2/9-21-82
SANDIA REPORT

SAND82-8022 • Unlimited Release • UC-13

Printed August 1982

TARTNP User's Manual for Sandia National Laboratories

DO NOT MICROFILM
COVER

MASTER

G. J. Miller

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550
for the United States Department of Energy
under Contract DE-AC04-76DP00789

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Issued by Sandia National Laboratories, operated for the United States Department of Energy by Sandia Corporation.

NOTICE: This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of the contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government, any agency thereof or any of their contractors or subcontractors. The views and opinions expressed herein do not necessarily state or reflect those of the United States Government, any agency thereof or any of their contractors or subcontractors.

PAGES 1 to 2
WERE INTENTIONALLY
LEFT BLANK

SAND82-8022
Unlimited Release
Printed August 1982

SAND--82-8022

DE82 021100

TARTNP USER'S MANUAL FOR SANDIA NATIONAL LABORATORIES

G. J. Miller
Scientific Computing Division
Sandia National Laboratories, Livermore

NOTICE
PORTIONS OF THIS REPORT ARE ILLEGIBLE. It
Has Been Reproduced From The Best Available
Copy To Permit The Broadest Possible Avail-
ability.

ABSTRACT

This report gives the operating instructions and input definitions for the TARTNP Monte Carlo neutron/photon transport code. It also describes the limitations of the code and the pitfalls that may be encountered in using it.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

ACKNOWLEDGMENTS

The author is grateful to Gary Rodrigue for his assistance in making TARTNP available to SNLL.

The author is particularly indebted to Ernest Plechaty and John Kimlinger for their help in transferring the code to SNLL, for the unrestricted use of their code documentation, and for their considerable efforts in helping debug the SNLL version of the code.

FOREWORD

This document and UCRL-50400 Vol. 14, "TARTNP: A Coupled Neutron-Photon Monte Carlo Transport Code," Ernest Plechaty and John Kimlinger, dated July 4, 1976, comprise the documentation for the TARTNP code at SNLL.

The UCRL-50400 document, which has been reprinted at SNLL, contains references to special Tally options that are not available in TARTNP at SNLL. They are Tally options 13, 14, 15, and 17.

This document is based on UCID-17026, "TARTNP User's Manual," J. Kimlinger and E. Plechaty, dated February 9, 1976. The basic format of that document has been retained as well as substantial portions that are relevant to the SNLL version of TARTNP.

CONTENTS

	<u>Page</u>
Introduction	11
TARTNP Operating Instructions	11
Restart Procedures	13
Restarting After an Interrupt	13
Units, Limitations, and Pitfalls	13
Units	13
Limitations	13
Pitfalls	14
Code Input and Various Output Definitions	14
APPENDIX A--LIST OF AVAILABLE ISOTOPES	43
APPENDIX B--NEUTRON ENERGY GROUPS	45
APPENDIX C--PHOTON ENERGY GROUPS	47
APPENDIX D--TALLY GROUP LIMITS FOR NEUTRONS AND PHOTONS	49
APPENDIX E--LIMITS FOR TALLY TYPES 7, 8, 9, AND 10	51
APPENDIX F--PROGRAM TALLY	53

TARTNP USER'S MANUAL FOR SANDIA NATIONAL LABORATORIES

Introduction

The TARTNP operating instructions contain the information necessary to start a problem and restart it after the termination of a run or after an error.

The limitations imposed on the code are dictated mainly by machine size. The code can check for certain geometric errors if the user exercises the options provided for that purpose.

The code-input section explains the significance of each input variable. The flexibility of the code is better understood after reading the entire input section.

TARTNP Operating Instructions

The TARTNP code at SNLL operates in batch mode on the CRAY. A procedure has been written which accesses the appropriate files and executes the program, thus freeing the user of the necessity of creating the Job Control Language (JCL) instructions. The procedure also provides options to manage a restart file(s) and files that result from using TARTNP Tally options 11, 12, or 16. The code has restart capabilities upon normal termination; also after abnormal termination, provided the code has been in execution more than 12 minutes.

The procedure is invoked by a statement which in its most simple form is

TARTNP,RSFN=TARTSR1,RSFID=GORDO,RSFPW=XYZ.

where the underlined arguments are user supplied, i.e., no defaults are furnished.

RSFN is Restart File Name

RSFID is Restart File ID

RSFPW is Restart File Maintenance Password

It is assumed, and the procedure requires, that these three arguments remain fixed for any series of runs.

There are six arguments that can be added to the invoking statement which have both default and alternate values. They are

SRSF (NO:YES)
PRSF (NO:YES)
RS (NO:YES)
LMAP (OFF:FULL)
TALN (NO:YES)
TALP (NO:YES)

where the value preceding the colon is the default, the value following the colon the alternate. Any or all may be added to the TARTNP statement. Absence of the option variable yields the default, inclusion yields the alternate condition. The option variables are defined as follows

SRSF is Save Restart File
PRSF is Purge Restart File
RS is run will be a Restart Run
LMAP is loader map sentinel
TALN is save Tally (11, 12, or 16) for Neutrons
TALP is save Tally (11, 12, or 16) for Photons

If PRSF is included, the file purging will occur before any other JCL instruction is executed, and will be of the highest available edition. If TALN and/or TALP are included, the saved permanent file(s) will be named TALLYN or TALLYP, respectively; and they will have the ID and PW defined on the TARTNP statement. No purging options have been included for these files since they will be automatically purged the next time the procedure is invoked.

A deck to execute TARTNP must include a front end job card, CRAY job and account cards, a card to access the procedure file, a library card, the procedure invoking card, a 7/8/9 end-of-record card, and the TARTNP input cards as defined in this document. An illustration follows. The nonunderlined portions of the statements need to be as illustrated. In this example, an edition of the restart file is being purged and a new edition is being saved upon successful completion of the run.

GJM35,KUNC,STMFC. TEST OF TART GORDO BOX 15
JOB,JN=GJM35,T=200,K=UNC. TEST OF TART GORDO BOX 15
ACCOUNT,A=0101010,E=22222,D=3333,R=P.
ACCESS,DN=LF,PDN=TARTPROC,ID=GORDO.
LIBRARY,DN=LF,V.
TARTNP,RSFN=TARTSR1,RSFID=GORDO,RSFPW=XYZ,PRSF,SRSF.
7/8/9

TARTNP input deck

7/8/9

Note that the procedure file is named TARTPROC. If for any reason you might want a listing of the procedures, contact the author. It is not possible to obtain a listing of the procedure file.

One last comment--the procedure is restricted to unclassified restart files. Additional access constraints will be needed for a classified file. The author will be glad to help create an appropriate JCL deck if/when the need arises.

Restart Procedures

When restarting TARTNP to continue a run that has terminated normally, it is necessary to add the RS argument to the procedure invocation statement, and also to change the value of N2 on Card One of the TARTNP input deck.

Restarting After an Interrupt

TARTNP will create a restart file after 12 minutes of execution and refresh the file every 12 minutes thereafter. If this file was saved (SRSF included on the procedure invocation statement), one can restart TARTNP by adding an RS argument to the procedure invocation statement and by placing a 1 in Column Two of Card One of the input deck, i.e., define N2 to be 1 for this type of restart. The code will then complete execution to the number of samples originally requested.

Units, Limitations, and Pitfalls

Units

The code units are as follows.

Parameter	
Time	shake (10^{-8} s)
Length	centimeter (cm)
Speed	centimeters per shake
Energy	millions of electron volts (MeV)

Limitations

The code limitations that are currently imposed are as follows.

Quantity	Limit
Zones	110 with five time edits
Quadratic boundary functions	100
Planes	100
Boundaries per zone	No limit

Quantity	Neutrons	Photons
Maximum input energy (MeV)	20	20
Minimum input energy (MeV)	1.31×10^{-9}	10^{-3}
Materials	20	20
Isotopes in a material	No limit	No limit
Output tally groups	50	50

Pitfalls

All sources must be generated inside the problem, but care must be taken in the interpretation of the problem if the sources are not generated in zones of equal statistical weight. If the output indicates a discrepancy in neutron conservation, check the ratio of weights of adjacent zones or look for overlapping zones. In the geometry calculation a small quantity called FUDGE is added to the coordinates of the particle to move it off the boundary; this quantity should be no larger than 0.1 of the thickness of the thinnest zone in the problem.

Code Input and Various Output Definitions

This section presents a card-by-card description of code input. The input cards described are listed below.

