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THE NUCLEON-MESON TRANSPORT CODE NMTC

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OAK RIDGE NATIONAL LABORATORY
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Item 24. on page 27 should be corrected to read:

24. NABØV: The total number of intranuclear-cascade particles and evaporated neutrons and protons produced above the cutoff energies in a nuclear interaction.

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THE NUCLEON-MESON TRANSPORT CODE NMTC

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ACKNOWLEDGMENTS

The Nucleon-Meson Transport Code NMTC has evolved as the result of the contributions made by many individuals. The code NTC, written by W. E. Kinney, was used as a starting point for developing NMTC, and many of the concepts and techniques used in NTC are retained in NMTC. We deeply appreciate the cooperative attitude and advice of H. W. Bertini which allowed the incorporation of his intranuclear-cascade code into NMTC and the help of Mrs. Arline Culkowski in making some of the programming intricacies of the intranuclear-cascade code understandable. We also thank Mrs. Miriam Guthrie for helpful discussions related to her evaporation code which is used in NMTC. Discussions with D. C. Irving concerning his general geometry routines and modifications required to make the O5R code applicable for present purposes are gratefully acknowledged.

The NMTC code has been developed under the guidance of R. G. Alsmiller, Jr. His counsel has been invaluable, and many of his ideas are contained in the code.

Miss Barbara Bishop and Mrs. Kay Chandler assisted in running the sample problem.

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ABSTRACT

The nucleon-meson transport code NMTC computes the transport of nucleons below 3.5 GeV and muons and charged pions below 2.5 GeV. Monte Carlo methods are employed to provide a detailed description of the transport process. High-energy nucleon-nucleus and pion-nucleus collisions are treated using the intranuclear-cascade-evaporation model. Virtually arbitrary geometries can be specified. The code is written in FORTRAN IV for the IBM 360/75 and IBM 360/91 computers.

In this report, the method of calculation used by the code is discussed, and the code input is described. Also, input and output for a sample problem are given.

I. INTRODUCTION

The nucleon-meson transport code NMTC computes the transport of nucleons below 3.5 GeV and muons and charged pions below 2.5 GeV. Monte Carlo methods are employed to provide a detailed description of the transport process. Virtually arbitrary geometries can be specified. The code is written in FORTRAN IV for the IBM 360/75 and IBM 360/91 computers.*†

NMTC consists of two basic transport codes: NMT and a modified version of O5R.[1] NMT transports particles in the energy range from the source particle energy down to a specified cutoff energy which, for nucleons, is usually chosen between 15 and 50 MeV. Neutrons produced in NMT below the cutoff energy are transported via the O5R code.** Charged particles are not transported below the NMT cutoff energy.

The source-particle description for NMT is specified in a user-written subroutine. The source particles may be protons, neutrons, charged pions, or muons. Arbitrary energy, direction, and spatial distributions for the source particles may be used, provided that the maximum energy does not exceed 3.5 GeV for nucleons and 2.5 GeV for muons and charged pions.

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*Two assembly language subroutines are used: LØC(X), which returns the absolute memory address of X, and FLRAN(R), which returns a random number R uniformly distributed from 0 to 1.

†Available memory on these machines varies with the local installation. Since NMTC has an approximate minimum storage requirement of 575,000 bytes, it may exceed the available memory on some 360/75 machines.

**Since NMT provides a complete description of the low-energy neutron source, the O5R code may be replaced rather easily for most problems by some other means of low-energy neutron transport.

The output from NMT normally consists of two reels of magnetic tape. One tape contains a complete description of each neutron produced below the NMT cutoff energy, and this tape is used as the low-energy neutron source input for O5R. The other tape, known as the nucleon-pion history tape, contains a series description of each "event" (nuclear interaction, geometry boundary crossing, pion decay, etc.) which occurred during the transport calculation. Creating such a history tape has the advantage of allowing repeated and various analyses of the same transport data. Results of interest for a particular problem are obtained by reading and processing the transport data stored on the history tape. Such analysis programs are not a part of the NMTC code and must therefore be written by the user. The O5R code also produces a history tape, and results of interest for the low-energy neutron transport are also obtained by a user-written analysis code.

In NMT, muons are transported in a separate calculation from nucleon and pion transport. The muon source description may either be specified by the user or obtained from the pion-decay data available on a previously generated nucleon-pion history tape.

The manner in which NMTC treats various physical processes in the transport calculation is described briefly in Sec. 2.* The description of nonelastic collision products in NMT is obtained using the intranuclear-cascade-evaporation model of nuclear interactions. At each nuclear interaction, an intranuclear-cascade and evaporation calculation is performed to obtain the energy and direction of the emitted nucleons and pions. Consequently, a unique feature of the code is that differential cross sections

*The method of calculation used in an earlier version of NMTC has previously been published.[2]

for nucleon and pion production from nucleon-nucleus and pion-nucleus nonelastic collisions are not required as input since they are, in effect, computed in the course of the transport calculation.

In Sec. 3, the input preparation for NMTC is discussed, and several auxiliary programs for use with NMTC are described.

In Sec. 4, a sample problem is given to illustrate the input required and the output produced by NMTC. Input and output for analysis routines written for the sample problem are also given.

2. METHOD OF CALCULATION

2.1 Charged-Particle Energy Loss

The energy loss of protons, charged pions, and muons by the excitation and ionization of atomic electrons is treated using the continuous slowing-down approximation. Thus, range straggling and angular deflections resulting from the stochastic nature of the multiple-scattering process are not taken into account. An approximate expression for the density-effect correction is used.[3]

The code computes proton range-energy tables for each material in the system. These same tables are used for muons and charged pions by making use of scaling relations.[4]

2.2 Nucleon-Nucleus and Pion-Nucleus Nonelastic Collisions

The intranuclear-cascade-evaporation model of nuclear interactions is employed to obtain the energy and direction of nucleons and pions produced in nucleon-nucleus and pion-nucleus collisions at energies above the NMT cutoff. At each nonelastic collision, an intranuclear-cascade calculation is performed using a subprogram version of Bertini's medium-energy intranuclear-cascade code.[5*] The intranuclear-cascade model used assumes that a nonelastic interaction with a nucleus may be described in terms of particle-particle collisions occurring within the nucleus and that the kinematics of these collisions are not influenced by the remaining nucleon population. Spatial variations of the energy distribution, number density, and potential of the nucleons inside the nucleus are taken into account.

*The particular version of the intranuclear-cascade code used in NMT is that designated as MECC-2 by Bertini. The only difference between the MECC-2 version used here and the MECC-3 version described by Bertini in Ref. 5 is in the options available for cutoff energies used in the intranuclear-cascade calculation.

Experimental data for free particle-particle cross sections are used in tracking particles within the nucleus. The intranuclear-cascade products are comprised of an excited residual nucleus and emitted protons, neutrons, and π^+-, π^--, and π^0-mesons.

Pion production in the intranuclear-cascade calculation is based on the isobar model of Sternheimer and Lindenbaum.[6] Only single- and double-pion production in nucleon-nucleon collisions and single-pion production in pion-nucleon collisions are accounted for. Since the practical thresholds for ternary-pion production by nucleons and double-pion production by pions are about 3.5 GeV and 2.5 GeV, respectively, the pion-production model presently used limits the maximum nucleon and pion energies that may be considered in NMT.

At present, very little data are available on the isobar angular distributions. In NMT, an option is provided whereby the scattering angle of all isobars in the center-of-mass system is selected from one of three distributions: isotropic, directly forward and backward (with equal probability), and 50% isotropic and 50% forward-backward. Based on the recent work of Bertini,[5] the last option is currently recommended.

The evaporation portion of the intranuclear-cascade-evaporation calculation is carried out using a subprogram version of Guthrie's evaporation code.[7]* This code provides the energy and direction of evaporated neutrons, protons, deuterons, tritons, ^{3}He's, and alpha particles, as well as the excitation and kinetic energy of the recoiling residual nucleus.

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*The particular version of the evaporation code used in NMT is designated EVAP-4 by Guthrie.

Nucleon and pion nonelastic collisions with hydrogen nuclei are treated in NMT using the same isobar model as used in the intranuclear-cascade calculations.

Below the NMT cutoff energies, proton-nucleus and pion-nucleus collisions (except for π^- capture at rest) are neglected. Particle production from neutron-nucleus nonelastic collisions in O5R is obtained using the same evaporation code as used in NMT in conjunction with experimental cross-section data on the O5R/NMTC master cross-section tape.*

2.3 Nucleon-Nucleus and Pion-Nucleus Elastic Collisions

The elastic collisions of protons and pions with all nuclei other than hydrogen are neglected. The inclusion of elastic collisions by neutrons with nuclei other than hydrogen is an input option in NMT since, in some instances, these collisions can be neglected without introducing appreciable error. If these elastic collisions are included, then NMT requires as input the appropriate elastic-scattering cross sections.**

The differential cross sections for the elastic collisions of nucleons and pions with hydrogen nuclei in NMT are taken from experimental data and are the same as those used in the intranuclear-cascade calculations.[5]

The elastic collisions of neutrons in O5R are treated using cross sections given on the O5R/NMTC master tape.

*The data contained on the O5R/NMTC master cross-section tape are given in Sec. 3.2.5.

**A method of obtaining the elastic-scattering cross sections needed by NMT for those elements contained on the O5R/NMTC master cross-section tape is discussed in Sec. 3.1.3.

2.4 Charged-Pion Decay in Flight

Charged pions are unstable and may decay into muons and neutrinos. Charged-pion decay in flight is taken into account using the known pion lifetime. The energy and angular distribution of the muon is obtained by assuming that the pion decay is isotropic in the rest frame of the pion and by using the Lorentz transformation to transform the distribution from the pion rest frame into the laboratory system. The neutrino produced is not considered.

2.5 Charged-Pion Decay and Capture at Rest

Positively charged pions which come to rest (i.e., reach the cutoff energy) are assumed to decay immediately into a positively charged muon and a neutrino, and the energy and angular distribution of the muon is obtained in the same manner as discussed above for pion decay in flight. Negatively charged pions which come to rest may either decay or be captured by a nucleus, depending on the material atom density. Accordingly, an option is provided in NMT as to the treatment of all π^--mesons reaching the cutoff energy. If decay is specified, all π^--mesons reaching the cutoff energy are assumed to decay immediately into negatively charged muons and neutrinos. If capture is selected, all π^--mesons reaching the cutoff energy are forced to undergo nuclear capture, and the energy and angular distribution of the particles produced as a result of this capture is obtained using the intranuclear-cascade-evaporation model. It has previously been shown that this model describes the π^--capture process quite well.[8]

2.6 Neutral-Pion Decay

The neutral pion is very unstable and for practical purposes may be assumed to decay into two photons at its point of origin. Accordingly, NMT does not transport neutral pions, although the energy, direction, and spatial point of the neutral pions produced are written on the nucleon-pion history tape.

2.7 Muon Decay in Flight and at Rest

Muons are unstable and will decay into electrons or positrons, depending on the charge of the muons, and into neutrinos. Muon decay in flight is taken into account using the known muon lifetime, and muons which come to rest are assumed to decay immediately. No information for the electrons, positrons, or neutrinos from muon decay is calculated.

2.8 NMT Cutoff Energies

The cutoff energies for proton and neutron transport in NMT are input variables. The cutoff energy for charged pions is calculated in NMT and is equal to the proton cutoff multiplied by the ratio of the charged-pion rest mass to the proton rest mass. Likewise, the cutoff energy for muons is calculated internally from the proton cutoff and is equal to the proton cutoff times the ratio of the muon rest mass to the proton rest mass. This fixed relationship for the charged-particle cutoff energies is a consequence of using the same range-energy tables for all charged particles.

Input values for the neutron and proton cutoff energies are usually taken to be in the 15- to 50-MeV region since below this energy region the residual range of charged particles is very short, and, in general, the intranuclear-cascade-evaporation model becomes inapplicable. The NMT cutoff energy for neutrons corresponds to the energy at which a transition is made from the treatment of nonelastic collisions by the intranuclear-cascade evaporation model to the treatment of nonelastic collisions by the evaporation model. The most appropriate value for this transition energy is not well defined. However, the work of Alsmiller and Hermann[9] indicate that, for the cases they considered, at $\sim$ 15 MeV the intranuclear-cascade-evaporation model is to be preferred over the evaporation model.

2.9 Pseudo Collisions in NMT

NMT provides an option as to whether or not records describing "pseudo" collisions which occur during the transport calculation are to be written on the history tape. These pseudo collisions arise as a consequence of the sampling schemes used to determine intercollision distances and the particular type of collision once a collision has occured.* To give a very simplified description of these sampling schemes, let $\Sigma(E)$ be the actual macroscopic cross section for a particular type of collision by a particle with energy E and let Σ_M be a maximum cross section for this type of collision such that $\Sigma_M \geq \Sigma(E)$ for all E. The pseudo cross section for this type of collision is then defined by $\Sigma_P(E) = \Sigma_M - \Sigma(E)$. Tentative collisions are selected using Σ_m and then a rejection technique is used to determine if this tentative collision is a real or pseudo collision. Thus, a tentative collision will be real with probability $\Sigma(E)/\Sigma_M$ and pseudo with probability $\Sigma_P(E)/\Sigma_M$. In the case of pseudo collisions, the direction and energy of the particle are unaltered. The types of collisions referred to here include not only nuclear collisions but also decay "collisions" by muons and charged pions.

*An exposition of the basic sampling procedures used in NMT has been given by Coleman.[10]

To improve estimates of the muon source that results from pion decay, NMT does not allow pion decay (or muon decay) to occur explicitly. Instead, the statistical weight of the pion (or muon) is multiplied by the nondecay probability at each collision. Thus, a contribution to the muon source is made at both real and pseudo collisions. It follows that in a nucleon-pion calculation pseudo-collision records must be written if muon-source data are to be read from the nucleon-pion history tape.

Pseudo collisions by nucleons are usually not needed for analysis purposes. An example of an exception is the case where particle fluxes are to be calculated from collision densities.

If pseudo collisions are not needed for subsequent analysis or muon transport, then it is better that they not be written since pseudo-collision information can occupy an appreciable portion of the history tape.

3. INPUT DESCRIPTION AND CODE OPERATION

3.1 NMT

3.1.1 NMT Input Description

The order of the input for NMT is as follows:

1. The primary NMT input data (described in Sec. 3.1.1.1).
2. Elastic scattering input data, if any (described in Sec. 3.1.1.2).
3. The geometry input data (described in Sec. 3.1.1.3).
4. Any input required by subroutine SØRS (described in Sec. 3.1.2).

3.1.1.1 Primary NMT Input

A description of the cards composing the primary NMT input data is listed below:

Cards A and B: FØRMAT (20A4)

80 columns each of Hollerith identification for the printed output.

Card C: FØRMAT (3Z4)

RANDØM: Hexadecimal representation of initial random number to be used in the generation of random numbers. Should be positive and end in 1, 3, or 5.

Card D: FØRMAT (E10.4 [a], E10.4 [b], E10.4 [c], I10 [d], I10 [e], I10 [f], I10 [g])

a. EMAX: The maximum energy of particles being transported in MeV. EMAX should be less than 3500 for source nucleons and less than 2500 for source pions. For source muons EMAX is arbitrary. However, if source muon data are to be obtained from a previously produced nucleon-pion history tape, then by conservation of energy EMAX should not be less than $E_{\pi,max} + m_{\pi} - m_{\mu} = E_{\pi,max} + 33$, where $E_{\pi,max}$ is the value of EMAX which was input for the nucleon-pion calculation, m_π is the charged-pion rest mass, and m_μ is the muon rest mass.

b. ELØP: The cutoff energy in MeV for transporting protons. The code computes the cutoff energy for pions as (pion rest mass/proton rest mass) × ELØP = 0.1488 × ELØP, and for muons as (muon rest mass/proton rest mass) × ELØP = 0.1129 × ELØP.

c. ELØN: The cutoff energy in MeV for transporting neutrons. Normally ELØN will be chosen equal to ELØP. For muon transport ELØN is irrelevant.

d. MXMAT: The number of different media, exclusive of voids, appearing in the system. $0 < \text{MXMAT} \le 16$.

e. MAXCAS: The number of source particles to be started in each batch.

f. MAXBCH: The number of batches to be run with the present set of input data. The total number of source particles initiated with the present input will be MAXCAS*MAXBCH. For muon transport using a previously produced nucleon-pion history tape, both MAXCAS and MAXBCH are calculated in subroutine MFPD; hence input values for these quantities are not used although they are written on the muon collision tape.

g. N1CØL: If N1CØL > 0, each cascade history will be computed only through the second generation, that is, only through the immediate descendants of source particles. If N1CØL ≤ 0, all generations will be computed. Normally N1CØL is input as 0 or left blank. N1CØL is irrelevant for muon transport.

Card E: FØRMAT ($\overset{a}{\text{I10}}$, $\overset{b}{\text{I10}}$, $\overset{c}{\text{I10}}$, $\overset{d}{\text{I10}}$, $\overset{e}{\text{I10}}$, $\overset{f}{\text{I10}}$)

a. NQUIT: The number of runs with the present set of input data. Normally NQUIT will be input as 1. At the end of each run, signaled by NCØL = -4 (see 3.1.4), subroutine USER(NCØL) is called. The standard version of this routine is a dummy. The user may provide his own version of USER to output specified variables or to change certain input quantities before the code calculates the next run, if any. In both cases, it will usually be necessary to include a labeled common called CØMØN (see page 58). USER is also called at the end of each batch.

b. NEUTP: If nucleons and pions are to be transported, NEUTP is the logical number for the tape on which descriptions of neutrons appearing below ELØN are written. If the transport is for muons and source muons are to be obtained from a previously produced nucleon-pion history tape, then NEUTP is the logical number of the nucleon-pion history tape.

c. NBERTP: The logical number of the tape containing the data needed in the intranuclear-cascade and evaporation calculations. If a calculation is to be made for muons, NBERTP should be input as 0.

d. NPØWR2: NGRØUP = $2^{NPØWR2}$. NGRØUP is the number of energy groups used in computing the range and energy tables. NPØWR2 $\leq$ 11. Normally a value of 10 or 11 should be input.

e. NPIDK: If NPIDK is positive, π^- mesons reaching the π energy cutoff (= .1488 ELØP) will be assumed to decay at the spatial point where the cutoff has been reached. For NPIDK $\leq$ 0, π^- mesons reaching their energy cutoff will be forced to interact via the intranuclear-cascade subroutine. NPIDK is irrelevant for muon transport.

f. NHSTP: The logical tape number of the nucleon-pion or muon history tape. If NHSTP is input as 0, it is assumed that the user will not write a history tape but will provide his own version of subroutine ANALYZ which normally writes the history tape.

Card F: FØRMAT (E10.4 [a], E10.4 [b], I10 [c], 20X, I10 [d])

All of the quantities on this card except NSEUDØ are irrelevant for muon transport.

a. ANDIT: A signal to indicate the assumed angular distribution of isobar states produced in nonelastic collisions with nucleons.

0.: distribution 50% isotropic, 50% forward-backward,

1.: all isotropic,

2.: all forward-backward.

Presently a value of 0. is recommended.

b. CTØFE: A signal to indicate the cutoff energy to be used in the intranuclear-cascade calculations. Normally CTØFE should be input as 0.

c. NEXITE: EX, the excitation of the residual nucleus immediately following an intranuclear cascade is determined by an energy balance involving the incident-particle kinetic energy, the escaping particle kinetic energies, and the average binding energy of the most loosely bound nucleon in the nucleus (taken as a constant = 7 MeV). EREC, the kinetic energy of the recoiling nucleus prior to evaporation, is computed from a momentum balance involving the incident and escaping-particle momenta. If NEXITE > 0, the code executes the FØRTRAN statement EX = EX - EREC, and this new value of EX is used as input to the evaporation calculation. If NEXITE $\leq$ 0, EREC is not subtracted from the value of EX that is computed initially. In this case, the values determined for EX will be conservatively high since the kinetic energy of the nucleus is not taken into account. Conversely, setting NEXITE > 0 will occasionally result in a negative value for EX since the scheme for calculating EX, and then EREC, does not yield a precise conservation of energy and momentum. When a negative value of EX occurs, the evaporation calculation is bypassed.

d. NSEUDØ: If NSEUDØ > 0, all pseudo collision records in all media, including internal voids, will be included on the history tape. For NSEUDO ≤ 0, all of these records will be excluded. A contribution to the muon source is made at <u>all</u> pion collisions. It follows that in a nucleon-pion calculation pseudo collision records should be written (NSEUDØ > 0) if muon source data are to be read from the nucleon-pion history tape.

Card G: FØRMAT (E10.3, I10, I10, I10) [fields a, b, c, d]

a. ELAS: The energy (MeV) above which elastic scattering of neutrons with nuclei other than hydrogen is ignored (≤ 100 MeV).

b. NØELAS: The total number (i.e., for all media) of different nuclide types for which elastic scattering is to be considered (excluding hydrogen).

c. NELSTP: The logical number of the BCD tape containing the elastic scattering data for NØELAS nuclides. If NELSTP is the logical number of the standard input, the code expects all of the elastic scattering data to be input on cards after the primary NMT input data and before the geometry input data.

d. NLEDIT: An elastic-scattering data edit signal:

= 0: no edit,

≠ 0: print an edit of all the elastic-scattering data on the standard output unit.

The following cards, H_M and $I_{M,1},\ldots, H_{M,NEL(M)}$ are input for each medium:

Card H_M: FØRMAT (E10.4, I10, I10) [a, b, c]

a. DENH(M): The density (atoms/cm^3) of hydrogen in medium M multiplied by 10^{-24}.

b. NEL(M): The number of nuclide types other than hydrogen in medium M. $1 \le$ NEL(M) ≤ 10.

c. NØEL(M): The number of nuclide types (other than hydrogen) for which elastic scattering is to be considered in medium M. $0 \le$ NØEL(M) $\le$ NEL(M).

Card(s) $I_{M,N}$: FØRMAT (E10.4, E10.4, E10.4, I10) [a, b, c, d]

a. ZZ(N,M): The charge number of the Nth nuclide in the Mth medium.

b. A(N,M): The mass number of the Nth nuclide in the Mth medium; A(N,M) > 1.

c. DEN(N,M): The atom density (atoms/cm^3) of the Nth nuclide other than hydrogen in the Mth medium multiplied by 10^{-24}.

d. ID(N,M): Identifier for the Nth elastic-scattering nuclide in the Mth medium. $0 \le$ ID(N,M) $\le$ NØELAS. ID specifies the position of the elastic-scattering data cards for nuclide (N,M) (cards J through Ø, described in Sec. 3.1.1.2) in the elastic-scattering input data.

The order of the $I_{M,N}$ cards for a given medium must be such that all nuclide types that are elastic scatterers are listed first; i.e., the first NØEL(M) nuclide types should be elastic scatterers with ID(N,M) > 0. If elastic scattering is not desired for a particular nuclide, then ID(N,M) for this nuclide should be 0. If elastic scattering is not used for any nuclide, then ELAS, NØELAS, NELSTP, NLEDIT, NØEL(M), and ID(N,M) should all be zero.

The media numbers selected must start at 1 and run consecutively through MXMAT.

