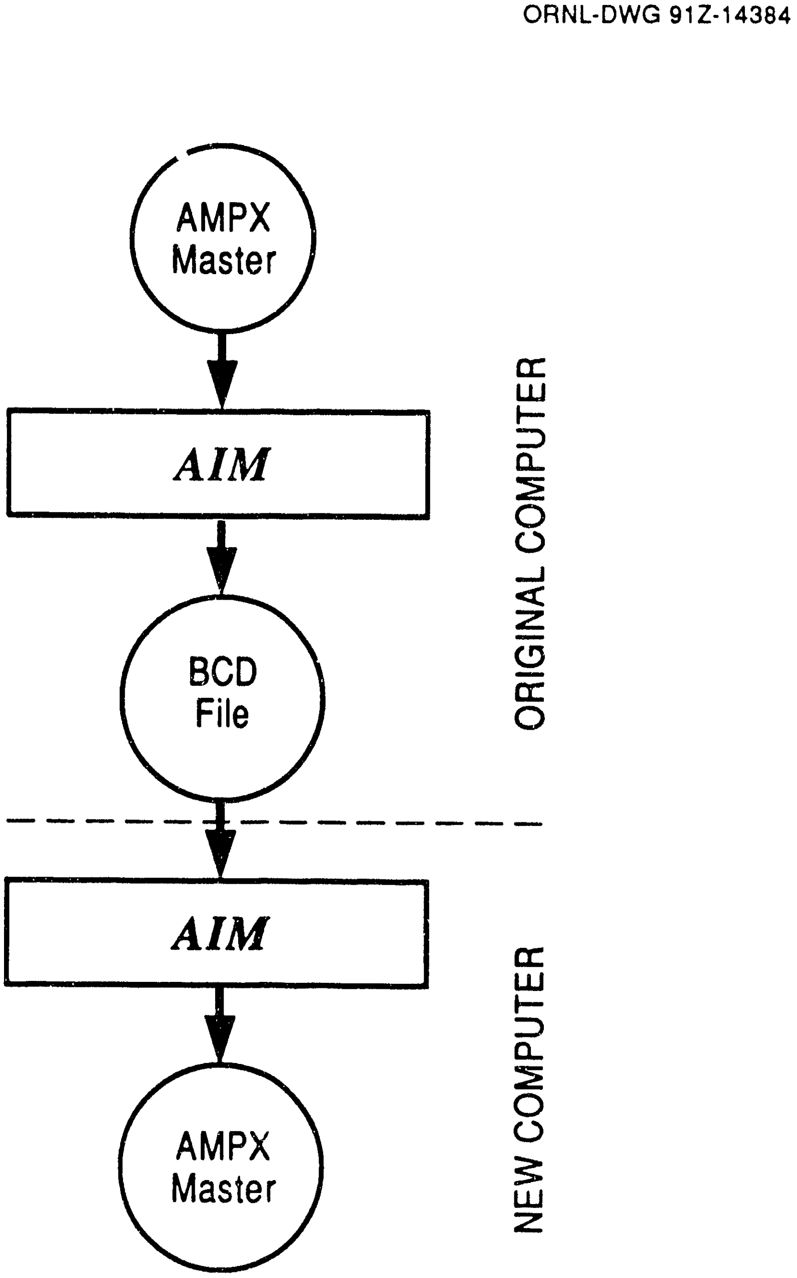
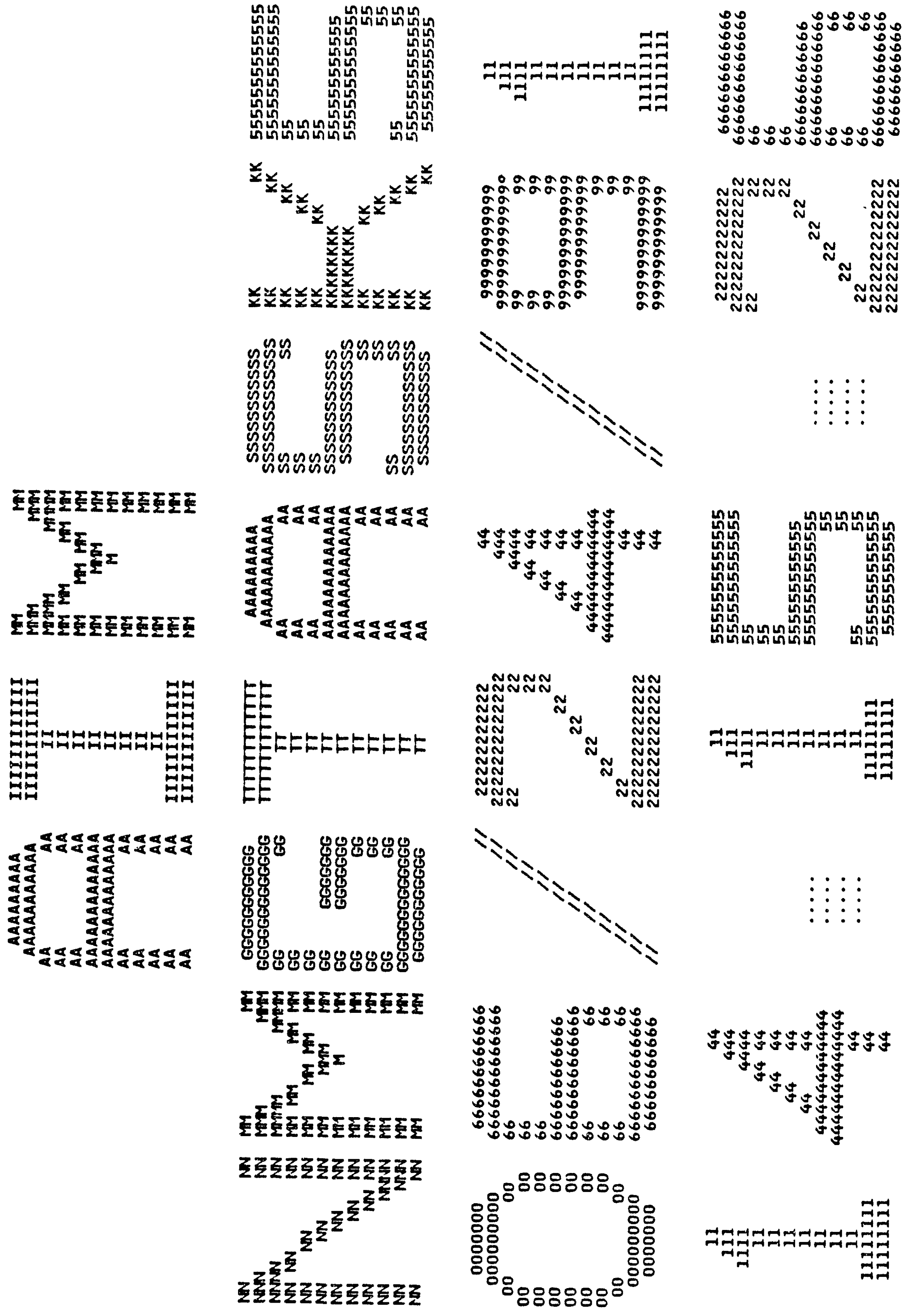


Fig. 6.SAMPLE PROBLEMS.14. Procedure for moving an AMPX master to a new computer.

```
   AMPX MODULE LOG AND LIST OF CARD INPUT DATA
 MODULE AIM      HAS BEEN CALLED
0$$ 70 71 1$$ 0 T      Convert Binary on 70 to BCD on 71
 MODULE AIM      IS FINISHED.
 CPU TIME     8.79 (SECONDS).  I/O'S       0 USER CODE 0000   SYSTEM CODE 000
 MODULE AIM      HAS BEEN CALLED
0$$ 2  71 1$$ 1 T      Convert BCD on 71 to Binary on 2
 MODULE AIM      IS FINISHED.
 CPU TIME    21.04 (SECONDS).  I/O'S       0 USER CODE 0000   SYSTEM CODE 000
 MODULE ALE      HAS BEEN CALLED
0$$ 2 E 2$$ 1 E T      Look at 2 to be sure it's there
 MODULE ALE      IS FINISHED.
 CPU TIME      .56 (SECONDS).  I/O'S       0 USER CODE 0000   SYSTEM CODE 000
```



```
AIM
NMGTASK5
06/24/91
14:15:26
```

```
                    TABLE OF CONTENTS
     U235                            TITLE                                                  ID
                                                                                             92235

   ELAPSED TIME   0.14 MIN.
```

Binary-to-BCD produces little print

```
                                  AAAAAAAAA     IIIIIIIIIIII    MM          MM
                                 AAAAAAAAAAA    IIIIIIIIIIII    MMM        MMM
                                AA         AA        II         MMMM      MMMM
                                AA         AA        II         MM MM    MM MM
                                AA         AA        II         MM   MM MM  MM
                                AAAAAAAAAAAAA        II         MM    MMM   MM
                                AAAAAAAAAAAAA        II         MM     M    MM
                                AA         AA        II         MM          MM
                                AA         AA        II         MM          MM
                                AA         AA        II         MM          MM
                                AA         AA   IIIIIIIIIIII    MM          MM
                                AA         AA   IIIIIIIIIIII    MM          MM

NN          NN  MM          MM   GGGGGGGGGGG    TTTTTTTTTTTT      AAAAAAAAA      SSSSSSSSSSS    KK          KK  5555555555555
NNN         NN  MMM        MMM  GGGGGGGGGGGGG   TTTTTTTTTTTT     AAAAAAAAAAA    SSSSSSSSSSSSS   KK         KK   5555555555555
NNNN        NN  MMMM      MMMM  GG         GG        TT         AA         AA   SS         SS   KK        KK    55
NN NN       NN  MM MM    MM MM  GG                   TT         AA         AA   SS               KK       KK     55
NN   NN     NN  MM   MM MM  MM  GG                   TT         AA         AA   SS               KK      KK      55
NN    NN    NN  MM    MMM   MM  GG    GGGGGGG        TT         AAAAAAAAAAAAA   SSSSSSSSSSSS    KKKKKKKK        555555555555
NN     NN   NN  MM     M    MM  GG    GGGGGGG        TT         AAAAAAAAAAAAA    SSSSSSSSSSSS   KKKKKKKK        5555555555555
NN      NN  NN  MM          MM  GG         GG        TT         AA         AA              SS   KK      KK                 55
NN       NN NN  MM          MM  GG         GG        TT         AA         AA              SS   KK       KK                55
NN        NNNN  MM          MM  GG         GG        TT         AA         AA   SS         SS   KK        KK    55         55
NN         NNN  MM          MM  GGGGGGGGGGGGG        TT         AA         AA   SSSSSSSSSSSSS   KK         KK   5555555555555
NN          NN  MM          MM   GGGGGGGGGGG         TT         AA         AA    SSSSSSSSSSS    KK          KK   55555555555

   0000000       666666666666              //    22222222222             44                //    99999999999          11
  000000000     6666666666666             //    2222222222222           444               //    9999999999999        111
 00       00    66                       //     22         22          4444              //     99         99       1111
00         00   66                      //                 22         44 44             //      99         99         11
00         00   66                     //                  22        44  44            //       99         99         11
00         00   666666666666          //                 22         44   44           //        9999999999999         11
00         00   6666666666666        //                22          44    44          //          999999999999         11
00         00   66         66       //               22          444444444444       //                     99         11
00         00   66         66      //              22           4444444444444      //                      99         11
 00       00    66         66     //             22                      44       //                       99         11
  000000000     6666666666666    //             2222222222222            44      //             9999999999999      11111111
   0000000       66666666666    //              2222222222222            44     //              999999999999       11111111

      11                 44                           11         666666666666                      0000000      5555555555555
     111                444                          111        6666666666666                     000000000     5555555555555
    1111               4444                         1111        66                               00       00    55
      11              44 44                           11        66                              00         00   55
      11             44  44                           11        66                              00         00   55
      11            44   44                           11        666666666666                    00         00   555555555555
      11           44    44         .....             11        6666666666666       .....       00         00   5555555555555
      11         444444444444       .....             11        66         66       .....       00         00              55
      11        4444444444444       .....             11        66         66       .....       00         00              55
      11                 44         .....             11        66         66       .....        00       00    55         55
   11111111              44                        11111111     6666666666666                     000000000     5555555555555
   11111111              44                        11111111      66666666666                       0000000       55555555555
```

```
                    TABLE OF CONTENTS
                         TITLE                                   ID
  3$ ARRAY    32 ENTRIES READ
  3* ARRAY    32 ENTRIES READ
  3T
    U235                                                          92235
 13* ARRAY   795 ENTRIES READ
 14* ARRAY  5258 ENTRIES READ
 16$ ARRAY    92 ENTRIES READ
 16T
 18$ ARRAY     2 ENTRIES READ
 18T
 19$ ARRAY   238 ENTRIES READ
 20* ARRAY   630 ENTRIES READ
 20T
 18$ ARRAY     2 ENTRIES READ
 18T
 19$ ARRAY   238 ENTRIES READ
 20* ARRAY   630 ENTRIES READ
 20T
 18$ ARRAY     2 ENTRIES READ
 18T
 19$ ARRAY   238 ENTRIES READ
 20* ARRAY   630 ENTRIES READ
 20T
 18$ ARRAY     2 ENTRIES READ
 18T
 19$ ARRAY   238 ENTRIES READ
 20* ARRAY   630 ENTRIES READ
 20T
 18$ ARRAY     2 ENTRIES READ
 18T
 19$ ARRAY   238 ENTRIES READ
 20* ARRAY   630 ENTRIES READ
 20T
 18$ ARRAY     2 ENTRIES READ
 18T
 19$ ARRAY   238 ENTRIES READ
 20* ARRAY   630 ENTRIES READ
```