Input Card No.	Type of Card	Sample of Information Contained
1	Control and data	Restart, problem name
2	Control	Number of JPB cards, sample size, source type, next problem
3	Control	Spectrum type, reaction edit, number of materials
3A	Control	Edit control, geometry debug
3B	Control	Photon minimum energy, photon edit, neutron/photon tracking control
3C	Data	Change neutron tracking energy group limits (optional)
4	Data	Change neutron tally group limits (optional)
4A	Data	Change photon tally group limits (optional)

Input Card No.	Type of Card	Sample of Information Contained
5	Data	Change energy group limits for neutron angular tally (tally Types 7, 8, 9, 10) (optional)
5A	Data	Change energy group limits for photon angular tally (tally Types 7, 8, 9, 10) (optional)
5B	Data	Reaction edits (neutrons only) (optional)
6	Data	JPBs
7	Data	FUDGE, source, angular distribution of source
8	Data	Source energy, number of pairs in spectrum, other source data
9	Data	Minimum energy, initial time, source data
9A	Data	Change cosine limits for neutron angular tallies (optional)
9B	Data	Change cosine limits for photon angular tallies (optional)
10	Data	Conic surface boundary function
11	Data	Planes
12	Data	Material in a zone, statistical weight, tally type units
12A	Data	Geometrical debug parameters (optional)
12B	Data	Continuation of Card 12A (optional)
14	Data	Time distribution of source (optional)
15	Data	Edit times
15A	Data	Energy-dependent neutron output tally multipliers (optional)
15B	Data	Energy-dependent photon output tally multipliers (optional)
16	Data	Energy spectrum (optional)
17,17A,17B	Data	Energy-angle-correlated source (optional) with angular weighting function
17C,17D	Data	Multiple-angle energy spectra (optional)

Input Card No.	Type of Card	Sample of Information Contained
18	Data	Isotopic composition of materials
19	Data	Isotopic composition of materials
19A	Data	Problem multipliers (optional)
20 21	Data	Multishell (cylindrical or spherical) (optional)
22	Data	Surface source (optional)
23 24	Data	Source information for Tally Types 18 and 19 (optional)

Following the title of certain cards and preceding the format appears the word "optional" in parentheses; this indicates that use of the card is optional and that it must be requested by some prior input sentinel. All other cards are necessary.

In punching cards, one should observe the following instructions:

1. Plus signs need not be punched.
2. A blank field is the same as a zero.
3. Floating-point numbers require a decimal point and may start at any column within their fields (usually 12 columns).
4. Input integers (fixed) must be right-adjusted within their fields (usually four columns).

INPUT CARD 1. RESTART, PROBLEM NAME
Format (I2, I1, 4A8, A5)

Columns	Name	Description
1-2	N2	Blank initially; if the code has created a restartable dump tape, this card must be used with the normal control cards, with a 1 inserted in Column 2. If on restart a 2 is put in Column 2, the code gives a full set of output tallies and continues to run to normal completion. If on restart a number greater than 2 is entered, the number of samples will be replaced by that number.
3	NCHAIN	NCHAIN = 0, neutronics and photonics transport.
4-40	HEAD	Problem name (alphanumeric).

INPUT CARD 2. NUMBER OF JPB CARDS, SAMPLE SIZE, SOURCE TYPE, NEXT PROBLEM
Format (7I4, I8, 9I4)

Columns	Name	Description
1-4	NGZ	Number of material-in-a-zone cards to be read in (see Card 12).
5-8	NG	Number of JPB cards to be read (see Card 6).
9-12	IPX	Number of conic surfaces (see Card 10). The functional form of these surfaces is $A(x - x_0)^2 + B(y - y_0)^2 + C(z - z_0)^2 = K^2$
13-16	IPL	Number of plane surfaces (see Card 11). The functional form of these surfaces is $x = M_1$, $y = M_2$, or $z = M_3$.
17-20	IX8	Number of planes perpendicular to the x-axis.
21-24	IY9	Number of planes perpendicular to the y-axis.
25-28	NSORS	Number of samples. This is the number of times the problem is to be replicated for the purpose of estimating standard deviations. The number should be 20 or more.
29-36	NSAMP	Sample size. The total number of particle histories in the problem is the sample size multiplied by the number of samples.
37-40	S1	Source indicator (IC00D). <u>S1 = 1:</u> A point source at $x = S3$, $y = S4$, $z = S5$. <u>S1 = 2:</u> A source uniformly distributed in a cylindrical volume with $R_{inner} = S3$, $R_{outer} = S4$, and length z , where $S5 < z < (S5 + S9)$. The cylinder is centered at $x_0 = S10$ and $y_0 = S11$. <u>Note:</u> If $S9 = 0.0$, the source is a disk at $z = S5$. <u>S1 = 3:</u> A source uniformly distributed in a spherical shell or a segment of a spherical shell with $R_i = S3$, $R_0 = S4$, centered at $x_0 = S10$, $y_0 = S11$, and $z_0 = S5$. The segment generated is given by $\cos \theta = S8 \cdot R + S15$, where $\cos \theta$ is relative to the z-axis and R is a random number. (To generate throughout a complete sphere, $S8 = 2.0$ and $S15 = -1.0$.) <u>S1 = 4:</u> A source uniformly distributed on a segment of a spherical surface. The shell is centered at $x_0 = S10$, $y_0 = S11$, and $z_0 = S5$, with radius $S9$. The segment generated is determined as in $S1 = 3$.

INPUT CARD 2 (cont.)

Columns	Name	Description
37-40 (cont.)	S1	<p><u>S1 = 5:</u> Source is a line, plane, or rectangular volume distributed over the surface defined by</p> $S3 < x < (S3 + S10)$ $S4 < y < (S4 + S11)$ $S5 < z < (S5 + S12)$ <p><u>S1 = 6:</u> A point source at $x = S3$, $y = S4$, and $z = S5$, with the reference direction for its angular distribution defined by the line joining the source point and the point $(S10, S11, S12)$. This source should not be used if $S3 = S4 = S10 = S11 = 0.0$.</p> <p><u>S1 = 7:</u> A source uniformly distributed over the surface of an inclined disk of inner radius $S3$ and outer radius $S4$. The disk is tangent at its center ($x = S10$, $z = S11$) to a sphere of radius $S5$ centered at $(0.0, 0.0, S12)$. The reference direction for the angular distribution is from $(S10, 0.0, S11)$ to $(0.0, 0.0, S12)$. If the disk is not rotated, use $S1 = 2$.</p> <p><u>S1 = 8:</u> A source uniformly distributed over the surface of an inclined isosceles triangle of height $S3$ and half-base $S4$. The triangle is tangent at its vertex to a sphere of radius $S5$ that is centered at $(0.0, 0.0, S12)$. The reference direction for the angular distribution is from $(S10, 0.0, S11)$ to $(0.0, 0.0, S12)$.</p> <p><u>S1 = 9:</u> A source uniformly distributed throughout the volume of up to 15 spherical shells (or segments of spherical shells). The choice of shell is determined by input probabilities (relative number in each shell). The segment generated is determined as in $S1 = 3$. Additional input required is to be on Cards 20 and 21.</p> <p><u>S1 = 10:</u> The same as $S1 = 9$, except that the shells are cylindrical. Part of the input is Δ_z, which is the length of the cylinder. Additional input is to be punched on Cards 20 and 21.</p> <p><u>S1 = 11:</u> A source uniformly distributed on one or more surfaces (maximum of 10) and directed inward with a cosine distribution. The surfaces may be cones, spheres, cylinders, or circular disks, as described by Card 22. The number of surfaces and the relative number of particles on each surface are described by Card 20.</p> <p><u>S1 = 12:</u> Not used.</p>

INPUT CARD 2 (cont.)

Columns	Name	Description
37-40	S1	<p><u>S1 = 13</u>: A multiple-angle multiple-energy source uniformly distributed on a segment of a spherical surface. Each energy spectrum will be generated between two $\cos \gamma$ limits. The angles γ will be measured from the normal to the spherical surface at the point at which each source particle is generated. The spherical surface is determined as in <u>S1 = 4</u>. Input for the source is entered on Cards 17C and 17D. ISPEC (Card 3, Columns 1-4) must be set to 12, and VN (Card 8, Columns 1-12) must be set to minus the number of spectra to be entered.</p>
41-44	IANG	<p>Cosine substitution indicator S2.</p> <p><u>S2 = 1</u>: The source cosine of the angle with reference to the y-axis (β) is to be replaced by the cosine of the angle with reference to the z-axis (γ).</p> <p><u>S2 = 2</u>: α is to be replaced by γ.</p> <p><u>S2 = 3</u>: β is to be replaced by $-\gamma$.</p> <p><u>S2 = 4</u>: α is to be replaced by $-\gamma$.</p> <p><u>S2 = 5</u>: γ is to be replaced by $-\gamma$.</p>
45-48	LZON	<p>Source zone. The number of the zone in which the source is to be generated. The source may be generated in more than one zone (enter lowest zone number), but it must be generated in zones to which a material is assigned, and all such zones should have identical zone weights.</p>
49-52	ITN	<p>Edit indicator for neutrons.</p> <p>Neutron edit type to be used by all zones not given an LTYPE (Card 12, Columns 59-60) input. Zones with a zero material number can only have edit type 3. The following edit indicator options are available:</p> <p><u>ITN = 1</u>: Expected collisions. This option must be used to get reaction edits.</p> <p><u>ITN = 2</u>: Path length in centimeters.</p> <p><u>ITN = 3</u>: Number of neutrons transported into a zone.</p> <p><u>ITN = 4</u>: Neutron momentum transported into a zone.</p> <p><u>ITN = 5</u>: Number flux entering a zone tallied as $1/(\cos \theta)$.</p>

INPUT CARD 2 (cont.)