The order of the H_M and $I_{M,N}$ cards is: H_1, $I_{1,1}$, $I_{1,2}$,..., $I_{1,NEL(1)}$, H_2, $I_{2,1}$, $I_{2,2}$,..., $I_{2,NEL(2)}$,..., H_{MXMAT}, $I_{MXMAT,1}$, $I_{MXMAT,2}$,..., $I_{MXMAT,NEL(MXMAT)}$.

3.1.1.2 Elastic-Scattering Input*

If so specified on cards G, H_M, and $I_{M,N}$ above, NMT will treat the elastic scattering of neutrons with nuclei other than hydrogen in the energy range from ELØN to ELAS. The neutron direction after scattering is chosen from the linearly anisotropic distribution $P(\mu) = (1 + 3f_1\mu)/2$, where μ is the cosine of the scattering angle. The elastic-scattering cross sections and f_1 values at various energy points from ELØN through ELAS are required as input by NMT.

The input format for the elastic-scattering data is given below. It will be assumed that NELSTP on Card G is specified as the logical number of the standard input so that card input is used for the elastic-scattering data.

*A method of obtaining elastic-scattering data from the O5R/NMTC master cross-section tape in the format required for NMT is given in Sec. 3.1.3.

Card J: FØRMAT (I5, I5, I5, I5, F10.5, 5A6)
(a: I5, b: I5, c: I5, d: I5, e: F10.5, f: 5A6)

a. IDT(1): Element identifier [conventionally, equal to (the charge number) × 1000 + (mass number), with mass number equal to zero for elements having natural isotopic composition].

b. IDT(2): Cross section identifier (conventionally, 2 for elastic-scattering cross sections, 71 for f_1 values).

c. IDT(3): May be left blank.

d. IDT(4): Number of following cards K which contain elastic-scattering cross sections.

e. FMAS: Atomic mass of element.

f. Thirty characters of Hollerith input.

The only number on Card J which is used internally by NMT is IDT(4); all other input is for identification purposes only.

Cards K: FØRMAT (E15.5, E15.5)
(a: E15.5, b: E15.5)

a. ES: Energy, in eV, for the elastic-scattering cross section.

b. SIGE: Elastic-scattering cross section, in barns, at energy ES.

Card L: Blank card.

Card M: This card has the same format as Card J and should contain the same information except that IDT(4) now refers to the number of Cards N containing f_1 values.

Cards N: FØRMAT (E15.5, E15.5)
(a: E15.5, b: E15.5)

a. EF: Energy, in eV, for the f_1 values.

b. F1: f_1 value at energy EF.

Card Ø: Blank card.

The series of K and N cards must be arranged in order of decreasing energy, and the highest energy value must be ≥ ELAS and the lowest value must be ≤ ELØN. There must be NØELAS sets of cards J through Ø, and the order of these sets must be correlated with ID(N,M) on card $I_{M,N}$. To illustrate, consider a material configuration containing two media with medium 1 composed of hydrogen, oxygen, and aluminum and medium 2 composed of oxygen and lead. Suppose that neutron elastic scattering is desired for all nuclides except lead and that oxygen is listed as the first nuclide on card $I_{M,N}$. Then NØELAS = 2, NØEL(1) = 2, ID(1,1) = 1, ID(2,1) = 2, NØEL(2) = 1, ID(1,2) = 1, and ID(2,2) = 0. Thus, the elastic-scattering data for oxygen would be input first and followed by the data for aluminum.

3.1.1.3 NMT Geometry Input

The geometry routines in NMT are identical to those used in O5R, and the geometry input is described in the O5R manual.[1] However, internal voids in NMT must be designated by medium number 6666 in the geometry input, whereas in the O5R geometry input internal voids are designated by medium number 1000. Particles in NMT may undergo pseudo collisions in medium 6666. The statistical weight of a pion or muon is reduced at these collisions to account for decay. For nucleons, the total cross section in medium 6666, which is equal to the pseudo cross section, is arbitrarily set equal to the maximum pion decay cross section.

3.1.2 Source-Particle Description

The source-particle data required by NMT are as follows:

E(1) = the source particle kinetic energy in MeV;

X(1) = the source particle x position coordinate in cm;

Y(1) = the source particle y position coordinate in cm;

Z(1) = the source particle z position coordinate in cm;

U(1) = the source particle x direction cosine;

V(1) = the source particle y direction cosine;

W(1) = the source particle z direction cosine;

WT(1) = the source particle statistical weight;

TIP(1)* = the source particle type:

0. = proton

1. = neutron

2. = π^+

3. = π^o

4. = π^-

5. = μ^+

6. = μ^-

The above source-particle data must be furnished in subroutine SØRS (NCØL), which is written by the user. SØRS is called when NCØL = -1 (start of run), NCØL = 1 (source particle), and NCØL = -4 (end of run). Any input required by SØRS should be read in when SØRS is called with NCØL = -1. Since the parameters E(1) through TIP(1) are stored in labeled common CØMØN, this common must be included in subroutine SØRS. A description of the variable list in common CØMØN can be obtained from

*The source-particle type should never be assigned a value of 3 since π^o particles are not transported in NMT.

the listing of subroutine SØRS used for the NMTC sample problem (Sec. 4).

In NMT muons are transported in a separate calculation from nucleons and pions. If NBERTP $\leq$ 0 (see Sec. 3.1.1.1), it is assumed that all particles are muons, whereas 0 < NBERTP indicates that all particles are either nucleons or pions. The user should choose values for TIP(1) that are in accordance with the value of NBERTP. When muon source data are to be read from a previously produced nucleon-pion history tape, subroutine SØRS (NCØL) should contain the FØRTRAN statement CALL MFPD(NCØL). Subroutine MFPD calls REDNMT (see Sec. 3.1.4) to read the nucleon-pion history tape and calculates parameters E(1) through TIP(1) for each source muon. It is assumed that muons are created from pion decay that occurs isotropically with respect to the pion at rest.

3.1.3 Obtaining NMT Elastic-Scattering Data: Program PUNCRØSS

One source of elastic-scattering data needed by NMT is the O5R/NMTC master cross-section tape. This tape contains elastic-scattering cross sections and f_1 values in the energy range of interest for a variety of elements.* The program PUNCRØSS is provided to read the master cross-section tape and to output on cards the elastic-scattering data needed by NMT. These output cards from PUNCRØSS have the same format as cards J through Ø described above and can be input direcly into NMT.

The program PUNCRØSS was obtained by modifying slightly the O5R auxiliary program PUNCHSIG. Whereas PUNCHSIG punches cross sections at all energy points present on the master tape for a specified element and cross-section type, PUNCRØSS punches only those cross sections in a specified energy range.

*A list of the elements for which cross sections are given on the O5R/NMTC master tape is given in Sec. 3.2.5.

The input description for PUNCRØSS is as follows:

Card A: FØRMAT ($\overset{a}{I5}$, $\overset{b}{I5}$)

a. MTAPE: Logical tape number of the master cross-section tape.

b. NTAPE: Logical number of the punch tape for card output.

Card B: FØRMAT ($\overset{a}{E10.4}$, $\overset{b}{E10.4}$)

a. ELØN: The lower energy limit (MeV) for which cross sections are desired. Normally, this energy should correspond to the neutron energy cutoff used in NMT (ELØN in NMT input).

b. ELAS: The upper energy limit (MeV) for which cross sections are desired.

The punched card output will contain cross sections in the energy range from the first energy point on the master tape below ELØN through the energy point on the master tape equal to (or the first above) energy ELAS.

Card(s) C: FØRMAT ($\overset{a}{I5}$, $\overset{b}{I5}$)

a. IDELM: Element identification number of cross sections to be punched.

b. IDSIG: Cross-section identification number of cross sections to be punched.

The conventions used for IDELM and IDSIG are given in Section 3.2.5. Card C must be repeated for each set of cross sections to be punched.

Card D: Blank card

Card D terminates the case for which cross sections are to be punched in the energy region specified by Card B. Cross sections in a different energy range may be obtained by repeating the set of Cards B, C,..., C, D. The order of the punched card output for a given cross-section set is the same as the order in which the cross sections are requested by Cards C.

The program terminates by reading the end-of-file on the standard input tape. The logical numbers for the standard input and output are set internally to 5 and 6, respectively.

The printed output from PUNCRØSS includes cross sections at all energy points on the master tape corresponding to IDELM and IDSIG. This is followed by the printed output for cross sections requested in the energy range from ELØN to ELAS.

3.1.4 NMT Analysis by History Tape

The standard version of NMT writes on tape a series description of individual events which constitute the cascade initiated by source particles. Creating such a history tape has the advantage of allowing repeated and various analyses of the same data. The particle events are characterized by event or "collision" parameters. When a history tape is to be created, the standard version of subroutine ANALYZ (NCØL) writes at least one binary FØRTRAN record per particle event. These records contain values for the following collision parameters:

1. NCØL: An integer identifying the type of "collision."

   NCØL: -4 End of run

   -3 End of batch

   -2 Not presently used

   -1 Start of run

   0 Not presently used

   1 Source-particle data

   2 Nuclear interaction (nonabsorption)

   3 A charged particle has slowed to its energy cutoff

4 Particle escape from system

5 Pseudo collision

6 Nuclear absorption

7 Internal medium boundary crossing

2. NØCAS: An integer identifying the current cascade.

3. NAME: An integer identifying the current particle within the current cascade.

4. MAT: An integer identifying the medium prior to the current event.

5. NMED: An integer identifying the medium of the current event. At an internal boundary crossing or an escape, MAT and NMED will identify the old and new media, respectively; at all other events, MAT and NMED will have the same value.

6. X
7. Y
8. Z

The position coordinates of the preceding event in cm.

9. XC
10. YC
11. ZC

The position coordinates of the current event in cm.

12. ØLDWT: The statistical weight of the particle before the event at (XC, YC, ZC).

13. WT: The statistical weight of the particle after the event at (XC, YC, ZC).

14. E: The kinetic energy of the particle at (X,Y,Z) in MeV.

15. EC: The kinetic energy of the particle at (XC,YC,ZC) in MeV.

16. U
17. V
18. W

(16.–18.) The x, y, and z direction cosines, respectively, of the particle at (XC,YC,ZC).

19. TIP: The particle type:

0 = proton

1 = neutron

2 = π^+

3 = π^o

4 = π^-

5 = μ^+

6 = μ^-

20. BØLD: A packed word giving the geometric block and zone location of (X,Y,Z).

21. BLZ: A packed word giving the geometric block and zone location of (XC,YC,ZC).

22. LELEM: An integer identifying the struck-nucleus type within a medium:

LELEM: -1 Hydrogen

0 The value given when a pseudo collision occurs

1, 2,... The nuclei types, excluding hydrogen, according to the order in which they are given in the input

23. NØPART: The number of intranuclear-cascade particles produced in a nuclear interaction; for pseudo collisions NØPART = -1.

24. NABØV: The total number of intranuclear-cascade particles and evaporated neutrons and protons produced above the cutoff energies in a nuclear interaction.

25. NBELØ: The total number of intranuclear-cascade particles produced below the cutoff energies in a nuclear interaction.

26. APR: The mass number A of the residual nucleus after intranuclear cascade and evaporation.

27. ZPR: The charge number Z of the residual nucleus after intranuclear cascade and evaporation.

28. EREC: The kinetic recoil energy of the residual nucleus after evaporation in MeV.

29. EX: The excitation energy of the compound nucleus prior to evaporation in MeV.

30. HEVSUM: The sum of the kinetic energies of all charged particles, other than protons, which are emitted during nuclear evaporation.

31. UU: The excitation of the residual nucleus after evaporation.

32. through 37. NPART(1) through NPART(6): The number of evaporated neutrons, protons, deuterons, tritons, ^{3}He's, and alphas, respectively.

For start of run, end of batch, and end-of-run "collisions," only NCØL is relevant, and parameters 2 through 37 are zero. For source "collisions" EC, XC, YC, and ZC are undefined; the energy and position of source particles are stored in E, X, Y, and Z. Parameters 26 through 37 are relevant only for NCØL = 2 or 6, and parameters 22-25 are relevant only for NCØL = 2, 5, or 6.

If a nuclear interaction occurs and NABØV is greater than zero, a record of the products having energies above cutoff is written containing:

NAMEA(I): The name of the product particle.

TIPA(I): The type of particle (see values for TIP).

EA(I): The kinetic energy of the particle in MeV.

UA(I), VA(I), WA(I): The x, y, and z direction cosines of the particle.

WTA(I): The statistical weight of the particle.

The index I runs from 1 through NABØV. An NABØV record is not written for pseudo collisions. At these collisions, the particle name, type, kinetic energy, and flight direction cosines are unaltered and are given by NAME, TIP, EC, U, V, and W, respectively. However, for pions and muons the statistical weight will be decreased so that WT < ØLDWT.

If NBELØ is greater than zero, a record of the products having energies below cutoff is written containing:

TIB(I): The type of particle (see values for TIP).

EB(I): The kinetic energy of the particle in MeV.

UB(I), VB(I), WB(I): The x, y, and z direction cosines of the particle.

WTB(I): The statistical weight of the particle.

The index I runs from 1 through NBELØ.

If NPART(J) is greater than zero, a record of evaporation products is written containing:

WTEVAP: The common statistical weight of the evaporated particles.

EPART(K,J): The energy of the Kth evaporated particle. The index K runs from 1 to NPART(J). A maximum of two records will be written corresponding to neutrons (J = 1) and protons (J = 2).

HEPART(K,L): The energy of the Kth evaporated particle of the Lth type. A maximum of four records will be written corresponding to deuterons (L = 1), tritons (L = 2), ^{3}He (L = 3), and alphas (L = 4).

Subroutine REDNMT is provided to read the history tape. The user's analysis program should call subroutine REDNMT to read each particle event on the tape. REDNMT stores collision parameters 1 through 37 and any NABØV, NBELØ, or NPART(J) data for the event into a labeled common called LABEL. The call statement for REDNMT is CALL REDNMT. There are no arguments in the call statement since all communication between REDNMT and the user's analysis program is through LABEL. The user's analysis program must set NHST (the logical number of the history tape to be read) and IØ (the logical number of the tape for printed output) before the first call to REDNMT.*

*REDNMT increments the logical number of the history tape (NHST) each time an end-of-tape (or end-of-file) marker is read. Whether or not this marker is detected by the program depends upon the manner in which the local operating system handles multireel data sets. For the ORNL operating system, the end-of-tape marker is not detected by the program so that NHST is unchanged irrespective of the number of tapes to be analyzed.

Common LABEL should appear in the user's NMT analysis program as:

```
CØMMØN/LABEL/NHST,N,IN,IØ,NCØL,NØCAS,NAME,MAT,NMED,LELEM,NØPART,
NABØV,NBELØ,MAXBCH,MAXCAS,MXMAT,NGRØUP,NPIDK,N1CØL,NQUIT,NEXCT,
NPART(6),NEL(8),NAMEA(40),X,Y,Z,XC,YC,ZC,ØLDWT,WT,E,EC,U,V,W,TIP,
APR,ZPR,EREC,EX,HEVSUM,UU,EMAX,WTEVAP,ZZ(10,16),A(10,16),SIGG(10,17),
SIGMX(7,17),HSIGG(5,17),TIPA(40),EA(40),UA(40),VA(40),WA(40),WTA(40),
TIB(40),EB(40),UB(40),VB(40),WB(40),WTB(40),EPART(100,2),EMIN(7),
BØLD,BLZ,HEPART(100,4)
```

Most of the variables in LABEL have been defined previously in the NMT input description (Sec. 3.1.1.1) or in this section; the others are defined below:

N: Value of NBERTP used in NMT input.

IN: Not used by REDNMT.

SIGG,SIGMX,HSIGG: Cross sections which are used by NMT and are written on the history tape.

EMIN(I): The cutoff energy in MeV used by NMT in transporting particles of type I. I = 1,...,7 corresponds to protons, neutrons, π^+, π^0, π^-, μ^+, and μ^-, respectively. [EMIN(4) will be 0. as NMT does not transport neutral pions.]

The above variables (N, SIGG, SIGMX, GSIGG, and EMIN), as well as most of the NMT input data, are written on the history tape at the start of run and are read and printed on IØ by REDNMT.

3.1.5 Analysis During Transport Calculation

One may choose not to write a history tape, in which case the user must replace the standard version of subroutine ANALYZ(NCØL) with his own version. Pertinent information is then obtained via the nonstandard subroutine ANALYZ (NCØL) during the NMT transport calculation. ANALYZ(NCØL) is called by the main program in NMT, and the particular event type is indicated by the value of NCØL. Collision parameters are stored in common CØMØN.

3.1.6 Program ENMT

An NMT history tape may be edited using the program ENMT. This program prints all of the collision parameters for each particle event. The output of ENMT is useful for uncovering analysis program errors and will often provide the user with a better understanding of how NMT operates.

The input description for this program is as follows:

Card A: (I10, I10, I10, I10, I10) (fields labelled a, b, c, d, e)

a. NHSTP: The logical number of the history tape.

b. NBCH1: The batch number in which editing will begin, NBCH1 ≥ 1.

c. NCAS1: The cascade number (within NBCH1) at which editing will begin, NCAS1 ≥ 1.

d. NBCH2: The batch number in which editing will terminate, NBCH2 ≥ 1.

e. NCAS2: The cascade number (within NBCH2) at which editing will terminate. If NCAS2 is input as zero, an edit will be obtained through the last cascade in NBCH2.

ENMT consists of a main program and subroutine REDNMT.

3.2 O5R

3.2.1 Modifications to the standard version of O5R*

The standard O5R routines BANKR, GETNC, INELAS, MAIN, MSØUR, and ØUTPT have been modified for the NMTC version of O5R. Also, subroutines DRES, QVAL, DØST, ENERGY, and DN2N have been added to the standard version. Subroutine MSØUR has been modified to read source neutron data from the neutron tape generated by NMT.

3.2.2 O5R Input

The order of the input for the NMTC version of O5R is as follows:

1. Input required by the standard version of O5R, which is described in the O5R manual.[1] (Since the NMTC version of reads the neutron source data from the neutron tape generated by NMT, all source parameters on Card G of the standard input may be left blank.)
2. A card giving the logical number of the neutron source tape (FØRMAT I5). This is the NEUTP tape generated by NMT.
3. Input for subroutine INELAS (described in Sec. 3.2.3).

3.2.3 Nonelastic Collisions in the NMTC Version of O5R

The treatment of nonelastic collisions in O5R is left to the discretion of the user. The description of nonelastic collision products is computed in subroutine INELAS. In the NMTC version of O5R, nonelastic collisions with nuclides other than D and ^{9}Be are treated using compound nucleus formation followed by nuclear evaporation. To accomplish the evaporation,

*The standard version of O5R is considered here to be the version presently available for distribution by the Radiation Shielding Information Center, Oak Ridge National Laboratory, Oak Ridge, Tennessee, 37830.

INELAS calls subroutine DRES, which is a subroutine version of the EVAP-4 evaporation code.[*7] Nonelastic collisions with deuterium are treated using the scheme suggested by Kalos, Goldstein, and Ray,[11] in which it is assumed that the momenta of secondaries are uniformly distributed in the center-of-mass system. For beryllium, the nonelastic process is assumed to be entirely (n,2n) with both neutrons being emitted isotropically in the laboratory system. The energy spectra of these neutrons are obtained from the data of Buckingham, Parker, and Pendlebury.[12]

The input for INELAS is as follows:

Card A: FØRMAT ($\overset{a}{\text{I5}}$)

a. NBT: The logical number of the tape containing the data for the evaporation calculations. This is the same as the NBERTP tape used by NMT. INELAS reads over the intranuclear-cascade data and then reads in the evaporation data.

The evaporation data are the same as those described in ref. 7. If ^{9}Be and/or D are the only materials used, then NBT should be input ≤ 0 and no tape supplied.

Card B_M: FØRMAT ($\overset{a}{\text{I5}}$, $\overset{b}{\text{I5}}$)

a. MXEL(M): The number of inelastic scatterers in medium M.

b. LD(M): The number of elastic scatterers in medium M.

---

*The DRES subroutine is also used for evaporation in NMT and is identical to the O5R DRES except for one labeled common.

Card $C_{M,K}$: FØRMAT (E10.0, E10.0) [a, b]

a. ZNØ(K,M): The charge number of the target nucleus for the Kth inelastic scatterer in medium M.

b. ANØ(K,M): The mass number of the target nucleus for the Kth inelastic scatterer in medium M.

M must be ≤ 16 and K must be ≤ 8. The order of the inelastic scatterers in a given medium must be the same as the order used in generating the systems data tape.

3.2.4 Cross-Section Requirements for the NMTC Version of 05R

Some care must be exercised in specifying the cross-section input to the NMTC version of 05R so that the nonelastic subroutine INELAS is called with the proper probability. Since 05R does not allow low-energy neutron absorption to occur explicitly, the neutron weight is reduced at each collision site by the nonabsorption probability. Consequently, subroutine INELAS should be called with probability $(\Sigma_{nonel} - \Sigma_a)/\Sigma_t$, where Σ_{nonel} is the nonelastic cross section, Σ_a is the cross section for low-energy neutron absorption, and Σ_t is the total cross section. In the context of the cross-section nomenclature used in the 05R manual,[1] $(\Sigma_{nonel} - \Sigma_a)$ takes on the same meaning as the "inelastic" cross section and the "scattering" cross section corresponds to $\Sigma_s = \Sigma_{el} + \Sigma_{nonel} - \Sigma_a$, where Σ_{el} is the cross section for elastic scattering. The formal definition of the total cross section is unchanged $(\Sigma_t = \Sigma_s + \Sigma_a)$.

For most elements the low-energy neutron absorption is due entirely to radiative capture. There are, however, notable exceptions. For example, nitrogen has a large (n,p) cross section for thermal and epithermal neutrons, and this cross section should be included in Σ_a and subtracted from Σ_{nonel}

in energy range from thermal to, say, an energy near the first excited level of the compound nucleus. Otherwise, INELAS could be entered by, say, a thermal neutron, and erroneous results would be obtained.

In summary, the following constraints should be noted in preparing the input to the NMTC version of O5R:

1. In preparing the systems data tape (CØDE 6), the elastic-scattering cross sections for all nuclides should be called for before the "inelastic"-scattering cross sections. (This order is made necessary by the manner in which subroutine INELAS is programmed.)
2. The cross sections needed are total, elastic, and nonelastic minus low-energy neutron absorption. These cross sections are specified on Cards D of the CØDE 6 input.
3. On Card D of the primary O5R input, LF1 should be input as zero for all "inelastic" scatterers since the actual angular distribution is computed in subroutine INELAS for nonelastic interactions.

3.2.5 Cross Sections on the O5R/NMTC Master Cross-Section Tape

The master cross-section tape referred to here is designated as "O5R/NMTC" to distinguish it from the "O5R" master cross-section tape that is made available by RSIC* as part of the code package for the standard version of O5R. The principal difference between these two cross-section libraries is that the cross sections for most elements on the O5R/NMTC tape extend to higher energies than those present on the O5R tape. The two

*Radiation Shielding Information Center, located at the Oak Ridge National Laboratory, Oak Ridge, Tennessee, 37830.

libraries also differ in that the elements for which cross sections are given are not the same, and cross sections given for some elements that are present on both tapes have been taken from different sources.