BCD-to-Binary produce much output which can be suppressed with the IPRES parameter.

```
                                  AAAAAAAAA     LL              EEEEEEEEEEEEE
                                 AAAAAAAAAAA    LL              EEEEEEEEEEEEE
                                AA         AA   LL              EE
                                AA         AA   LL              EE
                                AA         AA   LL              EE
                                AAAAAAAAAAAAA   LL              EEEEEEEEE
                                AAAAAAAAAAAAA   LL              EEEEEEEEE
                                AA         AA   LL              EE
                                AA         AA   LL              EE
                                AA         AA   LL              EE
                                AA         AA   LLLLLLLLLLLLL   EEEEEEEEEEEEE
                                AA         AA   LLLLLLLLLLLLL   EEEEEEEEEEEEE


NN         NN   MM         MM    GGGGGGGGGGG    TTTTTTTTTTTT      AAAAAAAAA      SSSSSSSSSSS    KK         KK   5555555555555
NNN        NN   MMM       MMM   GGGGGGGGGGGGG   TTTTTTTTTTTT     AAAAAAAAAAA    SSSSSSSSSSSSS   KK        KK    5555555555555
NNNN       NN   MMMM     MMMM   GG         GG        TT         AA         AA   SS         SS   KK       KK     55
NN NN      NN   MM MM   MM MM   GG                   TT         AA         AA   SS              KK      KK      55
NN  NN     NN   MM  MM MM  MM   GG                   TT         AA         AA   SS              KK     KK       55
NN   NN    NN   MM   MMM   MM   GG    GGGGGGG        TT         AAAAAAAAAAAAA   SSSSSSSSSSSS    KKKKKKK         555555555555
NN    NN   NN   MM    M    MM   GG    GGGGGGG        TT         AAAAAAAAAAAAA    SSSSSSSSSSSS   KKKKKKK         5555555555555
NN     NN  NN   MM         MM   GG         GG        TT         AA         AA              SS   KK     KK                  55
NN      NN NN   MM         MM   GG         GG        TT         AA         AA              SS   KK      KK                 55
NN       NNNN   MM         MM   GG         GG        TT         AA         AA   SS         SS   KK       KK     55         55
NN        NNN   MM         MM   GGGGGGGGGGGGG        TT         AA         AA   SSSSSSSSSSSSS   KK        KK    5555555555555
NN         NN   MM         MM    GGGGGGGGGGG         TT         AA         AA    SSSSSSSSSSS    KK         KK    55555555555


   0000000       666666666666              //    22222222222             44                //    99999999999          11
  000000000     6666666666666             //    2222222222222           444               //    9999999999999        111
 00       00    66                       //     22         22          4444              //     99         99       1111
00         00   66                      //                 22         44 44             //      99         99         11
00         00   66                     //                  22        44  44            //       99         99         11
00         00   666666666666          //                 22         44   44           //        9999999999999         11
00         00   6666666666666        //                22          44    44          //          999999999999         11
00         00   66         66       //               22          444444444444       //                     99         11
00         00   66         66      //              22           4444444444444      //                      99         11
 00       00    66         66     //             22                      44       //                       99         11
  000000000     6666666666666    //             2222222222222            44      //             9999999999999      11111111
   0000000       66666666666    //              2222222222222            44     //              999999999999       11111111


      11                 44                           11        7777777777777                    22222222222    5555555555555
     111                444                          111        777777777777                    2222222222222   5555555555555
    1111               4444                         1111        77        77                    22         22   55
      11              44 44                           11                 77                                22   55
      11             44  44                           11                77                                 22   55
      11            44   44                           11               77                                22     555555555555
      11           44    44          .....            11               77            .....             22       5555555555555
      11         444444444444        .....            11              77             .....           22                    55
      11        4444444444444        .....            11              77             .....         22                      55
      11                 44          .....            11             77              .....       22             55         55
   11111111              44                        11111111          77                         2222222222222   5555555555555
   11111111              44                        11111111          77                         2222222222222    55555555555
```

```
    0$ ARRAY      2 ENTRIES READ

    2$ ARRAY     10 ENTRIES READ

    0T

ALE WILL EDIT THE AMPX MASTER INTERFACE ON LOGICAL  2

 1.0                 LIBRARY IDENTIFIER    3

 2.0                 NUMBER OF NUCLIDES    1

 3.0    NUMBER OF NEUTRON ENERGY GROUPS  238

 4.0                FIRST THERMAL GROUP  149

 5.0     NORDHEIM DATA PROCESSING LEVEL    2

 6.0      NUMBER OF GAMMA ENERGY GROUPS    0

 7.0                                       0

 8.0                                       0

 9.0                                       0

10.0                                       0

SAMPLE PROBLEM
FOR THE XLACS
MODULE OF THE
AMPX77 SYSTEM
+++++++++++++
===============================================================================
LOGICAL  2 (AMPX MASTER LIBRARY)
DATASET NAME: SYS91175.T141358.RA000.NMGTASK5.R0000005
      VOLUME: SYSSA1
===============================================================================

ALE HAS BEEN ALLOCATED 100000 WORDS
```

```
TABLE OF CONTENTS FOR THE MASTER LIBRARY ON LOGICAL     2

   1     U235                                                                       92235

THIS LIBRARY HAS A 238 GROUP NEUTRON STRUCTURE WITH THE FOLLOWING BOUNDARIES:
  1 2.0000E+07   2 1.7333E+07   3 1.5683E+07   4 1.4550E+07   5 1.3840E+07   6 1.2840E+07   7 1.0000E+07   8 8.1873E+06
  9 6.4340E+06  10 4.8000E+06  11 4.3040E+06  12 3.0000E+06  13 2.4790E+06  14 2.3540E+06  15 1.8500E+06  16 1.5000E+06
 17 1.4000E+06  18 1.3560E+06  19 1.3170E+06  20 1.2500E+06  21 1.2000E+06  22 1.1000E+06  23 1.0100E+06  24 9.2000E+05
 25 9.0000E+05  26 8.7500E+05  27 8.6110E+05  28 8.2000E+05  29 7.5000E+05  30 6.7900E+05  31 6.7000E+05  32 6.0000E+05
 33 5.7300E+05  34 5.5000E+05  35 4.9952E+05  36 4.7000E+05  37 4.4000E+05  38 4.2000E+05  39 4.0000E+05  40 3.3000E+05
 41 2.7000E+05  42 2.0000E+05  43 1.5000E+05  44 1.2830E+05  45 1.0000E+05  46 8.5000E+04  47 8.2000E+04  48 7.5000E+04
 49 7.3000E+04  50 6.0000E+04  51 5.2000E+04  52 5.0000E+04  53 4.5000E+04  54 3.0000E+04  55 2.5000E+04  56 1.7000E+04
 57 1.3000E+04  58 9.5000E+03  59 8.0300E+03  60 6.0000E+03  61 3.9000E+03  62 3.7400E+03  63 3.0000E+03  64 2.5800E+03
 65 2.2900E+03  66 2.2000E+03  67 1.8000E+03  68 1.5500E+03  69 1.5000E+03  70 1.1500E+03  71 9.5000E+02  72 6.8300E+02
 73 6.7000E+02  74 5.5000E+02  75 3.0500E+02  76 2.8500E+02  77 2.4000E+02  78 2.1000E+02  79 2.0750E+02  80 1.9250E+02
 81 1.8600E+02  82 1.2200E+02  83 1.1900E+02  84 1.1500E+02  85 1.0800E+02  86 1.0000E+02  87 9.0000E+01  88 8.2000E+01
 89 8.0000E+01  90 7.6000E+01  91 7.2000E+01  92 6.7500E+01  93 6.5000E+01  94 6.1000E+01  95 5.9000E+01  96 5.3400E+01
 97 5.2000E+01  98 5.0600E+01  99 4.9200E+01 100 4.8300E+01 101 4.7000E+01 102 4.5200E+01 103 4.4000E+01 104 4.2400E+01
105 4.1000E+01 106 3.9600E+01 107 3.9100E+01 108 3.8000E+01 109 3.7000E+01 110 3.5500E+01 111 3.4600E+01 112 3.3750E+01
113 3.3250E+01 114 3.1750E+01 115 3.1250E+01 116 3.0000E+01 117 2.7500E+01 118 2.5000E+01 119 2.2500E+01 120 2.1000E+01
121 2.0000E+01 122 1.9000E+01 123 1.8500E+01 124 1.7000E+01 125 1.6000E+01 126 1.5100E+01 127 1.4400E+01 128 1.3750E+01
129 1.2900E+01 130 1.1900E+01 131 1.1500E+01 132 1.0000E+01 133 9.1000E+00 134 8.1000E+00 135 7.1500E+00 136 7.0000E+00
137 6.7500E+00 138 6.5000E+00 139 6.2500E+00 140 6.0000E+00 141 5.4000E+00 142 5.0000E+00 143 4.7500E+00 144 4.0000E+00
145 3.7300E+00 146 3.5000E+00 147 3.1500E+00 148 3.0500E+00 149 3.0000E+00 150 2.9700E+00 151 2.8700E+00 152 2.7700E+00
153 2.6700E+00 154 2.5700E+00 155 2.4700E+00 156 2.3800E+00 157 2.3000E+00 158 2.2100E+00 159 2.1200E+00 160 2.0000E+00
161 1.9400E+00 162 1.8600E+00 163 1.7700E+00 164 1.6800E+00 165 1.5900E+00 166 1.5000E+00 167 1.4500E+00 168 1.4000E+00
169 1.3500E+00 170 1.3000E+00 171 1.2500E+00 172 1.2250E+00 173 1.2000E+00 174 1.1750E+00 175 1.1500E+00 176 1.1400E+00
177 1.1300E+00 178 1.1200E+00 179 1.1100E+00 180 1.1000E+00 181 1.0900E+00 182 1.0800E+00 183 1.0700E+00 184 1.0600E+00
185 1.0500E+00 186 1.0400E+00 187 1.0300E+00 188 1.0200E+00 189 1.0100E+00 190 1.0000E+00 191 9.7500E-01 192 9.5000E-01
193 9.2500E-01 194 9.0000E-01 195 8.5000E-01 196 8.0000E-01 197 7.5000E-01 198 7.0000E-01 199 6.5000E-01 200 6.2500E-01
201 6.0000E-01 202 5.5000E-01 203 5.0000E-01 204 4.5000E-01 205 4.0000E-01 206 3.7500E-01 207 3.5000E-01 208 3.2500E-01
209 3.0000E-01 210 2.7500E-01 211 2.5000E-01 212 2.2500E-01 213 2.0000E-01 214 1.7500E-01 215 1.5000E-01 216 1.2500E-01
217 1.0000E-01 218 9.0000E-02 219 8.0000E-02 220 7.0000E-02 221 6.0000E-02 222 5.0000E-02 223 4.0000E-02 224 3.0000E-02
225 2.5300E-02 226 1.0000E-02 227 7.5000E-03 228 5.0000E-03 229 4.0000E-03 230 3.0000E-03 231 2.5000E-03 232 2.0000E-03
233 1.5000E-03 234 1.2000E-03 235 1.0000E-03 236 7.5000E-04 237 5.0000E-04 238 1.0000E-04 239 1.0000E-05

=========================================================================================================================

AMPX NUCLIDE        92235 U235
      HAS THE FOLLOWING DATA                         IS THE NUCLIDE SYMBOL          THERE ARE  124 RECORDS
  131 RESOLVED RESONANCES                    233.025 MASS(NEUTRON EQUIVALENTS)                    0 BONDARENKO TEMPS
    0 UNRESOLVED RESONANCE POINTS             92235. ZA                                           0 BONDARENKO GROUPS
   22 TEMP IND 1-D NEUT PROCESSES                  0 NEUTRON WGTING OPTION                        0 ID(41) NOT USED
   23 2-D NEUT PROCESSES                           0 NEUTRON WGT ID                               0 GAMMA PROD WGT ID
    0 TEMP DEP 1-D NEUT PROCESSES                  0 GAMMA WGTING OPTION                          0 ID(43) NOT USED
    0 1-D GAMMA PROCESSES                 0.00E+00 POWER/FISSION(WATT-SEC/FIS)                    0 GAMMA PROD WGTING OPTION
    0 2-D GAMMA PROCESSES                 0.00E+00 ENERGY/CAPTURE(WATT-SEC/CAP)                1395 ENDF MAT OF FAST NEUT DATA
    0 NEUT-TO-GAMMA PROCESSES                  28441 MAX 2-D LENGTH                               0 ENDF MAT OF THERMAL NEUT DATA
  111 TOTAL 2-D ARRAYS                             0 BONDARENKO PROCESSES                         0 ENDF MAT OF GAMMA DATA
    5 MAX ORDER OF L                               0 BONDARENKO SIGMA ZEROS                       0 ENDF MAT OF GAMMA PROD DATA

THE FOLLOWING 1-D NEUTRON ARRAYS ARE AVAILABLE
     1     2  3002     4    16    17    18  3018   452   455   456   102  3102   251   252   253    27   101  1099  3099
  1018  9002

NEUTRON REACTION CROSS SECTIONS FOR U235                                                                          92235

 XSEC ID        1             2             3002            4             16            17            18           3018
GRP.
    1     6.10743E+00   3.81456E+00   3.81456E+00   2.11945E-01   2.37495E-02   9.04339E-02   1.96549E+00   1.96549E+00
    2     6.02152E+00   3.56859E+00   3.56859E+00   2.16518E-01   1.11834E-01   9.28612E-02   2.03015E+00   2.03015E+00
    3     5.93941E+00   3.35500E+00   3.35500E+00   2.20590E-01   2.02400E-01   6.16326E-02   2.09781E+00   2.09780E+00
    4     5.85955E+00   3.23815E+00   3.23815E+00   2.24013E-01   2.79634E-01   3.70705E-02   2.07839E+00   2.07839E+00
    5     5.79717E+00   3.22828E+00   3.22828E+00   2.17813E-01   3.61897E-01   1.78668E-02   1.96880E+00   1.96880E+00
    6     5.75457E+00   3.35717E+00   3.35718E+00   1.84970E-01   4.50315E-01   8.78135E-04   1.75776E+00   1.75776E+00
    7     6.00573E+00   3.59133E+00   3.56617E+00   2.19007E-01   4.15243E-01   0.00000E+00   1.77322E+00   1.76999E+00
    8     6.57969E+00   4.04647E+00   3.99787E+00   6.59919E-01   2.81750E-01   0.00000E+00   1.57934E+00   1.61936E+00
    9     7.39329E+00   4.57603E+00   4.54194E+00   1.67781E+00   3.61881E-02   0.00000E+00   1.08617E+00   1.09813E+00
   10     7.80559E+00   4.84700E+00   4.84457E+00   1.83040E+00   0.00000E+00   0.00000E+00   1.10646E+00   1.10567E+00
   11     7.90380E+00   4.89052E+00   4.89766E+00   1.81351E+00   0.00000E+00   0.00000E+00   1.17080E+00   1.16668E+00
   12     7.68719E+00   4.62470E+00   4.62736E+00   1.77715E+00   0.00000E+00   0.00000E+00   1.24670E+00   1.24617E+00
   13     7.50727E+00   4.43675E+00   4.43696E+00   1.74999E+00   0.00000E+00   0.00000E+00   1.27637E+00   1.27636E+00
   14     7.24688E+00   4.15909E+00   4.16038E+00   1.74254E+00   0.00000E+00   0.00000E+00   1.29311E+00   1.29307E+00
   15     6.90241E+00   3.91270E+00   3.91233E+00   1.65101E+00   0.00000E+00   0.00000E+00   1.27269E+00   1.27255E+00
   16     6.76416E+00   3.86503E+00   3.86505E+00   1.57683E+00   0.00000E+00   0.00000E+00   1.24520E+00   1.24518E+00
```