Columns	Name	Description
49-52 (cont.)	ITN	<p><u>ITN = 6</u>: Momentum flux entering a zone.</p> <p><u>ITN = 7*</u>: Same as ITN = 3, but a time-independent angular distribution is added.</p> <p><u>ITN = 8*</u>: Number of neutrons transported into a zone as a function of energy tallied as $1/(\cos \theta)$, where $\cos \theta$ is the angle relative to the normal.</p> <p><u>ITN = 9*</u>: Momentum entering a zone as a function of energy and a time-independent angular distribution.</p> <p><u>ITN = 10*</u>: Momentum flux entering a zone as a function of energy and a time-independent angular distribution tallied as $V/(\cos \theta)$.</p> <p><u>ITN = 11</u>: See the note in this section. Will create a disc file of the coordinates of particles entering a zone in the form of</p> <div style="margin-left: 40px;"> <p>Word 1 = $x^2 + y^2$</p> <p>Word 2 = z</p> <p>Word 3 = V</p> <p>Word 4 = T</p> <p>Word 5 = L</p> <p>Word 6 = NS</p> <p>Word 7 = NSR</p> </div> <p>where x, y, and z are particle coordinates, V is velocity, T is time, L is zone number, NS is particle number, and NSR is sample number.</p> <p>NOTE: Tally Types 11, 12, or 16 can and will create huge files unless their use is limited to one or two zones, the problem run is of limited duration, and provided judicious care is used in identifying the zone(s) of interest. This latter can be accomplished in two ways.</p> <p>The first is to set ITN to 11, 12, or 16, in which case the material in a zone card (input Card 12) for all other zones must be modified by changing LTYPE (Column 60) to 3. Failure to do this will result in the ITN tally being generated for all zones which would generate a file you would neither want to create nor subsequently read.</p> <p>A second and better way to activate any of these tally options is to leave ITN blank and to change LTYPE (input Card 12) on the one or two zones of interest to be 11, 12, or 16. In this instance all other zones will be set to the default value of ITN = 3.</p>

*Limits for this type of tally are 50 zones, 19 angles, 24 energy bins.

INPUT CARD 2 (cont.)

Columns	Name	Description
---------	------	-------------

49-52 (cont.)	ITN	ITN = 12: See the note under ITN = 11. Will create a disc file of the coordinates of particles entering a zone in the form of
------------------	-----	---

Word 1 = x
Word 2 = y
Word 3 = z
Word 4 = A
Word 5 = B
Word 6 = G
Word 7 = V
Word 8 = T
Word 9 = L
Word 10 = NS
Word 11 = NSR

where A, B, and G are the direction cosines; the remainder of the variables are as defined for ITN = 11.

ITN = 13: Reserved for future use.

ITN = 14: Reserved for future use.

ITN = 15: Reserved for future use.

ITN = 16: See the note under ITN = 11. Will create a disc file containing the path length swept out in a zone plus other quantities in the form of

Word 1 = T
Word 2 = SMIN
Word 3 = E
Word 4 = J
Word 5 = L
Word 6 = LTAG
Word 7 = NS
Word 8 = NSR

where SMIN is the distance swept, E is the particle energy, J is the energy index, LTAG is the number of collisions the particle had, and the remainder are as defined for ITN = 11.

ITN = 17: Not used.

ITN = 18: Collect source in specific zones and move to the z-axis. Additional input is on Cards 23 and 24.

ITN = 19: Collect source and beam down z-axis. Additional input is on Cards 23 and 24.

INPUT CARD 2 (cont.)

Columns	Name	Description
49-52 (cont.)	ITN	<p><u>ITN = 20</u>: Monte Carlo collisions.</p> <p>The above ITN tallies are time- and energy-dependent and are normalized to one source neutron. In addition the energy deposition, expressed in MeV/zone, is also given.* (This is independent of the chosen edit type.) Using problem or zone multipliers, the energy deposition and fissions, expressed in MeV per gram of zone if the edit indicator is plus or in MeV per cubic centimeter of zone if the edit indicator is minus, are modified by the multiplier.</p>
53-56	ITM	<p>Type of time distribution. With an entry of 0 or 1, all source particles are generated with the same time coordinate. With an entry of 2 or greater, source particles are generated with a time coordinate picked from a given distribution of that many time entries on Card 14. A negative entry signals that a time spectrum of that many pairs of points $N(T)$ and T will be input on Card 14.</p>
57-60	IM	<p>Number of edit times. The number of time intervals into which the problem has been divided for recording output. Maximum number is 5 (see edit times, Card 15).</p>
61-64	ITX	<p>The number of cosine limits for tallying neutron angular distributions. Maximum allowed is 20. If ITX is zero, the code uses the following set of cosines: 1.0, 0.98, 0.95, 0.90, 0.82, 0.72, 0.60, 0.40, 0.20, 0.05, -0.05, -0.20, -0.40, -0.60, -0.72, -0.82, -0.90, -0.95, -0.98, -1.0 (see Card 9A).</p>
65-68	MORE	<p>Not used.</p>
69-72	NX	<p>Next problem sentinel. Enter 1 if another problem deck immediately follows the current one.</p>

*See problem or zone multipliers (Cards 12 and 19A) for the conversion of units.

INPUT CARD 3. SPECTRUM TYPE, DATA TAPE, REACTION EDIT, NUMBER OF MATERIALS
Format (3I4, 12X, 11I4)

Columns	Name	Description
1-4	ISPEC	<p>Point-by-point energy spectrum. This sentinel allows one to input an energy spectrum from which the source particles will be randomly generated. The code will integrate the function between points and divide it up into 201 equally probable energies.</p> <p>An entry of 1 indicates that the input is VN (Card 8) pairs of data N(E) and E (Card 16), where N(E) is the number of particles per unit energy at energy E (in MeV). The code assumes that the consecutive pairs of points are connected by a straight line of the form $AE + B$ and integrates over energy to obtain the number of neutrons in each interval.</p> <p>An entry of -1 indicates the input is F(E) and E, where $F(E)/E = N(E)$ (Card 16).</p> <p>An entry of 11 indicates that the source will be generated from a correlated energy-angle spectrum that is entered on Cards 17, 17A, and 17B.</p> <p>An entry of 12 indicates that the source will be generated from a series of different energy spectra defined between given $\cos \gamma$ limits and entered on Cards 17C and 17D (see Cards 17C and 17D). If $S1 = 13$, γ will be measured from the normal to a spherical surface (see description of column name S1 in Card 2 and discussion of Cards 17C and 17D). The output is an array of 50 equally probable energies (and associated slopes and slope intercepts) for each pair of angles.</p> <p>An entry of 2 indicates that the spectrum input is in histogram form. The input is VN (Card 8) pairs of data as follows:</p> $[N(E)_1 \text{ and } E_1], [N(E)_2 \text{ and } E_2], \dots, [0.0 \text{ and } E_{\max}]$ <p>where $N(E)_i$ is the number of particles between E_i and E_{i+1} (see Card 16).</p>
5-8	JR	<p>New random number. If an entry of 1 to 5 is made, the random number sequence will be originated with one of five numbers other than the usual one.</p>

INPUT CARD 3 (cont.)

Columns	Name	Description
9-12	IEDIF	Neutron-energy-difference edit indicator. With an entry of 1, the neutron output distributions that are a function of zone, energy, and time will be repeated, but with each tally divided by the difference in energy between each neutron tally group. With an entry of 2, the output will be multiplied by an input constant for each tally group that is read in on Card 15A.
13-16	JQ	Not used.
21-24	IA1	Not used.
25-28	IA3	Angular distribution intervals. If left blank, the code will assign 16 intervals to each anisotropic angular distribution. Optional input is 8 or 4.
29-32	IA5	Change number of groups. This sentinel is the number of group limits to be read in on Card 3C if the standard number of groups is not used. If this entry is left blank, 175 groups are followed.
33-36	IA6	Store cross-section sentinel. If 1, the total cross sections are not stored away by the generator. Normal usage requires this sentinel to be left blank.
37-40	IA7	Collision sentinel. If this sentinel is blank, neutron-emission probabilities will be used in the collision routine. An entry of 1 allows reaction probabilities to be used. If 1 is used, 1A10 should also be 1.
41-44	I13	Read in problem multipliers. This entry is the number of problem multipliers to be entered on Card 19A. The maximum is 5.
45-48	IA9	Reaction-edit sentinel. Enter the number of zones for which edits by reaction are requested. The input for these edits is on Card 5B.
49-52	IA10	Reaction list. 1A10 = 0 for emission neutronics, 1A10 = 1 for reaction neutronics and MCMEG, 1A10 = 2 for NIXON.
53-56	IA11	Change neutron or photon tally groups. An entry of 1 will allow the neutron-output tally groups to be changed. Input is on Card 4. An entry of 2 will change the photon tally groups. Input is on Card 4A. An entry of 3 will change both neutron and photon tally groups (Cards 4 and 4A).
61-64	IA13	Photon fluorescence. If 1 is entered, fluorescent photons will be transported.