A list of the cross sections contained on the O5R/NMTC master cross-section tape is given in Table I. A particular cross-section set is identified on the tape by an index denoting the element and an index denoting a particular type of cross section for this element. The index for element identification (which is used to denote both elements and isotopes) is, by convention, $1000 \times Z + A$, where Z is the atomic number and A is the mass number. A is set to zero for elements having a natural isotopic composition. The following convention is used for cross-section identification:

1 = total

2 = elastic scattering

9 = nonelastic

19 = nonelastic minus low-energy neutron absorption

20 = (n,γ)

21 = (n,p)

71 = the f_1 values for elastic scattering

A complete edit of the cross-section tape can be obtained by running CØDE 3 of the XSECT code.

TABLE I

Cross Sections on O5R/NMTC Master Tape

Element	Element Identifier	Cross Sections	Highest Energy (MeV)
H	1001	1, 2, 20	100
C	6000	1, 2, 9, 71	100
N	7000	1, 2, 9, 19, 21, 71	100
O	8000	1, 2, 9, 19, 20, 71	100
Na	11000	1, 2, 9, 19, 20, 71	25
Mg	12000	1, 2, 9, 19, 20, 71	25
Al	13000	1, 2, 9, 19, 20, 71	100
Si	14000	1, 2, 9, 19, 20, 71	25
P	15000	1, 2, 9, 19, 20, 71	19
S	16000	1, 2, 9, 19, 20, 71	18
Cl	17035	1, 2, 9, 19, 20, 71	15
K	19000	1, 2, 9, 19, 20, 71	25
Ca	20000	1, 2, 9, 19, 20, 71	25
Ti	22048	1, 2, 9, 20, 71	30
Fe	26000	1, 2, 19, 71	100
Cu	29000	1, 2, 9, 71	100
Cd	48112	1, 2, 9, 19, 71	15
Pb	82207	1, 2, 9, 19, 71	100

3.2.6 RED⌀5R

Subroutine RED⌀5R (L⌀G1, L⌀GMAX, NTYPE, NWPC⌀L) is available to read 05R history tape(s). The arguments are defined as follows:

L⌀G1 = The logical number of the first history tape.

* L⌀GMAX = The logical number of the last history tape. If there are M history tapes, then L⌀GMAX = L⌀G1 + M - 1.

NTYPE = An integer denoting the type of data returned by RED⌀5R;

NTYPE: 0 normal "collision" data

1 end of batch

3 end of run

NWPC⌀L = The number of words (collision parameters) per collision, $1 \le$ NWPC⌀L ≤ 36.

The first calling of RED⌀5R must provide values for the arguments L⌀G1, L⌀GMAX, and NWPC⌀L. The value of NWPC⌀L is obtained from the printed 05R output. NTYPE is returned to the calling program by RED⌀5R. A return with NTYPE = 0 indicates that RED⌀5R has stored values for the collision parameters in labeled common PARAMS. PARAMS should contain NWPC⌀L parameters in the same order as indicated by the NBIND values on Card I of the 05R input.

Example: Suppose NC⌀LL, SPDSQ, U, V, W, X, Y, Z, and WATE were selected as collision parameters on Card I of the 05R input. Then NWPC⌀L = 9 and common PARAMS should appear in the 05R analysis program as:

```
C⌀MM⌀N/PARAMS/NC⌀LL,SPDSQ,U,V,W,X,Y,Z,WATE
```

---

*The footnote on multireel data sets given in Sec. 3.1.4 applies here also. If the local operating system does not provide the user's program with any indication of an end-of-tape encounter, then L⌀GMAX is irrelevant.

4. NMTC SAMPLE PROBLEM

4.1 Sample Problem Description

Input, output, and appropriate analysis routines will be illustrated for a sample NMTC calculation. Consider a beam of 1500-MeV π^+-mesons normally incident on a Pb slab 18-cm* thick in the z direction and infinite in the x and y directions. The source is uniformly distributed over the slab surface at z = 0 cm and has a strength of 1 particle/cm^2-sec (see Fig. 1).

To define the quantities that will be calculated by the analysis programs, let

$$J_{\hat{z}}(z,E,\hat{\Omega};i)dEd\Omega$$

be the expected number of particles of type i at space coordinate z, with energy E in dE, going in the direction specified by the unit vector $\hat{\Omega}$ within the element of solid angle dΩ per unit area normal to $\hat{z}$ per unit time. Here, $\hat{z}$ is a unit vector that is normal to the slab in Fig. 1 and is in the direction of positive z. The values of i have the following meanings:

i	Particle Type
1	proton
2	neutron
3	π^+
5	π^-
6	μ^+
7	μ^-

*This thickness is equivalent to 204 g/cm^2 or roughly 1 mean free path based on the π^+ nonelastic cross section at 1500 MeV.

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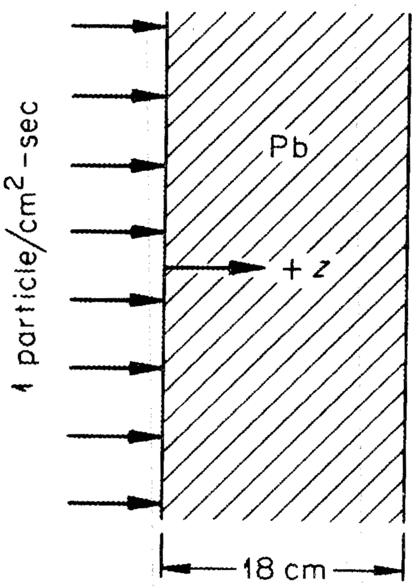


Fig. 1. Source and Material Geometry for Sample Problem.

Further definitions are:

$$J^{+}_{\hat{z}}(z;i) \equiv \int^{\hat{z}\cdot\hat{\Omega}>0} d\Omega \int_{E_1(i)}^{E_2(i)} dE\, J_{\hat{z}}(z,E,\hat{\Omega};i)$$

$$J^{-}_{\hat{z}}(z;i) \equiv \int^{\hat{z}\cdot\hat{\Omega}<0} d\Omega \int_{E_1(i)}^{E_2(i)} dE\, J_{\hat{z}}(z,E,\hat{\Omega};i) \quad .$$

These quantities will be referred to as the positive and negative partial currents, respectively, where i denotes the particle type. $J^{+}_{\hat{z}}(z;i)$ and $J^{-}_{\hat{z}}(z;i)$ are calculated in the sample problem for z = 0, 6, 12, and 18 cm.

The $E_2(i)$ values correspond to EMAX and are 1500 MeV for nucleons and pions and 1533 MeV for muons. For protons, pions, and muons, the values of $E_1(i)$ correspond to the cutoff energies for those particle types in NMT. A value of 15 MeV is used for the proton and neutron cutoff energies in NMT. From the proton cutoff, it follows that the cutoff for pions is 15 × 0.1488 = 2.23 MeV. The muon cutoff is selected as 0.1 MeV, so that in the muon-transport calculation ELØP is input as 0.1/0.1129 = 0.8857 MeV. O5R is used to transport neutrons below 15 MeV, and thermal neutrons are transported using a one-speed model with isotropic scattering in the laboratory system. Hence, $E_1(2) = 0$. In summary, the values of $E_1(i)$ are:

i	$E_1(i)$
1 - proton	15.00 (MeV)
2 - neutron	0.00
3 - π^+	2.23
5 - π^-	2.23
6 - μ^+	0.10
7 - μ^-	0.10

Negative pions reaching 2.23 MeV are assumed to undergo nuclear interaction; i.e., NPIDK is input as 0.

When an internal boundary is specified in the geometry input, medium boundary crossings will be reported only if the adjacent regions are assigned different medium numbers. For this reason, the geometry is specified using two media as shown in Fig. 2. The cross sections and densities of media 1 and 2 are, of course, identical.

4.2 Intercode Information Transfer

Figure 3 illustrates the code-to-code flow of information in running the sample problem. The NMT nucleon-pion-transport and NMT muon-transport blocks in Fig. 3 are enclosed by a dashed line because for the sample problem both transport calculations are carried out in the same job step; that is, the input data for nucleon-pion transport are followed by the input data for muon transport. At the end of the nucleon-pion transport calculation, NMT reads the muon input data and then performs the muon transport calculation. In Fig. 3 the nucleon-pion history tape, which is read both by the NMT analysis program and by NMT for the muon source, is labeled "NHSTP(NEUTP)" when used as the muon-source tape. This tape is designated as NHSTP when created by NMT in the nucleon-pion calculation and is designated as NEUTP

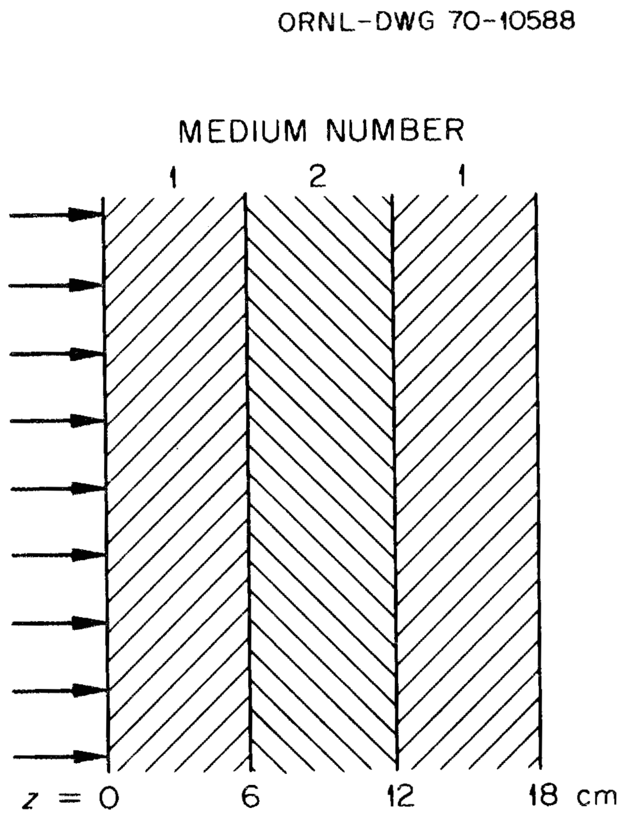
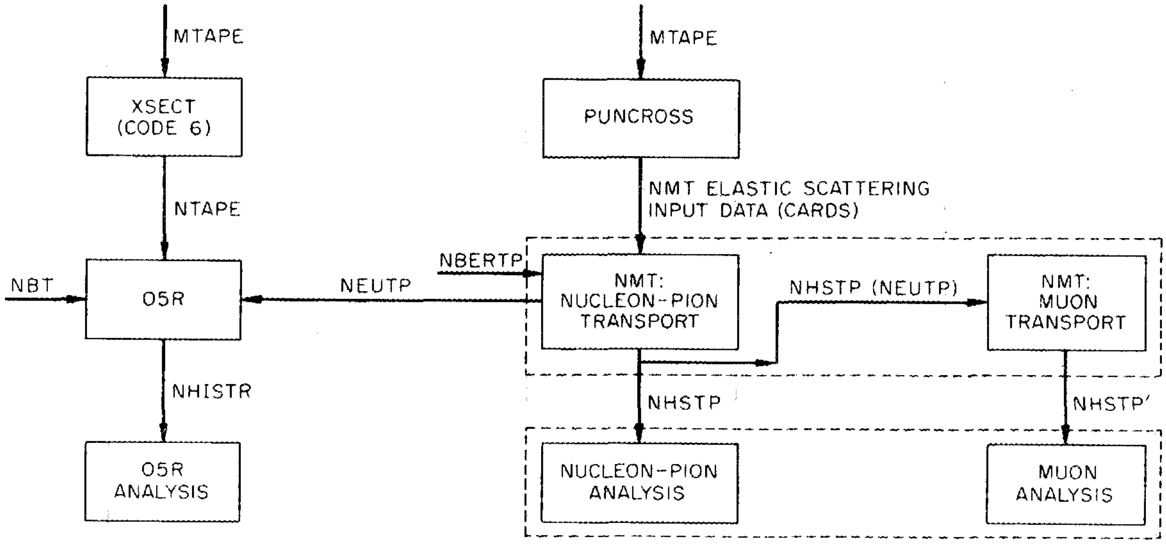


Fig. 2. Medium Designation for Sample Problem.

ORNL-DWG 70-10586



TAPE DESIGNATIONS:

MTAPE = O5R/NMTC MASTER CROSS SECTION TAPE

NTAPE = O5R SYSTEMS DATA TAPE

NBT = NBERTP = TAPE CONTAINING DATA NEEDED FOR INTRANUCLEAR-CASCADE AND EVAPORATION CALCULATIONS.

NHISTR = O5R HISTORY TAPE

NHSTP = NMT NUCLEON-PION HISTORY TAPE

NHSTP' = NMT MUON HISTORY TAPE

Fig. 3. Flow of Information for NMTC Sample Problem.

in the NMT input for muon transport. The nucleon-pion-analysis and muon-analysis blocks in Fig. 3 are enclosed by dashed lines because both analyses are done in the same program in the sample problem.

4.3 Listings of Input, Output, and Analysis Programs for Sample Problem

The card input for program PUNCRØSS, which generates the elastic-scattering data needed by NMT, is given in Table II, and the printed output is shown in Table III.

A listing of the NMT subroutine SØRS, which was written specifically for the sample problem, is shown in Table IV.

Card input and printed output for NMT are given in Tables V and VI, respectively.

A listing of the NMT analysis program written for the sample problem is given in Table VII, and the card input and printed output are given in Tables VIII and IX, respectively. The input consists of two cards. The first card contains the logical number of the nucleon-pion history tape (FØRMAT I10) and the second card contains the logical number of the muon history tape (FØRMAT I10).

Input and output for CØDE 6 of the XSECT program, which is used to generate the O5R systems data tape, are shown in Tables X and XI, respectively.

Card input and printed output for O5R are given in Tables XII and XIII, respectively.

A listing of the O5R analysis program written for the sample problem is given in Table XIV, and the card input and printed output are given in Tables XV and XVI. Input for the O5R analysis consists of one card, FØRMAT (5I5), containing values for the following quantities:

a. LØG1 (see Section 3.2.6)

b. LØGMAX (see Section 3.2.6)

c. NWPCØL (see Section 3.2.6)

d. MAXCAS (see Section 3.1.1.1)

e. MAXBCH (see Section 3.1.1.1)

The NMT edit program ENMT has been run to print the first cascade of the first batch contained on the nucleon-pion tape to illustrate the type of output provided by this program. The card input and printed output are given in Tables XVII and XVIII, respectively.

TABLE II

Input for PUNCRØSS Program

9	52	
	15.0	100.0
82207	2	
82207	71	

TABLE III

Output from PUNCRØSS Program

PAGE 1

*****THESE ARE CROSS SECTIONS ON MTAPE*****

ELEMENT=82207
SIGMA= 2
INTERPOLATION= 8
POINTS= 591
MASS= 0.0

ELASTIC

ENERGY (EV)	CROSS SECTION	ENERGY (EV)	CROSS SECTION	ENERGY (EV)	CROSS SECTION	ENERGY (EV)	CROSS SECTION
0.10000E 09	0.25599E 01	0.94059E 07	0.23030E 01	0.26948E 07	0.61514E 01	0.10500E 07	0.50636E 01
0.90000E 08	0.27380E 01	0.90000E 07	0.23494E 01	0.25634E 07	0.59384E 01	0.10422E 07	0.52089E 01
0.80000E 08	0.26499E 01	0.89472E 07	0.23639E 01	0.25000E 07	0.58355E 01	0.10000E 07	0.60864E 01
0.70000E 08	0.24603E 01	0.85108E 07	0.24895E 01	0.24384E 07	0.57384E 01	0.99137E 06	0.62169E 01
0.60000E 08	0.21299E 01	0.80957E 07	0.26182E 01	0.23195E 07	0.55505E 01	0.98000E 06	0.63946E 01
0.55000E 08	0.20570E 01	0.80000E 07	0.26493E 01	0.22500E 07	0.54404E 01	0.96000E 06	0.60031E 01
0.50000E 08	0.20300E 01	0.77009E 07	0.28230E 01	0.22063E 07	0.53647E 01	0.94302E 06	0.57552E 01
0.45000E 08	0.20580E 01	0.73253E 07	0.30582E 01	0.20987E 07	0.51785E 01	0.94000E 06	0.57117E 01
0.44000E 08	0.20569E 01	0.70000E 07	0.32792E 01	0.20000E 07	0.50077E 01	0.92000E 06	0.57205E 01
0.43000E 08	0.20356E 01	0.69681E 07	0.33024E 01	0.19964E 07	0.50020E 01	0.90000E 06	0.56295E 01
0.42000E 08	0.20240E 01	0.66282E 07	0.35601E 01	0.19500E 07	0.49287E 01	0.89703E 06	0.56252E 01
0.41000E 08	0.20321E 01	0.63050E 07	0.38263E 01	0.19000E 07	0.48503E 01	0.85328E 06	0.55600E 01
0.40000E 08	0.20799E 01	0.60000E 07	0.40992E 01	0.18990E 07	0.48498E 01	0.81167E 06	0.54961E 01
0.35000E 08	0.23035E 01	0.59975E 07	0.41018E 01	0.18500E 07	0.48225E 01	0.80000E 06	0.54778E 01
0.30000E 08	0.26499E 01	0.57050E 07	0.44254E 01	0.18064E 07	0.48249E 01	0.78000E 06	0.53882E 01
0.27500E 08	0.28892E 01	0.55000E 07	0.46685E 01	0.18000E 07	0.48253E 01	0.77208E 06	0.53529E 01
0.25000E 08	0.30574E 01	0.54267E 07	0.47418E 01	0.17500E 07	0.47687E 01	0.76000E 06	0.52989E 01
0.22500E 08	0.31944E 01	0.51621E 07	0.50190E 01	0.17183E 07	0.47840E 01	0.74000E 06	0.52098E 01
0.20000E 08	0.32499E 01	0.50000E 07	0.51991E 01	0.17000E 07	0.47929E 01	0.73443E 06	0.60083E 01
0.18017E 08	0.31691E 01	0.49103E 07	0.52739E 01	0.16500E 07	0.47977E 01	0.72000E 06	0.87210E 01
0.17500E 08	0.31467E 01	0.46708E 07	0.54818E 01	0.16345E 07	0.47963E 01	0.70000E 06	0.49326E 01
0.17139E 08	0.31100E 01	0.45000E 07	0.56380E 01	0.16000E 07	0.47933E 01	0.69861E 06	0.49662E 01
0.16303E 08	0.30227E 01	0.44430E 07	0.56662E 01	0.15548E 07	0.47991E 01	0.68000E 06	0.54445E 01
0.15508E 08	0.29365E 01	0.42263E 07	0.57770E 01	0.15500E 07	0.47997E 01	0.66454E 06	0.55309E 01
0.15000E 08	0.28797E 01	0.40202E 07	0.58879E 01	0.15000E 07	0.48470E 01	0.66000E 06	0.55568E 01
0.14751E 08	0.28436E 01	0.40000E 07	0.58991E 01	0.14790E 07	0.48660E 01	0.64000E 06	0.55195E 01
0.14032E 08	0.27369E 01	0.38242E 07	0.59910E 01	0.14500E 07	0.48928E 01	0.63213E 06	0.55050E 01
0.13348E 08	0.26320E 01	0.36376E 07	0.60935E 01	0.14068E 07	0.49326E 01	0.62000E 06	0.54825E 01
0.12697E 08	0.25290E 01	0.35000E 07	0.61727E 01	0.14000E 07	0.49392E 01	0.60130E 06	0.53081E 01
0.12500E 08	0.24971E 01	0.34602E 07	0.62047E 01	0.13500E 07	0.50262E 01	0.60000E 06	0.52960E 01
0.12077E 08	0.24337E 01	0.34000E 07	0.62538E 01	0.13382E 07	0.50465E 01	0.59000E 06	0.52460E 01
0.12000E 08	0.24220E 01	0.33000E 07	0.63373E 01	0.13000E 07	0.51138E 01	0.58000E 06	0.50960E 01
0.11500E 08	0.23467E 01	0.32915E 07	0.63403E 01	0.12730E 07	0.51503E 01	0.57197E 06	0.49754E 01
0.11488E 08	0.23452E 01	0.32000E 07	0.63734E 01	0.12500E 07	0.51821E 01	0.57000E 06	0.49460E 01
0.11000E 08	0.22812E 01	0.31310E 07	0.64000E 01	0.12109E 07	0.53134E 01	0.56000E 06	0.44960E 01
0.10928E 08	0.22748E 01	0.31000E 07	0.64122E 01	0.12000E 07	0.53512E 01	0.55000E 06	0.43960E 01
0.10500E 08	0.22355E 01	0.30000E 07	0.64540E 01	0.11518E 07	0.53222E 01	0.54408E 06	0.47963E 01
0.10395E 08	0.22363E 01	0.29783E 07	0.64357E 01	0.11500E 07	0.53211E 01	0.54000E 06	0.50960E 01
0.10000E 08	0.22394E 01	0.28330E 07	0.63121E 01	0.11000E 07	0.52418E 01	0.53000E 06	0.85960E 01
0.98882E 07	0.22510E 01	0.27500E 07	0.62406E 01	0.10956E 07	0.52262E 01	0.52000E 06	0.94960E 01

TABLE III (Cont'd.)