6.SAMPLE PROBLEMS.6 AVERAGE POINT CROSS SECTIONS

A user of cross sections is frequently faced with the task of having a function that is known as an array of energies and values which is needed in a multigroup format. Several modules in AMPX-77 relate to this task.

Suppose, for example, that one wants to average a function that varies as 1 over the velocity of the neutron over some simple weighting spectrum. (This procedure is widely employed when it has been recognized that, for thermal systems, many important data collections, such as fission products, are dominated by nuclides whose thermal cross sections vary as 1/v.)

The procedure for this task is shown in Fig. 6.SAMPLE PROBLEMS.15.

The input for this case is shown below, followed by portions of the output. Here we run CASTROL to put the cross sections in a format that the VEL program knows how to access, followed by a JERGENS run to create a simple weighting function, also written in a format VEL understands; then VEL is run to perform the group averaging and to write them on a master library on logical unit 1, after which an ALE run is made to ensure the data are there and in proper format.

ORNL-DWG 91Z-14385

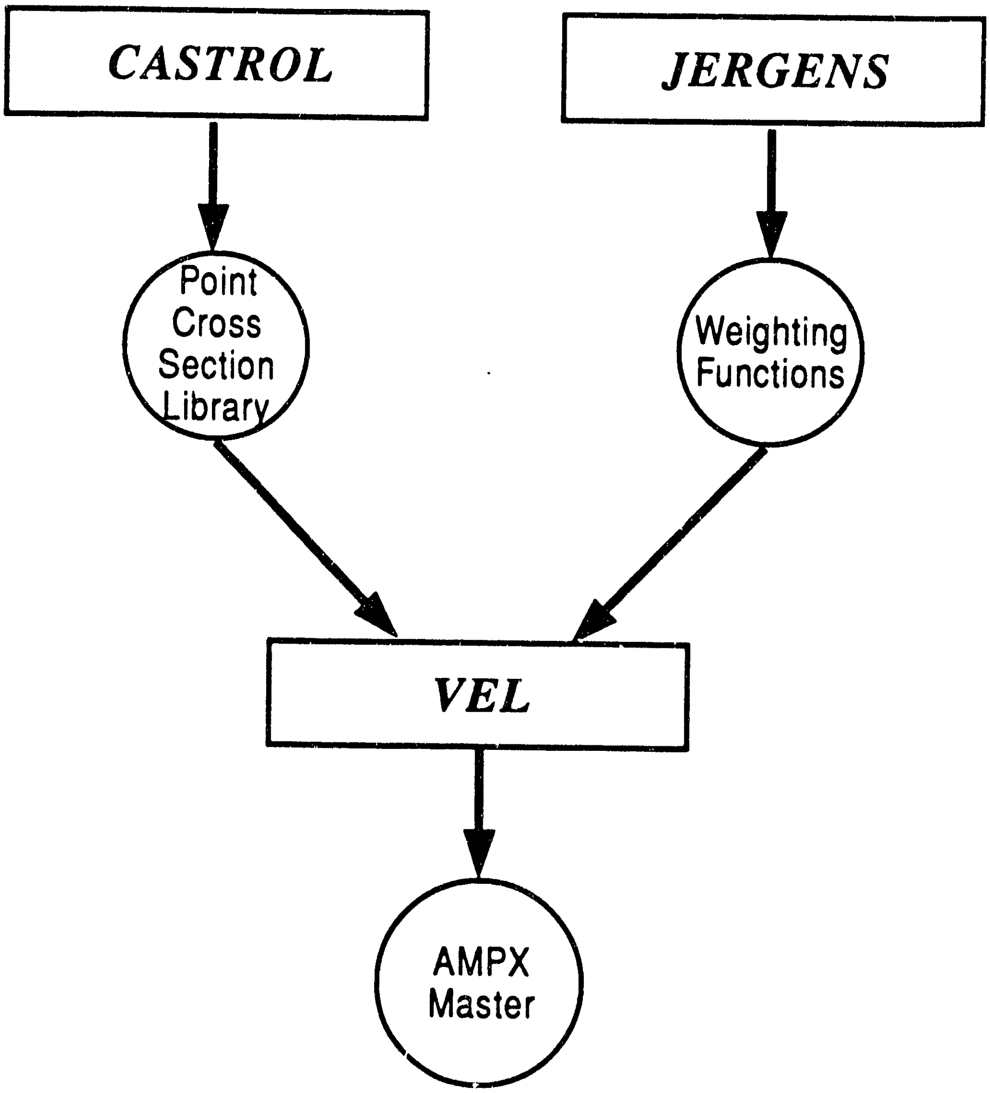


Fig. 6.SAMPLE PROBLEMS.15. Procedure to weight a point cross-section array.

```
   AMPX MODULE LOG AND LIST OF CARD INPUT DATA

 MODULE CASTROL  HAS BEEN CALLED

0$$ 30 1$$ 1 E T
2$$ 1000 3 100 4Z 1 2 T
3$$ 2 5                 ←——— 1/v function with value of 1.0 @ 2200 m/s
4** 1-5 50.3  2+7 3.56-5 T

 MODULE CASTROL  IS FINISHED.
 CPU TIME      .28 (SECONDS).  I/O'S       0 USER CODE 0000   SYSTEM CODE 000

 MODULE JERGENS  HAS BEEN CALLED

1$$ 1 T
3$$ 200 0 2 T  ←——— Create weight function

 MODULE JERGENS  IS FINISHED.
 CPU TIME      .63 (SECONDS).  I/O'S       0 USER CODE 0000   SYSTEM CODE 000

 MODULE VEL      HAS BEEN CALLED

0$$ 1 30 31 1$$ 1 238 0 E T
T
10$$ 1000 1000 0 11$$ 1000 100 3   99 200 3 12$$ 1099 T

 MODULE VEL      IS FINISHED.
 CPU TIME     1.52 (SECONDS).  I/O'S       0 USER CODE 0000   SYSTEM CODE 000

 MODULE ALE      HAS BEEN CALLED

0$$ 1 E 2$$ 1 E T

 MODULE ALE      IS FINISHED.
 CPU TIME      .33 (SECONDS).  I/O'S       0 USER CODE 0000   SYSTEM CODE 000
 CCCCCCCCCCC      AAAAAAAAA      SSSSSSSSSSS    TTTTTTTTTTTT    RRRRRRRRRRRR     OOOOOOOOOOO    LL
CCCCCCCCCCCCC    AAAAAAAAAAA    SSSSSSSSSSSSS   TTTTTTTTTTTT    RRRRRRRRRRRRR   OOOOOOOOOOOOO   LL
CC         CC   AA         AA   SS         SS        TT         RR         RR   OO         OO   LL
CC              AA         AA   SS                   TT         RR         RR   OO         OO   LL
CC              AA         AA   SS                   TT         RR         RR   OO         OO   LL
CC              AAAAAAAAAAAAA   SSSSSSSSSSSS         TT         RRRRRRRRRRRRR   OO         OO   LL
CC              AAAAAAAAAAAAA    SSSSSSSSSSSS        TT         RRRRRRRRRRRR    OO         OO   LL
CC              AA         AA              SS        TT         RR      RR      OO         OO   LL
CC              AA         AA              SS        TT         RR       RR     OO         OO   LL
CC         CC   AA         AA   SS         SS        TT         RR        RR    OO         OO   LL
CCCCCCCCCCCCC   AA         AA   SSSSSSSSSSSSS        TT         RR         RR   OOOOOOOOOOOOO   LLLLLLLLLLLL
 CCCCCCCCCCC    AA         AA    SSSSSSSSSSS         TT         RR         RR    OOOOOOOOOOO    LLLLLLLLLLLL

NN         NN   MM         MM    GGGGGGGGGGG    TTTTTTTTTTTT      AAAAAAAAA      SSSSSSSSSSS    KK         KK    66666666666
NNN        NN   MMM       MMM   GGGGGGGGGGGGG   TTTTTTTTTTTT     AAAAAAAAAAA    SSSSSSSSSSSSS   KK        KK    6666666666666
NNNN       NN   MMMM     MMMM   GG         GG        TT         AA         AA   SS         SS   KK       KK     66
NN NN      NN   MM MM   MM MM   GG                   TT         AA         AA   SS              KK      KK      66
NN  NN     NN   MM  MM MM  MM   GG                   TT         AA         AA   SS              KK     KK       66
NN   NN    NN   MM   MMM   MM   GG    GGGGGGG        TT         AAAAAAAAAAAAA   SSSSSSSSSSSS    KKKKKKKK        666666666666
NN    NN   NN   MM    M    MM   GG    GGGGGGG        TT         AAAAAAAAAAAAA    SSSSSSSSSSSS   KKKKKKK         6666666666666
NN     NN  NN   MM         MM   GG         GG        TT         AA         AA              SS   KK     KK       66         66
NN      NN NN   MM         MM   GG         GG        TT         AA         AA              SS   KK      KK      66         66
NN       NNNN   MM         MM   GG         GG        TT         AA         AA   SS         SS   KK       KK     66         66
NN        NNN   MM         MM   GGGGGGGGGGGGG        TT         AA         AA   SSSSSSSSSSSSS   KK        KK    6666666666666
NN         NN   MM         MM    GGGGGGGGGGG         TT         AA         AA    SSSSSSSSSSS    KK         KK    66666666666

   0000000       66666666666                //   22222222222             44                 //   99999999999          11
  000000000     6666666666666              //   2222222222222           444                //   9999999999999        111
 00       00    66                        //    22         22          4444               //    99         99       1111
00         00   66                       //                22         44 44              //     99         99         11
00         00   66                      //                 22        44  44             //      99         99         11
00         00   666666666666           //                22        44   44            //       9999999999999         11
00         00   6666666666666         //               22         44    44           //         999999999999         11
00         00   66         66        //              22          444444444444         //                  99         11
00         00   66         66       //             22           4444444444444       //                   99         11
 00       00    66         66      //            22                      44      //                    99         11
  000000000     6666666666666     //             2222222222222            44     //             9999999999999      11111111
   0000000       66666666666     //              2222222222222            44    //              999999999999       11111111

      11                 44                           11                 44                        0000000               44
     111                444                          111                444                       000000000             444
    1111               4444                         1111               4444                      00       00           4444
      11              44 44                           11              44 44                     00         00         44 44
      11             44  44                           11             44  44                     00         00        44  44
      11            44   44                           11            44   44                     00         00       44   44
      11           44    44          .....            11           44    44          .....      00         00      44    44
      11         444444444444        .....            11         444444444444        .....      00         00    444444444444
      11        4444444444444        .....            11        4444444444444        .....      00         00   4444444444444
      11                 44          .....            11                 44          .....       00       00             44
   11111111              44                        11111111              44                       000000000              44
   11111111              44                        11111111              44                        0000000               44
```

```
    2$ ARRAY      9 ENTRIES READ
    OT
STRING  1 MAT,MF,MT,C1,C2,L1,L2 1000  3  100     0.0000E+00     0.0000E+00    0    0
    3$ ARRAY      2 ENTRIES READ
    4* ARRAY      4 ENTRIES READ
    OT
    1$ ARRAY      1 ENTRIES READ
    OT
```

```
JERGENS
NMGTASK6
06/24/91
14:14:14
```

```
WEIGHTING FUNCTION      200
    HAS    0 COMMANDS ASSOCIATED WITH ITS CONSTRUCTION
    OR IT USES SPECIAL OPTION    2

THE VALUES OF OTHER PARAMETERS THAT MAY BE REQUIRED ARE--
        3.00000E+02 MAXWELLIAN TEMP (K)
        5.00000E+00 KT MULTIPLIER FOR LOW ENERGY JOIN POINT
        1.27000E+06 FISSION SPECTRUM EFFECTIVE TEMPERATURE (EV)
        6.74000E+04 LOW ENERGY CUT-OFF ON FISSION SPECTRUM
        0.00000E+00 SIGA PER HYDROGEN ATOM
        1.00000E-04 ACCURACY SPECIFIED
```

```
FUNCTION  200
          INTERPOLATION SPECIFICATIONS
            NBT        JNT
  1         189          2
  2         911          2
  3        1483          2

  PT       ENERGY          VALUE     PT      ENERGY          VALUE     PT      ENERGY          VALUE     PT      ENERGY          VALUE
--------------------------------- --------------------------------- --------------------------------- ---------------------------------
   1   1.0000E-05    9.9961E-06      51   6.0790E-03    4.8051E-03     101   2.7621E-02    9.4883E-03     151   9.3730E-02    2.4955E-03
   2   2.2621E-05    2.2601E-05      52   6.3085E-03    4.9424E-03     102   2.8321E-02    9.4689E-03     152   9.4778E-02    2.4231E-03
   3   3.8397E-05    3.8340E-05      53   6.5381E-03    5.0770E-03     103   2.9022E-02    9.4437E-03     153   9.5827E-02    2.3525E-03
   4   5.8117E-05    5.7987E-05      54   6.7676E-03    5.2088E-03     104   2.9722E-02    9.4130E-03     154   9.6876E-02    2.2837E-03
   5   8.2768E-05    8.2503E-05      55   7.0546E-03    5.3697E-03     105   3.0598E-02    9.3676E-03     155   9.7925E-02    2.2166E-03
   6   1.1358E-04    1.1308E-04      56   7.3415E-03    5.5264E-03     106   3.1473E-02    9.3148E-03     156   9.8974E-02    2.1513E-03
   7   1.4439E-04    1.4359E-04      57   7.6284E-03    5.6790E-03     107   3.2349E-02    9.2550E-03     157   1.0002E-01    2.0877E-03
   8   1.8291E-04    1.8162E-04      58   7.9154E-03    5.8276E-03     108   3.3225E-02    9.1890E-03     158   1.0107E-01    2.0257E-03
   9   2.2142E-04    2.1954E-04      59   8.2023E-03    5.9722E-03     109   3.4100E-02    9.1170E-03     159   1.0199E-01    1.9728E-03
  10   2.6957E-04    2.6677E-04      60   8.4893E-03    6.1129E-03     110   3.4976E-02    9.0397E-03     160   1.0291E-01    1.9211E-03
  11   3.1771E-04    3.1383E-04      61   8.7762E-03    6.2497E-03     111   3.6070E-02    8.9361E-03     161   1.0382E-01    1.8707E-03
  12   3.7789E-04    3.7241E-04      62   9.0631E-03    6.3828E-03     112   3.7165E-02    8.8255E-03     162   1.0474E-01    1.8214E-03
  13   4.3807E-04    4.3071E-04      63   9.3501E-03    6.5122E-03     113   3.8259E-02    8.7088E-03     163   1.0566E-01    1.7733E-03