INPUT CARD 3 (cont.)

Columns	Name	Description
65-68	IA14	Change neutron angular-distribution tally groups. An entry of 1 will change the standard 12 tally groups for special angular-distribution output (Card 5). An entry of greater than 1 limits the output to IA14 groups. $3 \leq IA14 \leq 24$.
69-72	IA4	Number of materials. The maximum number allowed is 20.

INPUT CARD 3A. EDIT CONTROL, GEOMETRY DEBUG, TAPE (TALLY TYPES 11 AND 12)
Format (8X, I4, 16X, 4I4, 8X, I4)

Columns	Name	Description
1-8		Not used.
9-12	IA17	An entry of 1 indicates that multipliers for the nonplanar boundary functions A and B are to be input on Card 10. If left blank, A and B (Card 10) are set to 1.0.
13-16		Not used.
29-32	IA21	Skip output by energy sentinel. If left blank, the code will give a full edit by energy tally group for the first, every odd-numbered, and last samples (if IA21 is -1, it will give a full edit for every sample. Otherwise it will skip IA21 samples between the first and last before giving a full edit.
33-36	IA22	Debug sentinel. An entry of 1 requires two cards, 12A and 12B, to define a geometric portion of the problem that the generator will saturate with particles to determine whether any space is not described properly. The generator will also calculate statistical volumes for those zones that are bounded by three-dimensional boundaries.
37-40	IA23	Distribution-by-energy tally edits. In the description that follows, when output for mass or volume is mentioned, this option is obtained by setting ITN (Card 2, Columns 49-52) plus or minus. If plus, output is per unit mass; if minus, it is per unit volume. <u>IA23 = 1:</u> The output by tally type over zone, time step, and energy tally group and the totals by zone will be multiplied by each problem multiplier (Card 19A). <u>IA23 = 2:</u> The output will be modified by the problem multiplier per unit mass or per unit volume of the zone.

INPUT CARD 3A (cont.)

Columns	Name	Description
37-40 (cont.)	IA23	<p><u>IA23 = 3</u>: The output will be modified by the problem multiplier times the zone multiplier (Card 12, Columns 61-72).</p> <p><u>IA23 = 4</u>: The output will be modified by the problem multiplier times the zone multiplier per unit mass or per unit volume of the zone.</p> <p><u>IA23 = 5</u>: The output will be modified by the problem multiplier times the zone multiplier times the energy multiplier defined by IEDIF (Card 3, Columns 9-12).</p>
41-44	IA24	<p>Flux tally edits.</p> <p><u>IA24 = 1</u>: The angular-distribution output (from tally Types 7, 8, 9, or 10) by zone, angular group, and angular energy group will be multiplied by each problem multiplier.</p> <p><u>IA24 = 2, 3, 4</u>: The output will be modified as IA23.</p>
53-56	IA27	<u>IA27 = 1</u> : List the changed cross sections.

INPUT CARD 3B. PHOTON MINIMUM ENERGY, PHOTON EDIT, NEUTRON/PHOTON TRACKING CONTROL Format (F12.5, 5I4)

Columns	Name	Description
1-12	EMIN	Minimum energy for photons. If a positive value is entered, this is the minimum value a scattered photon may have. If a negative value is entered and a photon scatters below this value, it is discarded and tallied under "energy gain" in the photon edit. If left blank, the code enters -0.001 as EMIN.
13-16	ITNG	<p>See the note under ITN = 11. It is applicable, substituting ITNG for ITN and LTYPEG for LTYPE.</p> <p>Edit indicator for photons. Photon edit type to be used by all zones not given an LTYPEG (Card 12, Columns 55-57) tally type. If left blank, ITNG is set to 3 (photons transported into a zone). See ITN, Card 2, Columns 49-52, for a description of available indicators.</p>

INPUT CARD 3B (cont.)

Columns	Name	Description
17-20	IA14G	Change photon angular-distribution tally groups. An entry of 1 will change the standard 12 tally groups for special angular-distribution output (ITNG = 7, 8, 9, or 10). Input for these changes is on Card 5A. An entry of greater than 1 limits the output to IA14G groups ($3 \leq \text{IA14G} \leq 24$).
21-24	ITXG	The number of cosine limits for tallying photon angular distributions. Maximum is 20. See ITX, Card 2, Columns 61-64, for standard limits. New limits are read in on Card 9B.
25-28	INEUT	Particle-following sentinel. If 0, neutrons and neutron-induced photons will be followed. If INEUT = 1, only neutrons will be followed. If INEUT = 2, only photons will be followed.
29-32	IGSENT	Edit indicator for photon energy difference. With an entry of 1, the photon output distributions that are a function of zone, time, and energy will be repeated, but with each tally divided by the difference in energy between each photon tally group. With an entry of 2, the output will be multiplied by an input constant for each tally group that is read in on Card 15B.

INPUT CARD 3C. CHANGE NEUTRON-TRACKING ENERGY GROUP LIMITS (optional) Format (18I4)

Columns	Name	Description
1-72	IL	Neutron-following group limits. If IA5 is nonzero, IA5 new group limits will be entered, 18 to a card. These limits are based on the standard 176 limits. A minimum of 5 and a maximum of 174 can be entered. The set of new limits must include the following: 1, 7, 25, 92, 114, and 176.

INPUT CARD 4. CHANGE NEUTRON TALLY GROUP LIMITS (optional)
Format (18I4)

Columns	Name	Description
1-72	ITAP	New neutron tally group limits. If IA11 (Card 3, Columns 53-56) is 1 or 3, three cards with the format (18I4) are needed to supply the new 51 group limits. These numbers are based on the initial group limits that the code uses for cross-section input. Of the 51 limits, the first and last ones must be 1 and 176.

INPUT CARD 4A. CHANGE PHOTON TALLY GROUP LIMITS (optional)
Format (18I4)

Columns	Name	Description
1-72	ITAPG	New photon tally group limits. If IA11 (Card 3, Columns 53-56) is 2 or 3, three cards are needed to supply the new photon tally group limits, which range from 1 to 144.

INPUT CARD 5. CHANGE ENERGY GROUP LIMITS FOR NEUTRON ANGULAR TALLY
(Tally Types 7, 8, 9, 10) (optional) Format (18I4)

Columns	Name	Description
1-72	ILAP	New neutron angular-distribution tally energy group limits. If IA14 is zero, this card is not used. If IA14 is 1, new limits are to be entered based on the 51 group neutron tally limits. Of the 13 limits, the first and the last must be 1 and 51. If IA14 is other than 1, IA14 + 1 limits are entered. IA14 cannot be greater than 24.

INPUT CARD 5A. CHANGE ENERGY GROUP LIMITS FOR PHOTON ANGULAR TALLY
(Tally Types 7, 8, 9, 10) (optional) Format (18I4)

Columns	Name	Description
1-72	IA14G	New photon angular-distribution tally group limits. If IA14G is 1, 13 new limits are to be entered based on the 51 group photon tally limits. The first should be 1, and the last should be 51. If IA14G is greater than 1, IA14G + 1 limits are entered. (IA14G $\leq$ 24.)

INPUT CARD 5B. REACTION EDITS (optional) Format (I4, 11I6)

Columns	Name	Description
1-70		Reaction-edit input.
1-4	L	Zone to be edited.
5-70	LI	Isotopes to be edited. Format (11I6). If left blank, all the reactions of all the isotopes in the zone will be individually tallied; otherwise only the isotopes requested will be edited by reaction. <u>A zone must be assigned Tally Type 1 (expected collisions) or Type 20 (Monte Carlo collisions) to be edited.</u> IA9 (Card 3, Column 48) of these cards will be read in.

INPUT CARD 6. JPB ZONE DESCRIPTION Format (18I4)

Columns	Name	Description
1-72	JZOND	JPB zone description. There is a maximum of nine sets of JPB values for each card. More than one card may be used to describe one zone. An entry of 1 in Column 73 signals that the next card of values is a continuation of the description of that zone. Each set is associated with one boundary of the zone. If a zone has fewer than nine boundaries, the remaining sets are left blank. B is the boundary number, negative for a plane and positive for a conic (any nonplanar boundary). P is the zone that a particle will most probably enter when it crosses boundary B. If more than one zone applies, P should be the zone having the lowest number. J is the sign of P.

Rules for Conic Boundary Functions Described by:

$$A(x - x_0)^2 + B(y - y_0)^2 + C(z - z_0)^2 = K^2$$

Rule 1: If all possible coordinate points of the zone lie outside the given conic surface, the sign of J is negative.

Rule 2: If all possible coordinate points of a zone lie inside the given conic surface, the sign of J is positive.

Rules for Planar Boundary Functions

The rules for the planes are the same whether they are perpendicular to the x-, y-, or z-axis; the rules will be explained by using planes perpendicular to the z-axis.

INPUT CARD 6 (cont.)