Output from PUNCRØSS Program

PAGE 2

ENERGY (EV)	CROSS SECTION	ENERGY (EV)	CROSS SECTION	ENERGY (EV)	CROSS SECTION	ENERGY (EV)	CROSS SECTION
0.51754E 06	0.79539E 01	0.20000E 06	0.80960E 01	0.64000E 05	0.10196E 02	0.34782E 05	0.10262E 02
0.51000E 06	0.45960E 01	0.19039E 06	0.83123E 01	0.63376E 05	0.10211E 02	0.34000E 05	0.10246E 02
0.50000E 06	0.32460E 01	0.18111E 06	0.85377E 01	0.62000E 05	0.10246E 02	0.33085E 05	0.10246E 02
0.49230E 06	0.35864E 01	0.17500E 06	0.86960E 01	0.60286E 05	0.10289E 02	0.33000E 05	0.10246E 02
0.49000E 06	0.36960E 01	0.17228E 06	0.87835E 01	0.60000E 05	0.10296E 02	0.32000E 05	0.10196E 02
0.48000E 06	0.43960E 01	0.16387E 06	0.90688E 01	0.59000E 05	0.10396E 02	0.31472E 05	0.10186E 02
0.47000E 06	0.47960E 01	0.15588E 06	0.93631E 01	0.58000E 05	0.10446E 02	0.31000E 05	0.10176E 02
0.46829E 06	0.48293E 01	0.15000E 06	0.95960E 01	0.57345E 05	0.10479E 02	0.30000E 05	0.10396E 02
0.46000E 06	0.49960E 01	0.14828E 06	0.96388E 01	0.57000E 05	0.10496E 02	0.29937E 05	0.10408E 02
0.45000E 06	0.51960E 01	0.14105E 06	0.98267E 01	0.56000E 05	0.10596E 02	0.29500E 05	0.10496E 02
0.44545E 06	0.52681E 01	0.13417E 06	0.10018E 02	0.55000E 05	0.10746E 02	0.29000E 05	0.11246E 02
0.42373E 06	0.56377E 01	0.12762E 06	0.10214E 02	0.54549E 05	0.10857E 02	0.28500E 05	0.11596E 02
0.40306E 06	0.60333E 01	0.12500E 06	0.10296E 02	0.54000E 05	0.10996E 02	0.28477E 05	0.11533E 02
0.40000E 06	0.60960E 01	0.12140E 06	0.10335E 02	0.53000E 05	0.11196E 02	0.28000E 05	0.10296E 02
0.39000E 06	0.61960E 01	0.11548E 06	0.10402E 02	0.52000E 05	0.11396E 02	0.27500E 05	0.99960E 01
0.38341E 06	0.64427E 01	0.10985E 06	0.10469E 02	0.51888E 05	0.11418E 02	0.27088E 05	0.99137E 01
0.38000E 06	0.65760E 01	0.10449E 06	0.10536E 02	0.51000E 05	0.11596E 02	0.27000E 05	0.98960E 01
0.37000E 06	0.71960E 01	0.10000E 06	0.10596E 02	0.50000E 05	0.11996E 02	0.26500E 05	0.99460E 01
0.36471E 06	0.81860E 01	0.99394E 05	0.10599E 02	0.49358E 05	0.12124E 02	0.26000E 05	0.10046E 02
0.36000E 06	0.91960E 01	0.94547E 05	0.10623E 02	0.49000E 05	0.12196E 02	0.25767E 05	0.10092E 02
0.35000E 06	0.99960E 01	0.90000E 05	0.10646E 02	0.48000E 05	0.12596E 02	0.25500E 05	0.10146E 02
0.34692E 06	0.82360E 01	0.89935E 05	0.10648E 02	0.47000E 05	0.12996E 02	0.25000E 05	0.10296E 02
0.34000E 06	0.52960E 01	0.88000E 05	0.10696E 02	0.46950E 05	0.13008E 02	0.24510E 05	0.10296E 02
0.33000E 06	0.51460E 01	0.86000E 05	0.10716E 02	0.46000E 05	0.13246E 02	0.24500E 05	0.10296E 02
0.32000E 06	0.66960E 01	0.85549E 05	0.10723E 02	0.45000E 05	0.11246E 02	0.24000E 05	0.10346E 02
0.31391E 06	0.69353E 01	0.84000E 05	0.10746E 02	0.44661E 05	0.10413E 02	0.23500E 05	0.10396E 02
0.31000E 06	0.70960E 01	0.82000E 05	0.10596E 02	0.44000E 05	0.89460E 01	0.23315E 05	0.10414E 02
0.30000E 06	0.72960E 01	0.81377E 05	0.10407E 02	0.43000E 05	0.93460E 01	0.23000E 05	0.10446E 02
0.29860E 06	0.73013E 01	0.80000E 05	0.99960E 01	0.42483E 05	0.94737E 01	0.22500E 05	0.10496E 02
0.28403E 06	0.73587E 01	0.78000E 05	0.11096E 02	0.42000E 05	0.95960E 01	0.22178E 05	0.10496E 02
0.27500E 06	0.73960E 01	0.77408E 05	0.10917E 02	0.41000E 05	0.97960E 01	0.21096E 05	0.10496E 02
0.27018E 06	0.74236E 01	0.76000E 05	0.10496E 02	0.40411E 05	0.99127E 01	0.20067E 05	0.10496E 02
0.25700E 06	0.75022E 01	0.74000E 05	0.11096E 02	0.40000E 05	0.99960E 01	0.19089E 05	0.10496E 02
0.25000E 06	0.75460E 01	0.73633E 05	0.10946E 02	0.39000E 05	0.10046E 02	0.18158E 05	0.10496E 02
0.24447E 06	0.75776E 01	0.72000E 05	0.10296E 02	0.38440E 05	0.10074E 02	0.17272E 05	0.10496E 02
0.23255E 06	0.76487E 01	0.70042E 05	0.10198E 02	0.38000E 05	0.10096E 02	0.16430E 05	0.10496E 02
0.22500E 06	0.76960E 01	0.70000E 05	0.10196E 02	0.37000E 05	0.10196E 02	0.15628E 05	0.10496E 02
0.22121E 06	0.77524E 01	0.68000E 05	0.10746E 02	0.36565E 05	0.10218E 02	0.14866E 05	0.10496E 02
0.21042E 06	0.79210E 01	0.66625E 05	0.10505E 02	0.36000E 05	0.10246E 02	0.14141E 05	0.10497E 02
0.20016E 06	0.80932E 01	0.66000E 05	0.10396E 02	0.35000E 05	0.10266E 02	0.13452E 05	0.10497E 02

TABLE III (Cont'd.)

Output from PUNCRØSS Program

PAGE 3

ENERGY (EV)	CROSS SECTION	ENERGY (EV)	CROSS SECTION	ENERGY (EV)	CROSS SECTION	ENERGY (EV)	CROSS SECTION
0.12795E 05	0.10498E 02	0.23375E 04	0.11299E 02	0.31635E 03	0.11298E 02	0.45008E 02	0.11329E 02
0.12500E 05	0.10498E 02	0.22235E 04	0.11299E 02	0.30092E 03	0.11298E 02	0.42813E 02	0.11330E 02
0.12171E 05	0.10563E 02	0.21151E 04	0.11299E 02	0.30000E 03	0.11298E 02	0.40725E 02	0.11331E 02
0.12000E 05	0.10598E 02	0.20119E 04	0.11299E 02	0.28624E 03	0.11299E 02	0.38739E 02	0.11331E 02
0.11578E 05	0.10683E 02	0.19138E 04	0.11299E 02	0.27228E 03	0.11300E 02	0.36850E 02	0.11332E 02
0.11500E 05	0.10699E 02	0.18205E 04	0.11299E 02	0.25901E 03	0.11301E 02	0.35053E 02	0.11333E 02
0.11013E 05	0.10796E 02	0.17317E 04	0.11299E 02	0.24637E 03	0.11302E 02	0.33343E 02	0.11334E 02
0.11000E 05	0.10799E 02	0.16472E 04	0.11299E 02	0.23436E 03	0.11302E 02	0.31717E 02	0.11334E 02
0.10500E 05	0.10999E 02	0.15669E 04	0.11299E 02	0.22293E 03	0.11303E 02	0.30170E 02	0.11335E 02
0.10476E 05	0.11013E 02	0.14905E 04	0.11299E 02	0.21206E 03	0.11304E 02	0.28699E 02	0.11336E 02
0.10000E 05	0.11300E 02	0.14178E 04	0.11299E 02	0.20171E 03	0.11305E 02	0.27299E 02	0.11337E 02
0.99651E 04	0.11300E 02	0.13486E 04	0.11299E 02	0.19188E 03	0.11306E 02	0.25968E 02	0.11337E 02
0.94791E 04	0.11300E 02	0.12829E 04	0.11299E 02	0.18252E 03	0.11306E 02	0.24701E 02	0.11338E 02
0.90168E 04	0.11300E 02	0.12203E 04	0.11299E 02	0.17362E 03	0.11307E 02	0.23496E 02	0.11339E 02
0.85771E 04	0.11300E 02	0.11608E 04	0.11299E 02	0.16515E 03	0.11308E 02	0.22350E 02	0.11340E 02
0.81588E 04	0.11300E 02	0.11042E 04	0.11299E 02	0.15709E 03	0.11309E 02	0.21260E 02	0.11340E 02
0.77609E 04	0.11300E 02	0.10503E 04	0.11299E 02	0.14943E 03	0.11310E 02	0.20224E 02	0.11341E 02
0.73824E 04	0.11300E 02	0.99909E 03	0.11299E 02	0.14215E 03	0.11311E 02	0.19237E 02	0.11342E 02
0.70223E 04	0.11300E 02	0.35037E 03	0.11299E 02	0.13521E 03	0.11311E 02	0.18299E 02	0.11343E 02
0.66798E 04	0.11300E 02	0.90402E 03	0.11299E 02	0.12862E 03	0.11312E 02	0.17407E 02	0.11343E 02
0.63541E 04	0.11300E 02	0.85993E 03	0.11299E 02	0.12235E 03	0.11313E 02	0.16558E 02	0.11344E 02
0.60442E 04	0.11300E 02	0.81799E 03	0.11299E 02	0.11638E 03	0.11314E 02	0.15750E 02	0.11344E 02
0.57494E 04	0.11300E 02	0.77809E 03	0.11299E 02	0.11070E 03	0.11315E 02	0.14982E 02	0.11345E 02
0.54690E 04	0.11300E 02	0.74015E 03	0.11299E 02	0.10530E 03	0.11316E 02	0.14251E 02	0.11346E 02
0.52023E 04	0.11300E 02	0.70405E 03	0.11299E 02	0.10017E 03	0.11316E 02	0.13556E 02	0.11347E 02
0.49485E 04	0.11300E 02	0.66971E 03	0.11299E 02	0.95283E 02	0.11317E 02	0.12895E 02	0.11347E 02
0.47072E 04	0.11300E 02	0.63705E 03	0.11299E 02	0.90636E 02	0.11318E 02	0.12266E 02	0.11348E 02
0.44776E 04	0.11300E 02	0.60598E 03	0.11299E 02	0.86215E 02	0.11319E 02	0.11668E 02	0.11349E 02
0.42592E 04	0.11300E 02	0.57643E 03	0.11299E 02	0.82011E 02	0.11320E 02	0.11099E 02	0.11349E 02
0.40515E 04	0.11300E 02	0.54831E 03	0.11299E 02	0.78011E 02	0.11320E 02	0.10558E 02	0.11350E 02
0.38539E 04	0.11300E 02	0.52157E 03	0.11299E 02	0.74206E 02	0.11321E 02	0.10043E 02	0.11351E 02
0.36660E 04	0.11300E 02	0.49613E 03	0.11299E 02	0.70587E 02	0.11322E 02	0.95529E 01	0.11352E 02
0.34072E 04	0.11300E 02	0.47194E 03	0.11299E 02	0.67145E 02	0.11323E 02	0.90870E 01	0.11352E 02
0.33171E 04	0.11299E 02	0.44892E 03	0.11299E 02	0.63870E 02	0.11324E 02	0.86438E 01	0.11353E 02
0.31553E 04	0.11299E 02	0.42703E 03	0.11299E 02	0.60755E 02	0.11324E 02	0.82223E 01	0.11354E 02
0.30014E 04	0.11299E 02	0.40620E 03	0.11299E 02	0.57792E 02	0.11325E 02	0.78213E 01	0.11354E 02
0.28551E 04	0.11299E 02	0.38639E 03	0.11299E 02	0.54973E 02	0.11326E 02	0.74398E 01	0.11355E 02
0.27158E 04	0.11299E 02	0.36755E 03	0.11299E 02	0.52292E 02	0.11327E 02	0.70771E 01	0.11356E 02
0.25834E 04	0.11299E 02	0.34962E 03	0.11299E 02	0.49742E 02	0.11328E 02	0.67319E 01	0.11356E 02
0.24574E 04	0.11299E 02	0.33257E 03	0.11298E 02	0.47316E 02	0.11328E 02	0.64036E 01	0.11357E 02

TABLE III (Cont'd.)

Output from PUNCRØSS Program

PAGE 4

ENERGY (EV)	CROSS SECTION	ENERGY (EV)	CROSS SECTION	ENERGY (EV)	CROSS SECTION	ENERGY (EV)	CROSS SECTION
0.60912E 01	0.11357E 02	0.86663E 00	0.11326E 02	0.11728E 00	0.10666E 02		
0.57941E 01	0.11358E 02	0.82437E 00	0.11310E 02	0.11156E 00	0.10650E 02		
0.55116E 01	0.11358E 02	0.78415E 00	0.11293E 02	0.10612E 00	0.10634E 02		
0.52428E 01	0.11359E 02	0.74592E 00	0.11277E 02	0.10095E 00	0.10618E 02		
0.49872E 01	0.11360E 02	0.70954E 00	0.11261E 02	0.10000E 00	0.10615E 02		
0.47439E 01	0.11360E 02	0.67493E 00	0.11245E 02	0.96024E-01	0.10576E 02		
0.45125E 01	0.11361E 02	0.64201E 00	0.11228E 02	0.91342E-01	0.10529E 02		
0.42925E 01	0.11362E 02	0.61071E 00	0.11212E 02	0.86888E-01	0.10482E 02		
0.40831E 01	0.11362E 02	0.58091E 00	0.11195E 02	0.82649E-01	0.10435E 02		
0.38840E 01	0.11363E 02	0.55259E 00	0.11179E 02	0.80000E-01	0.10405E 02		
0.36945E 01	0.11363E 02	0.52564E 00	0.11163E 02	0.78618E-01	0.10379E 02		
0.35143E 01	0.11363E 02	0.50001E 00	0.11147E 02	0.74785E-01	0.10306E 02		
0.33429E 01	0.11364E 02	0.47561E 00	0.11130E 02	0.71137E-01	0.10234E 02		
0.31799E 01	0.11364E 02	0.45242E 00	0.11113E 02	0.67667E-01	0.10161E 02		
0.30248E 01	0.11365E 02	0.43036E 00	0.11097E 02	0.64367E-01	0.10090E 02		
0.28773E 01	0.11365E 02	0.40937E 00	0.11080E 02	0.61229E-01	0.10019E 02		
0.27370E 01	0.11365E 02	0.38940E 00	0.11064E 02	0.60000E-01	0.99899E 01		
0.26035E 01	0.11366E 02	0.37041E 00	0.11047E 02	0.58242E-01	0.99219E 01		
0.24765E 01	0.11366E 02	0.35234E 00	0.11031E 02	0.55402E-01	0.98085E 01		
0.23557E 01	0.11367E 02	0.33516E 00	0.11015E 02	0.52699E-01	0.96964E 01		
0.22408E 01	0.11368E 02	0.31881E 00	0.10999E 02	0.50129E-01	0.95856E 01		
0.21315E 01	0.11368E 02	0.30326E 00	0.10983E 02	0.50000E-01	0.95799E 01		
0.20276E 01	0.11369E 02	0.28847E 00	0.10966E 02	0.47684E-01	0.94572E 01		
0.19287E 01	0.11369E 02	0.27440E 00	0.10950E 02	0.45359E-01	0.93295E 01		
0.18346E 01	0.11369E 02	0.26102E 00	0.10933E 02	0.43147E-01	0.92035E 01		
0.17452E 01	0.11369E 02	0.24829E 00	0.10917E 02	0.41042E-01	0.90793E 01		
0.16601E 01	0.11369E 02	0.23618E 00	0.10900E 02	0.40000E-01	0.90158E 01		
0.15791E 01	0.11370E 02	0.22466E 00	0.10884E 02	0.39041E-01	0.89346E 01		
0.15021E 01	0.11370E 02	0.21371E 00	0.10868E 02	0.37137E-01	0.87689E 01		
0.14288E 01	0.11370E 02	0.20328E 00	0.10851E 02	0.30000E-01	0.80939E 01		
0.13591E 01	0.11370E 02	0.19337E 00	0.10834E 02	0.25000E-01	0.74300E 01		
0.12928E 01	0.11371E 02	0.18394E 00	0.10817E 02				
0.12298E 01	0.11371E 02	0.17497E 00	0.10800E 02				
0.11698E 01	0.11372E 02	0.16643E 00	0.10783E 02				
0.11128E 01	0.11372E 02	0.15832E 00	0.10766E 02				
0.10585E 01	0.11372E 02	0.15060E 00	0.10749E 02				
0.10069E 01	0.11373E 02	0.14325E 00	0.10732E 02				
0.10000E 01	0.11373E 02	0.13627E 00	0.10716E 02				
0.95778E 00	0.11359E 02	0.12962E 00	0.10699E 02				
0.91105E 00	0.11342E 02	0.12330E 00	0.10683E 02				

TABLE III (Cont'd.)

Output from PUNCRØSS Program

PAGE 5

*****THESE ARE CROSS SECTIONS ABOVE CUTOFF---PUNCHED CARD OUTPUT FOR NMT INPUT*****
ELEMENT=82207
SIGMA= 2
INTERPOLATION= 8
POINTS= 26
MASS= 0.0
ELASTIC

ENERGY (EV)	CROSS SECTION	ENERGY (EV)	CROSS SECTION	ENERGY (EV)	CROSS SECTION	ENERGY (EV)	CROSS SECTION
0.10000E 09	0.25599E 01						
0.90000E 08	0.27380E 01						
0.80000E 08	0.26499E 01						
0.70000E 08	0.24603E 01						
0.60000E 08	0.21299E 01						
0.55000E 08	0.20570E 01						
0.50000E 08	0.20300E 01						
0.45000E 08	0.20580E 01						
0.44000E 08	0.20569E 01						
0.43000E 08	0.20356E 01						
0.42000E 08	0.20240E 01						
0.41000E 08	0.20321E 01						
0.40000E 08	0.20799E 01						
0.35000E 08	0.23035E 01						
0.30000E 08	0.26499E 01						
0.27500E 08	0.28892E 01						
0.25000E 08	0.30574E 01						
0.22500E 08	0.31944E 01						
0.20000E 08	0.32499E 01						
0.18017E 08	0.31691E 01						
0.17500E 08	0.31467E 01						
0.17139E 08	0.31100E 01						
0.16303E 08	0.30227E 01						
0.15508E 08	0.29365E 01						
0.15000E 08	0.28797E 01						
0.14751E 08	0.28436E 01						

TABLE III (Cont'd.)

Output from PUNCRØSS Program

PAGE 6

*****THESE ARE CROSS SECTIONS ON MTAPE*****

ELEMENT=82207
SIGMA= 71
INTERPOLATION= 8
POINTS= 410
MASS= 0.0

LEAD PEREY DATA FI

ENERGY (EV)	CROSS SECTION	ENERGY (EV)	CROSS SECTION	ENERGY (EV)	CROSS SECTION	ENERGY (EV)	CROSS SECTION
0.10000E 09	0.98569E 00	0.38242E 07	0.63122E 00	0.51754E 06	0.11439E 00	0.70042E 05	0.36417E-01
0.80000E 08	0.97576E 00	0.36376E 07	0.60247E 00	0.49230E 06	0.16257E 00	0.66626E 05	0.32621E-01
0.70000E 08	0.96461E 00	0.34602E 07	0.57512E 00	0.46829E 06	0.17057E 00	0.63376E 05	0.28982E-01
0.60000E 08	0.94309E 00	0.32915E 07	0.54910E 00	0.44545E 06	0.17818E 00	0.60286E 05	0.25520E-01
0.50000E 08	0.90631E 00	0.31310E 07	0.52436E 00	0.42373E 06	0.18000E 00	0.57345E 05	0.22227E-01
0.40000E 08	0.88482E 00	0.29783E 07	0.50081E 00	0.40306E 06	0.18000E 00	0.54549E 05	0.19094E-01
0.30000E 08	0.90993E 00	0.28330E 07	0.47842E 00	0.38341E 06	0.17668E 00	0.51888E 05	0.16115E-01
0.25000E 08	0.91979E 00	0.26948E 07	0.45712E 00	0.36471E 06	0.17294E 00	0.49358E 05	0.13820E-01
0.20000E 08	0.90848E 00	0.25634E 07	0.43686E 00	0.34692E 06	0.16938E 00	0.46950E 05	0.13146E-01
0.18017E 08	0.88497E 00	0.24384E 07	0.41758E 00	0.33000E 06	0.16600E 00	0.44661E 05	0.12505E-01
0.17139E 08	0.87497E 00	0.23195E 07	0.39925E 00	0.31391E 06	0.16278E 00	0.42483E 05	0.11895E-01
0.16303E 08	0.86545E 00	0.22063E 07	0.38181E 00	0.29860E 06	0.15958E 00	0.40411E 05	0.11315E-01
0.15508E 08	0.85289E 00	0.20987E 07	0.36522E 00	0.28403E 06	0.15521E 00	0.38440E 05	0.10763E-01
0.14751E 08	0.83890E 00	0.19964E 07	0.34948E 00	0.27018E 06	0.15105E 00	0.36565E 05	0.10238E-01
0.14032E 08	0.82559E 00	0.18990E 07	0.33561E 00	0.25700E 06	0.14710E 00	0.34782E 05	0.97389E-02
0.13348E 08	0.80967E 00	0.18064E 07	0.32241E 00	0.24447E 06	0.14334E 00	0.33085E 05	0.92639E-02
0.12697E 08	0.79437E 00	0.17183E 07	0.30986E 00	0.23255E 06	0.13976E 00	0.31472E 05	0.88121E-02
0.12077E 08	0.77982E 00	0.16345E 07	0.29792E 00	0.22121E 06	0.13636E 00	0.29937E 05	0.83823E-02
0.11488E 08	0.77314E 00	0.15548E 07	0.28656E 00	0.21042E 06	0.13313E 00	0.28477E 05	0.79735E-02
0.10928E 08	0.76782E 00	0.14790E 07	0.27575E 00	0.20016E 06	0.13005E 00	0.27088E 05	0.75847E-02
0.10395E 08	0.76275E 00	0.14068E 07	0.26547E 00	0.19039E 06	0.12712E 00	0.25767E 05	0.72147E-02
0.98882E 07	0.76034E 00	0.13382E 07	0.25570E 00	0.18111E 06	0.12433E 00	0.24510E 05	0.68629E-02
0.94059E 07	0.76613E 00	0.12730E 07	0.24640E 00	0.17228E 06	0.11879E 00	0.23315E 05	0.65282E-02
0.89472E 07	0.77163E 00	0.12109E 07	0.23755E 00	0.16387E 06	0.11311E 00	0.22178E 05	0.62098E-02
0.85108E 07	0.77687E 00	0.11518E 07	0.22829E 00	0.15588E 06	0.10772E 00	0.21096E 05	0.59069E-02
0.80957E 07	0.78185E 00	0.10956E 07	0.21930E 00	0.14828E 06	0.10259E 00	0.20067E 05	0.56188E-02
0.77009E 07	0.78539E 00	0.10422E 07	0.21075E 00	0.14105E 06	0.97707E-01	0.19089E 05	0.53448E-02
0.73253E 07	0.78840E 00	0.99137E 06	0.20236E 00	0.13417E 06	0.93063E-01	0.18158E 05	0.50841E-02
0.69681E 07	0.79078E 00	0.94302E 06	0.19317E 00	0.12762E 06	0.88647E-01	0.17272E 05	0.48362E-02
0.66282E 07	0.78840E 00	0.89703E 06	0.18444E 00	0.12140E 06	0.84445E-01	0.16430E 05	0.46003E-02
0.63050E 07	0.78613E 00	0.85323E 06	0.17612E 00	0.11548E 06	0.80449E-01	0.15628E 05	0.43760E-02
0.59975E 07	0.78398E 00	0.81167E 06	0.16822E 00	0.10985E 06	0.76647E-01	0.14866E 05	0.41625E-02
0.57050E 07	0.78193E 00	0.77208E 06	0.15818E 00	0.10449E 06	0.73031E-01	0.14141E 05	0.39595E-02
0.54267E 07	0.77999E 00	0.73443E 06	0.14764E 00	0.99394E 05	0.69321E-01	0.13452E 05	0.37664E-02
0.51621E 07	0.77813E 00	0.69861E 06	0.13761E 00	0.94547E 05	0.63892E-01	0.12795E 05	0.35827E-02
0.49103E 07	0.76848E 00	0.66454E 06	0.12807E 00	0.89935E 05	0.58728E-01	0.12171E 05	0.34080E-02
0.46708E 07	0.74573E 00	0.63213E 06	0.11900E 00	0.85549E 05	0.53815E-01	0.11578E 05	0.32418E-02
0.44430E 07	0.72409E 00	0.60130E 06	0.11036E 00	0.81377E 05	0.49142E-01	0.11013E 05	0.30837E-02
0.42263E 07	0.69323E 00	0.57197E 06	0.10930E 00	0.77408E 05	0.44697E-01	0.10476E 05	0.29333E-02
0.40202E 07	0.66145E 00	0.54408E 06	0.10860E 00	0.73633E 05	0.40469E-01	0.99651E 04	0.27902E-02

TABLE III (Cont'd.)