  14   4.9825E-04    4.8874E-04      64   9.6370E-03    6.6380E-03     114   3.9354E-02    8.5865E-03     164   1.0658E-01    1.7263E-03
  15   5.7348E-04    5.6089E-04      65   9.9957E-03    6.7901E-03     115   4.0722E-02    8.4270E-03     165   1.0749E-01    1.6805E-03
  16   6.4870E-04    6.3262E-04      66   1.0354E-02    6.9369E-03     116   4.2090E-02    8.2611E-03     166   1.0841E-01    1.6357E-03
  17   7.2392E-04    7.0393E-04      67   1.0713E-02    7.0783E-03     117   4.3458E-02    8.0900E-03     167   1.0933E-01    1.5920E-03
  18   7.9915E-04    7.7482E-04      68   1.1072E-02    7.2144E-03     118   4.5169E-02    7.8700E-03     168   1.1025E-01    1.5494E-03
  19   8.9318E-04    8.6284E-04      69   1.1430E-02    7.3455E-03     119   4.7306E-02    7.5883E-03     169   1.1116E-01    1.5078E-03
  20   9.8721E-04    9.5022E-04      70   1.1789E-02    7.4716E-03     120   4.9978E-02    7.2296E-03     170   1.1208E-01    1.4673E-03
  21   1.0812E-03    1.0369E-03      71   1.2148E-02    7.5929E-03     121   5.4655E-02    6.5977E-03     171   1.1300E-01    1.4277E-03
  22   1.1753E-03    1.1230E-03      72   1.2506E-02    7.7093E-03     122   5.6993E-02    6.2850E-03     172   1.1392E-01    1.3891E-03
  23   1.2693E-03    1.2085E-03      73   1.2865E-02    7.8211E-03     123   5.9039E-02    6.0152E-03     173   1.1483E-01    1.3515E-03
  24   1.3868E-03    1.3144E-03      74   1.3224E-02    7.9284E-03     124   6.0829E-02    5.7829E-03     174   1.1575E-01    1.3148E-03
  25   1.5044E-03    1.4193E-03      75   1.3582E-02    8.0313E-03     125   6.2619E-02    5.5548E-03     175   1.1667E-01    1.2790E-03
  26   1.6219E-03    1.5233E-03      76   1.4031E-02    8.1537E-03     126   6.4185E-02    5.3590E-03     176   1.1759E-01    1.2441E-03
  27   1.7394E-03    1.6262E-03      77   1.4479E-02    8.2696E-03     127   6.5751E-02    5.1670E-03     177   1.1850E-01    1.2101E-03
  28   1.8570E-03    1.7283E-03      78   1.4927E-02    8.3790E-03     128   6.7122E-02    5.0024E-03     178   1.1942E-01    1.1769E-03
  29   1.9745E-03    1.8293E-03      79   1.5376E-02    8.4823E-03     129   6.8492E-02    4.8410E-03     179   1.2034E-01    1.1446E-03
  30   2.1214E-03    1.9543E-03      80   1.5824E-02    8.5795E-03     130   6.9862E-02    4.6829E-03     180   1.2125E-01    1.1131E-03
  31   2.2683E-03    2.0778E-03      81   1.6272E-02    8.6709E-03     131   7.1232E-02    4.5283E-03     181   1.2217E-01    1.0824E-03
  32   2.4153E-03    2.1998E-03      82   1.6721E-02    8.7566E-03     132   7.2602E-02    4.3771E-03     182   1.2309E-01    1.0525E-03
  33   2.5622E-03    2.3204E-03      83   1.7169E-02    8.8368E-03     133   7.3801E-02    4.2477E-03     183   1.2401E-01    1.0234E-03
  34   2.7091E-03    2.4396E-03      84   1.7617E-02    8.9117E-03     134   7.5000E-02    4.1211E-03     184   1.2492E-01    9.9503E-04
  35   2.8560E-03    2.5573E-03      85   1.8066E-02    8.9813E-03     135   7.6199E-02    3.9973E-03     185   1.2584E-01    9.6739E-04
  36   3.0029E-03    2.6736E-03      86   1.8514E-02    9.0459E-03     136   7.7398E-02    3.8762E-03     186   1.2676E-01    9.4047E-04
  37   3.1866E-03    2.8170E-03      87   1.9074E-02    9.1199E-03     137   7.8596E-02    3.7578E-03     187   1.2768E-01    9.1424E-04
  38   3.3702E-03    2.9583E-03      88   1.9635E-02    9.1865E-03     138   7.9795E-02    3.6423E-03     188   1.2859E-01    8.8871E-04
  39   3.5539E-03    3.0974E-03      89   2.0195E-02    9.2461E-03     139   8.0994E-02    3.5294E-03     189   1.2925E-01    8.7089E-04
  40   3.7375E-03    3.2344E-03      90   2.0756E-02    9.2988E-03     140   8.2193E-02    3.4194E-03     190   1.3182E-01    8.5391E-04
  41   3.9212E-03    3.3693E-03      91   2.1316E-02    9.3451E-03     141   8.3242E-02    3.3253E-03     191   1.3439E-01    8.3757E-04
  42   4.1048E-03    3.5021E-03      92   2.1876E-02    9.3851E-03     142   8.4290E-02    3.2333E-03     192   1.3696E-01    8.2185E-04
  43   4.283[illegible]E-03    3.6329E-03      93   2.2437E-02    9.4191E-03     143   8.5339E-02    3.1434E-03     193   1.3953E-01    8.0671E-04
  44   4.4721E-03    3.7616E-03      94   2.2997E-02    9.4473E-03     144   8.6388E-02    3.0555E-03     194   1.4210E-01    7.9211E-04
  45   4.7017E-03    3.9198E-03      95   2.3558E-02    9.4700E-03     145   8.7437E-02    2.9696E-03     195   1.4467E-01    7.7804E-04
  46   4.9312E-03    4.0748E-03      96   2.4118E-02    9.4873E-03     146   8.8486E-02    2.8858E-03     196   1.4725E-01    7.6445E-04
  47   5.1608E-03    4.2268E-03      97   2.4819E-02    9.5019E-03     147   8.9534E-02    2.8039E-03     197   1.4982E-01    7.5134E-04
  48   5.3903E-03    4.3758E-03      98   2.5519E-02    9.5089E-03     148   9.0583E-02    2.7239E-03     198   1.5239E-01    7.3866E-04
  49   5.6199E-03    4.5218E-03      99   2.6220E-02    9.5087E-03     149   9.1632E-02    2.6459E-03     199   1.5496E-01    7.2641E-04
  50   5.8494E-03    4.6649E-03     100   2.6920E-02    9.5017E-03     150   9.2681E-02    2.5698E-03     200   1.5753E-01    7.1455E-04
```

```
                                VV          VV  EEEEEEEEEEEEE   LL
                                VV          VV  EEEEEEEEEEEEE   LL
                                VV          VV  EE              LL
                                VV          VV  EE              LL
                                VV          VV  EE              LL
                                VV          VV  EEEEEEEEE       LL
                                 VV        VV   EEEEEEEEE       LL
                                   VV     VV    EE              LL
                                    VV   VV     EE              LL
                                     VV VV      EE              LL
                                      VVV       EEEEEEEEEEEEE   LLLLLLLLLLLLL
                                       V        EEEEEEEEEEEEE   LLLLLLLLLLLLL

NN          NN  MM          MM   GGGGGGGGGGG    TTTTTTTTTTTT      AAAAAAAAA      SSSSSSSSSSS    KK          KK   666666666666
NNN         NN  MMM        MMM  GGGGGGGGGGGGG   TTTTTTTTTTTT     AAAAAAAAAAA    SSSSSSSSSSSSS   KK         KK   6666666666666
NNNN        NN  MMMM      MMMM  GG         GG        TT         AA         AA   SS         SS   KK        KK    66
NN NN       NN  MM MM    MM MM  GG                   TT         AA         AA   SS                KK       KK     66
NN   NN     NN  MM   MM MM  MM  GG                   TT         AA         AA   SS                KK      KK      66
NN    NN    NN  MM    MMM   MM  GG    GGGGGGG        TT         AAAAAAAAAAAAA   SSSSSSSSSSSS    KKKKKKKK        666666666666
NN     NN   NN  MM     M    MM  GG    GGGGGGG        TT         AAAAAAAAAAAAA    SSSSSSSSSSSS   KKKKKKKK        6666666666666
NN      NN  NN  MM          MM  GG         GG        TT         AA         AA              SS   KK      KK      66         66
NN       NN NN  MM          MM  GG         GG        TT         AA         AA              SS   KK       KK     66         66
NN        NNNN  MM          MM  GG         GG        TT         AA         AA   SS         SS   KK        KK    66         66
NN         NNN  MM          MM  GGGGGGGGGGGGG        TT         AA         AA   SSSSSSSSSSSSS   KK         KK   6666666666666
NN          NN  MM          MM   GGGGGGGGGGG         TT         AA         AA    SSSSSSSSSSS    KK          KK   66666666666

   0000000       666666666666               //   22222222222             44                 //   99999999999          11
  000000000     6666666666666              //   2222222222222           444                //   9999999999999        111
 00       00    66                        //    22         22          4444               //    99         99       1111
00         00   66                       //                22         44 44              //     99         99         11
00         00   66                      //                 22        44  44             //      99         99         11
00         00   666666666666           //                22         44   44            //       9999999999999         11
00         00   6666666666666         //                22         44    44           //         999999999999         11
00         00   66         66        //              22          444444444444        //                    99         11
00         00   66         66       //             22           4444444444444       //                     99         11
 00       00    66         66      //            22                      44        //                      99         11
  000000000     6666666666666     //            2222222222222            44       //            9999999999999      11111111
   0000000       66666666666     //             2222222222222            44      //             999999999999       11111111

      11                 44                           11        5555555555555                      0000000       666666666666
     111                444                          111        5555555555555                     000000000     6666666666666
    1111               4444                         1111        55                               00       00    66
      11              44 44                           11        55                              00         00   66
      11             44  44                           11        55                              00         00   66
      11            44   44                           11        555555555555                    00         00   666666666666
      11           44    44          .....            11        5555555555555        .....      00         00   6666666666666
      11         444444444444        .....            11                   55        .....      00         00   66         66
      11        4444444444444        .....            11                   55        .....      00         00   66         66
      11                 44          .....            11        55         55        .....       00       00    66         66
   11111111              44                        11111111     5555555555555                     000000000     6666666666666
   11111111              44                        11111111      55555555555                       0000000       66666666666
 INPUT
     1 MASTER LIBRARY LOGICAL UNIT
    30 FUNCTION LIBRARY LOGICAL UNIT
    31 WEIGHTING FUNCTION LIBRARY LOGICAL UNIT
     1 NUMBER OF COUPLING COMMANDS
   238 NUMBER OF NEUTRON ENERGY GROUPS
     0 NUMBER OF GAMMA ENERGY GROUPS
     2 MASTER LIBRARY "VERSION" LEVEL

          CREATE STRING WITH         FUNCTION        WEIGHTING FUNCTION    PARTICLE TYPE
COMMAND  IDENTIFIER   PROCESS       MAT MF  MT          MAT MF  MT
      1        1000      1000      1000  3 100           99  3 200               0

COMMAND  1 IS BEING EXECUTED         1         2         3     1483
```