Columns	Name	Description
1-72 (cont.)	JZOND	<p><u>Rule 1:</u> If all z-coordinates in the zone are algebraically greater than the plane intercept with the z-axis, J is negative.</p> <p><u>Rule 2:</u> If all z-coordinates in the zone are algebraically less than the plane intercept with the z-axis, J is positive.</p> <p>These four rules allow the construction of a problem with a minimum of effort.</p> <p><u>Note:</u> Sometimes it may be necessary to reference a plane that is not actually a boundary of the zone. In this instance, the value of P is not important. A given boundary should never be mentioned twice in one zone description. Outside zones must be described by at least one boundary.</p>

The rules for JPB can be pictorially represented for conics by the following figure.

INPUT CARD 7. FUDGE, SOURCE, ANGULAR DISTRIBUTION OF SOURCE
Format (6F12.5)

Columns	Name	Description
1-12	FUDGE	This is the amount added to the distance a particle is advanced to a boundary to ensure that it will be in a new zone. A value of 0.0005 is typical for normal size problems. If this entry is left blank, it is set to 0.0005.
13-24	XN	S3. Input for source description. See name S1 in Card 2.
25-36	YN	S4. See S1 in Card 2.
37-48	ZN	S5. See S1 in Card 2.
49-60	GPPP	S6. The angular distribution of the source is such that the cosine of the angle between the particle and a reference direction is uniformly distributed in the interval (S7, S6 + S7); that is, the cosine is computed from $S6 \cdot R + S7$, where R is a random number between 0 and 1. The azimuthal angle is uniformly distributed in the interval (0, 2π). The reference direction is the positive z-axis, except when S1 = 6, 7, or 8. An isotropic source is obtained by setting S6 = 2.0 and S7 = -1.0. A source beamed in the positive direction down the z-axis is obtained by setting S6 = 0.0 and S7 = 1.0.
61-72	GPXP	S7.

INPUT CARD 8. SOURCE ENERGY, NUMBER OF PAIRS IN SPECTRUM, OTHER SOURCE.
Format (6F12.5)

Columns	Name	Description
1-12	VN	Source energy in MeV. A positive entry will give a monoenergetic source at the indicated value. A zero entry will give a fission source. A negative entry indicates that it will be chosen from an energy spectrum made of that many pairs of points, or from that many energy-angle pairs if ISPEC = 11, or from that many different energy spectra if ISPEC = 12.
13-72		S8, S9, S10, S11, S12. See S1 in Card 2.

INPUT CARD 9. MINIMUM ENERGY, INITIAL TIME, SOURCE DATA
Format (6F12.5)

Columns	Name	Description
1-12	VMIN	Minimum energy in MeV for neutrons. If a positive value is entered, this is the minimum value a scattered neutron may have. If a negative value is entered and a neutron scatters below this value, the neutron is discarded. The number discarded is tallied under velocity gain in the output. If this entry is left blank, the code enters 2.51×10^{-8} as VMIN.
13-24	TN	Initial time coordinate. If the "type of time distribution" has a value of 0 or 1, all source particles will have this value as their initial time coordinate. Negative times are not allowed.
25-36	S13	E_{min} for Tally Type 11 or 12. No particles will be written on tape if they are below this energy. If this entry is left blank, 2.5×10^{-8} is entered.
37-48	S14	Temperature of Maxwellian distribution used for input energy spectrum. If this entry is left blank, the code assumes a value of 1.29.
49-60	S15	See S1 in Card 2.
61-72	S16	E_{max} for Tally Type 11 or 12. No particles above this energy will be written on tape. If this entry is left blank, 20 MeV is entered.

INPUT CARD 9A. CHANGE COSINE LIMITS FOR NEUTRON-ANGULAR-DISTRIBUTION TALLIES
(optional) Format (6F12.5)

Columns	Name	Description
1-72	ANGLI	Enter ITX (Card 2, Columns 61-64) cosine values starting with plus 1.0 and monotonically decreasing to minus 1.0. The cosine values are truncated to the least one-hundredth (e.g., 0.9899 = 0.98).

INPUT CARD 9B. CHANGE COSINE LIMITS FOR PHOTON-ANGULAR-DISTRIBUTION TALLIES
(optional) Format (6F12.5)

Columns	Name	Description
1-72		Enter ITXG (Card 3B, Columns 21-24) cosine values. The values are truncated to the least one-hundredth (e.g., 0.9899 = 0.98).

INPUT CARD 10. CONIC SURFACE BOUNDARY FUNCTION
Format (5F12.5, 2F10.3)

Columns	Name	Description
1-80	CONIC	<p>$x_0, t_0, z_0, C, K, A,$ and B are the constants that describe conic surfaces in</p> $A(x - x_0)^2 + B(y - y_0)^2 + C(z - z_0)^2 = K^2$ <p>The card for Boundary 1 is first, for Boundary 2 is second, and so on. (A and B need not be input; see Card 3A, Columns 9-12.)</p>

INPUT CARD 11. PLANES Format (6F12.5)

Columns	Name	Description
1-72	PLANE	<p>M for planes. The constants M are intercepts of the axes for the plane boundaries. The constants for planes perpendicular to the x-axis are listed first, those for planes perpendicular to the z-axis are listed last. The plane boundaries are numbered according to the order of the constants: the first is -1, the second is -2, and so on. There are six planes to a card.</p>

INPUT CARD 12. MATERIAL IN A ZONE, STATISTICAL WEIGHT, TALLY TYPE UNITS
Format (F9.0, I3, 3F12.5, F6.0, 2I3, F12.5)

Columns	Name	Description
1-9	WGTGAM	Zonal statistical weight for photons. See description of weight on Card 12, Columns 13-24. If this entry is left blank, the weight assigned to neutrons will be entered.
10-12	NDAT4	Material in a zone. This is the number of the material assigned to each zone. The card for Zone 1 is first, that for Zone 2 is second, and so on. This material-in-a-zone card is required for each inside zone. (If zero is entered, the zone becomes a leakage zone.) This number is in a fixed format; that is, it is right-adjusted to column 12.

INPUT CARD 12 (cont.)

Columns	Name	Description
13-24	WGT	Zonal statistical weight for neutrons. Weights other than 1.0 are used in high-attenuation problems to force particle flow into regions of interest. Weights must be powers of 2, and ratios of weights of adjacent zones must be 1/2, 1, or 2. The product of weight and number of particles is conserved at a boundary crossing. For example, if a particle crosses from a high-weight zone to a low-weight zone, the particle is split into two particles. If a particle crosses from a low-weight zone into a high-weight zone, the particle is discarded with probability 1/2. If the weight is left blank, it is assumed to be 1.0.
25-36	ETA	Relative density. This is the ratio of the density of the material in the zone to the density used in the material input. If this entry is left blank, the code enters a 1.0.
37-48	VOFL	Minimum energy for neutrons in a zone. Zones that are not assigned a value here are assumed to have the value of VMIN. See Card 9, Columns 1-12, or description.
49-54	EMING	Minimum energy for photons in a zone. Zones that are not assigned a value here are assumed to have the value of EMIN from Card 3B, Columns 1-12.
55-57	LTYPEG	Photon edit indicator. Each zone may have a separate photon tally type. If this entry is left blank, ITNG, Card 3B, Columns 13-16, is inserted.
58-60	LTYPE	Neutron edit indicator. LTYPE allows each zone to have one of the tally types listed for ITN, Card 2, Columns 49-52, with the same limitation as described. If this entry is left blank, ITN is inserted.
61-72	UNITS	Zone multiplier. In addition to standard output, a constant can be entered for each zone to modify the output to different units. (See discussion after the listing of the options for ITN, Card 2, Columns 49-52.)

INPUT CARD 12A. GEOMETRICAL DEBUG PARAMETERS (optional)
Format (I12, 4F12.5)

Columns	Name	Description
1-60		If the debug sentinel (Card 3A, Column 36) is set to 1, a geometric volume of the problem defined by Cards 12A and 12B will be saturated with particles in order to determine whether any space is not properly described. Any errors found will be printed out. If there are too many errors, the problem will be terminated. Statistical volumes will also be calculated for those zones that are bounded by three-dimensional boundaries. The values for IC00D, etc., given on Cards 12A and 12B have nothing to do with the source input for the problem but are used for the generator-debug routine only. The volume of the problem to be examined can be either cylindrical, spherical, or rectangular.
12	IC00D	IC00D = 2, 3, or 5 for cylindrical, spherical, or rectangular volume (defined as S1, Card 2).
13-24	FRAC	The number of particles per cubic centimeter used to saturate the given volume. Note that a 50-zone problem with a volume of $1.5 \times 10^5 \text{ cm}^3$ takes about 1 min of computer time to test 1.5×10^5 particles and calculates volumes to about $\pm 10\%$.
25-60		RA, RB, Z1. Used to define the volume. Equivalent to input parameters S3, S4, and S5 (see S1, Card 2).

INPUT CARD 12B. CONTINUATION OF CARD 12A (optional)

Format (6F12.5)

Columns	Name	Description
1-72		SA, Z3, X0, Y0, SA2, S51. Used to define the volume. Equivalent to input parameters S8, S9, S10, S11, S12, and S15 (see S1, Card 2).