Output from PUNCRØSS Program

PAGE 7

ENERGY (EV)	CROSS SECTION	ENERGY (EV)	CROSS SECTION	ENERGY (EV)	CROSS SECTION	ENERGY (EV)	CROSS SECTION
0.94791E 04	0.26542E-02	0.12829E 04	0.35920E-03	0.17362E 03	0.48613E-04	0.23496E 02	0.65790E-05
0.90168E 04	0.25247E-02	0.12203E 04	0.34168E-03	0.16515E 03	0.46242E-04	0.22350E 02	0.62581E-05
0.85771E 04	0.24016E-02	0.11608E 04	0.32502E-03	0.15709E 03	0.43986E-04	0.21260E 02	0.59529E-05
0.81588E 04	0.22845E-02	0.11042E 04	0.30917E-03	0.14943E 03	0.41841E-04	0.20224E 02	0.56626E-05
0.77609E 04	0.21730E-02	0.10503E 04	0.29409E-03	0.14215E 03	0.39801E-04	0.19237E 02	0.53864E-05
0.73824E 04	0.20671E-02	0.99909E 03	0.27975E-03	0.13521E 03	0.37860E-04	0.18299E 02	0.51237E-05
0.70223E 04	0.19662E-02	0.95037E 03	0.26610E-03	0.12862E 03	0.36013E-04	0.17407E 02	0.48738E-05
0.66798E 04	0.18704E-02	0.90402E 03	0.25312E-03	0.12235E 03	0.34257E-04	0.16558E 02	0.46361E-05
0.63541E 04	0.17791E-02	0.85993E 03	0.24078E-03	0.11638E 03	0.32586E-04	0.15750E 02	0.44100E-05
0.60442E 04	0.16924E-02	0.81799E 03	0.22904E-03	0.11070E 03	0.30997E-04	0.14982E 02	0.41950E-05
0.57494E 04	0.16098E-02	0.77809E 03	0.21787E-03	0.10530E 03	0.29485E-04	0.14251E 02	0.39904E-05
0.54690E 04	0.15313E-02	0.74015E 03	0.20724E-03	0.10017E 03	0.28047E-04	0.13556E 02	0.37958E-05
0.52023E 04	0.14566E-02	0.70405E 03	0.19713E-03	0.95283E 02	0.26679E-04	0.12895E 02	0.36106E-05
0.49485E 04	0.13856E-02	0.66971E 03	0.18752E-03	0.90636E 02	0.25378E-04	0.12266E 02	0.34345E-05
0.47072E 04	0.13180E-02	0.63705E 03	0.17837E-03	0.86215E 02	0.24140E-04	0.11668E 02	0.32670E-05
0.44776E 04	0.12537E-02	0.60598E 03	0.16967E-03	0.82011E 02	0.22963E-04	0.11099E 02	0.31077E-05
0.42592E 04	0.11926E-02	0.57643E 03	0.16140E-03	0.78011E 02	0.21843E-04	0.10558E 02	0.29561E-05
0.40515E 04	0.11344E-02	0.54831E 03	0.15353E-03	0.74206E 02	0.20778E-04	0.10043E 02	0.28120E-05
0.38539E 04	0.10791E-02	0.52157E 03	0.14604E-03	0.70587E 02	0.19764E-04	0.95529E 01	0.26748E-05
0.36660E 04	0.10265E-02	0.49613E 03	0.13892E-03	0.67145E 02	0.18800E-04	0.90870E 01	0.25444E-05
0.34072E 04	0.97641E-03	0.47194E 03	0.13214E-03	0.63870E 02	0.17884E-04	0.86438E 01	0.24203E-05
0.33171E 04	0.92879E-03	0.44892E 03	0.12570E-03	0.60755E 02	0.17011E-04	0.82223E 01	0.23022E-05
0.31553E 04	0.88349E-03	0.42703E 03	0.11957E-03	0.57792E 02	0.16182E-04	0.78213E 01	0.21900E-05
0.30014E 04	0.84040E-03	0.40620E 03	0.11374E-03	0.54973E 02	0.15393E-04	0.74398E 01	0.20832E-05
0.28551E 04	0.79942E-03	0.38639E 03	0.10819E-03	0.52292E 02	0.14642E-04	0.70771E 01	0.19816E-05
0.27158E 04	0.76043E-03	0.36755E 03	0.10291E-03	0.49742E 02	0.13928E-04	0.67319E 01	0.18849E-05
0.25834E 04	0.72334E-03	0.34962E 03	0.97894E-04	0.47316E 02	0.13248E-04	0.64036E 01	0.17930E-05
0.24574E 04	0.68806E-03	0.33257E 03	0.93119E-04	0.45008E 02	0.12602E-04	0.60912E 01	0.17055E-05
0.23375E 04	0.65451E-03	0.31635E 03	0.88578E-04	0.42813E 02	0.11988E-04	0.57941E 01	0.16224E-05
0.22235E 04	0.62259E-03	0.30092E 03	0.84258E-04	0.40725E 02	0.11403E-04	0.55116E 01	0.15432E-05
0.21151E 04	0.59222E-03	0.28624E 03	0.80149E-04	0.38739E 02	0.10847E-04	0.52428E 01	0.14680E-05
0.20119E 04	0.56334E-03	0.27228E 03	0.76240E-04	0.36850E 02	0.10318E-04	0.49872E 01	0.13964E-05
0.19138E 04	0.53587E-03	0.25901E 03	0.72521E-04	0.35053E 02	0.98147E-05	0.47439E 01	0.13283E-05
0.18205E 04	0.50973E-03	0.24637E 03	0.68985E-04	0.33343E 02	0.93360E-05	0.45125E 01	0.12635E-05
0.17317E 04	0.48487E-03	0.23436E 03	0.65620E-04	0.31717E 02	0.88807E-05	0.42925E 01	0.12019E-05
0.16472E 04	0.46122E-03	0.22293E 03	0.62420E-04	0.30170E 02	0.84476E-05	0.40831E 01	0.11433E-05
0.15669E 04	0.43873E-03	0.21206E 03	0.59376E-04	0.28699E 02	0.80356E-05	0.38840E 01	0.10875E-05
0.14905E 04	0.41733E-03	0.20171E 03	0.56480E-04	0.27299E 02	0.76437E-05	0.36945E 01	0.10345E-05
0.14178E 04	0.39698E-03	0.19183E 03	0.53725E-04	0.25968E 02	0.72709E-05	0.35143E 01	0.98401E-06
0.13486E 04	0.37762E-03	0.18252E 03	0.51105E-04	0.24701E 02	0.69163E-05	0.33429E 01	0.93602E-06

TABLE III (Cont'd.)

Output from PUNCRØSS Program

PAGE 8

ENERGY (EV)	CROSS SECTION	ENERGY (EV)	CROSS SECTION	ENERGY (EV)	CROSS SECTION	ENERGY (EV)	CROSS SECTION
0.31799E 01	0.89037E-06	0.43036E 00	0.12050E-06	0.58242E-01	0.16308E-07		
0.30248E 01	0.84695E-06	0.40937E 00	0.11462E-06	0.55402E-01	0.15512E-07		
0.28773E 01	0.80564E-06	0.38940E 00	0.10903E-06	0.52699E-01	0.14756E-07		
0.27370E 01	0.76635E-06	0.37041E 00	0.10371E-06	0.50129E-01	0.14036E-07		
0.26035E 01	0.72897E-06	0.35234E 00	0.98656E-07	0.47684E-01	0.13352E-07		
0.24765E 01	0.69342E-06	0.33516E 00	0.93844E-07	0.45359E-01	0.12700E-07		
0.23557E 01	0.65960E-06	0.31881E 00	0.89268E-07	0.43147E-01	0.12081E-07		
0.22408E 01	0.62743E-06	0.30326E 00	0.84914E-07	0.41042E-01	0.11492E-07		
0.21315E 01	0.59683E-06	0.28847E 00	0.80773E-07	0.39041E-01	0.10931E-07		
0.20276E 01	0.56773E-06	0.27440E 00	0.76833E-07	0.37137E-01	0.10398E-07		
0.19287E 01	0.54004E-06	0.26102E 00	0.73086E-07				
0.18346E 01	0.51370E-06	0.24829E 00	0.69522E-07				
0.17452E 01	0.48865E-06	0.23618E 00	0.66131E-07				
0.16601E 01	0.46481E-06	0.22466E 00	0.62906E-07				
0.15791E 01	0.44214E-06	0.21371E 00	0.59838E-07				
0.15021E 01	0.42058E-06	0.20328E 00	0.56919E-07				
0.14288E 01	0.40007E-06	0.19337E 00	0.54143E-07				
0.13591E 01	0.38056E-06	0.18394E 00	0.51503E-07				
0.12928E 01	0.36200E-06	0.17497E 00	0.48991E-07				
0.12298E 01	0.34434E-06	0.16643E 00	0.46602E-07				
0.11698E 01	0.32755E-06	0.15832E 00	0.44329E-07				
0.11128E 01	0.31157E-06	0.15060E 00	0.42167E-07				
0.10585E 01	0.29638E-06	0.14325E 00	0.40110E-07				
0.10069E 01	0.28192E-06	0.13627E 00	0.38154E-07				
0.95778E 00	0.26817E-06	0.12962E 00	0.36293E-07				
0.91105E 00	0.25510E-06	0.12330E 00	0.34523E-07				
0.86663E 00	0.24265E-06	0.11728E 00	0.32840E-07				
0.82437E 00	0.23082E-06	0.11156E 00	0.31238E-07				
0.78415E 00	0.21956E-06	0.10612E 00	0.29715E-07				
0.74592E 00	0.20885E-06	0.10095E 00	0.28265E-07				
0.70954E 00	0.19867E-06	0.96024E-01	0.26887E-07				
0.67493E 00	0.18898E-06	0.91342E-01	0.25576E-07				
0.64201E 00	0.17976E-06	0.86888E-01	0.24328E-07				
0.61071E 00	0.17100E-06	0.82649E-01	0.23142E-07				
0.58091E 00	0.16266E-06	0.78618E-01	0.22013E-07				
0.55259E 00	0.15472E-06	0.74785E-01	0.20940E-07				
0.52564E 00	0.14718E-06	0.71137E-01	0.19918E-07				
0.50001E 00	0.14000E-06	0.67667E-01	0.18947E-07				
0.47561E 00	0.13317E-06	0.64367E-01	0.18023E-07				
0.45242E 00	0.12668E-06	0.61229E-01	0.17144E-07				

TABLE III (Cont'd.)

Output from PUNCRØSS Program

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*****THESE ARE CROSS SECTIONS ABOVE CUTOFF---PUNCHED CARD OUTPUT FOR NMT INPUT*****

ELEMENT=82207
SIGMA= 71
INTERPOLATION= 8
POINTS= 14
MASS= 0.0

LEAD PEREY DATA F1

ENERGY (EV)	CROSS SECTION	ENERGY (EV)	CROSS SECTION	ENERGY (EV)	CROSS SECTION	ENERGY (EV)	CROSS SECTION
0.10000E 09	0.98569E 00						
0.80000E 08	0.97576E 00						
0.70000E 08	0.96461E 00						
0.60000E 08	0.94309E 00						
0.50000E 08	0.90631E 00						
0.40000E 08	0.88482E 00						
0.30000E 08	0.90993E 00						
0.25000E 08	0.91979E 00						
0.20000E 08	0.90848E 00						
0.18017E 08	0.88497E 00						
0.17139E 08	0.87497E 00						
0.16303E 08	0.86545E 00						
0.15508E 08	0.85289E 00						
0.14751E 08	0.83890E 00						

INPUT EXAUSTED. NORMAL TERMINATION

TABLE IV

Subroutine SØRS for Sample Problem

```
      SUBROUTINE SORS(NCOL)
      COMMON/COMON/A(10,17),ALPHA(60),APR,ARG(17),BETA(60),BLZ(200),
     1 COSKS,COSPHI,COSTH,D,DELSIG,DEN(10,17),DENH(17),DKWT,
     2 E(200),EA(40),EB(40),EC(200),EION(10,17),EMAX,EMIN(7),
     3 EP(60),EPART(100,2),EREC,EX,GAM(60),HEVSUM,HSIGG(5,17),
     4 HSIG,IBERT,ITYP,KIND(60),LELEM,MAT,MAXBCH,MAXCAS,
     5 MXMAT,N,NABOV,NAMAX,NAME(200),NAMEA(40),NBELO,NBERTP,NBOGUS,
     6 NEGEX,NEL(17),NEUTNO,NEUTP,NGROUP,NPIDK,NMED(200),NO,
     7 NOBCH,NOCAS,NOMAX,NOPART,NPART(6),NQUIT,OLDWT
     8,SIGG(10,17),SIGMX(7,17),SINKS,SINPHI,SINTH,TIP(200),
     9 TIPA(40),TIPB(40),U(200),UA(40),UB(40),UMAX,UU,V(200),
     1 VA(40),VB(40),W(200),WA(40),WB(40),WT(200),WTA(40),
     2 WTB(40),X(200),XC(200),Y(200),YC(200),Z(200),ZC(200),
     3 ZZ(10,17),ZPR
      IF(NBERTP.LE.0) GO TO 10
      E(1) = EMAX
      X(1) = 0.
      Y(1) = 0.
      Z(1) = 0.
      U(1) = 0.
      V(1) = 0.
      W(1) = 1.
      WT(1)= 1.
      TIP(1)= 2.0
      RETURN
   10 CALL MFPD(NCOL)
      RETURN
      END
```

TABLE V

NMT Input

```
                                                                                CARD A
NMTC SAMPLE PROBLEM - 1500 MEV PI+ MESONS NORMALLY INCIDENT                     CARD B
ON INFINITE PB SLAB 204 GM./SQ.CM. (18 CM.) THICK.THIS IS NMT INPUT.            CARD C
93600A780FD1
     1500.          15.          15.          2          25          20        0  CARD D
        1            8            1          11           0           9           CARD E
       0.           0.            1                                   1           CARD F
    100.0            1            5           1                                   CARD G
       0.            1            1                                                   H1
      82.         207.        0.033           1                                 CARD I11
       0.            1            1                                                   H2
      82.         207.        0.033           1                                 CARD I12
82207     2     8    26    0.0      ELASTIC
     0.10000E 09      0.25599E 01                                  82207    2     1
     0.90000E 08      0.27380E 01                                  82207    2     2
     0.80000E 08      0.26499E 01                                  82207    2     3
     0.70000E 08      0.24603E 01                                  82207    2     4
     0.60000E 08      0.21299E 01                                  82207    2     5
     0.55000E 08      0.20570E 01                                  82207    2     6
     0.50000E 08      0.20300E 01                                  82207    2     7
     0.45000E 08      0.20580E 01                                  82207    2     8
     0.44000E 08      0.20569E 01                                  82207    2     9
     0.43000E 08      0.20356E 01                                  82207    2    10
     0.42000E 08      0.20240E 01                                  82207    2    11
     0.41000E 08      0.20321E 01                                  82207    2    12
     0.40000E 08      0.20799E 01                                  82207    2    13
     0.35000E 08      0.23035E 01                                  82207    2    14
     0.30000E 08      0.26499E 01                                  82207    2    15
     0.27500E 08      0.28892E 01                                  82207    2    16
     0.25000E 08      0.30574E 01                                  82207    2    17
     0.22500E 08      0.31944E 01                                  82207    2    18
     0.20000E 08      0.32499E 01                                  82207    2    19
     0.18017E 08      0.31691E 01                                  82207    2    20
     0.17500E 08      0.31467E 01                                  82207    2    21
     0.17139E 08      0.31100E 01                                  82207    2    22
     0.16303E 08      0.30227E 01                                  82207    2    23
     0.15508E 08      0.29365E 01                                  82207    2    24
     0.15000E 08      0.28797E 01                                  82207    2    25
     0.14751E 08      0.28436E 01
                                                               END OF82207    2    27
82207    71     8    14    0.0      LEAD     PEREY DATA            F1
     0.10000E 09      0.98569E 00                                  82207   71     1
     0.80000E 08      0.97576E 00                                  82207   71     2
     0.70000E 08      0.96461E 00                                  82207   71     3
     0.60000E 08      0.94309E 00                                  82207   71     4
     0.50000E 08      0.90631E 00                                  82207   71     5
     0.40000E 08      0.88482E 00                                  82207   71     6
     0.30000E 08      0.90993E 00                                  82207   71     7
     0.25000E 08      0.91979E 00                                  82207   71     8
     0.20000E 08      0.90848E 00                                  82207   71     9
     0.18017E 08      0.88497E 00                                  82207   71    10
     0.17139E 08      0.87497E 00                                  82207   71    11
     0.16303E 08      0.86545E 00                                  82207   71    12
     0.15508E 08      0.85289E 00                                  82207   71    13
     0.14751E 08      0.83890E 00                                  82207   71    14
                                                               END OF82207   71    15
    2      MALE                                                              GEOM   A
XZONE BNDS      -10000.,       10000.                                        GEOM   B
YZONE BNDS      -10000.,       10000.                                        GEOM   C
ZZONE BNDS           0.,          18.                                        GEOM   D
ZONE        1      1     1                                                   GEOM   E
XBLOK BNDS      -10000.,       10000.                                        GEOM   F
YBLOK BNDS      -10000.,       10000.                                        GEOM   G
ZBLOK BNDS           0.,           6.,        12.,         18.               GEOM   H
BLOCK       1      1     1                                                   GEOM  J1
MEDIA              1                                                         GEOM  K1
BLOCK       1      1     2                                                   GEOM  J2
MEDIA              2                                                         GEOM  K2
BLOCK       1      1     3                                                   GEOM  J3
MEDIA              1                                                         GEOM  K3
    0     NO QUADRIC SURFACES                                                GEOM   Q
NMTC SAMPLE PROBLEM - THIS IS THE NMT INPUT TO TRANSPORT MUONS.               CARD A
```

TABLE V (Cont'd.)

NMT Input

```
                                                                      BLANK             CARD B
2799734DB115                                                                            CARD C
     1533.     0.8857        15.          2         25         20           0           CARD D
         1          9          0         11          0          2                       CARD E
        0.         0.          1                                1                       CARD F
       0.0          0          0          0                                             CARD G
        0.          1          0                                                            H1
       82.       207.      0.033          0                                             CARD I11
        0.          1          0                                                            H2
       82.       207.      0.033          0                                             CARD I12
    2      MALE                                                                         GEOM   A
XZONE BNDS     -10000..     10000.                                                      GEOM   B
YZONE BNDS     -10000..     10000.                                                      GEOM   C
ZZONE BNDS          0..        18.                                                      GEOM   D
ZONE        1     1     1                                                               GEOM   E
XBLOK BNDS     -10000..     10000.                                                      GEOM   F
YBLOK BNDS     -10000..     10000.                                                      GEOM   G
ZBLOK BNDS          0..         6..        12..        18.                              GEOM   H
BLOCK       1     1     1                                                               GEOM  J1
MEDIA             1                                                                     GEOM  K1
BLOCK       1     1     2                                                               GEOM  J2
MEDIA             2                                                                     GEOM  K2
BLOCK       1     1     3                                                               GEOM  J3
MEDIA             1                                                                     GEOM  K3
    0     NO QUADRIC SURFACES                                                           GEOM   Q
```

TABLE VI

NMT Output

```
NMTC SAMPLE PROBLEM - 1500 MEV PI+ MESONS NORMALLY INCIDENT              CARD A
ON INFINITE PB SLAB 204 GM./SQ.CM. (18 CM.) THICK.THIS IS NMT INPUT.     CARD B
                     INITIAL RANDOM NO. 93600A780FD1
EMAX =0.1500E 04   ELOP =0.1500E 02  ELON =0.1500E 02  MXMAT =  2   MAXCAS =   25   MAXBCH =   20
NQUIT =     1   NEUTP =    8   NBERTP =    1   NPOWR2 = 11   NPIDK =    0   NHSTP =    9
ANDIT=0.0         CTOFE=0.0         NICOL= 0   NEXITE=   1   NSEUDO=   1
ELAS =0.1000E 03   NOELAS =     1   NELSTP =     5   NLEDIT =   1
HSIGMX    0.29500E-24   0.14600E-23   0.20030E-24   0.0         0.66900E-25
THIS IS MEDIUM  1
DENH( 1) =0.0           NEL( 1) =  1  NOEL( 1) =  1
ZZ( 1, 1) = 82.0  A( 1, 1) = 207.0  DEN( 1, 1) = 0.330000E-01  ID( 1, 1) =    1
THIS IS MEDIUM  2
DENH( 2) =0.0           NEL( 2) =  1  NOEL( 2) =  1
ZZ( 1, 2) = 82.0  A( 1, 2) = 207.0  DEN( 1, 2) = 0.330000E-01  ID( 1, 2) =    1
82207    2    8   26    0.0   ELASTIC

   0.10000E 03    0.25599E 01
   0.90000E 02    0.27380E 01
   0.80000E 02    0.26499E 01
   0.70000E 02    0.24603E 01
   0.60000E 02    0.21299E 01
   0.55000E 02    0.20570E 01
   0.50000E 02    0.20300E 01
   0.45000E 02    0.20580E 01
   0.44000E 02    0.20569E 01
   0.43000E 02    0.20356E 01
   0.42000E 02    0.20240E 01
   0.41000E 02    0.20321E 01
   0.40000E 02    0.20799E 01
   0.35000E 02    0.23035E 01
   0.30000E 02    0.26499E 01
   0.27500E 02    0.28892E 01
   0.25000E 02    0.30574E 01
   0.22500E 02    0.31944E 01
   0.20000E 02    0.32499E 01
   0.18017E 02    0.31691E 01
   0.17500E 02    0.31467E 01
   0.17139E 02    0.31100E 01
   0.16303E 02    0.30227E 01
   0.15508E 02    0.29365E 01
   0.15000E 02    0.28797E 01
   0.14751E 02    0.28436E 01
82207   71    8   14    0.0    LEAD    PEREY DATA         F1

   0.10000E 03    0.98569E 00
   0.80000E 02    0.97576E 00
   0.70000E 02    0.96461E 00
   0.60000E 02    0.94309E 00
   0.50000E 02    0.90631E 00
   0.40000E 02    0.88482E 00
   0.30000E 02    0.90993E 00
   0.25000E 02    0.91979E 00
   0.20000E 02    0.90848E 00
   0.18017E 02    0.88497E 00
   0.17139E 02    0.87497E 00
   0.16303E 02    0.86545E 00
   0.15508E 02    0.85269E 00
   0.14751E 02    0.83890E 00

        'GEOMETRIC'CROSS SECTIONS FOR NUCLIDES 1- 1 IN MEDIUM  1 IN RECIPROCAL CENTIMETERS
 0.8104E-01
    MAXIMUM HYDROGEN CROSS SECTIONS FOR PARTICLE TYPES 1 THROUGH 5 IN MEDIUM  1 IN RECIPROCAL CENTIMETERS
              0.0          0.0          0.0          0.0          0.0

    TRANSPORT CROSS SECTIONS(THE SUM OF 'GEOMETRIC' XSECTS+MAX HYDROGEN XSECT+MAX DECAY XSECT) FOR PARTICLE
                    TYPES 1 THROUGH 7 IN MEDIUM  1 IN RECIPROCAL CENTIMETERS
        0.8104E-01  0.8104E-01  0.8806E-01  0.0        0.8806E-01  0.8885E-04  0.8885E-04
```

TABLE VI (Cont'd.)