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NEUTRON ARRAYS FOR SET PREPARED BY THE VEL MODULE--USE CLAROL TO PREPARE A DIFFERENT TITLE   IDENTIFIER        1000
 XSEC ID    1000         1099
 GRP.
    1     3.72935E-05   3.81049E-08
    2     3.93965E-05   1.09601E-07
    3     4.10637E-05   2.08250E-07
    4     4.23065E-05   2.56517E-07
    5     4.36982E-05   6.94549E-07
    6     4.81808E-05   9.66071E-06
    7     5.34311E-05   3.08953E-05
    8     5.97181E-05   1.08274E-04
    9     6.82750E-05   3.31530E-04
   10     7.47594E-05   1.99867E-04
   11     8.46974E-05   9.77809E-04
   12     9.65335E-05   6.77916E-04
   13     1.02435E-04   1.96366E-04
   14     1.10307E-04   9.47646E-04
   15     1.23357E-04   8.20841E-04
   16     1.32240E-04   2.60387E-04
   17     1.35621E-04   1.18208E-04
   18     1.37709E-04   1.06610E-04
   19     1.40537E-04   1.87131E-04
   20     1.43845E-04   1.42864E-04
   21     1.48503E-04   2.93658E-04
   22     1.55039E-04   2.72798E-04
   23     1.62113E-04   2.80053E-04
   24     1.66882E-04   6.31191E-05
   25     1.68986E-04   7.93089E-05
   26     1.70865E-04   4.42822E-05
   27     1.73651E-04   1.31662E-04
   28     1.79725E-04   2.26372E-04
   29     1.88392E-04   2.31543E-04
   30     1.93834E-04   2.94367E-05
   31     1.99846E-04   2.29101E-04
   32     2.07878E-04   8.82491E-05
   33     2.12452E-04   7.50188E-05
   34     2.19809E-04   1.63821E-04
   35     2.28661E-04   9.50322E-05
   36     2.36023E-04   9.57842E-05
   37     2.42773E-04   6.33144E-05
   38     2.48624E-04   6.28059E-05
   39     2.63706E-04   2.14744E-04
   40     2.90869E-04   1.75634E-04
   41     3.28904E-04   1.90731E-04
   42     3.81026E-04   1.23281E-04
   43     4.26886E-04   4.91204E-05
   44     4.71556E-04   5.91450E-05
   45     5.23567E-04   2.87197E-05
   46     5.50874E-04   5.49790E-06
   47     5.68194E-04   1.24865E-05
   48     5.85160E-04   3.47648E-06
   49     6.18486E-04   2.26004E-05
   50     6.73653E-04   1.61086E-05
   51     7.04929E-04   4.41500E-06
   52     7.30945E-04   1.18603E-05
   53     8.31835E-04   4.56425E-05
   54     9.62182E-04   2.05236E-05
   55     1.11031E-03   4.34134E-05
   56     1.30645E-03   3.01980E-05
   57     1.51143E-03   3.53079E-05
   58     1.70363E-03   1.89236E-05
   59     1.91215E-03   3.28052E-05
   60     2.29289E-03   4.84925E-05
   61     2.57554E-03   4.71565E-06
   62     2.75147E-03   2.48183E-05
   63     3.01827E-03   1.69779E-05
   64     3.22878E-03   1.34224E-05
   65     3.35954E-03   4.51336E-06
   66     3.56939E-03   2.25891E-05
   67     3.89523E-03   1.68326E-05
   68     4.07597E-03   3.69109E-06
   69     4.39493E-03   2.99097E-05
   70     4.92477E-03   2.15068E-05
   71     5.61409E-03   3.71438E-05
```

Weighting Function

$\frac{1}{v}$ Averages

```
                                                  AAAAAAAAA     LL              EEEEEEEEEEEEE
                                                 AAAAAAAAAAA    LL              EEEEEEEEEEEEE
                                                AA         AA   LL              EE
                                                AA         AA   LL              EE
                                                AA         AA   LL              EE
                                                AAAAAAAAAAAAA   LL              EEEEEEEEE
                                                AAAAAAAAAAAAA   LL              EEEEEEEEE
                                                AA         AA   LL              EE
                                                AA         AA   LL              EE
                                                AA         AA   LL              EE
                                                AA         AA   LLLLLLLLLLLLL   EEEEEEEEEEEEE
                                                AA         AA   LLLLLLLLLLLLL   EEEEEEEEEEEEE


NN         NN   MM         MM    GGGGGGGGGGG    TTTTTTTTTTTT      AAAAAAAAA      SSSSSSSSSSS    KK          KK   66666666666
NNN        NN   MMM       MMM   GGGGGGGGGGGGG   TTTTTTTTTTTT     AAAAAAAAAAA    SSSSSSSSSSSSS   KK         KK   6666666666666
NNNN       NN   MMMM     MMMM   GG         GG        TT         AA         AA   SS         SS   KK        KK    66
NN NN      NN   MM MM   MM MM   GG                   TT         AA         AA   SS              KK       KK     66
NN  NN     NN   MM  MM MM  MM   GG                   TT         AA         AA   SS              KK      KK      66
NN   NN    NN   MM   MMM   MM   GG     GGGGGG        TT         AAAAAAAAAAAAA   SSSSSSSSSSSS    KKKKKKKK        666666666666
NN    NN   NN   MM    M    MM   GG     GGGGGG        TT         AAAAAAAAAAAAA    SSSSSSSSSSSS   KKKKKKKK        6666666666666
NN     NN  NN   MM         MM   GG         GG        TT         AA         AA              SS   KK      KK      66         66
NN      NN NN   MM         MM   GG         GG        TT         AA         AA              SS   KK       KK     66         66
NN       NNNN   MM         MM   GG         GG        TT         AA         AA   SS         SS   KK        KK    66         66
NN        NNN   MM         MM   GGGGGGGGGGGGG        TT         AA         AA   SSSSSSSSSSSSS   KK         KK   6666666666666
NN         NN   MM         MM    GGGGGGGGGGG         TT         AA         AA    SSSSSSSSSSS    KK          KK   66666666666


   0000000       66666666666               //    22222222222             44                //    99999999999         11
  000000000     6666666666666             //    2222222222222           444               //    9999999999999       111
 00       00    66                       //     22         22          4444              //     99         99      1111
00         00   66                      //                 22         44 44             //      99         99        11
00         00   66                     //                  22        44  44            //       99         99        11
00         00   666666666666          //                  22        44   44           //        9999999999999        11
00         00   6666666666666        //                 22         44    44          //          999999999999        11
00         00   66         66       //                22         444444444444       //                     99        11
00         00   66         66      //               22          4444444444444      //                      99        11
 00       00    66         66     //              22                     44       //                       99        11
  000000000     6666666666666    //             2222222222222            44      //             9999999999999     11111111
   0000000       66666666666    //              2222222222222            44     //              999999999999      11111111


     11                  44                          11         5555555555555                    22222222222             44
    111                 444                         111         5555555555555                   2222222222222           444
   1111                4444                        1111         55                              22         22          4444
     11               44 44                          11         55                                         22         44 44
     11              44  44                          11         55                                         22        44  44
     11             44   44                          11         555555555555                              22        44   44
     11            44    44          .....           11         5555555555555        .....              22         44    44
     11          444444444444        .....           11                    55        .....            22         444444444444
     11         4444444444444        .....           11                    55        .....          22          4444444444444
     11                  44          .....           11         55         55        .....        22                     44
  11111111               44                       11111111      5555555555555                   2222222222222            44
  11111111               44                       11111111       55555555555                    2222222222222            44
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TABLE OF CONTENTS FOR THE MASTER LIBRARY ON LOGICAL    1

   1     SET PREPARED BY THE VEL MODULE--USE CLAROL TO PREPARE A DIFFERENT TITLE                  1000

THIS LIBRARY HAS A 238 GROUP NEUTRON STRUCTURE WITH THE FOLLOWING BOUNDARIES:
   1 2.0000E+07    2 1.7333E+07    3 1.5683E+07    4 1.4550E+07    5 1.3840E+07    6 1.2840E+07    7 1.0000E+07    8 8.1873E+06
   9 6.4340E+06   10 4.8000E+06   11 4.3040E+06   12 3.0000E+06   13 2.4790E+06   14 2.3540E+06   15 1.8500E+06   16 1.5000E+06
  17 1.4000E+06   18 1.3560E+06   19 1.3170E+06   20 1.2500E+06   21 1.2000E+06   22 1.1000E+06   23 1.0100E+06   24 9.2000E+05
  25 9.0000E+05   26 8.7500E+05   27 8.6110E+05   28 8.2000E+05   29 7.5000E+05   30 6.7900E+05   31 6.7000E+05   32 6.0000E+05
  33 5.7300E+05   34 5.5000E+05   35 4.9952E+05   36 4.7000E+05   37 4.4000E+05   38 4.2000E+05   39 4.0000E+05   40 3.3000E+05
  41 2.7000E+05   42 2.0000E+05   43 1.5000E+05   44 1.2830E+05   45 1.0000E+05   46 8.5000E+04   47 8.2000E+04   48 7.5000E+04
  49 7.3000E+04   50 6.0000E+04   51 5.2000E+04   52 5.0000E+04   53 4.5000E+04   54 3.0000E+04   55 2.5000E+04   56 1.7000E+04
  57 1.3000E+04   58 9.5000E+03   59 8.0300E+03   60 6.0000E+03   61 3.9000E+03   62 3.7400E+03   63 3.0000E+03   64 2.5800E+03
  65 2.2900E+03   66 2.2000E+03   67 1.8000E+03   68 1.5500E+03   69 1.5000E+03   70 1.1500E+03   71 9.5000E+02   72 6.8300E+02
  73 6.7000E+02   74 5.5000E+02   75 3.0500E+02   76 2.8500E+02   77 2.4000E+02   78 2.1000E+02   79 2.0750E+02   80 1.9250E+02
  81 1.8600E+02   82 1.2200E+02   83 1.1900E+02   84 1.1500E+02   85 1.0800E+02   86 1.0000E+02   87 9.0000E+01   88 8.2000E+01
  89 8.0000E+01   90 7.6000E+01   91 7.2000E+01   92 6.7500E+01   93 6.5000E+01   94 6.1000E+01   95 5.9000E+01   96 5.3400E+01
  97 5.2000E+01   98 5.0600E+01   99 4.9200E+01  100 4.8300E+01  101 4.7000E+01  102 4.5200E+01  103 4.4000E+01  104 4.2400E+01
 105 4.1000E+01  106 3.9600E+01  107 3.9100E+01  108 3.8000E+01  109 3.7000E+01  110 3.5500E+01  111 3.4600E+01  112 3.3750E+01
 113 3.3250E+01  114 3.1750E+01  115 3.1250E+01  116 3.0000E+01  117 2.7500E+01  118 2.5000E+01  119 2.2500E+01  120 2.1000E+01
 121 2.0000E+01  122 1.9000E+01  123 1.8500E+01  124 1.7000E+01  125 1.6000E+01  126 1.5100E+01  127 1.4400E+01  128 1.3750E+01
 129 1.2900E+01  130 1.1900E+01  131 1.1500E+01  132 1.0000E+01  133 9.1000E+00  134 8.1000E+00  135 7.1500E+00  136 7.0000E+00
 137 6.7500E+00  138 6.5000E+00  139 6.2500E+00  140 6.0000E+00  141 5.4000E+00  142 5.0000E+00  143 4.7500E+00  144 4.0000E+00
 145 3.7300E+00  146 3.5000E+00  147 3.1500E+00  148 3.0500E+00  149 3.0000E+00  150 2.9700E+00  151 2.8700E+00  152 2.7700E+00
 153 2.6700E+00  154 2.5700E+00  155 2.4700E+00  156 2.3800E+00  157 2.3000E+00  158 2.2100E+00  159 2.1200E+00  160 2.0000E+00
 161 1.9400E+00  162 1.8600E+00  163 1.7700E+00  164 1.6800E+00  165 1.5900E+00  166 1.5000E+00  167 1.4500E+00  168 1.4000E+00
 169 1.3500E+00  170 1.3000E+00  171 1.2500E+00  172 1.2250E+00  173 1.2000E+00  174 1.1750E+00  175 1.1500E+00  176 1.1400E+00
 177 1.1300E+00  178 1.1200E+00  179 1.1100E+00  180 1.1000E+00  181 1.0900E+00  182 1.0800E+00  183 1.0700E+00  184 1.0600E+00
 185 1.0500E+00  186 1.0400E+00  187 1.0300E+00  188 1.0200E+00  189 1.0100E+00  190 1.0000E+00  191 9.7500E-01  192 9.5000E-01
 193 9.2500E-01  194 9.0000E-01  195 8.5000E-01  196 8.0000E-01  197 7.5000E-01  198 7.0000E-01  199 6.5000E-01  200 6.2500E-01
 201 6.0000E-01  202 5.5000E-01  203 5.0000E-01  204 4.5000E-01  205 4.0000E-01  206 3.7500E-01  207 3.5000E-01  208 3.2500E-01
 209 3.0000E-01  210 2.7500E-01  211 2.5000E-01  212 2.2500E-01  213 2.0000E-01  214 1.7500E-01  215 1.5000E-01  216 1.2500E-01
 217 1.0000E-01  218 9.0000E-02  219 8.0000E-02  220 7.0000E-02  221 6.0000E-02  222 5.0000E-02  223 4.0000E-02  224 3.0000E-02
 225 2.5300E-02  226 1.0000E-02  227 7.5000E-03  228 5.0000E-03  229 4.0000E-03  230 3.0000E-03  231 2.5000E-03  232 2.0000E-03
 233 1.5000E-03  234 1.2000E-03  235 1.0000E-03  236 7.5000E-04  237 5.0000E-04  238 1.0000E-04  239 1.0000E-05
============================================================================================================================