INPUT CARD 14. TIME DISTRIBUTION OF SOURCE (optional)

Format (5F12.5)

Columns	Name	Description
1-60	TL	Time distribution table. If entry for "type of time distribution" (Card 2, Columns 53-56) is 2 or greater, this card is used. The number of times equal to that entry is entered, six at a time, to a maximum of 12. The time coordinate is sampled in such a way that the initial time coordinate is chosen with equal probability from each interval and is chosen uniformly within the interval. Time is in shakes (10^{-8} s). If ITM (Card 2, Columns 53-56) is negative, then that many pairs of points N(T) and T will be entered (three pairs of points to a card, up to a maximum of 100 pairs). N(T) is in particles per shake and T is in shakes. This is not a histogram. The code assumes that consecutive pairs of points are connected by a straight line of the form $AT + B$, and it integrates over time to obtain the number of particles in each interval.

INPUT CARD 15. EDIT TIMES

Format (5F12.5)

Columns	Name	Description
1-60	TCT	Times at which edits are taken. The various output quantities are accumulated up to the edit times. A maximum of five is allowed. Time is in shakes.

INPUT CARD CARD 15A. ENERGY-DEPENDENT NEUTRON OUTPUT TALLY MULTIPLIERS (OPTIONAL)

Format (6F12.5)

Columns	Name	Description
1-72	EDIF	If IEDIF (Card 3, Columns 9-12) is equal to 2, 50 numbers are read in to be used as tally group multipliers for the output by energy.

INPUT CARD 15B. ENERGY-DEPENDENT PHOTON OUTPUT TALLY MULTIPLIERS (OPTIONAL)

Format (6F12.5)

Columns	Name	Description
1-72	EDIG	If IGSENT (Card 3B, columns 29-32) is equal to 2, 50 numbers are read in to be used as tally group multipliers for the photon output by energy.

INPUT CARD 16. ENERGY SPECTRUM (OPTIONAL)
Format (6F12.5)

Columns	Name	Description
1-72	FNS	<p>If the entry on Card 8, Columns 1-12, is zero or positive, or if ISPEC (Card 3, Columns 1-4) is 11 or 12, this card should be omitted.</p> <p>If the entry on Card 3, Columns 1-4, is 1, this table will consist of pairs of entries $N(E)$ and E, where E is in MeV. There are VN (Card 8, Columns 1-12) of these pairs.</p>

INPUT CARD 17. ENERGY-ANGLE-CORRELATED SOURCE WITH ANGULAR-DISTRIBUTION
WEIGHTING FUNCTION (OPTIONAL) Format (6F12.5)

Columns	Name	Description
1-72	FNS	<p>Input array for angle of source. If ISPEC (Card 3, Columns 1-4) is 11, then VN (Card 8, Columns 1-12) pairs of entries of $N(\gamma)$ and γ make up this table. The entries should range from -1.0 to +1.0.</p>

INPUT CARD 17A. ENERGY-ANGLE-CORRELATED SOURCE WITH ANGULAR-DISTRIBUTION
WEIGHTING FUNCTION (OPTIONAL) Format (I4)

Columns	Name	Description
1-4	K2	<p>Number of energy-angle pairs. If ISPEC (Card 3, Columns 1-4) is 11, this entry is the number of pairs of energy and angle to be entered on Card 17B.</p>

INPUT CARD 17B. ENERGY-ANGLE-CORRELATED SOURCE WITH ANGULAR-DISTRIBUTION
WEIGHTING FUNCTION (OPTIONAL) Format (6F12.5)

Columns	Name	Description
1-72	FNS	<p>Energy-angle table. If ISPEC is 11, K2 pairs of data $[E_1, \gamma_1] \dots [E_{K2}, \gamma_{K2}]$ are entered. Values of γ should range from -1.0 to +1.0, but they do not have to be the same as on Card 17.</p>

INPUT CARD 17C. MULTIPLE-ANGLE ENERGY SPECTRA (OPTIONAL)
Format (2I12, 2F12.5)

Columns	Name	Description
1-48		Multiple-angle energy spectra control. If ISPEC (Card 3, Columns 1-4) is 12, there will be VN (Card 8, Columns 1-12) 17C cards. Each 17C card will be followed by as many 17D cards as necessary.
1-12	ISOU	Relative number of particles in this spectrum.
13-24	NUMB	Number of pairs of points N(E) and E to be entered on Card 17D (maximum of 100).
25-36 37-48	COS1 COS2	COS1 and COS2 are the limits of $\cos \gamma$ between which this spectrum will be generated. If S1 (Card 2, Columns 37-40) is 13, the angles γ will be measured from the normal to a spherical surface at the point of generation. Otherwise the angles are measured with respect to the z-axis.

INPUT CARD 17D. MULTIPLE-ANGLE ENERGY SPECTRA (OPTIONAL)
Format (6F12.5)

Columns	Name	Description
1-72	FNS	Energy array. Number (Card 17C, Columns 13-24) of pairs of entries of N(E) and E, where N(E) is the number of particles per unit energy E (in MeV). There are three pairs to a card. Every 17C card will be followed by as many 17D cards as are necessary.

INPUT CARD 18. ISOTOPIC COMPOSITION OF MATERIALS
Format (2I3, F10.3, 4(F8.6, 16))

Columns	Name	Description
1-3	M	Material number. Materials must be numbered in consecutive order.
4-6	ISUBM	Number of isotopes in the material.
7-16	XISUBM	Density of the material in grams per cubic centimeter.
17-24	XISUBM	Atom fraction of first isotope in the material.

INPUT CARD 18 (cont.)

Columns	Name	Description
25-30	ISUBM	ZA of the first isotope in the material (ZZZAAA).
31-38	XISUBM	Fraction of the second isotope.
39-44	ISUBM	ZA of the second isotope, etc.

INPUT CARD 19. ISOTOPIC COMPOSITION OF MATERIALS Format (16X, 4(F8.6, 16))

Columns	Name	Description
1-72		This card is to be used if the number of isotopes in a material is greater than 4.
1-16		Not used.
17-24	XISUBM	Fraction of fifth (or multiple of fifth) isotope.
25-30	ISUBM	Fifth (or multiple of fifth) isotope, etc.

INPUT CARD 19A. PROBLEM MULTIPLIERS (OPTIONAL) Format (5F12.5)

Columns	Name	Description
1-60	PROBM	Problem multipliers. If I13 (Card 3, Columns 41-44) is nonzero, I13 problem multipliers are entered. The energy deposited (expressed in MeV/g or MeV/cm ³) and fissions (expressed as number of fissions per gram or cubic centimeter) by zone and time step are multiplied by these conversion factors. (See Card 2, Columns 49-52, and IA23, IA24, Card 3A, Columns 37-44.)

INPUT CARD 20. MULTIPLE SHELLS; CYLINDRICAL OR SPHERICAL (OPTIONAL) Format (12, 10F7.0)

Columns	Name	Description
1-72		Used only when S1 is 9, 10, or 11 (Card 2, Columns 37-40).
1-2	LSOR	Number of source shells (maximum of 15).
3-72	SOURC	Relative number of particles in each shell (Format 10F7.0).

INPUT CARD 21. MULTIPLE SHELLS (CYLINDRICAL OR SPHERICAL) (OPTIONAL)
Format (6F12.5, F8.1)

Columns	Name	Description
1-80		Used only when S1 is 9 or 10. There will be LSOR (Card 20, Columns 1-2) of these cards.
1-12	RI	Inner radius.
13-24	RO	Outer radius.
25-26	XOV	Displacement of center on x-axis.
37-48	YOV	Displacement of center on y-axis.
49-60	ZOV	Displacement of center on z-axis.
61-72	ZDEL	Length of cylinder (for S1 = 10 only).
73-80	TIM	Initial time coordinate.

INPUT CARD 22. SURFACE SOURCE (OPTIONAL)
Format (2I3, 6E11.4)

Columns	Name	Description
1-72		Boundary data for source S1 = 11. If S1 = 11, the number of these cards will be LSOR (Card 20, Columns 1-2).
1-3	I	Type of surface on which source is generated. <u>I = 1:</u> conic surface. <u>I = 2:</u> sphere. <u>I = 3:</u> cylinder. <u>I = 4:</u> circular disk.
4-6	L	Probable zone in which source is generated.
7-17	RI	Z1 for a conic source and R for other sources.
18-28	RO	Z2 for a conic source. A2 for sphere (the segment of sphere generated is defined by $A1 \cdot R + A2$). Z2 for cylinder. RO for disk.
29-39	XO	XO for all sources.
40-50	YO	YO for all sources.
51-61	ZO	ZO for all sources.

INPUT CARD 22 (cont.)

Columns	Name	Description
62-72	Z	-(slope)**2 for a conic source. A1 for sphere. Z1 for cylinder. +1. for disk, indicating the direction of the normal to the surface (-1. for a source beamed in the positive direction, +1. for a source beamed in the negative direction).