NMT Output

'GEOMETRIC'CROSS SECTIONS FOR NUCLIDES 1- 1 IN MEDIUM 2 IN RECIPROCAL CENTIMETERS

0.8104E-01

MAXIMUM HYDROGEN CROSS SECTIONS FOR PARTICLE TYPES 1 THROUGH 5 IN MEDIUM 2 IN RECIPROCAL CENTIMETERS

0.0 0.0 0.0 0.0 0.0

TRANSPORT CROSS SECTIONS(THE SUM OF 'GEOMETRIC' XSECTS+MAX HYDROGEN XSECT+MAX DECAY XSECT) FOR PARTICLE TYPES 1 THROUGH 7 IN MEDIUM 2 IN RECIPROCAL CENTIMETERS

0.8104E-01 0.8104E-01 0.8806E-01 0.0 0.8806E-01 0.8885E-04 0.8885E-04

TABLE VI (Cont'd.)

NMT Output

```
    2      MALE
XZONE BNDS  -0.100000 05.  0.100000 05
YZONE BNDS  -0.100000 05.  0.100000 05
ZZONE BNDS   0.0        .  0.180000 02

ZONE        1    1    1
XBLOK BNDS  -0.100000 05.  0.100000 05
YBLOK BNDS  -0.100000 05.  0.100000 05
ZBLOK BNDS   0.0        .  0.600000 01.  0.120000 02.  0.180000 02

BLOCK       1    1    1
MEDIA            1

BLOCK       1    1    2
MEDIA            2

BLOCK       1    1    3
MEDIA            1

    0   NO QUADRIC SURFACES
```

END BATCH	1	OSA NEUTRONS PRODUCED IN THIS BATCH	649	CUMULATIVE NO. CASCADES COMPLETED	25
END BATCH	2	OSA NEUTRONS PRODUCED IN THIS BATCH	806	CUMULATIVE NO. CASCADES COMPLETED	50
END BATCH	3	OSA NEUTRONS PRODUCED IN THIS BATCH	493	CUMULATIVE NO. CASCADES COMPLETED	75
END BATCH	4	OSA NEUTRONS PRODUCED IN THIS BATCH	577	CUMULATIVE NO. CASCADES COMPLETED	100
END BATCH	5	OSA NEUTRONS PRODUCED IN THIS BATCH	448	CUMULATIVE NO. CASCADES COMPLETED	125
END BATCH	6	OSA NEUTRONS PRODUCED IN THIS BATCH	710	CUMULATIVE NO. CASCADES COMPLETED	150
END BATCH	7	OSA NEUTRONS PRODUCED IN THIS BATCH	714	CUMULATIVE NO. CASCADES COMPLETED	175
END BATCH	8	OSA NEUTRONS PRODUCED IN THIS BATCH	358	CUMULATIVE NO. CASCADES COMPLETED	200
END BATCH	9	OSA NEUTRONS PRODUCED IN THIS BATCH	882	CUMULATIVE NO. CASCADES COMPLETED	225
END BATCH	10	OSA NEUTRONS PRODUCED IN THIS BATCH	745	CUMULATIVE NO. CASCADES COMPLETED	250
END BATCH	11	OSA NEUTRONS PRODUCED IN THIS BATCH	757	CUMULATIVE NO. CASCADES COMPLETED	275
END BATCH	12	OSA NEUTRONS PRODUCED IN THIS BATCH	557	CUMULATIVE NO. CASCADES COMPLETED	300
END BATCH	13	OSA NEUTRONS PRODUCED IN THIS BATCH	758	CUMULATIVE NO. CASCADES COMPLETED	325
END BATCH	14	OSA NEUTRONS PRODUCED IN THIS BATCH	561	CUMULATIVE NO. CASCADES COMPLETED	350
END BATCH	15	OSA NEUTRONS PRODUCED IN THIS BATCH	416	CUMULATIVE NO. CASCADES COMPLETED	375
END BATCH	16	OSA NEUTRONS PRODUCED IN THIS BATCH	526	CUMULATIVE NO. CASCADES COMPLETED	400
END BATCH	17	OSA NEUTRONS PRODUCED IN THIS BATCH	698	CUMULATIVE NO. CASCADES COMPLETED	425
END BATCH	18	OSA NEUTRONS PRODUCED IN THIS BATCH	510	CUMULATIVE NO. CASCADES COMPLETED	450
END BATCH	19	OSA NEUTRONS PRODUCED IN THIS BATCH	642	CUMULATIVE NO. CASCADES COMPLETED	475
END BATCH	20	OSA NEUTRONS PRODUCED IN THIS BATCH	637	CUMULATIVE NO. CASCADES COMPLETED	500

	REAL NONHYDROG COLLISIONS	PSEUDO NONHYDROG COLLISIONS	REAL HYDROGEN COLLISIONS	PSEUDO HYDROGEN COLLISIONS	PSEUDO DECAY COLLISIONS	REAL ELASTIC COLLISIONS	PSEUDO ELASTIC COLLISIONS
MEDIUM 1	0.10200E 04	0.43700E 03	0.0	0.0	0.46000E 02	0.10100E 03	0.69600E 03
MEDIUM 2	0.59400E 03	0.26500E 03	0.0	0.0	0.17000E 02	0.59000E 02	0.37500E 03

PSEUDO COLLISIONS WITHIN INTERNAL VOID BY PARTICLES OF

TYPE 1	TYPE 2	TYPE 3	TYPE 4	TYPE 5	TYPE 6	TYPE 7
0.0	0.0	0.0	0.0	0.0	0.0	0.0

END OF RUN   NEGEX = 0   LOWAZ = 0   FINAL RANDOM NO. = C441FFB46CDD

TIME= 5 MINUTES 50.70 SECONDS

TABLE VI (Cont'd.)

NMT Output

```
NMTC SAMPLE PROBLEM - THIS IS THE NMT INPUT TO TRANSPORT MUONS.          CARD A
                                                          BLANK          CARD B
                    INITIAL RANDOM NO. 279973400B115
EMAX =0.1533E 04   ELOP =0.8857E 00  ELON =0.1500E 02  MXMAT =   2    MAXCAS =      25    MAXBCH =      20
NQUIT =        1   NEUTP =       9   NBERTP =      0   NPOWR2 = 11    NPIDK =        0    NHSTP =        2
ANDIT=0.0          CTOFE=0.0         NICOL= 0    NEXITE=   1   NSEUDO=   1
ELAS =0.0          NOELAS =      0    NELSTP =      0    NLEDIT =   0
THIS IS MEDIUM  1
DENH( 1) =0.0          NEL( 1) =  1  NOEL( 1) =  0
ZZ( 1, 1) = 82.0  A( 1, 1) = 207.0  DEN( 1, 1) = 0.330000E-01  ID( 1, 1) =     0
THIS IS MEDIUM  2
DENH( 2) =0.0          NEL( 2) =  1  NOEL( 2) =  0
ZZ( 1, 2) = 82.0  A( 1, 2) = 207.0  DEN( 1, 2) = 0.330000E-01  ID( 1, 2) =     0

            'GEOMETRIC'CROSS SECTIONS FOR NUCLIDES 1- 1 IN MEDIUM  1 IN RECIPROCAL CENTIMETERS
  0.0
     MAXIMUM HYDROGEN CROSS SECTIONS FOR PARTICLE TYPES 1 THROUGH 5 IN MEDIUM  1 IN RECIPROCAL CENTIMETERS
                       0.0          0.0          0.0          0.0          0.0

     TRANSPORT CROSS SECTIONS(THE SUM OF 'GEOMETRIC' XSECTS+MAX HYDROGEN XSECT+MAX DECAY XSECT) FOR PARTICLE
                  TYPES 1 THROUGH 7 IN MEDIUM  1 IN RECIPROCAL CENTIMETERS
                0.0        0.0        0.2902E-01  0.0        0.2902E-01  0.3673E-03  0.3673E-03

            'GEOMETRIC'CROSS SECTIONS FOR NUCLIDES 1- 1 IN MEDIUM  2 IN RECIPROCAL CENTIMETERS
  0.0
     MAXIMUM HYDROGEN CROSS SECTIONS FOR PARTICLE TYPES 1 THROUGH 5 IN MEDIUM  2 IN RECIPROCAL CENTIMETERS
                       0.0          0.0          0.0          0.0          0.0

     TRANSPORT CROSS SECTIONS(THE SUM OF 'GEOMETRIC' XSECTS+MAX HYDROGEN XSECT+MAX DECAY XSECT) FOR PARTICLE
                  TYPES 1 THROUGH 7 IN MEDIUM  2 IN RECIPROCAL CENTIMETERS
                0.0        0.0        0.2902E-01  0.0        0.2902E-01  0.3673E-03  0.3673E-03
```

TABLE VI (Cont'd.)

NMT Output

```
    2      MALE
XZONE BNDS  -0.100000 05,  0.100000 05
YZONE BNDS  -0.100000 05,  0.100000 05
ZZONE BNDS   0.0         .  0.180000 02

ZONE      1    1    1
XBLOK BNDS  -0.100000 05,  0.100000 05
YBLOK BNDS  -0.100000 05,  0.100000 05
ZBLOK BNDS   0.0         .  0.600000 01,  0.120000 02,  0.180000 02

BLOCK     1    1    1
MEDIA          1

BLOCK     1    1    2
MEDIA          2

BLOCK     1    1    3
MEDIA          1

    0   NO QUADRIC SURFACES
```

TABLE VI (Cont'd.)

NMT Output

```
                          READING LOG.  9 AS NMT TAPE

MAXBCH  MAXCAS  MXMAT  NGROUP   NPIDK ' NICOL   NQUIT  NEXITE  NSPRED  NWSPRD  NSEUDO  NBERTP
  20      25      2     2048      0       0       1       1       0       0       1       1

                               EMAX   0.1500E 04

                        CUTOFF ENERGIES FOR TYPES 1-7
  0.1500E 02  0.1500E 02  0.2232E 01  0.2156E 01  0.2232E 01  0.1693E 01  0.1693E 01

MEDIUM   1

  NUCLIDE NO.     Z NO.         A NO.      'GEOMETRIC' XSECT (PER CM)
      1        0.8200E 02    0.2070E 03          0.8104E-01

   TRANSPORT XSECTS FOR PARTICLE TYPES 1-7 IN MEDIUM     1 IN PER CM
   0.8104E-01  0.8104E-01  0.8806E-01  0.0       0.8806E-01  0.8885E-04  0.8885E-04

   MAX HYDROGEN XSECTS FOR PARTICLE TYPES 1-5 IN MEDIUM    1 IN PER CM
   0.0         0.0         0.0         0.0         0.0

MEDIUM   2

  NUCLIDE NO.     Z NO.         A NO.      'GEOMETRIC' XSECT (PER CM)
      1        0.8200E 02    0.2070E 03          0.8104E-01

   TRANSPORT XSECTS FOR PARTICLE TYPES 1-7 IN MEDIUM     2 IN PER CM
   0.8104E-01  0.8104E-01  0.8806E-01  0.0       0.8806E-01  0.8885E-04  0.8885E-04

   MAX HYDROGEN XSECTS FOR PARTICLE TYPES 1-5 IN MEDIUM    2 IN PER CM
   0.0         0.0         0.0         0.0         0.0

END BATCH   1   OSR NEUTRONS PRODUCED IN THIS BATCH   0   CUMULATIVE NO. CASCADES COMPLETED   45
END BATCH   2   OSR NEUTRONS PRODUCED IN THIS BATCH   0   CUMULATIVE NO. CASCADES COMPLETED   82
END BATCH   3   OSR NEUTRONS PRODUCED IN THIS BATCH   0   CUMULATIVE NO. CASCADES COMPLETED  113
END BATCH   4   OSR NEUTRONS PRODUCED IN THIS BATCH   0   CUMULATIVE NO. CASCADES COMPLETED  151
END BATCH   5   OSR NEUTRONS PRODUCED IN THIS BATCH   0   CUMULATIVE NO. CASCADES COMPLETED  194
END BATCH   6   OSR NEUTRONS PRODUCED IN THIS BATCH   0   CUMULATIVE NO. CASCADES COMPLETED  238
END BATCH   7   OSR NEUTRONS PRODUCED IN THIS BATCH   0   CUMULATIVE NO. CASCADES COMPLETED  280
END BATCH   8   OSR NEUTRONS PRODUCED IN THIS BATCH   0   CUMULATIVE NO. CASCADES COMPLETED  318
END BATCH   9   OSR NEUTRONS PRODUCED IN THIS BATCH   0   CUMULATIVE NO. CASCADES COMPLETED  360
END BATCH  10   OSR NEUTRONS PRODUCED IN THIS BATCH   0   CUMULATIVE NO. CASCADES COMPLETED  394
END BATCH  11   OSR NEUTRONS PRODUCED IN THIS BATCH   0   CUMULATIVE NO. CASCADES COMPLETED  439
END BATCH  12   OSR NEUTRONS PRODUCED IN THIS BATCH   0   CUMULATIVE NO. CASCADES COMPLETED  471
END BATCH  13   OSR NEUTRONS PRODUCED IN THIS BATCH   0   CUMULATIVE NO. CASCADES COMPLETED  515
END BATCH  14   OSR NEUTRONS PRODUCED IN THIS BATCH   0   CUMULATIVE NO. CASCADES COMPLETED  554
END BATCH  15   OSR NEUTRONS PRODUCED IN THIS BATCH   0   CUMULATIVE NO. CASCADES COMPLETED  580
END BATCH  16   OSR NEUTRONS PRODUCED IN THIS BATCH   0   CUMULATIVE NO. CASCADES COMPLETED  610
END BATCH  17   OSR NEUTRONS PRODUCED IN THIS BATCH   0   CUMULATIVE NO. CASCADES COMPLETED  649
END BATCH  18   OSR NEUTRONS PRODUCED IN THIS BATCH   0   CUMULATIVE NO. CASCADES COMPLETED  678
END BATCH  19   OSR NEUTRONS PRODUCED IN THIS BATCH   0   CUMULATIVE NO. CASCADES COMPLETED  712
END BATCH  20   OSR NEUTRONS PRODUCED IN THIS BATCH   0   CUMULATIVE NO. CASCADES COMPLETED  754
```

	REAL NONHYDROG COLLISIONS	PSEUDO NONHYDROG COLLISIONS	REAL HYDROGEN COLLISIONS	PSEUDO HYDROGEN COLLISIONS	PSEUDO DECAY COLLISIONS	REAL ELASTIC COLLISIONS	PSEUDO ELASTIC COLLISIONS
MEDIUM 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MEDIUM 2	0.0	0.0	0.0	0.0	0.10000E 01	0.0	0.0

TABLE VI (Cont'd.)

NMT Output

PSEUDO COLLISIONS WITHIN INTERNAL VOID BY PARTICLES OF

TYPE 1	TYPE 2	TYPE 3	TYPE 4	TYPE 5	TYPE 6	TYPE 7
0.0	0.0	0.0	0.0	0.0	0.0	0.0

END OF RUN NEGEX = 0 LOWAZ = 0 FINAL RANDOM NO. = 42FF138551F1

TIME= 12.05 SECONDS

JOB TERMINATED BY READING END OF FILE ON LOG. 5

TABLE VII

Listing of NMT Analysis Program

```
C      NMT ANALYSIS- SAMPLE PROBLEM
       DIMENSION PC(4,2,7),PCUR(4,2,7),PCUR2(4,2,7)
       COMMON/LABEL/
     1        NHST ,N,IN,IO,NCOL,NOCAS,NAME,MAT,NMED,LELEM,NOPART,NABOV
     2, NBELO,MAXBCH,MAXCAS,MXMAT,NGROUP,NPIDK,N1COL,NQUIT,NEXCT
     3,NPART(6),NEL(8),NAMEA(40)
     4      , X,Y,Z,XC,YC,ZC,OLDWT,WT,E,EC,U,V,W,TIP,APR,ZPR,EREC,EX
     5,HEVSUM,UU,EMAX,WTEVAP,ZZ(10,16),A(10,16),SIGG(10,17),SIGMX(7,17)
     6,HSIGG(5,17),TIPA(40),EA(40),UA(40),VA(40),WA(40),WTA(40)
     7,TIB(40) ,EB(40),UB(40),VB(40),WB(40),WTB(40),EPART(100,2),EMIN(7)
     8,BOLD,BLZ,HEPART(100,4)
       IN=5
       IO=6
  1    READ (IN,2,END=999) NHST
    2 FORMAT(I10)
   10 CALL REDNMT
      NCL = NCOL + 5
      GOTO(70,60,25,20,25,10,10,10,40,10,10,40,25),NCL
C NCOL =   -4,-3,-2,-1, 0, 1, 2, 3, 4, 5, 6, 7, 8
   20 DO 22 I=1,4
      DO 22 J=1,2
      DO 22 K=1,7
      PC(I,J,K) = 0.
      PCUR(I,J,K) = 0.
   22 PCUR2(I,J,K)= 0.
      PBCH = FLOAT(MAXCAS)
      BCHS = FLOAT(MAXBCH)
      GO TO 10
   25 WRITE(IO,26) NCOL
   26 FORMAT(1H1,' NCOL = ',I5,' IN MAIN')
      CALL ERROR
      RETURN
   40 NTYP = IFIX(TIP) + 1
      IF(W) 42,45,47
   42 NSIGN = 1
      GO TO 49
   45 WRITE(IO,46) W
   46 FORMAT(1H1,' W = ',E17.7,' IN MAIN')
      GOTO 10
   47 NSIGN = 2
   49 IZ = IFIX( ZC/6.0 ) + 1
      PC(IZ,NSIGN,NTYP) = PC(IZ,NSIGN,NTYP) + WT
      GO TO 10
   60 DO 65 I=1,4
      DO 65 J=1,2
      DO 65 K=1,7
      PCUR(I,J,K) = PCUR(I,J,K) +  PC(I,J,K)/PBCH
      PCUR2(I,J,K)= PCUR2(I,J,K) +(PC(I,J,K)/PBCH)**2
   65 PC(I,J,K) = 0.
      GO TO 10
   70 BCHSS = BCHS -1
      IF(BCHSS.EQ.0.) BCHSS =1
      DO 75  I=1,4
      DO 75  J=1,2
      DO 75  K=1,7
      IF(PCUR(I,J,K).EQ.0.) GO TO 75
      PCUR2(I,J,K)=(PCUR2(I,J,K)/BCHS - (PCUR(I,J,K)/BCHS)**2)/BCHSS
C     SAMPLE VARIANCE (TREATING EACH BATCH AS A SAMPLE).
      PCUR(I,J,K) =  PCUR(I,J,K)/BCHS
      PCUR2(I,J,K)= 100.* SQRT( ABS( PCUR2(I,J,K)))/PCUR(I,J,K)
C    RELATIVE STANDARD DEVIATION EXPRESSED IN PERCENT.
   75 CONTINUE
      WRITE(IO,80)
   80 FORMAT(1H1,14X, ' NMT OUTPUT FOR SAMPLE PROBLEM'/ 8X, ' PARTIAL CU
     1RRENTS AT Z = 0,6,12, AND 18 CM.'/11X, ' IN AN 18 CM. THICK INFINI
     2TE PB SLAB'/5X,'UNITS-(PARTICLES/CM2/SEC)/(INCIDENT PI+/CM2/SEC)')
      WRITE(IO,82)
   82 FORMAT(1H0,17X,' PARTICLE IDENTIFICATION'/11X,'1-PROT,2-NEUT,3-PI+
     1,5-PI-,6-MU+,7-MU-')
      N1=1
      N2=5
```

TABLE VII (Cont'd.)

Listing of NMT Analysis Program

```
      NBERTP=N
      IF(NBERTP.GT.0) GO TO 85
      N1 = 6
      N2 = 7
   85 WRITE(IO,86)
   86 FORMAT(1H0,'Z POS.(CM)      0.0          6.0          12.          18.
     1      ')
      DO 100  NTYP = N1,N2
      IF(NTYP.EQ.4)  GO TO 100
      WRITE(IO,87)  NTYP,EMIN(NTYP)
   87 FORMAT(1H0, 2X,' PARTICLE TYPE = ',I2, 4X,' CUTOFF ENERGY = ',E11.
     13,' MEV')
      DO  95 NSIGN =1,2
      IF(NSIGN.GT.1)  GO TO 89
      WRITE(IO,88)
   88 FORMAT(1H0,15X,' NEGATIVE PARTIAL CURRENTS')
      GO TO 95
   89 WRITE(IO,90)
   90 FORMAT(1H0,15X,' POSITIVE PARTIAL CURRENTS')
   95 WRITE(IO,96) (PCUR(I,NSIGN,NTYP),I=1,4), (PCUR2(I,NSIGN,NTYP),I=1,4)
   96 FORMAT(1H0,'  VALUE      ',4E12.4/' REL. ERROR',4E12.3)
  100 CONTINUE
      GO TO 1
  999 WRITE(IO,1000)  IN
 1000 FORMAT(1H0,' ENDFILE READ ON LOG. UNIT',I4)
      CALL EXIT
      RETURN
      END
```

TABLE VIII

NMT Analysis Input

9
2

TABLE IX

NMT Analysis Output

```
                                  READING LOG.  9 AS NMT TAPE

 MAXBCH  MAXCAS   MXMAT  NGROUP   NPIDK   N1COL   NQUIT  NEXITE  NSPRED  NWSPRD  NSEUDO  NBERTP
   20      25       2     2048      0       0       1       1       0       0       1       1

                                     EMAX    0.1500E 04

                                 CUTOFF ENERGIES FOR TYPES 1-7
  0.1500E 02  0.1500E 02  0.2232E 01  0.2156E 01  0.2232E 01  0.1693E 01  0.1693E 01

MEDIUM    1

   NUCLIDE NO.      Z NO.          A NO.      'GEOMETRIC' XSECT (PER CM)
       1         0.8200E 02    0.2070E 03            0.8104E-01

     TRANSPORT XSECTS FOR PARTICLE TYPES 1-7 IN MEDIUM     1 IN PER CM
     0.8104E-01  0.8104E-01  0.8806E-01  0.0          0.8806E-01  0.8885E-04  0.8885E-04

     MAX HYDROGEN XSECTS FOR PARTICLE TYPES 1-5 IN MEDIUM    1 IN PER CM
     0.0          0.0          0.0          0.0          0.0

MEDIUM    2

   NUCLIDE NO.      Z NO.          A NO.      'GEOMETRIC' XSECT (PER CM)
       1         0.8200E 02    0.2070E 03            0.8104E-01

     TRANSPORT XSECTS FOR PARTICLE TYPES 1-7 IN MEDIUM     2 IN PER CM
     0.8104E-01  0.8104E-01  0.8806E-01  0.0          0.8806E-01  0.8885E-04  0.8885E-04

     MAX HYDROGEN XSECTS FOR PARTICLE TYPES 1-5 IN MEDIUM    2 IN PER CM
     0.0          0.0          0.0          0.0          0.0
```

TABLE IX (Cont'd.)