AMPX NUCLIDE        1000 SET PREPARED BY THE VEL MODULE--USE CLAROL TO PREPARE A DIFFERENT TITLE
       HAS THE FOLLOWING DATA                                   IS THE NUCLIDE SYMBOL         THERE ARE     2 RECORDS
    0 RESOLVED RESONANCES                              0.000 MASS(NEUTRON EQUIVALENTS)                      0 BONDARENKO TEMPS
    0 UNRESOLVED RESONANCE POINTS                         0. ZA                                             0 BONDARENKO GROUPS
    2 TEMP IND 1-D NEUT PROCESSES                          0 NEUTRON WGTING OPTION                          0 ID(41) NOT USED
    0 2-D NEUT PROCESSES                                   0 NEUTRON WGT ID                                 0 GAMMA PROD WGT ID
    0 TEMP DEP 1-D NEUT PROCESSES                          0 GAMMA WGTING OPTION                            0 ID(43) NOT USED
    0 1-D GAMMA PROCESSES                           0.00E+00 POWER/FISSION(WATT-SEC/FIS)                    0 GAMMA PROD WGTING OPTION
    0 2-D GAMMA PROCESSES                           0.00E+00 ENERGY/CAPTURE(WATT-SEC/CAP)                   0 ENDF MAT OF FAST NEUT DATA
    0 NEUT-TO-GAMMA PROCESSES                              0 MAX 2-D LENGTH                                 0 ENDF MAT OF THERMAL NEUT DATA
    0 TOTAL 2-D ARRAYS                                     0 BONDARENKO PROCESSES                           0 ENDF MAT OF GAMMA DATA
    0 MAX ORDER OF L                                       0 BONDARENKO SIGMA ZEROS                         0 ENDF MAT OF GAMMA PROD DATA

THE FOLLOWING 1-D NEUTRON ARRAYS ARE AVAILABLE
  1000  1099

NEUTRON REACTION CROSS SECTIONS FOR SET PREPARED BY THE VEL MODULE--USE CLAROL TO PREPARE A DIFFERENT TITLE         1000

 XSEC ID    1000          1099
GRP.
    1     3.72935E-05   3.81049E-08
    2     3.93965E-05   1.09601E-07
    3     4.10637E-05   2.08250E-07
    4     4.23065E-05   2.56517E-07
    5     4.36982E-05   6.94543E-07
    6     4.81808E-05   9.66071E-06
    7     5.34311E-05   3.08953E-05
    8     5.97181E-05   1.08274E-04
    9     6.82750E-05   3.31530E-04
   10     7.47594E-05   1.99867E-04
   11     8.46974E-05   9.77809E-04
   12     9.65335E-05   6.77916E-04
   13     1.02435E-04   1.96366E-04
   14     1.10307E-04   9.47646E-04
   15     1.23357E-04   8.20841E-04
   16     1.32240E-04   2.60387E-04
   17     1.35521E-04   1.18208E-04
```

6.SAMPLE PROBLEMS.7 CONVERT THE CROSS SECTIONS ON AN AMPX MASTER LIBRARY FOR USE IN THE ANISN PROGRAM

This example assumes that we want to use the ANISN program and that we have a set of cross sections for carbon on an AMPX master library that we wish to convert. This master library was part of those produced in the runs described in Sect. 6.SAMPLE PROBLEMS.1.

As you will recall, these cross sections had 238 energy groups, with 90 of those being "thermal" groups. Let us assume that our ANISN library will be constructed such that every possible transfer from the original library will have a position in the final library and that we want to have the group-averaged values for (n,γ), (n,p), elastic scattering, inelastic scattering, and (n,2n) also included.

ANISN expects its cross sections to be formatted in a rectangular array with the structure discussed in Sect. INFORMATION.3 of this document.

Each group has a column of values that is IHM words long. The total cross section is in position IHT in the column, $\overline{\nu\sigma_f}$ is in IHT-1, σ_a is in IHT-2, and positions above this are available for other processes, if necessary. The values for scatter to a group are located in the positions below IHT, with the within-group term located in position IHS.

In our example, three of the positions down to IHT are usurped, as described above. We want to add space for (n,γ), (n,p), elastic, inelastic, and (n,2n); therefore, our IHT is in position 8. With 90 thermal groups, we can have a maximum of 89 upscatter values, though many of these will certainly be zero for carbon. To include all positions, IHS will be in

$$\begin{aligned} \text{IHS} &= \text{IHT} + \text{upscatters} + 1 \\ &= 8 + 89 + 1 = 98. \end{aligned}$$

Also with 238 groups, there are 237 possible downscatters; hence, IHM is

$$\begin{aligned} \text{IHM} &= \text{IHS} + \text{downscatters} \\ &= 98 + 237 = 235. \end{aligned}$$

The procedure we will use to generate the ANISN values is shown in Fig. 6.SAMPLE PROBLEMS.16.

The input data for this task are shown below, followed by portions of the output it generated. Here we run NITAWL to extract data for carbon from logical 60 and to write it on a working library, which ALPO can read, on logical 4. ALPO then reads this and makes an ANISN binary library on logical unit 20.

ORNL-DWG 91Z-14386

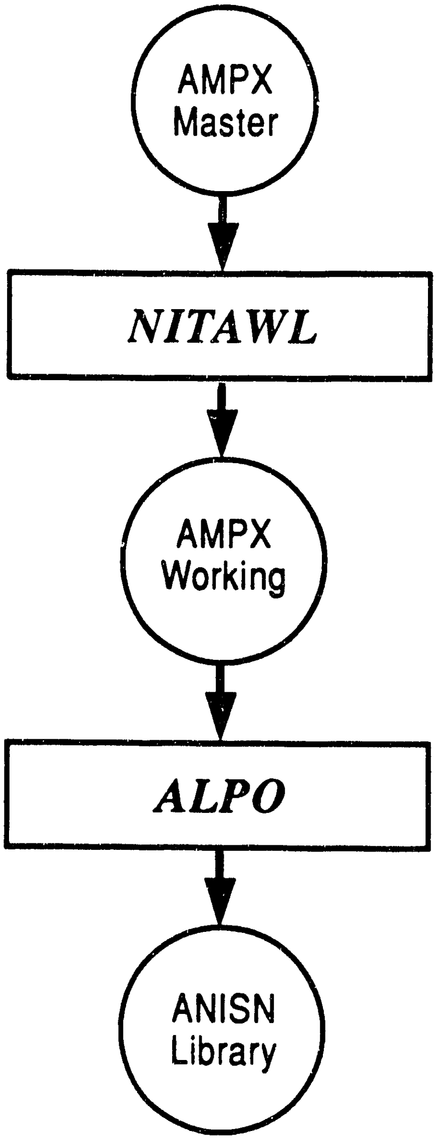


Fig. 6.SAMPLE PROBLEMS.16. Procedure to make ANISN cross sections.

```
    AMPX MODULE LOG AND LIST OF CARD INPUT DATA

 MODULE NITAWL   HAS BEEN CALLED

0$$ 60 E 1$$ 0 1 E T
2$$ 6000 T
```

Create a working library

```
 MODULE NITAWL   IS FINISHED.
 CPU TIME     4.20 (SECONDS).  I/O'S       0 USER CODE 0000   SYSTEM CODE 000

 MODULE ALPO     HAS BEEN CALLED

-1$$ 102 103 2 4 16 E 0$$ 20 E 1$$ 1 8 98 235 5 1 1 0 100000 T
2$$ 4 0 T
```

Convert to ANISN format

```
 MODULE ALPO     IS FINISHED.
 CPU TIME     2.54 (SECONDS).  I/O'S       0 USER CODE 0000   SYSTEM CODE 000
```

```
                NN          NN  IIIIIIIIIIII    TTTTTTTTTTTT      AAAAAAAAA     WW          WW  LL
                NNN         NN  IIIIIIIIIIII    TTTTTTTTTTTT     AAAAAAAAAAA    WW          WW  LL
                NNNN        NN       II              TT         AA         AA   WW          WW  LL
                NN NN       NN       II              TT         AA         AA   WW          WW  LL
                NN   NN     NN       II              TT         AA         AA   WW          WW  LL
                NN    NN    NN       II              TT         AAAAAAAAAAAAA   WW     W    WW  LL
                NN     NN   NN       II              TT         AAAAAAAAAAAAA   WW    WWW   WW  LL
                NN      NN  NN       II              TT         AA         AA   WW   WW WW  WW  LL
                NN       NN NN       II              TT         AA         AA   WW WW    WW WW  LL
                NN        NNNN       II              TT         AA         AA   WWWW      WWWW  LL
                NN         NNN  IIIIIIIIIIII         TT         AA         AA   WWW        WWW  LLLLLLLLLLLLL
                NN          NN  IIIIIIIIIIII         TT         AA         AA   WW          WW  LLLLLLLLLLLLL

NN          NN  MM          MM   GGGGGGGGGGG    TTTTTTTTTTTT      AAAAAAAAA      SSSSSSSSSSS    KK          KK  7777777777777
NNN         NN  MMM        MMM  GGGGGGGGGGGGG   TTTTTTTTTTTT     AAAAAAAAAAA    SSSSSSSSSSSSS   KK         KK   777777777777
NNNN        NN  MMMM      MMMM  GG         GG        TT         AA         AA   SS         SS   KK        KK    77        77
NN NN       NN  MM MM    MM MM  GG                   TT         AA         AA   SS              KK       KK              77
NN   NN     NN  MM   MM MM  MM  GG                   TT         AA         AA   SS              KK      KK              77
NN    NN    NN  MM    MMM   MM  GG    GGGGGGG        TT         AAAAAAAAAAAAA   SSSSSSSSSSSS    KKKKKKKK               77
NN     NN   NN  MM     M    MM  GG    GGGGGGG        TT         AAAAAAAAAAAAA    SSSSSSSSSSSS   KKKKKKKK               77
NN      NN  NN  MM          MM  GG         GG        TT         AA         AA              SS   KK      KK            77
NN       NN NN  MM          MM  GG         GG        TT         AA         AA              SS   KK       KK           77
NN        NNNN  MM          MM  GG         GG        TT         AA         AA   SS         SS   KK        KK         77
NN         NNN  MM          MM  GGGGGGGGGGGGG        TT         AA         AA   SSSSSSSSSSSSS   KK         KK        77
NN          NN  MM          MM   GGGGGGGGGGG         TT         AA         AA    SSSSSSSSSSS    KK          KK       77

   0000000       88888888888                //     0000000       99999999999                //   99999999999          11
  000000000     8888888888888              //     000000000     9999999999999              //   9999999999999        111
 00       00    88         88             //     00       00    99         99             //    99         99       1111
00         00   88         88            //     00         00   99         99            //     99         99         11
00         00   88         88           //      00         00   99         99           //      99         99         11
00         00    88888888888           //       00         00   9999999999999          //       9999999999999         11
00         00    88888888888          //        00         00    999999999999         //         999999999999         11
00         00   88         88        //         00         00              99        //                    99         11
00         00   88         88       //          00         00              99       //                     99         11
 00       00    88         88      //            00       00               99      //                      99         11
  000000000     8888888888888     //              000000000     9999999999999     //            9999999999999      11111111
   0000000       88888888888     //                0000000      999999999999     //             999999999999       11111111

      11           0000000                            11        5555555555555                         11         666666666666
     111          000000000                          111        5555555555555                        111        6666666666666
    1111         00       00                        1111        55                                  1111        66
      11        00         00                         11        55                                    11        66
      11        00         00                         11        55                                    11        66
      11        00         00                         11        555555555555                          11        666666666666
      11        00         00        .....            11        5555555555555        .....            11        6666666666666
      11        00         00        .....            11                   55        .....            11        66         66
      11        00         00        .....            11                   55        .....            11        66         66
      11         00       00         .....            11        55         55        .....            11        66         66
   11111111       000000000                        11111111     5555555555555                      11111111     6666666666666
   11111111        0000000                         11111111      55555555555                       11111111      66666666666
```