INPUT CARD 23. SOURCE INFORMATION FOR TALLY TYPES 18 AND 19 (OPTIONAL) Format (5F12.5)

Columns	Name	Description
1-60		Input for Tally Types 18 and 19.
1-12	RMAXI	Radius of disk or spherical segment.
13-24	ZIN	The z-coordinate of disk or Z0 for a spherical segment.
25-36	LIN19	Zone in which disk is generated.
37-48	KIN	Number of particles to be created.
49-60	NGI	All zones greater than or equal to NGI will be normalized by KIN.

INPUT CARD 24. SOURCE INFORMATION FOR TALLY TYPES 18 AND 19 (OPTIONAL) Format (5F12.5)

Columns	Name	Description
1-60		Input for Tally Types 18 and 19.
1-12	MSPRS	If MSPRS = 1, source will be put on a cylindrical disk. If MSPRS = 2, source will be on a spherical segment.
13-24	SPX0	Displacement on x-axis for spherical segment.
25-36	SPY0	Displacement of y-axis for a spherical segment.
37-48	GSPH	The spherical segment is derived by $GSPH \cdot R + GSPH1 = \cos \theta$, where $\cos \theta$ is relative to the z-axis and R is a random number.
49-60	GSPH1	

APPENDIX A--LIST OF AVAILABLE ISOTOPES

1	0-nu-1	26000	26-fe-nat	92236	92-u-236
1001	1-h-1	27059	27-co-59	92237	92-u-237
1002	1-h-2	28000	28-ni-nat	92238	92-u-238
1003	1-h-3	28058	28-ni-58	92239	92-u-239
2003	2-he-3	29000	29-cu-nat	92240	92-u-240
2004	2-he-4	31000	31-ga-nat	93237	93-np-237
3006	3-li-6	40000	40-zr-nat	94238	94-pu-238
3007	3-li-7	41093	41-nb-93	94239	94-pu-239
4007	4-be-7	42000	42-mo-nat	94240	94-pu-240
4009	4-be-9	47107	47-ag-107	94241	94-pu-241
5010	5-b-10	47109	47-ag-109	94242	94-pu-242
5011	5-b-11	48000	48-cd-nat	94243	94-pu-243
6012	6-c-12	50000	50-sn-nat	95241	95-am-241
7014	7-n-14	56138	56-ba-138	95242	95-am-242
8016	8-o-16	63000	63-eu-nat	95243	95-am-243
9019	9-f-19	64000	64-gd-nat	96242	96-cm-242
11023	11-na-23	67165	67-ho-165	96243	96-cm-243
12000	12-mg-nat	73181	73-ta-181	96244	96-cm-244
13027	13-al-27	74000	74-w-nat	96245	96-cm-245
14000	14-si-nat	75185	75-re-185	96246	96-cm-246
15031	15-p-31	75187	75-re-187	96247	96-cm-247
16032	16-s-32	78000	78-pt-nat	96248	96-cm-248
17000	17-cl-nat	79197	79-au-197	97249	97-bk-249
18000	18-ar-nat	82000	82-pb-nat	98249	98-cf-249
19000	19-k-nat	90231	90-th-231	98250	98-cf-250
20000	20-ca-nat	90232	90-th-232	98251	98-cf-251
22000	22-ti-nat	90233	90-th-233	98252	98-cf-252
23051	23-v-51	92233	92-u-233	99120	fission
24000	24-cr-nat	92234	92-u-234		products
25055	25-mn-55	92235	92-u-235		

nat indicates the naturally occurring element.

APPENDIX B--NEUTRON ENERGY GROUPS

1	1.307e-09	36	2.940e-05	71	1.338e-04	106	2.646e-02	141	4.069e+00
2	5.227e-09	37	3.099e-05	72	1.406e-04	107	3.267e-02	142	4.396e+00
3	2.091e-08	38	3.345e-05	73	1.511e-04	108	3.953e-02	143	4.704e+00
4	3.267e-08	39	3.601e-05	74	1.601e-04	109	4.704e-02	144	4.991e+00
5	4.704e-08	40	3.866e-05	75	1.694e-04	110	5.761e-02	145	5.353e+00
6	8.322e-08	41	4.048e-05	76	1.789e-04	111	7.002e-02	146	5.658e+00
7	1.307e-07	42	4.234e-05	77	1.887e-04	112	8.322e-02	147	6.042e+00
8	1.882e-07	43	4.329e-05	78	1.988e-04	113	9.891e-02	148	6.367e+00
9	2.561e-07	44	4.619e-05	79	2.091e-04	114	1.307e-01	149	6.737e+00
10	3.345e-07	45	4.717e-05	80	2.741e-04	115	1.820e-01	150	7.156e+00
11	4.234e-07	46	4.918e-05	81	3.267e-04	116	2.075e-01	151	7.548e+00
12	5.123e-07	47	5.123e-05	82	3.811e-04	117	2.417e-01	152	7.910e+00
13	7.527e-07	48	5.332e-05	83	4.704e-04	118	2.710e-01	153	8.322e+00
14	1.176e-06	49	5.654e-05	84	4.991e-04	119	2.940e-01	154	8.787e+00
15	1.511e-06	50	5.763e-05	85	5.658e-04	120	3.345e-01	155	9.177e+00
16	2.091e-06	51	6.097e-05	86	6.042e-04	121	3.777e-01	156	9.665e+00
17	2.741e-06	52	6.325e-05	87	6.367e-04	122	4.234e-01	157	1.012e+01
18	3.533e-06	53	6.557e-05	88	7.156e-04	123	5.123e-01	158	1.058e+01
19	4.704e-06	54	6.674e-05	89	8.322e-04	124	6.325e-01	159	1.101e+01
20	5.658e-06	55	7.034e-05	90	9.177e-04	125	7.527e-01	160	1.155e+01
21	6.737e-06	56	7.155e-05	91	1.058e-03	126	8.834e-01	161	1.199e+01
22	8.322e-06	57	7.527e-05	92	1.307e-03	127	1.025e+00	162	1.250e+01
23	9.620e-06	58	7.780e-05	93	1.581e-03	128	1.176e+00	163	1.307e+01
24	1.101e-05	59	7.908e-05	94	1.882e-03	129	1.338e+00	164	1.354e+01
25	1.307e-05	60	8.167e-05	95	2.208e-03	130	1.511e+00	165	1.386e+01
26	1.468e-05	61	8.431e-05	96	2.561e-03	131	1.694e+00	166	1.413e+01
27	1.581e-05	62	8.834e-05	97	2.940e-03	132	1.887e+00	167	1.441e+01
28	1.758e-05	63	9.108e-05	98	3.345e-03	133	2.091e+00	168	1.468e+01
29	1.882e-05	64	9.386e-05	99	3.777e-03	134	2.305e+00	169	1.519e+01
30	2.075e-05	65	9.668e-05	100	4.234e-03	135	2.530e+00	170	1.575e+01
31	2.277e-05	66	9.811e-05	101	5.763e-03	136	2.741e+00	171	1.633e+01
32	2.417e-05	67	1.025e-04	102	7.527e-03	137	3.011e+00	172	1.692e+01
33	2.561e-05	68	1.099e-04	103	1.025e-02	138	3.267e+00	173	1.752e+01
34	2.710e-05	69	1.176e-04	104	1.511e-02	139	3.533e+00	174	1.813e+01
35	2.862e-05	70	1.256e-04	105	2.091e-02	140	3.811e+00	175	1.875e+01
									2.000e+01