NMT Analysis Output

NMT OUTPUT FOR SAMPLE PROBLEM
PARTIAL CURRENTS AT Z = 0.6.12. AND 18 CM.
IN AN 18 CM. THICK INFINITE PB SLAB
UNITS-(PARTICLES/CM2/SEC)/(INCIDENT PI+/CM2/SEC)

PARTICLE IDENTIFICATION
1-PROT,2-NEUT,3-PI+,5-PI-,6-MU+,7-MU-

Z POS. (CM)	0.0	6.0	12.	18.
PARTICLE TYPE = 1	CUTOFF ENERGY = 0.150E 02 MEV			
NEGATIVE PARTIAL CURRENTS				
VALUE	0.1199E-01	0.5992E-02	0.3994E-02	0.0
REL. ERROR	0.426E 02	0.729E 02	0.688E 02	0.0
POSITIVE PARTIAL CURRENTS				
VALUE	0.0	0.1038E 00	0.1138E 00	0.7983E-01
REL. ERROR	0.0	0.156E 02	0.115E 02	0.192E 02
PARTICLE TYPE = 2	CUTOFF ENERGY = 0.150E 02 MEV			
NEGATIVE PARTIAL CURRENTS				
VALUE	0.5808E 00	0.3770E 00	0.1835E 00	0.0
REL. ERROR	0.574E 01	0.102E 02	0.171E 02	0.0
POSITIVE PARTIAL CURRENTS				
VALUE	0.0	0.6229E 00	0.8265E 00	0.8263E 00
REL. ERROR	0.0	0.881E 01	0.656E 01	0.534E 01
PARTICLE TYPE = 3	CUTOFF ENERGY = 0.223E 01 MEV			
NEGATIVE PARTIAL CURRENTS				
VALUE	0.1997E-01	0.9957E-02	0.9968E-02	0.0
REL. ERROR	0.370E 02	0.397E 02	0.397E 02	0.0
POSITIVE PARTIAL CURRENTS				
VALUE	0.0	0.7797E 00	0.5875E 00	0.4495E 00
REL. ERROR	0.0	0.222E 01	0.356E 01	0.551E 01
PARTICLE TYPE = 5	CUTOFF ENERGY = 0.223E 01 MEV			
NEGATIVE PARTIAL CURRENTS				
VALUE	0.1199E-01	0.1983E-02	0.0	0.0
REL. ERROR	0.426E 02	0.100E 03	0.0	0.0
POSITIVE PARTIAL CURRENTS				
VALUE	0.0	0.7977E-02	0.1198E-01	0.1594E-01
REL. ERROR	0.0	0.459E 02	0.546E 02	0.526E 02

TABLE IX (Cont'd.)

NMT Analysis Output

READING LOG. 2 AS NMT TAPE

MAXBCH	MAXCAS	MXMAT	NGROUP	NPIDK	NICOL	NQUIT	NEXITE	NSPRED	NWSPRD	NSEUDO	NBERTP
20	25	2	2048	0	0	1	1	0	0	1	0

EMAX 0.1533E 04

CUTOFF ENERGIES FOR TYPES 1-7
0.8857E 00 0.1500E 02 0.1318E 00 0.1273E 00 0.1318E 00 0.1000E 00 0.1000E 00

MEDIUM 1

NUCLIDE NO.	Z NO.	A NO.	'GEOMETRIC' XSECT (PER CM)
1	0.8200E 02	0.2070E 03	0.0

TRANSPORT XSECTS FOR PARTICLE TYPES 1-7 IN MEDIUM 1 IN PER CM
0.0 0.0 0.2902E-01 0.0 0.2902E-01 0.3673E-03 0.3673E-03

MAX HYDROGEN XSECTS FOR PARTICLE TYPES 1-5 IN MEDIUM 1 IN PER CM
0.0 0.0 0.0 0.0 0.0

MEDIUM 2

NUCLIDE NO.	Z NO.	A NO.	'GEOMETRIC' XSECT (PER CM)
1	0.8200E 02	0.2070E 03	0.0

TRANSPORT XSECTS FOR PARTICLE TYPES 1-7 IN MEDIUM 2 IN PER CM
0.0 0.0 0.2902E-01 0.0 0.2902E-01 0.3673E-03 0.3673E-03

MAX HYDROGEN XSECTS FOR PARTICLE TYPES 1-5 IN MEDIUM 2 IN PER CM
0.0 0.0 0.0 0.0 0.0

TABLE IX (Cont'd.)

NMT Analysis Output

NMT OUTPUT FOR SAMPLE PROBLEM
PARTIAL CURRENTS AT Z = 0.6.12. AND 18 CM.
IN AN 18 CM. THICK INFINITE PB SLAB
UNITS-(PARTICLES/CM2/SEC)/ INCIDENT PI+/CM2/SEC)

PARTICLE IDENTIFICATION
1-PROT,2-NEUT,3-PI+,5-PI-,6-MU+,7-MU-

Z POS. (CM)	0.0	6.0	12.	18.

PARTICLE TYPE = 6 CUTOFF ENERGY = 0.100E 00 MEV

NEGATIVE PARTIFL CURRENTS

VALUE	0.1351E-03	0.5038E-04	0.0	0.0
REL. ERROR	0.444E 02	0.551E 02	0.0	0.0

POSITIVE PARTIAL CURRENTS

VALUE	0.0	0.6539E-03	0.1204E-02	0.1577E-02
REL. ERROR	0.0	0.611E 01	0.489E 01	0.372E 01

PARTICLE TYPE = 7 CUTOFF ENERGY = 0.100E 00 MEV

NEGATIVE PARTIAL CURRENTS

VALUE	0.5078E-04	0.2370E-04	0.0	0.0
REL. ERROR	0.567E 02	0.100E 03	0.0	0.0

POSITIVE PARTIAL CURRENTS

VALUE	0.0	0.0	0.3530E-04	0.7218E-04
REL. ERROR	0.0	0.0	0.700E 02	0.713E 02

ENDFILE READ ON LOG. UNIT 5

TABLE X

Input for XSECT Program

```
CODE 6
  PB SYSTEM DATA FØR NMTC SAMPLE PROBLEM.
     2   2.5E 07     5.E-01
     2   64
82207    1     2                          .033
82207    9                                .033
     2   64
82207    1     2                          .033
82207    9                                .033
     1
82207   64
```

TABLE XI

Output from XSECT Program

```
                         JULY 23 1960

CODE 6     SYSTEMS DATA TAPE

  PB SYSTEM DATA FOR NMTC SAMPLE PROBLEM.

MEDIA= 2     ETOP= 0.25000E 08     ECUT= 0.50000E 00

MEDIUM 1     POINTS  64
         ELEMENT     DENSITY       SIGMAS
           82207   0.03300000        1. 2. 0. 0. 0
           82207   0.03300000        9. 0. 0. 0. 0

MEDIUM 2     POINTS  64
         ELEMENT     DENSITY       SIGMAS
           82207   0.03300000        1. 2. 0. 0. 0
           82207   0.03300000        9. 0. 0. 0. 0

    1 F1 SCATTERERS     ELEMENT      POINTS
                         82207          64

A-OK


           END OF FILE READ ON INPUT TAPE
```

TABLE XII

Ø5R Input

```
NMTC SAMPLE PROB.-1500MEV PI+ MESONS ON PB.THIS IS O5R INPUT.                  CARD  A
  900 1200    20    1       0.5     1                                          CARD  B
    2    1                                                                     CARD  C
    1    0                                                                     CARD D1
      207.          0.                                                         CARD E1
      2.71       0.984        0.                                               CARD F1
    1    0                                                                     CARD D2
      207.          0.                                                         CARD E2
      2.71       0.984        0.                                               CARD F2
                                                       BLANK SOURCE CARD       CARD  G
                                                       BLANK SOURCE CARD       CARD  H
    2    3      101001001110010001000000000000000000      100400700            CARD  I
2267159B1351                                                                   CARD  J
    0    1    0    0                                                           CARD  K
    0    0    0    0    0    0         1.       0.984          1.              CARD M1
   -1                                                                          CARD M2
    0    0                                                                     CARD  N
    0    0                                                                     CARD  P
    2      MALE                                                                GEOM  A
XZONE BNDS     -10000..      10000.                                            GEOM  B
YZONE BNDS     -10000..      10000.                                            GEOM  C
ZZONE BNDS          0..         18.                                            GEOM  D
ZONE         1     1     1                                                     GEOM  E
XBLOK BNDS     -10000..      10000.                                            GEOM  F
YBLOK BNDS     -10000..      10000.                                            GEOM  G
ZBLOK BNDS          0..         6..        12..        18.                     GEOM  H
BLOCK        1     1     1                                                     GEOM J1
MEDIA              1                                                           GEOM K1
BLOCK        1     1     2                                                     GEOM J2
MEDIA              2                                                           GEOM K2
BLOCK        1     1     3                                                     GEOM J3
MEDIA              1                                                           GEOM K3
    0   NO QUADRIC SURFACES                                                    GEOM  Q
    8                                                                          MSOUR
    9

    1    1
       82.       207.
    1    1
       82.       207.
```

TABLE XIII

Ø5R Output

```
NMTC SAMPLE PROB.-1500MEV PI+ MESONS ON PB.THIS IS O5R INPUT.          CARD  A
AUG.  3 1960

NSTRT=  900   NMOST= 1200   NITS= 20   NQUIT=  1   EBOT= 0.50000D 00   THERM= 1

MEDIA=  2     CTAPES=  1,  1     ETAPE=    0.38567D 08     NFONE= 1     STAPE=  0

FI SCATTERERS       ELEMENT ID        NPOINTS
                       82207             64

MEDIUM= 1     LMAX=  2      NPTS=  64      NFISHN= 0

    ELEM ID               SIGMA ID                      DENSTY              MASS          LF1
     82207        1.     2.     0.     0.     0         0.03300000          207.00000        1
     82207        9.     0.     0.     0.     0         0.03300000            0.0            0

SLOTH=     0.27100D 01      SLOPS=     0.98400D 00      SLØFS=     0.0

MEDIUM= 2     LMAX=  2      NPTS=  64      NFISHN= 0

    ELEM ID               SIGMA ID                      DENSTY              MASS          LF1
     82207        1.     2.     0.     0.     0         0.03300000          207.00000        1
     82207        9.     0.     0.     0.     0         0.03300000            0.0            0

SLOTH=     0.27100D 01      SLOPS=     0.98400D 00      SLØFS=     0.0

ESOUR=     0.0              UINP=      0.0              VINP=      0.0              WINP=      0.0              WTSTRT= 0.0

XSTRT=     0.0              YSTRT=     0.0              ZSTRT=     0.0              NMED=   0       NREG=   0

NHISTR=  2     NHISMX=  3      1 0 1 0 0 1 0 0 1 1 1 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

WORDS/COLL=    8      COLL/REC= 31      NCØLLS=  1   0   0   4   0   0   7   0   0
NCOLL
SPDSQ
W
Z
WATE
SPOLD
WOLD
OLDWT
226715981351

NSPLT= 0      NKILL= 1      MXREG=  0      MAXGP=  0

  0   0   0      0   0   0          0.10000D 01     0.98400D 00     0.10000D 01

 -1   0   0      0   0   0          0.0             0.0             0.0

NSOUR= 0      MFISTP=  0

PHI TAPE=     0
```

TABLE XIII (Cont'd.)

Ø5R Output

```
    2      MALE
XZONE BNDS   -0.100000 05,  0.100000 05
YZONE BNDS   -0.100000 05,  0.100000 05
ZZONE BNDS    0.0        ,  0.180000 02

ZONE        1      1      1
XBLOK BNDS   -0.100000 05,  0.100000 05
YBLOK BNDS   -0.100000 05,  0.100000 05
ZBLOK BNDS    0.0        ,  0.600000 01,  0.120000 02,  0.180000 02

BLOCK       1      1      1
MEDIA              1

BLOCK       1      1      2
MEDIA              2

BLOCK       1      1      3
MEDIA              1

    0    NO QUADRIC SURFACES

MEMORY NOT USED= 25481
```

TABLE XIII (Cont'd.)

Ø5R Output

WEIGHT	X AVERAGE	Y AVERAGE	Z AVERAGE	RANDOM	NMEM
0.64719067D 03	0.10300940D 01	0.38464646D 00	0.77075092D 01	226715981351	649

--- INELAS INPUT DATA ---

NBT = 9

MEDIUM = 1 NO. INELASTIC SCATTERERS = 1 NO. ELASTIC SCATTERERS = 1

CHG. AND MASS NO. OF INELASTIC SCATTERERS---
Z = 82.0 A = 207.0

MEDIUM = 2 NO. INELASTIC SCATTERERS = 1 NO. ELASTIC SCATTERERS = 1

CHG. AND MASS NO. OF INELASTIC SCATTERERS---
Z = 82.0 A = 207.0

0.0	0.0	0.0	0.0	8947A715D571	701
0.80383370D 03	0.10140543D 00	-0.69807032D 00	0.85432238D 01	8947A715D571	806
0.0	0.0	0.0	0.0	E6844B67462D	867
0.49192917D 03	0.22169005D 00	-0.24128102D 00	0.84883917D 01	E6844B67462D	493
0.0	0.0	0.0	0.0	4CEE2AC058E5	529
0.57555153D 03	0.29960568D 00	-0.18593595D 00	0.95548772D 01	4CEE2AC058E5	577
0.0	0.0	0.0	0.0	27062E3F2655	614
0.44641676D 03	-0.11005791D 00	-0.63879332D 00	0.92719606D 01	27062E3F2655	448
0.0	0.0	0.0	0.0	B826BDBC98C5	474
0.70829305D 03	0.14481131D 00	-0.76744860D 00	0.72532021D 01	B826BDBC98C5	710
0.0	0.0	0.0	0.0	4964DFB3C0A1	756
0.71195143D 03	-0.13792347D 00	-0.96655973D-01	0.68891879D 01	4964DFB3C0A1	714
0.0	0.0	0.0	0.0	068756CC43E1	769
0.35710280D 03	0.41807915D 00	-0.20035209D 01	0.89272430D 01	068756CC43E1	358
0.0	0.0	0.0	0.0	DEB908B33C25	382
0.87957228D 03	-0.14900808D 00	0.34685380D 00	0.97409281D 01	DEB908B33C25	882
0.0	0.0	0.0	0.0	6AF25E3EA6AD	955
0.74341350D 03	-0.15593147D 01	-0.38273216D 00	0.80304307D 01	6AF25E3EA6AD	745
0.0	0.0	0.0	0.0	CE09767D2035	804
0.75511293D 03	0.60243304D 00	0.34931739C-01	0.84836537D 01	CE09767D2035	757
U.0	0.0	0.0	0.0	A9B69E0B4FE5	800
0.55578876D 03	0.16737848D 00	-0.11834540D 01	0.90305687D 01	A9B69E0B4FE5	557
0.0	0.0	0.0	0.0	8026E698F8C1	600
0.75602703D 03	0.10731086D 01	-0.10712671D 01	0.92729238D 01	8026E698F8C1	758
0.0	0.0	0.0	0.0	E928B62EBDFD	800
0.55973625D 03	0.11825780D 01	-0.73569800D 00	0.67816779D 01	E928B62EBDFD	561
0.0	0.0	0.0	0.0	EDF735A23EED	593
0.41541429D 03	0.18215856D 01	-0.21135694D 01	0.86329630D 01	EDF735A23EED	416
0.0	0.0	0.0	0.0	A06DA1C8694D	456
0.52490126D 03	0.73118889D 00	0.37310224D-01	0.76939842D 01	A06DA1C8694D	526
0.0	0.0	0.0	0.0	FCB534C0F46D	562
0.69660708D 03	0.12397516D 01	0.26960285D 00	0.83175188D 01	FCB534C0F46D	698
0.0	0.0	0.0	0.0	B1A86F493429	743
0.50901512D 03	-0.62384956D 00	0.20025306D 00	0.88384707D 01	B1A86F493429	510
0.0	0.0	0.0	0.0	39E207EE48B1	545
0.64075695D 03	-0.16191801D 01	-0.11253382D 00	0.83805685D 01	39E207EE48B1	642
0.0	0.0	0.0	0.0	F49175AD1C95	704
0.63592386D 03	0.64197776D 00	0.3235657UD 00	0.61179301D 01	F49175AD1C95	637
0.0	0.0	0.0	0.0	622E4019E985	684

TIME= 2 MINUTES 18.50 SECONDS

END OF FILE READ ON INPUT TAPE

TABLE XIV

Listing of Ø5R Analysis Program

```
C      ANALYSIS PROGRAM FOR 05R IN NMTC SAMPLE PROBLEM
       DIMENSION C(4,2,3),C2(4,2,3),CUR(4,2,3)
       COMMON/PARAMS/NCOL,SPDSQ,W,Z,WATE,SPOLD,WOLD,OLDWT
       DO 2 I =1,4
       DO 2 J = 1,2
       DO 2 K =1,3
       C  (I,J,K) = 0.
       C2 (I,J,K) = 0.
     2 CUR(I,J,K) = 0.
       READ(5,3) NHISTR,NHISMX,NWPCOL,MAXCAS,MAXBCH
     3 FORMAT(5I5)
       PBCH = FLOAT(MAXCAS)
       BCHS = FLOAT(MAXBCH)
       WRITE(6,4)NHISTR,NHISMX,NWPCOL,MAXCAS,MAXBCH
     4 FORMAT(1H1,11X,' 05R ANALYSIS FOR NMTC SAMPLE PROBLEM'/
      1  9X,'NHISTR = ',I5,'  NHISMX = ',I5,'  NWPCOL = ',I5/15X,
      2 'MAXCAS = ',I5,'  MAXBCH = ',I5)
     5 CALL REDOSR(NHISTR,NHISMX,NTYPE,NWPCOL)
       IF(NTYPE)10,20,80
    10 WRITE(6,11) NTYPE,NCOL
    11 FORMAT(1H1,'NTYPE = ',I5,'   NCOL = ',I5)
       CALL ERROR
    20 IF(NCOL)10,5,25
    25 GO TO (5, 10, 10, 30, 10, 10, 30,10, 10),NCOL
C   NCOL =   1,  2,  3,  4,  5,  6,  7, 8,  9
    30 IF(WOLD) 42,45,47
    42 NS = 1
       GO TO 49
    45 WRITE(6,46) WOLD
    46 FORMAT(1H1,' WOLD = ',E17.7,' IN MAIN')
       GO TO 5
    47 NS = 2
    49 IZ =  IFIX(Z/6.) + 1
       N=1
C   N=1 CURRENT OF NEUTRONS ABOVE THERMAL.
       IF(SPDSQ.EQ.1.) N=2
C   N=2 THERMAL NEUTRON CURRENT.
    50 CUR(IZ,NS,N) =  CUR(IZ,NS,N) +  OLDWT
       IF(N.EQ.3) GO TO 5
       N=3
C   N=3 IS TOTAL  (N=1 AND N=2).
       GO TO 50
    80 GO TO ( 85, 10, 95) ,NTYPE
    85 DO 86 I=1,4
       DO 86 J=1,2
       DO 86 K=1,3
       C(I,J,K) = C(I,J,K) +   CUR(I,J,K)/PBCH
       C2(I,J,K)= C2(I,J,K) + (CUR(I,J,K)/PBCH)**2
    86 CUR(I,J,K) = 0.
       GO TO 5
    95 BCHSS = BCHS -1
       IF(BCHSS.EQ.0) BCHSS = 1
       DO 97 I =1,4
       DO 97 J =1,2
       DO 97 K =1,3
       IF(  C (I,J,K).EQ.0) GO TO 97
       C2(I,J,K) =(C2(I,J,K)/BCHS - (C(I,J,K)/BCHS)**2) /BCHSS
       C (I,J,K) = C(I,J,K)/BCHS
       C2(I,J,K) = 100.* SQRT( ABS( C2(I,J,K))) / C(I,J,K)
    97 CONTINUE
       WRITE(6,99)
    99 FORMAT(1HO, 3X,' PARTIAL NEUTRON CURRENTS AT Z = 0, 6,12 AND 18CM.
      1'/11X, ' IN AN 18 CM. THICK INFINITE PB SLAB.'/
      2  6X,'UNITS-(NEUTRONS/CM2/SEC)/(INCIDENT PI+/CM2/SEC)')
       DO 200  N = 1,3
       GO TO (100,110,115),N
   100 WRITE(6,101)
   101 FORMAT(1HO,'  OF NEUTRONS ABOVE THERMAL AND BELOW NMT NEUTRON CUTO
      XFF ENERGY')
       GO TO 120
   110 WRITE(6,111)
```

TABLE XIV (Cont'd.)