```
    0$ ARRAY      9 ENTRIES READ

    1$ ARRAY     12 ENTRIES READ

    OT

SELECT  1 NUCLIDES FROM THE MASTER  LIBRARY ON LOGICAL 60
        0 NUCLIDES FROM THE WORKING LIBRARY ON LOGICAL  2
        0 NUCLIDES FROM THE WORKING LIBRARY ON LOGICAL  3
          TO CREATE THE NEW WORKING LIBRARY ON LOGICAL  4

        0 RESONANCE CALCULATIONS HAVE BEEN REQUESTED
        0 OUTPUT OPTION FOR AMPX FORMATTED CROSS SECTION DATA

THE STORAGE ALLOCATED FOR THIS CASE IS 200000 WORDS

    2$ ARRAY      1 ENTRIES READ

    OT

 GENERAL INFORMATION CONCERNING CROSS SECTION LIBRARY
   TAPE IDENTIFICATION NUMBER                4321
   NUMBER OF NUCLIDES ON TAPE                   2
   NUMBER OF NEUTRON ENERGY GROUPS            238
   FIRST THERMAL NEUTRON ENERGY GROUP         149
   NUMBER OF GAMMA ENERGY GROUPS                0

   DIRECT ACCESS UNIT NUMBER  9 REQUIRES 144 BLOCKS OF LENGTH  8172 WORDS


 XSDRN TAPE   4321
                        SAMPLE PROBLEM
                        FOR THE XLACS
                        MODULE OF THE
                        AMPX77 SYSTEM
                        +++++++++++++

 NUCLIDES FROM XSDRN TAPE
    1    C-12 (GRAPHITE KERNEL AT THERMAL)                                                   6000

C-12 (GRAPHITE KERNEL AT THERMAL)                                                 6000     TEMPERATURE=     0.00
                             THERMAL SCATTERING MATRIX NUMBER   1 AT A TEMPERATURE OF    296.01 WAS SELECTED.

  ELAPSED TIME   0.04 MIN.
  THIS XSDRN WORKING TAPE WAS CREATED 08/09/91 AT 10.15.36
  THE TITLE OF THE PARENT CASE IS AS FOLLOWS
  SAMPLE PROBLEM
  FOR THE XLACS
  MODULE OF THE
      TAPE ID                        4321        NUMBER OF NUCLIDES              1
      NUMBER OF NEUTRON GROUPS        238        NUMBER OF GAMMA GROUPS          0
      FIRST THERMAL GROUP             149        LOGICAL UNIT                    4
                                 TABLE OF CONTENTS
    C-12 (GRAPHITE KERNEL AT THERMAL)                                      ID      6000

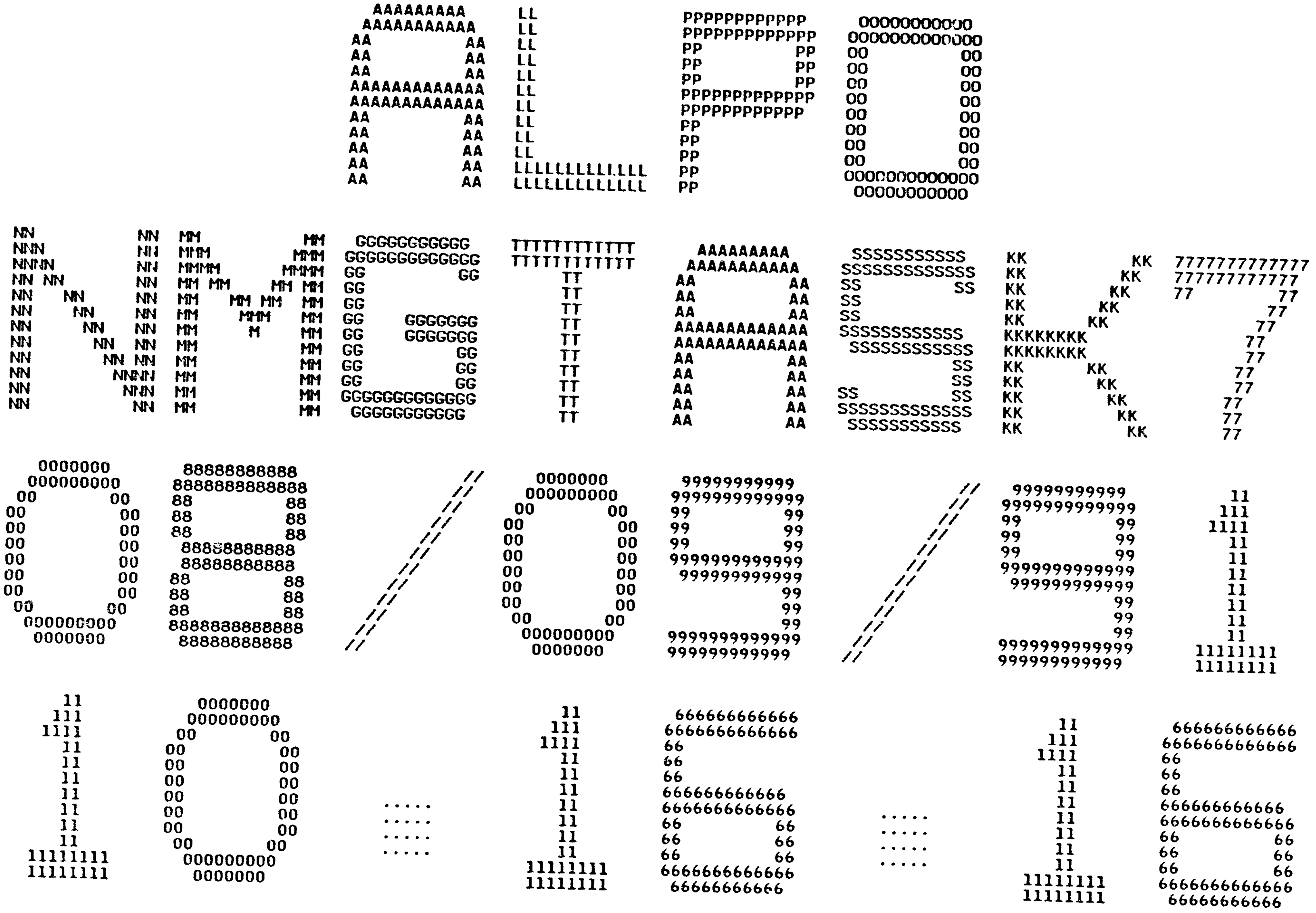
      TAPE COPY USED      0 I/O'S, AND TOOK    1.87 SECONDS

-1$ ARRAY    100 ENTRIES READ

 0$ ARRAY      2 ENTRIES READ

 1$ ARRAY      9 ENTRIES READ

 0T
```


ALPO
NMGTASK7
08/09/91
10:16:16

```
AN ANISN LIBRARY WILL BE CREATED ON LOGICAL 20

THE INPUT WORKING LIBRARY WITH THE LARGEST BLOCKSIZE IS  4

   1 FILE(S) WILL BE CONVERTED

THE TOTAL CROSS SECTION POSITION WILL BE  8

THE WITHIN-GROUP POSITION WILL BE 98

THE CROSS SECTION TABLE LENGTH WILL BE 235

THE MAXIMUM ORDER OF P(L) ALLOWED ON THE ANISN LIBRARY IS  5

 FIRST OUTPUT OPTION  1

SECOND OUTPUT OPTION  1

TRANSPORT CORRECTION OPTION    0

THE ANISN LIBRARY WILL BE WRITTEN IN BINARY FORMAT

THE FOLLOWING PROCESSES WILL BE PLACED IN THE TABLES

POSITION    PROCESS IDENTIFIER

  1                102
  2                103
  3                  2
  4                  4
  5                 16

    2$ ARRAY      2 ENTRIES READ

    0T

THE WORKING LIBRARY ON LOGICAL  4
  WITH 238 NEUTRON ENERGY GROUPS
   AND   0 GAMMA ENERGY GROUPS
   AND A FIRST THERMAL GROUP OF 149
   WILL PRODUCE DATA WITH 137 DOWNSCATTERS AND  89 UPSCATTERS

ALL NUCLIDES WILL BE SELECTED FROM THE LIBRARY
```

Edit of P_0 data

```
THE LIBRARY CONTENTS ARE
  NOG   ITL ICT    ID              TITLE
  238   235   0     1 PO DATA FOR C-12 (GRAPHITE KERNEL AT THERMAL)                                  AMPX ID        6000

PSN.   GRP.  1      GRP.  2      GRP.  3      GRP.  4      GRP.  5      GRP.  6      GRP.  7      GRP.  8
   1 2.00582E-04  2.02183E-04  1.64116E-04  1.23878E-04  8.68080E-05  7.03495E-05  1.09200E-04  8.18548E-05
   2 1.71565E-02  1.07748E-02  2.11645E-03  3.43848E-06  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
   3 9.13789E-01  8.69890E-01  8.76952E-01  7.99004E-01  8.59567E-01  7.84984E-01  7.27174E-01  9.24024E-01
   4 4.19146E-01  4.95431E-01  4.68357E-01  4.24218E-01  4.00051E-01  4.22648E-01  3.08324E-01  2.50302E-01
   5 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
   6 1.22862E-01  1.02680E-01  8.18551E-02  8.11174E-02  8.73452E-02  1.01681E-01  1.50829E-01  3.26241E-02
   7 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
   8 1.45579E+00  1.46800E+00  1.42716E+00  1.30434E+00  1.34696E+00  1.30931E+00  1.18633E+00  1.20695E+00
   9 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
     PSN.   10 THRU PSN.   97 SAME AS ABOVE
  98 6.87288E-01  5.66916E-01  5.13504E-01  3.86170E-01  4.79541E-01  5.90756E-01  3.97809E-01  5.35823E-01
  99 0.00000E+00  1.57984E-01  1.76984E-01  1.71598E-01  2.31654E-01  3.50644E-01  1.71886E-01  3.09719E-01
 100 0.00000E+00  0.00000E+00  4.82829E-02  4.33332E-02  8.10115E-02  1.80220E-01  1.08633E-01  1.02793E-01
 101 0.00000E+00  0.00000E+00  0.00000E+00  3.12556E-02  4.54278E-02  1.68655E-01  1.00313E-01  7.22221E-02
 102 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  3.69949E-02  1.25244E-01  6.42103E-02  7.61749E-02
 103 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  3.61962E-02  2.90498E-02  4.52809E-02
 104 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  1.00550E-02  1.53157E-02
 105 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  1.57534E-02
 106 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
     PSN.  107 THRU PSN.  235 SAME AS ABOVE

PSN.   GRP.  9      GRP. 10      GRP. 11      GRP. 12      GRP. 13      GRP. 14      GRP. 15      GRP. 16
   1 3.60578E-05  2.49645E-05  1.79526E-05  1.19633E-05  9.29876E-06  6.34341E-06  4.05006E-06  3.07682E-06
   2 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
   3 1.09164E+00  1.66502E+00  2.13883E+00  1.94340E+00  1.58468E+00  1.77542E+00  1.89586E+00  2.07866E+00
   4 1.22669E-01  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
   5 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
   6 9.81606E-05  2.49645E-05  1.79526E-05  1.19633E-05  9.29876E-06  6.34341E-06  4.05006E-06  3.07682E-06
   7 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
   8 1.21441E+00  1.66505E+00  2.13885E+00  1.94341E+00  1.58469E+00  1.77542E+00  1.89586E+00  2.07866E+00
   9 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
     PSN.   10 THRU PSN.   97 SAME AS ABOVE
  98 5.60618E-01  6.04153E-01  1.15332E+00  7.08283E-01  1.80944E-01  7.07853E-01  6.98309E-01  2.96260E-01
  99 3.82690E-01  3.01408E-01  1.06087E+00  7.07490E-01  1.85092E-01  1.02320E+00  8.97752E-01  3.95344E-01
 100 4.37222E-02  5.50482E-03  2.29616E-01  0.00000E+00  1.69630E-01  1.01436E+00  3.80534E-01  1.38568E-01
 101 1.45785E-01  3.35140E-02  1.64134E-02  0.00000E+00  0.00000E+00  1.08406E-01  3.56601E-02  0.00000E+00
 102 6.09497E-02  3.56511E-02  1.66093E-01  3.87522E-02  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
 103 1.53202E-02  2.62091E-03  4.22183E-02  5.33335E-02  1.69219E-02  5.94164E-05  0.00000E+00  0.00000E+00
 104 1.51226E-02  4.46823E-03  2.49788E-02  1.07549E-02  1.12273E-02  8.91446E-02  8.57401E-03  0.00000E+00
 105 3.26991E-02  1.42652E-02  4.71247E-02  2.55271E-02  3.77581E-03  9.45994E-03  4.78885E-02  5.00076E-03
 106 3.75235E-02  1.68585E-02  4.84111E-02  2.09854E-02  5.25757E-03  1.71768E-02  1.08422E-03  1.01694E-02
 107 0.00000E+00  1.94193E-02  7.38201E-02  2.95933E-02  6.18774E-03  2.46283E-02  1.52392E-02  4.71218E-04
 108 0.00000E+00  0.00000E+00  7.28056E-02  4.35513E-02  7.90975E-03  2.46076E-02  1.52575E-02  4.82963E-03
 109 0.00000E+00  0.00000E+00  0.00000E+00  3.49494E-02  1.11683E-02  4.03054E-02  2.30180E-02  4.48212E-03
 110 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  8.57803E-03  4.51250E-02  3.13106E-02  7.36659E-03
 111 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  3.34852E-02  3.02571E-02  9.00934E-03
 112 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  2.17270E-02  8.32392E-03
 113 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  5.86938E-03
 114 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
     PSN.  115 THRU PSN.  235 SAME AS ABOVE