APPENDIX C--PHOTON ENERGY GROUPS

1	1.000e-04	36	1.559e-03	71	8.180e-03	106	4.200e-02	141	3.505e-01
2	1.089e-04	37	1.700e-03	72	8.383e-03	107	4.736e-02	142	3.855e-01
3	1.103e-04	38	1.838e-03	73	8.600e-03	108	4.851e-02	143	4.241e-01
4	1.166e-04	39	1.910e-03	74	8.982e-03	109	5.023e-02	144	4.665e-01
5	1.500e-04	40	2.142e-03	75	9.200e-03	110	5.500e-02	145	5.132e-01
6	2.000e-04	41	2.240e-03	76	9.400e-03	111	6.100e-02	146	5.645e-01
7	2.158e-04	42	2.410e-03	77	9.560e-03	112	6.745e-02	147	6.209e-01
8	2.172e-04	43	2.470e-03	78	9.660e-03	113	6.746e-02	148	6.830e-01
9	2.501e-04	44	2.630e-03	79	9.800e-03	114	6.951e-02	149	7.513e-01
10	2.515e-04	45	2.750e-03	80	1.001e-02	115	7.350e-02	150	8.264e-01
11	3.000e-04	46	2.820e-03	81	1.039e-02	116	7.835e-02	151	9.091e-01
12	3.244e-04	47	2.960e-03	82	1.075e-02	117	8.067e-02	152	1.000e+00
13	3.847e-04	48	3.180e-03	83	1.114e-02	118	8.552e-02	153	1.125e+00
14	3.881e-04	49	3.547e-03	84	1.192e-02	119	8.795e-02	154	1.266e+00
15	4.000e-04	50	3.606e-03	85	1.265e-02	120	9.054e-02	155	1.424e+00
16	4.374e-04	51	3.700e-03	86	1.303e-02	121	9.230e-02	156	1.602e+00
17	4.390e-04	52	3.828e-03	87	1.386e-02	122	9.600e-02	157	1.802e+00
18	5.000e-04	53	4.030e-03	88	1.470e-02	123	1.000e-01	158	2.027e+00
19	5.500e-04	54	4.150e-03	89	1.520e-02	124	1.050e-01	159	2.281e+00
20	5.943e-04	55	4.300e-03	90	1.571e-02	125	1.097e-01	160	2.566e+00
21	5.947e-04	56	4.496e-03	91	1.639e-02	126	1.098e-01	161	2.887e+00
22	6.000e-04	57	4.810e-03	92	1.700e-02	127	1.149e-01	162	3.247e+00
23	6.836e-04	58	5.163e-03	93	1.716e-02	128	1.150e-01	163	3.653e+00
24	6.850e-04	59	5.467e-03	94	1.806e-02	129	1.211e-01	164	4.110e+00
25	7.000e-04	60	5.546e-03	95	1.898e-02	130	1.212e-01	165	4.624e+00
26	7.541e-04	61	5.934e-03	96	1.967e-02	131	1.351e-01	166	5.202e+00
27	7.555e-04	62	5.980e-03	97	2.010e-02	132	1.486e-01	167	5.852e+00
28	8.000e-04	63	6.250e-03	98	2.095e-02	133	1.635e-01	168	6.583e+00
29	8.197e-04	64	6.543e-03	99	2.175e-02	134	1.799e-01	169	7.406e+00
30	8.211e-04	65	6.750e-03	100	2.225e-02	135	1.978e-01	170	8.332e+00
31	9.000e-04	66	6.980e-03	101	2.312e-02	136	2.176e-01	171	9.373e+00
32	1.000e-03	67	7.113e-03	102	2.553e-02	137	2.394e-01	172	1.055e+01
33	1.080e-03	68	7.251e-03	103	2.918e-02	138	2.633e-01	173	1.186e+01
34	1.140e-03	69	7.713e-03	104	3.316e-02	139	2.897e-01	174	1.335e+01
35	1.360e-03	70	7.942e-03	105	3.750e-02	140	3.186e-01	175	2.000e+01

APPENDIX D--TALLY GROUP LIMITS FOR NEUTRONS AND PHOTONS

TALLY GROUP LIMITS FOR NEUTRONS (DEFAULT SET)

1 1.307e-09	11 6.097e-05	21 5.763e-03	31 2.091e+00	41 8.322e+00
2 8.322e-08	12 7.155e-05	22 2.646e-02	32 2.530e+00	42 9.177e+00
3 4.234e-07	13 8.431e-05	23 7.002e-02	33 3.011e+00	43 1.012e+01
4 2.091e-06	14 9.811e-05	24 2.075e-01	34 3.533e+00	44 1.101e+01
5 6.737e-06	15 1.338e-04	25 3.777e-01	35 4.069e+00	45 1.199e+01
6 1.468e-05	16 1.789e-04	26 5.123e-01	36 4.704e+00	46 1.307e+01
7 2.277e-05	17 3.267e-04	27 7.527e-01	37 5.353e+00	47 1.386e+01
8 2.940e-05	18 6.042e-04	28 1.025e+00	38 6.042e+00	48 1.413e+01
9 4.048e-05	19 1.058e-03	29 1.338e+00	39 6.737e+00	49 1.441e+01
10 4.918e-05	20 2.561e-03	30 1.694e+00	40 7.540e+00	50 1.519e+01
				2.000e+01

TALLY GROUP LIMITS FOR PHOTONS (DEFAULT SET)

1 1.000e-04	11 5.980e-03	21 1.700e-02	31 9.600e-02	41 1.000e+00
2 1.360e-03	12 6.750e-03	22 1.898e-02	32 1.097e-01	42 1.424e+00
3 1.838e-03	13 7.251e-03	23 2.095e-02	33 1.150e-01	43 2.027e+00
4 2.240e-03	14 8.180e-03	24 2.312e-02	34 1.351e-01	44 2.887e+00
5 2.630e-03	15 8.982e-03	25 3.316e-02	35 1.799e-01	45 4.110e+00
6 2.960e-03	16 9.560e-03	26 4.736e-02	36 2.394e-01	46 5.202e+00
7 3.606e-03	17 1.001e-02	27 5.500e-02	37 3.185e-01	47 6.583e+00
8 4.030e-03	18 1.114e-02	28 6.746e-02	38 4.241e-01	48 8.332e+00
9 4.496e-03	19 1.303e-02	29 7.835e-02	39 5.645e-01	49 1.055e+01
10 5.467e-03	20 1.520e-02	30 8.795e-02	40 7.513e-01	50 1.335e+01
				2.000e+01

APPENDIX E--LIMITS FOR TALLY TYPES 7, 8, 9, AND 10

COSINES OF ANGULAR DISTRIBUTION LIMITS FOR TALLY TYPES 7,8,9, AND 10

1 1.0	5 0.82	9 0.20	13 -0.40	17 -0.90
2 0.98	6 0.72	10 0.05	14 -0.60	18 -0.95
3 0.95	7 0.60	11 -0.05	15 -0.72	19 -0.98
4 0.90	8 0.40	12 -0.20	16 -0.82	-1.00

PHOTON ENERGY TALLY GROUP LIMITS FOR TALLY TYPES 7, 8, 9, AND 10

1 1.00e-04	5 2.31e-02	9 7.51e-01
2 2.62e-03	6 6.75e-02	10 2.03e+00
3 8.98e-03	7 1.15e-01	11 4.11e+00
4 1.30e-02	8 3.19e-01	12 8.33e+00
		2.00e+01

NEUTRON ENERGY TALLY GROUP LIMITS FOR TALLY TYPES 7, 8, 9, AND 10

1 1.31e-09	5 2.07e-01	9 7.55e+00
2 6.71e-06	6 1.02e+00	10 1.01e+01
3 1.34e-04	7 3.01e+00	11 1.20e+01
4 1.06e-03	8 5.35e+00	12 1.41e+01
		2.00e+01

APPENDIX F--PROGRAM TALLY

The program TALLY resides on the CRAY and was written to list the permanent files, TALLYN or TALLYP, which are created when ITN(G) Tally Options 11, 12, or 16 are chosen in TARTNP.

One input data card is needed with an 11, 12, or 16 punched in Columns (1-2). All data on the file will be listed.

The JCL instructions following the Job and Account Cards will be illustrated. Note that the same ID and PW as used in the TARTNP run must be used.

```
ACCESS,DN=$BLD,PDN=TALLY,ID=GORDO.  
ACCESS,DN=FT01,PDN=TALLYN,ID=GORDO,M=XYZ,UQ.  
LDR.  
7/8/9  
data card  
7/8/9
```

If the permanent file is of photon data, use PDN=TALLYP on second card.

Note that DN=FT01 has been accessed in such a way that you can purge it by adding the following instruction after the LDR card:

```
DELETE,DN=FT01.
```

Do Not
Microfilm Distr.

UNLIMITED RELEASE

INITIAL DISTRIBUTION

J. R. Kimlinger, LLNL, L-71 (2)
E. F. Plechaty, LLNL, L-71 (2)
G. H. Rodrigue, LLNL, L-306

K. M. Matzen, 4247
J. E. Morel, 4231
T. P. Wright, 4231
J. H. Renken, 4365
J. S. Philbin, 4452
R. S. Claassen, 8000; Attn: D. M. Olson, 8100
A. N. Blackwell, 8200
L. Gutierrez, 8400
D. L. Hartley, 8500

M. Hall, 8112
S. G. Peglow, 8112
J. M. Stephenson, 8112
G. C. Slury, 8112
H. M. Witek, 8112
B. A. Benedetti, 8121
C. S. Hoyle, 8122
B. L. Kistler, 8122
V. D. Revelli, 8122
L. I. Weingarten, 8122
R. J. Gallagher, 8124
J. S. Kraabel, 8124
K. W. Battleson, 8131
D. K. Dean, 8131
P. G. Heppner, 8131
B. F. Murphey, 8300; Attn: D. M. Schuster, 8310
R. L. Rinne, 8320
W. Bauer, 8340

K. W. Dolan, 8322
J. Vitko, 8328
G. W. Anderson, 8330; Attn: R. J. Kee, 8331
R. Y. Lee, 8334
R. E. Huddleston, 8332
G. B. Drummond, 8336

G. J. Miller, 8332 (53)
J. S. Binkley, 8341
L. G. Haggmark, 8341
W. D. Wilson, 8341
W. B. Gauster, 8347
L. W. Dahlke, 8444 (2)
C. T. Oien, 8444 (2)

Publications Division, 8265, for TIC (2)
Publications Division, 8265/Technical Library Processes Division, 3141
Technical Library Processes Division, 3141 (3)
M. A. Pound, 8214, for Central Technical Files (3)