Listing of Ø5R Analysis Program

```
111 FORMAT(1HO,'  OF THERMAL NEUTRONS')
    GO TO 120
115 WRITE(6,116)
116 FORMAT(1HO,'  OF ALL NEUTRONS BELOW NMT NEUTRON CUTOFF ENERGY')
120 DO 150 NS = 1,2
    IF(NS.GT.1) GO TO 125
    WRITE(6,121)
121 FORMAT(1HO,15X,' NEGATIVE PARTIAL CURRENTS')
    GO TO 150
125 WRITE(6,126)
126 FORMAT(1HO,15X,' POSITIVE PARTIAL CURRENTS')
150 WRITE(6,160) (C(I,NS,N),I=1,4), (C2(I,NS,N),I=1,4)
160 FORMAT(1HO,' VALUE     ',4E12.4/' REL. ERROR',4E12.3)
200 CONTINUE
    CALL EXIT
    RETURN
    END
```

TABLE XV

Ø5R Analysis Input

2	2	8	25	20

TABLE XVI

Ø5R Analysis Output

```
           O5R ANALYSIS FOR NMTC SAMPLE PROBLEM
     NHISTR =     2  NHISMX =     2  NWPCOL =      8
           MAXCAS =    25  MA)BCH =    20

   PARTIAL NEUTRON CURRENTS AT Z = 0. 6,12 AND 18CM.
        IN AN 18 CM. THICK INFINITE PB SLAB.
   UNITS-(NEUTRONS/CM2/SEC)/(INCIDENT PI+/CM2/SEC)

 OF NEUTRONS ABOVE THERMAL AND BELOW NMT NEUTRON CUTOFF ENERGY

                NEGATIVE PARTIAL CURRENTS

 VALUE       0.1398E 02  0.1746E 02  0.1194E 02  0.0
REL. ERROR    0.509E 01   0.579E 01   0.598E 01   0.0

                POSITIVE PARTIAL CURRENTS

 VALUE       0.0         0.1339E 02  0.1755E 02  0.1262E 02
REL. ERROR    0.0         0.535E 01   0.538E 01   0.547E 01

 OF THERMAL NEUTRONS

                NEGATIVE PARTIAL CURRENTS

 VALUE       0.0         0.0         0.0         0.0
REL. ERROR    0.0         0.0         0.0         0.0

                POSITIVE PARTIAL CURRENTS

 VALUE       0.0         0.0         0.0         0.0
REL. ERROR    0.0         0.0         0.0         0.0

 OF ALL NEUTRONS BELOW NMT NEUTRON CUTOFF ENERGY

                NEGATIVE PARTIAL CURRENTS

 VALUE       0.1398E 02  0.1746E 02  0.1194E 02  0.0
REL. ERROR    0.509E 01   0.579E 01   0.598E 01   0.0

                POSITIVE PARTIAL CURRENTS

 VALUE       0.0         0.1339E 02  0.1755E 02  0.1262E 02
REL. ERROR    0.0         0.535E 01   0.538E 01   0.547E 01
```

TABLE XVII

Input for NMT Edit Program

9	1	1	1	1

TABLE XVIII

Output from NMT Edit Program

```
                              READING LOG.  9 AS NMT TAPE

  MAXBCH  MAXCAS   MXMAT  NGROUP   NPIDK   NICOL   NQUIT  NEXITE  NSPRED  NWSPRD  NSEUDO  NBERTP
    20      25       2     2048      0       0       1       1       0       0       1       1

                                  EMAX   0.1500E 04

                              CUTOFF ENERGIES FOR TYPES 1-7
  0.1500E 02  0.1500E 02  0.2232E 01  0.2156E 01  0.2232E 01  0.1693E 01  0.1693E 01

MEDIUM    1

   NUCLIDE NO.     Z NO.        A NO.     'GEOMETRIC' XSECT (PER CM)
       1        0.8200E 02   0.2070E 03          0.8104E-01

   TRANSPORT XSECTS FOR PARTICLE TYPES 1-7 IN MEDIUM     1 IN PER CM
    0.8104E-01  0.8104E-01  0.8806E-01  0.0          0.8806E-01  0.8885E-04  0.8885E-04

   MAX HYDROGEN XSECTS FOR PARTICLE TYPES 1-5 IN MEDIUM     1 IN PER CM
    0.0         0.0         0.0         0.0         0.0

MEDIUM    2

   NUCLIDE NO.     Z NO.        A NO.     'GEOMETRIC' XSECT (PER CM)
       1        0.8200E 02   0.2070E 03          0.8104E-01

   TRANSPORT XSECTS FOR PARTICLE TYPES 1-7 IN MEDIUM     2 IN PER CM
    0.8104E-01  0.8104E-01  0.8806E-01  0.0          0.8806E-01  0.8885E-04  0.8885E-04

   MAX HYDROGEN XSECTS FOR PARTICLE TYPES 1-5 IN MEDIUM     2 IN PER CM
    0.0         0.0         0.0         0.0         0.0

NCOL  NOCAS  NAME  MAT  NMED  LELEM NOPART  NABOV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD      BLZ
  1     1     1     1     1     0     0       0      0      0      0      0      0      0      0   00082081  00082081
         X          Y          Z           XC           YC           ZC          OLDWT        WT           E            EC
      0.0        0.0        0.0         0.7863E 66   0.7863E 66   0.7863E 66   0.1000E 01   0.1000E 01   0.1500E 04   0.7863E 66
         U          V          W           TIP          APR          ZPR          EREC         EX           HEVSUM       UU
      0.0        0.0        0.1000E 01  0.2000E 01   0.0          0.0          0.0          0.0          0.0          0.0

NCOL  NOCAS  NAME  MAT  NMED  LELEM NOPART  NABOV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD      BLZ
  5     1     1     1     1     0    -1       0      0      0      0      0      0      0      0   00082081  00082081
         X          Y          Z           XC           YC           ZC          OLDWT        WT           E            EC
      0.0        0.0        0.0         0.0          0.0          0.1115E 01   0.1000E 01   0.9988E 00   0.1500E 04   0.1483E 04
         U          V          W           TIP          APR          ZPR          EREC         EX           HEVSUM       UU
      0.0        0.0        0.1000E 01  0.2000E 01   0.0          0.0          0.0          0.0          0.0          0.0

NCOL  NOCAS  NAME  MAT  NMED  LELEM NOPART  NABOV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD      BLZ
  5     1     1     1     1     0    -1       0      0      0      0      0      0      0      0   00082081  00082081
         X          Y          Z           XC           YC           ZC          OLDWT        WT           E            EC
      0.0        0.0        0.1115E 01  0.0          0.0          0.5742E 01   0.9988E 00   0.9975E 00   0.1483E 04   0.1411E 04
         U          V          W           TIP          APR          ZPR          EREC         EX           HEVSUM       UU
      0.0        0.0        0.1000E 01  0.2000E 01   0.0          0.0          0.0          0.0          0.0          0.0

NCOL  NOCAS  NAME  MAT  NMED  LELEM NOPART  NABOV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD      BLZ
  7     1     1     1     2     0     0       0      0      0      0      0      0      0      0   00082081  00102081
         X          Y          Z           XC           YC           ZC          OLDWT        WT           E            EC
      0.0        0.0        0.5742E 01  0.0          0.0          0.6000E 01   0.9975E 00   0.9975E 00   0.1411E 04   0.1407E 04
         U          V          W           TIP          APR          ZPR          EREC         EX           HEVSUM       UU
      0.0        0.0        0.1000E 01  0.2000E 01   0.0          0.0          0.0          0.0          0.0          0.0

NCOL  NOCAS  NAME  MAT  NMED  LELEM NOPART  NABOV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD      BLZ
  5     1     1     2     2     0    -1       0      0      0      0      0      0      0      0   00102081  00102081
         X          Y          Z           XC           YC           ZC          OLDWT        WT           E            EC
      0.0        0.0        0.6000E 01  0.0          0.0          0.8850E 01   0.9975E 00   0.9961E 00   0.1407E 04   0.1364E 04
         U          V          W           TIP          APR          ZPR          EREC         EX           HEVSUM       UU
      0.0        0.0        0.1000E 01  0.2000E 01   0.0          0.0          0.0          0.0          0.0          0.0

NCOL  NOCAS  NAME  MAT  NMED  LELEM NOPART  NABOV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD      BLZ
  2     1     1     2     2     1     8      11      1     26      7      1      0      0      0   00102081  00102081
         X          Y          Z           XC           YC           ZC          OLDWT        WT           E            EC
      0.0        0.0        0.8850E 01  0.0          0.0          0.1099E 02   0.9961E 00   0.9948E 00   0.1364E 04   0.1331E 04
         U          V          W           TIP          APR          ZPR          EREC         EX           HEVSUM       UU
      0.0        0.0        0.1000E 01  0.2000E 01   0.1650E 03   0.7200E 02   0.4194E 01   0.5283E 03   0.1574E 02   0.5928E 01

             NAMEA     TIPA         EA          UA           VA           WA           WTA
               2    0.3000E 01  0.3257E 02 -0.5585E 00  0.9398E-01  0.8242E 00  0.9948E 00
               3    0.1000E 01  0.2232E 03 -0.2530E 00 -0.5159E 00  0.8184E 00  0.9948E 00
               4    0.0         0.2188E 03  0.6782E 00 -0.3816E 00  0.6281E 00  0.9948E 00
               5    0.1000E 01  0.1467E 03 -0.4940E 00 -0.5903E 00  0.6384E 00  0.9948E 00
               6    0.1000E 01  0.6555E 02 -0.8586E-01  0.9962E 00 -0.1742E-01  0.9948E 00
               7    0.0         0.3256E 02 -0.6507E-01 -0.9960E 00  0.6195E-01  0.9948E 00
               8    0.0         0.2485E 02  0.5845E 00 -0.4991E 00  0.6397E 00  0.9948E 00
               9    0.1000E 01  0.2117E 02 -0.6551E 00 -0.1738E 00 -0.7353E 00  0.9948E 00
              10    0.1000E 01  0.2067E 02 -0.2409E-01 -0.2195E 00  0.9753E 00  0.9948E 00
              11    0.0         0.1690E 02  0.5178E 00  0.7016E 00 -0.4895E 00  0.9948E 00
              12    0.0         0.2174E 02  0.9722E 00 -0.5756E-01  0.2272E 00  0.9948E 00
```

TABLE XVIII (Cont'd.)

Output from NMT Edit Program

```
                 TIPB         EB         UB         VB         WB        WTB
            0.1000E 01 0.1239E 02 0.3706E 00 0.6970E 00 0.6139E 00 0.9948E 00

               WTEVAP    EPART ARRAY(EVAP  NEUTRON  ENERGY)
            0.9948E 00 0.6339E 01 0.2117E 02 0.5172E 01 0.4954E 01 0.5659E 01 0.1175E 02 0.2889E 01 0.5515E 01
                       0.2067E 02 0.1095E 02 0.2115E 01 0.4698E 01 0.5408E 01 0.9630E 01 0.2194E 01 0.1435E 02
                       0.7948E 00 0.6584E 01 0.4408E 01 0.9730E 00 0.4575E 01 0.6839E 01 0.2196E 01 0.1987E 01
                       0.3493E 00 0.2797E 00

               WTEVAP    EPART ARRAY(EVAP  PROTON   ENERGY)
            0.9948E 00 0.8499E 01 0.1194E 02 0.1690E 02 0.2174E 02 0.1339E 02 0.9857E 01 0.8864E 01

               WTEVAP   HEPART ARRAY(EVAP DEUTERON  ENERGY)
            0.9948E 00 0.1574E 02

NCOL  NOCAS   NAME     MAT   NMED  LELEM NOPART  NABOV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD       BLZ
  7     1       3       2      1      0      0      0      0      0      0      0      0      0      0  00102081  00182081
          X          Y          Z         XC         YC         ZC      OLDWT         WT          E         EC
      0.0        0.0        0.1099E 02 -0.3119E 00 -0.6361E 00 0.1200E 02 0.9948E 00 0.9948E 00 0.2232E 03 0.2232E 03
          U          V          W        TIP        APR        ZPR       EREC         EX     HEVSUM         UU
    -0.2530E 00 -0.5159E 00 0.8184E 00 0.1000E 01 0.0     0.0        0.0        0.0        0.0        0.0

NCOL  NOCAS   NAME     MAT   NMED  LELEM NOPART  NABOV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD       BLZ
  2     1       3       1      1      1      2      2      0      5      0      0      0      0      0  00182081  00182081
          X          Y          Z         XC         YC         ZC      OLDWT         WT          E         EC
    -0.3119E 00 -0.6361E 00 0.1200E 02 -0.1707E 01 -0.3481E 01 0.1651E 02 0.9948E 00 0.9948E 00 0.2232E 03 0.2232E 03
          U          V          W        TIP        APR        ZPR       EREC         EX     HEVSUM         UU
    -0.2530E 00 -0.5159E 00 0.8184E 00 0.1000E 01 0.2010E 03 0.8100E 02 0.7814E 00 0.4844E 02 0.0        0.6315E 01

            NAMEA       TIPA         EA         UA         VA         WA        WTA
             13      0.1000E 01 0.1324E 03 0.3404E 00 0.1867E 00 0.9215E 00 0.9948E 00
             14      0.0        0.3465E 02 -0.7139E 00 -0.5920E-01 -0.6977E 00 0.9948E 00

               WTEVAP    EPART ARRAY(EVAP  NEUTRON  ENERGY)
            0.9948E 00 0.3916E 01 0.6063E 00 0.6902E 00 0.1146E 01 0.3094E 00

NCOL  NOCAS   NAME     MAT   NMED  LELEM NOPART  NABOV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD       BLZ
  4     1      13       1      0      0      0      0      0      0      0      0      0      0      0  00182081  00000000
          X          Y          Z         XC         YC         ZC      OLDWT         WT          E         EC
    -0.1707E 01 -0.3481E 01 0.1651E 02 -0.1158E 01 -0.3180E 01 0.1800E 02 0.9948E 00 0.9948E 00 0.1324E 03 0.1324E 03
          U          V          W        TIP        APR        ZPR       EREC         EX     HEVSUM         UU
     0.3404E 00 0.1867E 00 0.9215E 00 0.1000E 01 0.0        0.0        0.0        0.0        0.0        0.0

NCOL  NOCAS   NAME     MAT   NMED  LELEM NOPART  NABOV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD       BLZ
  7     1       4       2      1      0      0      0      0      0      0      0      0      0      0  00102081  00182081
          X          Y          Z         XC         YC         ZC      OLDWT         WT          E         EC
      0.0        0.0        0.1099E 02 0.1089E 01 -0.6130E 00 0.1200E 02 0.9948E 00 0.9948E 00 0.2188E 03 0.1758E 03
          U          V          W        TIP        APR        ZPR       EREC         EX     HEVSUM         UU
     0.6782E 00 -0.3816E 00 0.6281E 00 0.0        0.0        0.0        0.0        0.0        0.0        0.0

NCOL  NOCAS   NAME     MAT   NMED  LELEM NOPART  NABOV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD       BLZ
  3     1       4       1      1      0      0      0      0      0      0      0      0      0      0  00182081  00182081
          X          Y          Z         XC         YC         ZC      OLDWT         WT          E         EC
     0.1089E 01 -0.6130E 00 0.1200E 02 0.3519E 01 -0.1980E 01 0.1425E 02 0.9948E 00 0.9948E 00 0.1758E 03 0.1500E 02
          U          V          W        TIP        APR        ZPR       EREC         EX     HEVSUM         UU
     0.6782E 00 -0.3816E 00 0.6281E 00 0.0        0.0        0.0        0.0        0.0        0.0        0.0

NCOL  NOCAS   NAME     MAT   NMED  LELEM NOPART  NABOV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD       BLZ
  7     1       5       2      1      0      0      0      0      0      0      0      0      0      0  00102081  00182081
          X          Y          Z         XC         YC         ZC      OLDWT         WT          E         EC
      0.0        0.0        0.1099E 02 -0.7808E 00 -0.9331E 00 0.1200E 02 0.9948E 00 0.9948E 00 0.1467E 03 0.1467E 03
          U          V          W        TIP        APR        ZPR       EREC         EX     HEVSUM         UU
    -0.4940E 00 -0.5903E 00 0.6384E 00 0.1000E 01 0.0        0.0        0.0        0.0        0.0        0.0

NCOL  NOCAS   NAME     MAT   NMED  LELEM NOPART  NABOV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD       BLZ
  5     1       5       1      1      0     -1      0      0      0      0      0      0      0      0  00182081  00182081
          X          Y          Z         XC         YC         ZC      OLDWT         WT          E         EC
    -0.7808E 00 -0.9331E 00 0.1200E 02 -0.4097E 01 -0.4896E 01 0.1629E 02 0.9948E 00 0.9948E 00 0.1467E 03 0.1467E 03
          U          V          W        TIP        APR        ZPR       EREC         EX     HEVSUM         UU
    -0.4940E 00 -0.5903E 00 0.6384E 00 0.1000E 01 0.0        0.0        0.0        0.0        0.0        0.0

NCOL  NOCAS   NAME     MAT   NMED  LELEM NOPART  NABOV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD       BLZ
  4     1       5       1      0      0      0      0      0      0      0      0      0      0      0  00182081  00000000
          X          Y          Z         XC         YC         ZC      OLDWT         WT          E         EC
    -0.4097E 01 -0.4896E 01 0.1629E 02 -0.5424E 01 -0.6482E 01 0.1800E 02 0.9948E 00 0.9948E 00 0.1467E 03 0.1467E 03
          U          V          W        TIP        APR        ZPR       EREC         EX     HEVSUM         UU
    -0.4940E 00 -0.5903E 00 0.6384E 00 0.1000E 01 0.0        0.0        0.0        0.0        0.0        0.0

NCOL  NOCAS   NAME     MAT   NMED  LELEM NOPART  NABOV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD       BLZ
  5     1       6       2      2      0     -1      0      0      0      0      0      0      0      0  00102081  00102081
          X          Y          Z         XC         YC         ZC      OLDWT         WT          E         EC
      0.0        0.0        0.1099E 02 -0.6715E 00 0.7791E 01 0.1085E 02 0.9948E 00 0.9948E 00 0.6555E 02 0.6555E 02
          U          V          W        TIP        APR        ZPR       EREC         EX     HEVSUM         UU
    -0.8586E-01 0.9962E 00 -0.1742E-01 0.1000E 01 0.0       0.0        0.0        0.0        0.0        0.0

NCOL  NOCAS   NAME     MAT   NMED  LELEM NOPART  NABOV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD       BLZ
  2     1       6       2      2      1      1      0      1      5      0      0      0      0      0  00102081  00102081
          X          Y          Z         XC         YC         ZC      OLDWT         WT          E         EC
    -0.6715E 00 0.7791E 01 0.1085E 02 -0.1430E 01 0.1660E 02 0.1070E 02 0.9948E 00 0.9948E 00 0.6555E 02 0.6555E 02
          U          V          W        TIP        APR        ZPR       EREC         EX     HEVSUM         UU
```

TABLE XVIII (Cont'd.)

Output from NMT Edit Program

```
   -0.8586E-01  0.9962E 00 -0.1742E-01  0.1000E 01  0.2020E 03  0.8200E 02  0.4474E 00  0.5827E 02  0.0          0.8976E 01

                   TIPB        EB          UB          VB          WB          WTB
               0.1000E 01  0.7094E 01  0.2613E 00  0.7027E 00 -0.6617E 00  0.9948E 00

                  WTEVAP      EPART ARRAY(EVAP  NEUTRON  ENERGY)
               0.9948E 00  0.4440E 01  0.4262E 01  0.1784E 01  0.1346E 01  0.4719E 00

NCOL  NOCAS   NAME    MAT   NMED  LELEM NOPART  NABOV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD       BLZ
  3     1       7      2     2      0      0      0      0      0      0      0      0      0      0   00102081   00102081
        X            Y             Z          XC          YC          ZC         OLDWT        WT          E           EC
      0.0          0.0          0.1099E 02 -0.9550E-02 -0.1462E 00  0.1100E 02  0.9948E 00  0.9948E 00  0.3256E 02  0.1500E 02
        U            V             W          TIP         APR         ZPR         EREC        EX        HEVSUM        UU
   -0.6507E-01 -0.9960E 00  0.6195E-01  0.0         0.0         0.0         0.0         0.0         0.0         0.0

NCOL  NOCAS   NAME    MAT   NMED  LELEM NOPART  NABOV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD       BLZ
  3     1       8      2     2      0      0      0      0      0      0      0      0      0      0   00102081   00102081
        X            Y             Z          XC          YC          ZC         OLDWT        WT          E           EC
      0.0          0.0          0.1099E 02  0.4241E-01 -0.3621E-01  0.1104E 02  0.9948E 00  0.9948E 00  0.2485E 02  0.1500E 02
        U            V             W          TIP         APR         ZPR         EREC        EX        HEVSUM        UU
    0.5845E 00 -0.4991E 00  0.6397E 00  0.0         0.0         0.0         0.0         0.0         0.0         0.0

NCOL  NOCAS   NAME    MAT   NMED  LELEM NOPART  NABOV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD       BLZ
  6     1       9      2     2      1      0      0      0      3      0      0      0      0      0   00102081   00102081
        X            Y             Z          XC          YC          ZC         OLDWT        WT          E           EC
      0.0          0.0          0.1099E 02 -0.2412E 01 -0.6397E 00  0.8284E 01  0.9948E 00  0.9948E 00  0.2117E 02  0.2117E 02
        U            V             W          TIP         APR         ZPR         EREC        EX        HEVSUM        UU
   -0.6551E 00 -0.1738E 00 -0.7353E 00  0.1000E 01  0.2050E 03  0.8200E 02  0.8920E-01  0.2810E 02  0.0         0.2773E 01

                  WTEVAP      EPART ARRAY(EVAP  NEUTRON  ENERGY)
               0.9948E 00  0.2233E 01  0.4282E 00  0.4499E 00

NCOL  NOCAS   NAME    MAT   NMED  LELEM NOPART  NABOV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD       BLZ
  7     1      10      2     1      0      0      0      0      0      0      0      0      0      0   00102081   00182081
        X            Y             Z          XC          YC          ZC         OLDWT        WT          E           EC
      0.0          0.0          0.1099E 02 -0.2492E-01 -0.2271E 00  0.1200E 02  0.9948E 00  0.9948E 00  0.2067E 02  0.2067E 02
        U            V             W          TIP         APR         ZPR         EREC        EX        HEVSUM        UU
   -0.2409E-01 -0.2195E 00  0.9753E 00  0.1000E 01  0.0         0.0         0.0         0.0         0.0         0.0

NCOL  NOCAS   NAME    MAT   NMED  LELEM NOPART  NABOV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD       BLZ
  4     1      10      1     0      0      0      0      0      0      0      0      0      0      0   00182081   00000000
        X            Y             Z          XC          YC          ZC         OLDWT        WT          E           EC
   -0.2492E-01 -0.2271E 00  0.1200E 02 -0.1731E 00 -0.1578E 01  0.1800E 02  0.9948E 00  0.9948E 00  0.2067E 02  0.2067E 02
        U            V             W          TIP         APR         ZPR         EREC        EX        HEVSUM        UU
   -0.2409E-01 -0.2195E 00  0.9753E 00  0.1000E 01  0.0         0.0         0.0         0.0         0.0         0.0

NCOL  NOCAS   NAME    MAT   NMED  LELEM NOPART  NABOV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD       BLZ
  3     1      11      2     2      0      0      0      0      0      0      0      0      0      0   00102081   00102081
        X            Y             Z          XC          YC          ZC         OLDWT        WT          E           EC
      0.0          0.0          0.1099E 02  0.6179E-02  0.8372E-02  0.1099E 02  0.9948E 00  0.9948E 00  0.1690E 02  0.1500E 02
        U            V             W          TIP         APR         ZPR         EREC        EX        HEVSUM        UU
    0.5178E 00  0.7016E 00 -0.4895E 00  0.0         0.0         0.0         0.0         0.0         0.0         0.0

NCOL  NOCAS   NAME    MAT   NMED  LELEM NOPART  NABOV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD       BLZ
  3     1      12      2     2      0      0      0      0      0      0      0      0      0      0   00102081   00102081
        X            Y             Z          XC          YC          ZC         OLDWT        WT          E           EC
      0.0          0.0          0.1099E 02  0.4554E-01 -0.2696E-02  0.1100E 02  0.9948E 00  0.9948E 00  0.2174E 02  0.1500E 02
        U            V             W          TIP         APR         ZPR         EREC        EX        HEVSUM        UU
    0.9722E 00 -0.5756E-01  0.2272E 00  0.0         0.0         0.0         0.0         0.0         0.0         0.0

NCOL  NOCAS   NAME    MAT   NMED  LELEM NOPART  NABOV  NBELO NPART1 NPART2 NPART3 NPART4 NPART5 NPART6    BOLD       BLZ
  3     1      14      1     1      0      0      0      0      0      0      0      0      0      0   00182081   00182081
        X            Y             Z          XC          YC          ZC         OLDWT        WT          E           EC
   -0.1707E 01 -0.3481E 01  0.1651E 02 -0.1828E 01 -0.3491E 01  0.1639E 02  0.9948E 00  0.9948E 00  0.3465E 02  0.1500E 02
        U            V             W          TIP         APR         ZPR         EREC        EX        HEVSUM        UU
   -0.7139E 00 -0.5920E-01 -0.6977E 00  0.0         0.0         0.0         0.0         0.0         0.0         0.0
```

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