PSN.   GRP. 17      GRP. 18      GRP. 19      GRP. 20      GRP. 21      GRP. 22      GRP. 23      GRP. 24
   1 2.75760E-06  2.57292E-06  2.33654E-06  2.07639E-06  1.74154E-06  1.35929E-06  1.26141E-06  1.23057E-06
   2 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
   3 2.14645E+00  2.18759E+00  2.24249E+00  2.30544E+00  2.39129E+00  2.50685E+00  2.62507E+00  2.70117E+00
   4 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
   5 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
   6 2.75760E-06  2.57292E-06  2.33654E-06  2.07639E-06  1.74154E-06  1.35929E-06  1.26141E-06  1.23057E-06
   7 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
   8 2.14645E+00  2.18759E+00  2.24250E+00  2.30544E+00  2.39129E+00  2.50686E+00  2.62507E+00  2.70117E+00
   9 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00
     PSN.   10 THRU PSN.   97 SAME AS ABOVE
  98 1.43158E-01  1.37889E-01  2.45031E-01  2.00771E-01  4.13454E-01  4.25920E-01  4.90315E-01  1.30319E-01
  99 2.53209E-01  2.46490E-01  4.39389E-01  3.48751E-01  7.48002E-01  7.18990E-01  8.06330E-01  2.07692E-01
 100 1.68565E-01  2.10570E-01  4.03936E-01  3.00714E-01  6.24776E-01  5.53053E-01  6.18998E-01  1.72449E-01
 101 2.44479E-02  1.46688E-01  3.29283E-01  2.72548E-01  5.70776E-01  5.21365E-01  5.38374E-01  1.27566E-01
 102 0.00000E+00  6.78876E-03  2.21674E-01  2.41102E-01  5.15571E-01  4.55181E-01  4.59377E-01  1.17914E-01
 103 0.00000E+00  0.00000E+00  0.00000E+00  1.23784E-01  4.53914E-01  4.37223E-01  2.83632E-01  3.94091E-02
 104 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  1.33603E-01  2.90299E-01  1.27513E-01  0.00000E+00
 105 0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  0.00000E+00  7.88491E-03  4.02071E-03  0.00000E+00
```

```
THE LIBRARY CONTENTS ARE
  NOG    ITL  ICT     ID                 TITLE
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7. FIDO (ANISN) INPUT SYSTEM

The FIDO (Flexible Input Data Option) input method is designed to allow the entering or modifying of large data arrays with minimum effort. Special advantage is taken of patterns of repetition or symmetry wherever possible. The FIDO system was patterned after the input method used with the FLOCO coding system at Los Alamos and was first applied to the DTF-II code. Since that time, numerous features requested by users have been added, a free-field option has been developed, and the application of FIDO has spread to innumerable codes.

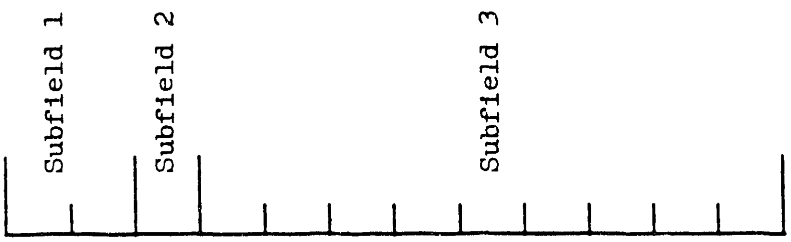
The data are entered in units called "arrays." An array comprises a group of contiguous storage locations which are to be filled with data at one time. In the AMPX input instructions (Sect. 3.INSTRUCTIONS), the number of entries in each array is denoted within [ ]'s. The arrays usually correspond on a one-to-one basis with FORTRAN arrays used in the program. A group of one or more arrays read with a single call to the FIDO package forms a "block," and the special delimiter, "T," is required to signify the end of each block. Arrays within a block may be read in any order with respect to each other, but an array belonging to one block must not be shifted to another. The same array can be filled with "0" using a special option, and then a few scattered locations could be changed by reading in a new set of data for that array. If no entries to the arrays in a block are required, the delimiter alone satisfies the input requirement.

To facilitate data preparation, many "default" data values have been programmed into the AMPX modules. Where such values exist, the values are denoted in Sect. 3.INSTRUCTIONS within ( )'s. The user can always override the "default" value by entering a data value in the appropriate array.

Three major types of input are available: fixed-field input, free-field input, and user-field input.

7.FIDO.1 FIXED-FIELD INPUT

Each card is divided into six 12-column data fields, each of which is divided into three subfields. The following sketch illustrates a typical data field. The three subfields always comprise 2, 1, and 9 columns, respectively.



To begin the first array of a block, an *array originator field* is placed in any field on a card:

Subfield 1: An integer *array identifier* < 100 specifying the data array to be read in
Subfield 2: An *array-type indicator*:
"$" if the array is integer data
"*" if the array is real data
Subfield 3: Blank

Data are then placed in successive fields until the required number of entries has been satisfied. A sample data sheet, shown on the next page, illustrates this input.

In entering data, it is convenient to think of an "index" or "pointer" that is under control of the user, and which specifies the position in the array into which the next data entry is to go. The pointer is always positioned at array location No. 1 by entering the array originator field. The pointer subsequently moves according to the data operator chosen. Blank fields are a special case in that they do not cause any data modification and do not move the pointer.

A *data field* has the following form:

Subfield 1: The *data numerator*, an integer <100. We refer to this entry as N_1 in the following discussion.
Subfield 2: One of the special *data operators* listed below.
Subfield 3: A nine-character *data entry*, to be read in F9.0 format. It will be converted to an integer if the array is a "$" array or if a special array operator such as Q is being used. Note that an exponent is permissible but not required. Likewise, a decimal is permissible but not required. If no decimal is supplied it is assumed to be immediately to the left of the exponent, if any, and otherwise to the right of the last column. This entry is referred to as N_3 in the following discussion.

A list of data operators and their effect on the array being input follows:

The data operator field is blank when one wants to make a single entry of data. The data entry in the third subfield is entered in the location indicated by the pointer, and the pointer is advanced by one. If the data portion in N_3 is blank, the field is ignored.

A "+" or "−" indicates exponentiation. The data entry in the third field is multiplied by $10^{\pm N_1}$, where N_1 is the data numerator in the first subfield, and the sign is in the data operator field. The pointer advances by one. In cases where an exponent is needed, this option allows the entering of more significant figures than the blank option.

Note that the use of "&" for a "+" is no longer allowed.

An "R" indicates that the data entry is to be repeated N_1 times. The pointer advances by N_1.

Name General Example of Fido Input Charge Date Page

			IDENTIFICATION	REMARKS (DO NOT PUNCH)
1	1 $			Begin the 1$ array, fixed-field, integral
13		1		Enter 1
25	F	2		Fill array with 2
37	2 *			Begin the 2* array, fixed-field, real
49		1 . 2 3 4		Enter 1.234
61		1 2 . 3 4 - 1	1 0	" "
1	5 -	1 2 3 4 + 0 2		" "
13	3 -	1 2 3 4		" "
25		7		" 7.0
37				A blank field is always ignored
49	T			Terminate this block
61			2 0	No entries may follow T on a card
1	3 *			Begin 3* array, fixed-field real
13	9 I	0		Enter 0,1,2,3,4,5,6,7,8,9,10,10,10
25	3 R	1 0		as real numbers
37	3 * *	1 0 S 1 0		Repeat 3* in free-field, skip
49	1 1	1 2		to 11th entry, correct sequence to
61			3 0	----9,10,11,12
1	4 * *	2 I 1 4 . 0		Begin 4* array, free-field, real
13	2 Q 4			Enter 1,2,3,4, 1,2,3,4, 1,2,3,4
25		E		End reading this array; remainder of array unchanged.
37		T		Terminate this block
49				
61			4 0	

R - REPEAT I - INTERPOLATE S - SKIP T - TERMINATE

An "I" indicates linear interpolation. The data numerator, N_1, indicates the number of interpolated points to be supplied. The data entry in the third subfield is entered, followed by N_1 interpolated entries equally spaced between that value and the data entry found in the third subfield of the next nonblank field. The pointer is advanced by $N_1 + 1$. The field following an "I" field is then processed normally, according to its own data operator. The "I" entry is especially valuable for specifying a spatial mesh. In "$" arrays, interpolated values will be rounded to the nearest integer.

An "L" indicates logarithmic interpolation. The effect is the same as that of "I," except that the resulting data are evenly separated in log-space. This method is especially convenient for specifying energy meshes that use equal lethargy bins.

A "Q" is used to repeat sequences of numbers. The length of the sequence is given by the third subfield, N_3. The sequence of N_3 entries is to be repeated N_1 times. The pointer advances by N_1*N_3. If either N_1 or N_3 is 0, then a sequence of $N_1 + N_3$ is repeated one time only, and the pointer advances by $N_1 + N_3$. This feature is especially valuable for geometry specification.

The "N" option has the same effect as the "Q," except that the order of the sequence is reversed each time it is entered. This feature is valuable for the type of symmetry possessed by S_n quadrature coefficients.

An "M" has the same effect as "N," except that the sign of each entry in the sequence is reversed each time the sequence is entered. For example, the entries

1 2 3 2M2

would be equivalent to

1 2 3 −3 −2 2 3.

This option is also useful in entering quadrature coefficients.

A "Z" causes $N_1 + N_3$ locations to be set to 0. The pointer is advanced by $N_1 + N_3$.

A "C" causes the position of the last array item entered to be printed. This is the position of the pointer, less 1. The pointer is not moved.

An "O" causes the print trigger to be changed. The trigger is originally off. Successive "O" fields turn it on and off alternately. When the trigger is on, each card image is listed as it is read.

An "S" indicates that the pointer is to skip N_1 positions leaving those array positions unchanged. If the third subfield is blank, the pointer is advanced by N_1. If the third subfield is nonblank that data entry is entered following the skip, and the pointer is advanced by $N_1 + 1$.

An "A" moves the pointer to the position, N_3, specified in the third subfield.

An "F" fills the remainder of the array with the datum entered in the third subfield.

An "E" skips over the remainder of the array. The array length criterion is always satisfied by an E, no matter how many entries have been specified. No more entries to an array may be given following an "E," except that data entry may be restarted with an "A."

The reading of data to an array is terminated when a new array origin field is supplied or when the block is terminated. If an incorrect number of positions has been filled, an error edit is given, and a flag is set which will later abort execution of the problem. FIDO then continues with the next array if an array origin was read. Otherwise, it returns control to the calling program.

A *block termination* consists of a field having "T" in the second subfield. All entries following "T" on a card are ignored, and control is returned from FIDO to the calling program.

Comment cards can be entered within a block by placing an apostrophe (') in column 1. Then columns 2–80 will be listed, with column 2 being used for printer carriage control. Such cards have no effect on the data array or pointer.

7.FIDO.2 FREE-FIELD INPUT

With free-field input, data are written without fixed restrictions as to field and subfield size and positioning on the card. The options used with fixed-field input are available, although some are slightly restricted in form. Data arrays using fixed- and free-field input can be intermingled at will within a given block.

In general, the free-field form of input is much easier to use and to read.

The concept of three subfields per field is still applicable to free-field input, but if no entry for a field is required, no reserve space is needed. Only columns 1–72 may be used, as with fixed-field input.

The *array originator field* can begin in any position. The array identifiers and type indicators are used as a fixed-field input. The type indicator is entered twice, to designate free-field input (i.e., "$$" or "**"). The blank third subfield required in fixed-field input is not required. For example:

31**

indicates that array 31, a real-data array, will follow in free-field format. A "##" type indicator can be used to input real double-precision arrays.

Data fields may follow the array origin field immediately. The data field entries are identical to the fixed-field entries with the following restrictions:

1. Any number of blanks may separate fields, but at least one blank must follow a third subfield entry if one is used.
2. If both first- and second-subfield entries are used, no blanks may separate them (i.e., 24S, but not 24 S).
3. Numbers written with exponents must not have imbedded blanks (i.e., 0.0E+4, 1.0E4, or even 1+4, but not 1.0 E4).
4. In third-subfield data entries, only 9 digits, including the decimal but not including the exponent field, can be used (i.e., 123456.89E07, but not 123456.789E07).
5. The Z entry must be of the form 738Z, not Z738, or 738 Z.
6. The + or − data operators are not needed and are not available.
7. The Q, N, and M entries are restricted: 3Q4, 1N4, or M4, but not 4Q, 4N, or 4M.

7.FIDO.3 USER-FIELD INPUT

If the user follows the array identifier in the array originator field with the character "U" or "V," the input format is to be specified by the user. If "U" is specified, the FORTRAN format to be used must be supplied in columns 1–72 of the next card. The format must be enclosed by the usual parentheses. Then the data for the entire array must follow on successive cards. The rules of ordinary FORTRAN input as to exponents, blanks, etc., apply. If the array data do not fill the last card, the remainder must be left blank.

A "V" has the same effect as a "U" except that the format read in the last preceding "U," array is used.

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